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Role of sanitation in preventing faecal contamination of the domestic environment and protecting health: An observational study.

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LONDON SCHOOL OF HYGIENE & TROPICAL MEDICINE

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Research group affiliation: Environmental Health Group (EHG)
Declaration

I, Tarique Mohammad Nurul Huda, confirm that the work presented in this thesis is my own. Where information has been derived from other sources, I confirm that this has been indicated in the thesis.

Signed____________________________  Date: 31\textsuperscript{st} January, 2016

Tarique Mohammad Nurul Huda
Abstract

This thesis assesses the potential public health significance of, sanitation quality and coverage by using microbiological indicator and secondary health outcome data. Sanitation was categorised using The Millennium Development Goal (MDG) definition of improved (private pit latrine with a slab or better) and unimproved (toilets connected to open, pit latrine without a slab, hanging toilet, shared toilets).

A spot check of sanitation facilities was conducted in 460 target houses and 1,784 neighbouring houses. Faecal contamination of the household environment was assessed by looking for evidence of contamination with faecal coliforms on children’s hands and on ‘sentinel’ toys (standardised toy balls provided by the study). An analysis of secondary data was conducted on sanitation and reported diarrhoea among children <5 years of age that had been collected as part of an impact evaluation.

Households with private improved sanitation had lower faecal coliform contamination than households with unimproved sanitation [difference in means: -0.31 log_{10} colony forming units (CFU)/toy ball; 95% CI: -0.61, -0.01]. Access to 100% private improved sanitation coverage in the neighbourhood was associated with a small but statistically insignificant difference in contamination of sentinel toys (difference in means: -0.09 log_{10} CFU/toy; 95% CI: -0.56, 0.38). Other household sanitary practices such as cleanliness of latrine, wastewater disposal and disposal of animal faeces were important and statistically significant (P value ≤0.06) determinants of household faecal contamination. Children from households with access to private improved sanitation had a similar prevalence of diarrhoea to those with unimproved sanitation (Prevalence Ratio [PR] =1.00; 95% CI: 0.89, 1.13). Children from households with appropriate solid waste disposal systems had lower prevalence of diarrhoea compared to those without (PR=0.78; 95% CI: 0.65, 0.95).
Improved sanitation infrastructure quality and coverage may have limited roles in preventing transmission of diarrhoea causing enteric pathogens in the study context in which diarrhoea is endemic. Although in this study, private use and cleanliness of latrine were associated reduction in faecal contamination, but these factors were not associated with reduced diarrhoea prevalence. This may be because, firstly data were collected from slightly different contexts and time, secondly indicator organisms are only weakly associated presence of enteric pathogens and thirdly the population in this study context may have developed some degree of immunity to common circulating pathogens. Findings from this observational studies presented in this thesis adds to the evidence base, which do not support the inclusion of shared facilities as improved. There may be other more important source of children’s exposure to enteric pathogens that onsite sanitation access cannot prevent. Other sanitation related factors like maintenance of sanitation facility, use by all household members including children and faecal sludge management should be considered while defining improved sanitation for international monitoring. We also need to increase research efforts to integrate sanitation, water quality, handwashing and nutritional interventions and to understand better ways to monitor the impact of these interventions.
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<td>Bangladesh Demographic and Health Survey</td>
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<td>CFU</td>
<td>Colony Forming Units</td>
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<td>CHP</td>
<td>Community Hygiene Promoter</td>
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<tr>
<td>CI</td>
<td>Confidence Interval</td>
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<tr>
<td>CV</td>
<td>Coefficient of Variation</td>
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<td>DAG</td>
<td>Directed Acyclic Graph</td>
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<tr>
<td>DFID</td>
<td>Department For International Development</td>
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<td>DHS</td>
<td>Demographic and Health Survey</td>
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<td>DPHE</td>
<td>Department of Public Health Engineering</td>
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<tr>
<td>EC</td>
<td><em>Escherichia coli</em></td>
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<tr>
<td>ECVG</td>
<td><em>E. coli Virulence Genes</em></td>
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<td>ERC</td>
<td>Ethical Review Committee</td>
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<td>EPA</td>
<td>Environmental Protection Agency</td>
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<td>FC</td>
<td>Faecal Coliform</td>
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<tr>
<td>FIB</td>
<td>Faecal Indicator Bacteria</td>
</tr>
<tr>
<td>GBP</td>
<td>Great Britain Pound</td>
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<tr>
<td>GEE</td>
<td>Generalised Estimating Equation</td>
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<tr>
<td>GIS</td>
<td>Geographic Information System</td>
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<tr>
<td>GLS</td>
<td>Generalised Least Squares</td>
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<tr>
<td>GoB</td>
<td>Government of Bangladesh</td>
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<tr>
<td>GPS</td>
<td>Global Positioning System</td>
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<td>HH</td>
<td>Household</td>
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<tr>
<td>icddr,b</td>
<td>International Centre for Diarrhoeal Disease Research Bangladesh</td>
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<td>IGME</td>
<td>Inter-agency Group for child mortality estimation</td>
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<td>JMP</td>
<td>WHO/UNICEF Joint Monitoring Programme for Water Supply and Sanitation</td>
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<td>LSHTM</td>
<td>London School of Hygiene and Tropical Medicine</td>
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<td>MDD</td>
<td>Minimum Detectable Difference</td>
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<td>MDG</td>
<td>Millennium Development Goal</td>
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<td>MST</td>
<td>Microbial Source Tracking</td>
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<td>PAF</td>
<td>Population Attributable Fraction</td>
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<td>PB</td>
<td>Primary Barrier</td>
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<td>PCA</td>
<td>Principal Component Analysis</td>
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<td>PR</td>
<td>Prevalence Ratio</td>
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<td>OR</td>
<td>Odds Ratio</td>
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<td>SB</td>
<td>Secondary Barrier</td>
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<tr>
<td>SD</td>
<td>Standard Deviation</td>
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<td>SDG</td>
<td>Sustainable Development Goal</td>
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<td>SHARE</td>
<td>Sanitation and Hygiene Applied Research for Equity</td>
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<td>SHEWA-B</td>
<td>Sanitation Hygiene Education and Water Supply in Bangladesh Programme</td>
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<tr>
<td>SOP</td>
<td>Standard Operating Procedures</td>
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<tr>
<td>TNTC</td>
<td>Too Numerous To Count</td>
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<tr>
<td>TTC</td>
<td>Thermo-Tolerant Coliform</td>
</tr>
<tr>
<td>UK</td>
<td>United Kingdom</td>
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<td>UN</td>
<td>United Nations</td>
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<td>UNICEF</td>
<td>United Nations Children’s Fund</td>
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<td>US</td>
<td>United States</td>
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<td>USEPA</td>
<td>US Environmental Protection Agency</td>
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<tr>
<td>VIF</td>
<td>Variance Inflation Factor</td>
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<td>VIP</td>
<td>Ventilated Improved Pit Latrine</td>
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<tr>
<td>Vs.</td>
<td>Versus</td>
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<td>WATSAN</td>
<td>Water Sanitation and Hygiene</td>
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<td>WHO</td>
<td>World Health Organisation</td>
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Chapter 1: Background and literature review

1.1 Background

1.1.1. Burden of diarrhoeal diseases

Globally, deaths due to diarrhoea among children under five years of age fell by more than 50% in 2013 in comparison to 1990 [1]. Despite these substantial reductions diarrhoea is still one of the leading causes of mortality [1, 2] and morbidity [3] among children under five. According to the UN Inter-agency Group for Child Mortality Estimation (IGME), worldwide an estimated 6.3 million children younger than five years died in 2013. About 9% (0.448-0.750 million) of these deaths were caused by diarrhoea [2, 4]. The incidence of diarrhoea declined, from 3.4 episodes/child per year in 1990, to 2.9 episodes/child per year in 2010. However, there were still 1.7 billion episodes of diarrhoea in 2010, in 139 low and middle income countries [3]. In the South East Asian region of the WHO, there were 2.4 episodes of diarrhoea per child year in 2010 [3].

Diarrhoea is also found to be a risk factor for pneumonia [5]. Moreover repeated episodes of early childhood diarrhoea have a lasting influence on physical growth, [6] cognitive function [7], school performance [6-10], obesity associated co-morbidities [10] and reduced economic productivity [11]. So, for the health and development of the children of low and middle income countries, the cost of diarrhoea remains high, and interventions to reduce child mortality and morbidity due to diarrhoeal diseases need to be given a high priority [3, 12].

1.1.2. Transmission of infectious diarrhoea

Most cases of diarrhoea are transmitted through the faecal-oral route [13]. The agents causing diarrhoea, including viruses, bacteria, protozoa and parasitic worms can transmit from one host to another through several pathways, via the environment [14]. The pathways, through which diarrhoea causing enteric pathogens can be transmitted from faeces, through the environment to a new host, are illustrated in the ‘F diagram’ (Figure 1) [14-16]. In the environment, the
pathogens can be transmitted through contaminated food and drink, person to person contact, contact with objects and flies (either through contaminated food and utensils or landing directly on children) [17]. The transmission can occur in the context of both the domestic and public domain [18].

**Figure 1.1:** The F diagram showing transmission pathways of infectious diarrhoea [15, 16]

### 1.1.3. Diarrhoea prevention strategy

As shown in the Figure 1.1, there are several potential points for intervention in the environment that may reduce transmission of diarrhoea causing pathogens. Interventions to improve sanitation create a primary barrier. In contexts with suboptimal sanitation, additional environmental interventions may be needed as secondary barriers. WHO and UNICEF recommend five strategies to reduce diarrhoea that include environmental and non-environmental interventions. The strategies include 1) rotavirus and measles vaccinations; 2) promotion of early and exclusive breastfeeding; and vitamin A supplementation; 3) promotion of handwashing with soap; 4) improved water supply (quantity and quality), including

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treatment and safe storage of household water; and 5) community-wide sanitation promotion [19, 20].

1.1.4 Definition of sanitation

In the broadest sense the term sanitation may refer to the safe collection, storage, treatment and disposal, reuse, or recycling of human excreta (faeces and urine); as well as the drainage, disposal, recycling and reuse of household wastewater and storm water; along with management of household, industrial and hazardous solid waste [21]. According to the World Health Organisation “sanitation generally refers to the provision of facilities and services for the safe disposal of human urine and faeces” [22]. This definition ignores the disposal of sullage or wastewater. In most epidemiological studies sanitation is usually referred to safe disposal of human excreta [23, 24]. In this thesis the term sanitation refers to the disposal of human excreta.

1.1.5 Classification of sanitation used for international monitoring

International monitoring of sanitation helps to understand a country’s needs, it can inform policy and facilitates the implementation of policies to improve services. Worldwide there is a wide variety of sanitation technologies [25]. Demographic and Health Surveys (DHS) have identified over 400 different sanitation classifications in countries in which the surveys have been undertaken[26]. Contextual factors such as geographical location, population density, wealth, availability of materials, water level, acceptability and traditional practices determine the type of sanitation technologies that are suitable and available. Most of the sanitation facilities that are suitable in rural areas of low-income countries are onsite (pit latrines, septic tanks and other household level technologies that do not involve sewerage). Globally, as of 2010, 60% of urban residents reported using facilities linked to sewers compared to only 12% in rural areas. Sixty four percent of the rural population reported using onsite sanitation facilities [25].

Sanitation facilities vary in terms of technology but also in terms of ownership and user profile. These variations can affect not only user experience [27-
but also the extent to which faeces are contained, which in turn reduces contamination of the environment and thereby protects health [30]. For international monitoring of sanitation facilities this variation is a challenge. Ideally, for international monitoring, sanitation would be classified on the basis of evidence for its relative effectiveness in delivering both health and non-health benefits, but this evidence base is weak.

Since the 1930s monitoring of sanitation has been carried out in response to international targets [31]. Adopted in 2000, The Millennium Development Goals (MDGs) became the latest framework for doing this. Target 10 of the MDGs aimed to halve by 2015, the proportion of people without sustainable access to safe drinking water and basic sanitation, in comparison to 1990 [21, 32, 33]. The WHO/UNICEF Joint Monitoring Programme (JMP) for water supply and sanitation is the official United Nations mechanism tasked with monitoring towards the MDG related to water and sanitation. Access to sanitation is monitored using the indicator “proportion of population with access to improved sanitation” [33-35]. The terminology used for the MDG target is “basic sanitation” but JMP refers to basic sanitation as “improved sanitation”.

According to the JMP an "improved" sanitation facility is one that hygienically separates human excreta from human contact [36]. The JMP is constrained by the need to ensure that its definition and indicators can be monitored by existing household survey instruments. Moreover, the JMP also needs to make sure that the data used are comparable across countries and time [25]. So the JMP definition is focused on sanitation technology access at a household level in an attempt to strike a workable balance between what is desirable to measure and what is possible [37]. The improved sanitation facilities include pit latrines with slabs, ventilated improved pit latrines and flush/pour-flush latrines (Table 1). For the MDG target, shared facilities are considered unimproved [35, 38]. Throughout this chapter the term ‘improved sanitation’ will be used to refer to the current JMP technology classification definition without considering sharing status. In addition to the basic indicator to measure “access” or “no-access” to improved sanitation, in 2008 the
JMP also proposed the concept of a “sanitation ladder” to provide disaggregated information on access to sanitation [39]. This four rung ladder of sanitation (individual improved, shared improved, unimproved and no facility) outlines a hierarchy of predefined sanitation technologies, allowing the JMP to assess sanitation progress without changing the MDG definition (Figure 1.1). The sanitation technologies that meet the criteria of individual improved or shared improved are assumed to be better at hygienically separating faeces from the environment and thereby reducing health risk [34, 40].

Table 1.1: Definitions of sanitation proposed by WHO/UNICEF Joint monitoring programme for water supply and sanitation (JMP) and the Government of Bangladesh (GoB) [36, 41]

<table>
<thead>
<tr>
<th>Toilet characteristics</th>
<th>Improved</th>
<th>Hygienic</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>JMP technology type</td>
<td>MDG</td>
</tr>
<tr>
<td>Sanitation technology</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Flush or pour-flush toilet to</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>Sewerage pipe/Septic tank/Pit</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pit toilet with slab and lid/flap</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>Ventilated Improved Pit toilet</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>Composting toilet</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td><strong>Pit toilet with slab</strong></td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>Number of households using toilet facility</td>
<td>Not considered</td>
<td>1</td>
</tr>
</tbody>
</table>

*This was proposed by the working group on sanitation as presented in the JMP 2014 [36] report but later it was decided to continue to consider shared sanitation as unimproved [42].

As the world approached the deadline for the MDGs, new targets for the post 2015-Sustainable Development Goals (SDGs) were proposed and these also include sanitation [42, 43]. The JMP is revising its definitions to monitor progress towards sanitation for the SDGs. There was discussion as to whether to include sanitation facilities shared among no more than five households or 30 persons, whichever is fewer, as improved [36] (Table 1.1). For the MDG target, shared facilities were considered to be unimproved because of concern regarding cleanliness,
maintenance and access [35, 38]. However, the implications of using a shared facility are likely to be different for urban public and rural private facilities. In the crowded, urban areas of most low income countries, shared facilities might be the only viable option, to avoid open defecation. Whereas in rural areas households with family ties often share a facility to keep the cost down [35].

In addition to the definition provided by the JMP countries often have their own definition of sanitation for monitoring progress. For example the Government of Bangladesh (GoB) categorises sanitation as hygienic or unhygienic. The hygienic sanitation facilities exclude pit latrines with a slab (Table 1.1) [41] and allow sharing by a maximum of two households.

Despite the diversity of definitions used globally, there is very limited empirical evidence to judge the extent to which the definitions of sanitation facilities reflect their performance in separating faeces from the environment.
**Open defecation:** when human faeces are disposed of in fields, forest, bushes, open bodies of water, beaches or other open spaces or disposed of with solid waste.

**Unimproved sanitation facilities:** do not ensure hygienic separation of human excreta from human contact. Unimproved facilities include pit latrines without a slab or platform, hanging latrines and bucket latrines.

**Shared sanitation facilities:** Sanitation facilities of an otherwise acceptable type shared between two or more households. Only facilities that are not shared or not public are considered improved.

**Improved sanitation facilities:** are likely to ensure hygienic separation of human excreta from human contact. They include the following facilities:
- Flush/pour flush to:
  - piped sewer system
  - septic tank
  - pit latrine
- Ventilated improved pit (VIP) latrine
- Pit latrine with slab
- Composting toilet

Figure 1.2: JMP sanitation ladder [25]
1.1.6 Sanitation and diarrhoea

Improved sanitation through separating human faeces from the household environment is expected to create a primary barrier to break the chain of transmission of enteric pathogens through fields, fingers, fluids and flies (Figure 1) [14-16]. Inappropriate disposal of human faeces has been found to be associated with increased risk of childhood diarrhoea in several epidemiological studies conducted across different low-income country contexts [44, 45]. For example, in Ethiopia, children in households with no toilet facility were at six times greater risk of diarrhoea than children living in households with a toilet facility, after adjusting for other socio-economic and environmental determinants of diarrhoea [46]. Improper disposal of children's faeces was found to be associated with higher diarrhoeal disease risk among children under five years of age in several studies conducted in low income country contexts [44, 46, 47]. For example, in the Philippines, disposal of children's faeces in the open was associated with a 34% increase in clinically diagnosed diarrhoea among children under two years of age [48].

Evidence from several systematic reviews suggests that interventions to improve excreta disposal are effective in preventing diarrhoea morbidity. A meta-analysis conducted by Fewtrell and colleagues suggests that sanitation interventions in low-income country settings reduce diarrhoeal illness, with a pooled relative risk of 0.68 (0.53-0.0.87)[49]. This meta-analysis included two studies of sanitation intervention. In both of these studies, there was little evidence that the relationship between sanitation and diarrhoea was confounded by socioeconomic status [45, 50]. A Cochrane review conducted by Clasen and colleagues suggests that in low-income settings, interventions to improve excreta disposal are effective in preventing diarrhoeal disease [24]. However, due to major differences among the studies in term of study context, exposure levels, type of intervention, as well as methodological deficiencies in the studies themselves, the review could not provide any quantification of the pooled effect of the interventions on diarrhoea.

A recent systematic review conducted by Wolf and colleagues included randomized controlled trials, quasi-randomised trials with control group,
observational studies using matching techniques and observational studies with a well-defined control group. The meta-analysis from this study reported a relative risk of 0.72 (95% CI: 0.59, 0.88), indicating that improved sanitation had a protective effect on diarrhoeal incidence, compared to unimproved sanitation. Inadequate sanitation is not only linked with diarrhoea morbidity but also with mortality [37, 51-53]. In 2012, an estimated 58% (Population-Attributable Fraction, PAF) of the diarrhoea deaths that occurred in 145 low and middle-income countries were attributable to inadequate water, sanitation and hygiene [53].

Although the evidence regarding the effectiveness of sanitation interventions in preventing diarrhoea has been criticized as being of relatively poor quality, it is considered to be sufficient to support the provision of sanitation for all, especially in low income countries [37, 54].

1.1.7 Sanitation and health

Health

Inadequate sanitation is an important risk factor for poor health, especially in low and middle income countries [37, 53-56]. Estimates from 2012 suggest that globally 280,000 deaths were caused by inadequate sanitation. Inadequate sanitation is also associated with risk of other infectious disease such as trachoma [37, 57, 58], helminthiases [37, 59, 60] and schistosomiasis [54]. Inadequate sanitation is also linked with stunting [61-64]. For example, a study conducted in India found that, compared to open defecation, household access to a toilet facility was associated with 16-39% reduced odds of stunting among children aged 0-23 months [61].

Quality of Life

In addition to health, sanitation is linked with quality of life [65] indicators such as safety/security, privacy/dignity, attendance in school [54, 66-68] and economic development (health system cost, days lost at work or school and convenience time) [54, 56, 69, 70]. Above all, sanitation has been recognized as being a human right by the United Nations General Assembly [71, 72].
1.1.8 Global sanitation context

Globally, the proportion of people with access to private improved sanitation has increased from 54% in 1990 to 68% in 2015. Yet, as of 2015, 946 million people worldwide still defecate in the open and an estimated 2.4 billion people were without access to private improved sanitation facilities. The Global MDG target of 77 percent has been missed by 9% points and almost 700 million people [25].

There is disparity in access to sanitation between rural and urban areas. Globally seven out of 10 people without access to private improved sanitation, and nine out of ten people who practice open defecation, live in rural areas. Southern Asia and Africa still have the lowest coverage of private improved sanitation. There are still 47 countries in the world in which less than half of the population has access to private improved sanitation. Globally, there are 638 million people who use shared sanitation facilities. These facilities, if not for their shared status, would otherwise be considered improved sanitation. Among those who use sanitation facilities of an otherwise improved type, the proportion that share these facilities with others is similar in urban (11%) and rural (12%) areas [25].

1.1.9. The Bangladesh context

Bangladesh, situated in Southern Asia, with a population of more than 160 million (2015 estimate)[25], is one of the most densely populated countries in the world (Population density=1,203 per sq. Km)[73]. According to recent estimates, Bangladesh has an under-five mortality rate of 46 per 1000 live births [74]. According to the 2014 Demographic and Health Survey (BDHS), 6% of children below the age of five years were reported to have had at least one episode of diarrhoea during the preceding two weeks [74]. More than 5% of the under-five child mortality is due to diarrhoea [75]. The percentage of the population living in urban areas has increased from 20% in 1990 to 34% in 2015 [25].

Bangladesh has made good progress in terms of access to sanitation. The proportion of the population with access to private improved sanitation increased from 34% in 1990 to 61% in 2015. The proportion of the population that practices
open defecation decreased from 34% in 1990 to only one percent in 2015. However, irrespective of this good progress, Bangladesh, like many nations, did not meet the MDG target related to sanitation [76]. So, improving sanitation is one of the highest priorities for Bangladesh in order to improve the health and wellbeing of children under five.

There are limited disparities between rural and urban areas in term of progress towards the MDG target related to sanitation access. There is more open defecation in rural areas than in urban areas [36, 77]. However access to improved sanitation is slightly higher in rural areas than in urban areas (62% vs. 58%). The type of sanitation facilities used in Bangladesh varies widely. The majority of the population uses onsite sanitation facilities. In 2013, only 15% of the households in urban areas, and 0.1% of households in rural areas, had a sewerage connection. The most common type of toilet facility available to these households was a pit latrine with a slab (47% in rural and 29% in urban areas).

1.2 Literature review and rationale of the study

This chapter presents the findings from a comprehensive literature review. The literature review aimed to assess the role of latrine quality and coverage on microbiological faecal contamination of the household environment and secondly on diarrhoea.

1.2.1 Protocol for comprehensive literature review

1.2.1.1 Research questions

The literature review was conducted to find answers to the following research questions based on available literature:

1. What is the effect of household sanitation quality on diarrhoea incidence among children under 5?
2. What is the effect of household sanitation quality on faecal contamination of the household environment?
3. What is the effect of a neighbourhood’s sanitation coverage on faecal contamination of the household environment?
4. What indicators of household faecal contamination are used?

1.2.1.2 Criteria for inclusion in the literature review

Studies were considered eligible if they compared the effect of different types of sanitation quality and coverage on household faecal contamination and diarrhoea. Two exposures and two outcomes were considered. The first exposure was access to household sanitation. The primary focus of the search was to search the literature with regard to improved sanitation access, as defined by the JMP [25, 36]. However, since some literature may provide relevant evidence without using the standard terminology used by the JMP, any study that compared any classification of domestic excreta disposal facilities was considered. The second exposure was neighbourhood sanitation coverage, which included any type of sanitation facility. ‘Community’ referred to a neighbourhood or village. The first outcome was diarrhoea among children under five years of age. The second outcome was household faecal contamination, which refers to the microbiological contamination of household surfaces (e.g., floors); fomites (e.g., objects such as toys); hands of children and their caregivers; and household drinking water. Studies were included regardless of study design and location. Articles published in English from the year 2000 till 15th October 2015 were searched, since the term ‘improved sanitation’ and its related definition was introduced by the JMP in 2000 [25].

1.2.1.3 Conducting the search and identification of studies

Articles published in English from journals, conference proceedings, and books, were searched using OvidSP (Ovid Technologies 2015). The data bases Embase (Table 7.1), Global Health (Table 7.2) and Medline (Table 7.3) were searched. The Cochrane Library was also searched for systematic reviews that included the terms ‘sanitation’, ‘excreta disposal’, ‘faeces disposal’ or ‘sewage’. Relevant conference proceeding were hand searched. Researchers working within the sector from institutions, including LSHTM, ICDDR,B and Stanford University were also contacted to gain their recommendations on any additional articles. In addition, the reference list of all studies identified by the above methods, were checked.
Through this process about 5000 titles were identified for review. The search terms are presented in Tables 7.1 to 7.3 in Appendix 1.

All the references identified were transferred and saved in Endnote (EndNote X7). Then using Endnote, duplicates were identified and checked before deletion from the library. The titles were then reviewed first to check if they were relevant according to inclusion criteria. Then the abstracts of the selected articles were reviewed to see if they were relevant according to the inclusion criteria.

1.2.2 Findings from the literature review

The findings from the literature search are presented in two broad sections. The first section (1.2b.1-1.2b.3) presents literature on what is known about how household latrine quality and neighbourhood latrine coverage relate to faecal contamination and diarrhoea. The second section (1.2b.4) presents literature on the link between faecal contamination and health.

1.2.2.1 Sanitation type and diarrhoea

There is limited evidence linking the quality of sanitation facilities with faecal contamination. Nor is there sufficient evidence to support associations between sanitation quality and diarrhoea [24, 37, 78, 79]. Most of the intervention studies compared diarrhoea prevalence/incidence among groups that received a sanitation intervention with groups that did not receive a sanitation intervention [50, 78-81]. Most of the observational studies assessed the effect of access to any type of sanitation on diarrhoea morbidity [45, 48, 82-88]. The few studies that did explore the effect of different types of sanitation facilities on diarrhoeal episodes did not use the sanitation definition proposed by the JMP for international monitoring [30, 35, 89]. For example, an observational study conducted in Mexico, found that children under five years of age, in households with ‘poor’ sanitation (pit latrines and septic tank) had a higher risk of diarrhoea than children in households with sewage disposal systems [89]. Although, in this study socio-economic variables where included in the multivariable analysis, to adjust for confounding due to difference in socio-economic status, this was an observational study. So confounding by socioeconomic status
cannot be ruled out completely. There is evidence from a small number of observational studies that access to flush or pour flush toilets connected to a piped sewer system [90] or septic tank/pit and composting toilets (hygienic) are associated with a lower risk of diarrhoea [30, 91-96]. However, from these studies it is not known whether pit latrines with a slab (improved, as defined by JMP) provide similar protection from diarrhoea.

Several observational studies have used data from Demographic and Health Surveys (DHS) to assess the effect of improved sanitation on diarrhoea risk. A study conducted in Philippines found that households with access to unimproved sanitation had higher odds of reported diarrhoea (OR 1.63; 95% CI 0.99–2.69) compared to those with access to private improved sanitation [97]. A second study conducted in Malawi, found that children from households with access to private improved sanitation facilities had 45% lower odds of diarrhoea [98] compared to those with no sanitation facility. A third study conducted by Fuller and colleagues used 217 demographic and health surveys from 74 countries. The study found that access to an improved latrine was associated with reduced prevalence of diarrhoea [Prevalence Ratio (PR): 0.93; 95% CI: 0.92-0.95] [99]. In the above mentioned studies effect of sanitation on diarrhoea was independent of the effect of socio-economic factors. However these studies used cross sectional data from nationwide surveys, so cannot rule out the effect of confounding due to socio-economic factors completely.

The observed effects of sanitation quality on diarrhoea, found in the analysis conducted by Fuller and colleagues varied by country and time [99]. One explanation for this variation could be variation in the level of error in the categorisation of sanitation facilities during data collection across these surveys. Demographic and Health Surveys (DHS) have identified over 400 different sanitation classifications in countries in which the surveys have been undertaken [26]. So due to the wide variety of sanitation facilities, it is very difficult to categorise these sanitation facilities reliably across different context. Moreover the questions used in DHS to capture the data on latrine classification are focused on the design of the
toilet rather than the functionality of the toilet [21]. For example a pit latrine with a slab may be considered as improved by the JMP because of the design. But if there is a leakage in the pit, the faeces will come out of the pit and contaminate the environment. So this toilet cannot be considered to separate faeces from the environment hygienically and thereby the JMP should not consider it to be improved. This kind of complexity is not captured by the DHS questionnaire [100]. As a result these surveys are likely to include substantial error in the categorisation of sanitation facilities.

There is also evidence from large nationwide surveys that access to private improved sanitation is associated with reduced diarrhoea incidence. A study conducted in India used data from a large nationwide survey with district level representation of India’s rural households. The data show that, on average, children living in households using a private improved sanitation facility have 1.26 percentage points less diarrhoea (10% reduction from 12.1% diarrhoea prevalence) compared to children living in households with unimproved sanitation [101]. A second study conducted by Kumar and colleagues used data from a nationally representative household survey to quantify the effect of improved sanitation access on diarrhoea incidence on India, using propensity score matching. Access to improved sanitation was associated with a 2.2 percent point reduction in the risk of contracting diarrhoea [102]. These large surveys are prone to substantial measurement error in categorising sanitation facilities. Moreover, in these large nationwide surveys data on reported diarrhoea is collected at one point in time and as such does not capture the seasonality of diarrhoea. Sanitation may have variable effects depending on the season. A nationwide study conducted in rural Indonesia suggested that the lack of improved latrines was associated with higher reported diarrhoea (OR=1.23, 95% CI=1.18-1.29) [51] and under five child mortality (OR = 1.29, 95% CI = 1.25–1.31). This study used the JMP definition and collected longitudinal diarrhoea data to capture variation in seasonality. However this finding has not been replicated in other low-income country contexts.
Some studies were identified that looked at the effect of sharing a toilet facility on diarrhoea. A recent systematic review identified 21 studies with which to compare health outcomes associated with shared versus individual household latrines [103]. However, most of these studies did not adequately address potential confounding factors and did not allow the effect of different types of shared sanitation to be distinguished. An analysis of DHS from 51 countries found shared, improved sanitation facilities to be associated with adverse health outcomes [104] as compared to individual improved latrines, adjusting for potential confounding variables. However this finding was not consistent across all countries, suggesting that the social and economic context is also important. A multi-country case-control study conducted in seven low income country sites in sub-Saharan Africa and South Asia found families of children with moderate to severe diarrhoea more commonly used shared facilities than control families (48% vs. 41% OR=1.2; 95% CI: 1.1-1.3) [105]. Although this finding was consistent across wealth index quintiles, there was significant between-country variation. This would suggest that local context plays an important role. Sharing may also have a variable effect depending on whether a setting is rural or urban and whether the sanitation facility is being shared by extended family, neighbours, and acquaintances or with the public. Consequently limited data are available to understand which contexts are likely to be safe for sharing sanitation.

1.2.2.2 Sanitation and household faecal contamination

Sanitation is expected to create a barrier to break the chain of transmission of diarrhoeal disease [15, 16, 30, 51]. However there is limited evidence about the impact of onsite sanitation quality on specific transmission pathways or on the relative importance of these pathways. The consideration of microbial contamination of surfaces, soil and fomites as possible transmission pathways has been relatively understudied [106].

1.2.2.2.1 Faecal contamination of water

Understanding of faecal-oral disease transmission pathways in relation to sanitation has largely focused on contamination of drinking water [107-116].
However, the literature looking at sanitation and water quality has produced inconsistent results [116-120]. Most of the studies that assessed the relationship between sanitation and water quality had limited sample size or categorised sanitation differently from the JMP definition. However, an observational study by McGarvey and colleagues collected data from a representative sample of 703 households from six coastal districts of Ghana. The study found households with a pit latrine or no facility have two to three times higher odds of having two or more *E. coli* per 100 ml of water relative to those with a water seal toilet, even after adjustment for other sanitary and socio-demographic characteristics [116]. Another study conducted by Mattioli and colleagues found that having an improved sanitation facilities was associated with a 1.7 fold decrease in the odds of detecting *E. coli* virulence genes in stored water [117]. In contrast, findings from a few observational studies suggest that sanitation is not associated with level of faecal indicator bacteria (FIB) in stored water [118-120]. But these observational studies had a limited sample size and were not designed to perform a statistical analysis of the association between sanitation and water quality that adjusted for the effect of confounding variables.

1.2.2.2 Faecal contamination of hands

There is limited evidence to link the level or presence of faecal contamination on hands with household sanitation level [106]. A study conducted by Pickering and colleagues measured levels of FIB (*E. coli*, faecal streptococci) on hands in 334 households in Tanzania. Households which had improved toilets (JMP definition) were found to have lower levels of faecal streptococci on children’s and mother’s hands [106]. A second case-control study conducted in Tanzania (n<306) found that use of improved sanitation (JMP) was not associated with presence of FIB (*E. coli* and enterococci) enteric viruses (enterovirus, adenovirus, and rotavirus) *E. coli* virulence genes (ECVG) and human-specific *Bacteroidales* faecal markers on the hands of adult female caregivers [117]. A third study conducted in Mozambique measured hand contamination using a finger imprint method. This method collects 10 finger prints from each participant and then these are placed in chromogenic agar that stains
Enterococcus spp. and E. coli spp. Levels of faecal indicator bacteria on the fingertips of female caregivers were not found to be associated with the type of sanitation in the household [121].

There may be a few alternative explanations for the inconsistencies in findings from these different studies. Firstly the inconsistencies in findings can be due to the difference in indicator organism chosen as outcome. In the study conducted in Tanzania by Pickering and colleagues, level of E. coli on hand were not associated with sanitation type but level of faecal streptococci on hands were associated with sanitation type [106]. Secondly the inconsistency in findings can be due to the variation in the methods of sample collection. Hand rinse technique is likely to collect sample from larger surface area of hand than finger imprint technique and may be more accurate indicator of contamination of hand [122]. Thirdly, the inconsistency could be due to difference in contexts. A study found that there was important variation in the level of hand contamination in samples collected from different neighbourhoods [121]. Similarly the factors that contribute to contamination of hands may vary depending on the broader geographical and socio-cultural contexts.

1.2.2.2.3 Faecal contamination of domestic surfaces and soil

The literature linking faecal contamination of domestic surfaces, soil and fomites with sanitation level (JMP definition) is limited [116, 123-128]. For example, a microbial survey of faecal contamination and selected diarrhoea pathogens in soil, surfaces and produce was implemented in Tanzania among 20 households using private pit latrines. In this study all the samples were analysed for FIB (E. coli and enterococci). There were no significant differences in the FIB levels that were cultured from soil in households which had pit latrine with a concrete slab and those that had a pit latrine without a slab [123]. The study was also underpowered to detect difference in FIB levels among households with improved and unimproved sanitation. A second study conducted in Tanzania found that households with access to improved (individual or shared) latrines had lower mean E. coli concentration in the hand contact surfaces within the toilet, compared to households with access to
unimproved latrine technologies. However when shared sanitation was categorised as unimproved according to MDG classification there no difference in mean *E. coli* concentration in households with access to improved and unimproved latrines [129]. There was no correlation in the level of bacteria found in latrines with the level of bacteria found on the other household surfaces [129]. Although this study provides empirical evidence for the validity of the JMP technology classification it merged data collected from urban and rural areas, potentially hiding the extent to which this is likely to vary by context. Moreover the extent to which a particular household surface comes in contact with young children is not well known.

### 1.2.2.2.4 Faecal contamination of fomites

It is hypothesised that toys are likely to have high levels of faecal contamination and play an important role in diarrhoeal disease transmission [130-133]. If sanitation facilities are effective in separating human faeces from the environment then this is likely to reduce the microbial contamination of household objects (for example a toy ball). Several small scale observational studies have assessed the effect of sanitation on faecal contamination of the household environment.

In a study conducted in Bangladesh, 39 households with improved sanitation and 61 households with unimproved sanitation were enrolled to assess if faecal contamination of a standard-size toy ball (introduced by the study) was associated with sanitation quality. The mean level of faecal coliforms on the toy balls were found to be higher in households with unimproved sanitation compared to households with improved sanitation. However, the mean level of faecal streptococci was similar in households with improved and unimproved sanitation [134]. A recent study conducted by Torondel and colleagues looked at the correlation between household characteristics and microbiological contamination of toy ball (also introduced by the study) in rural Indian context. The study did not find any difference between households with or without presence of a functional latrine in terms of the presence of any thermotolerant coliforms (TTC) on the toy ball [135]. While these studies demonstrated the feasibility of using sentinel toys as a measure
of household faecal contamination, the studies did not categorise sanitation according to the JMP definition.

A study was conducted in Bangladesh with the aim of comparing the levels of FIB (faecal coliforms and \textit{E. coli}) in indicator fomites (sentinel toys and clothes) in households with improved (JMP) and unimproved latrines. The levels of faecal coliforms on toys in households with improved sanitation were lower (geometric mean: 8 CFU/100 ml) compared to households with unimproved sanitation (geometric mean: 57 CFU/100 ml). There was no significant difference in the geometric means of \textit{E. coli} on the toy comparing households with improved and unimproved sanitation. However, the study had small sample size (n=50)[136]. In another study, conducted in Peru, faecal contamination of toy balls was measured in a subsample of households (n=160) enrolled for an impact evaluation of a water and sanitation program. Improved sanitation as defined by JMP was associated with lower geometric mean concentration (MPN/100ml) of faecal indicator bacteria (\textit{E. coli}) [137] on toys compared to households that lacked improved sanitation. Another study conducted in Honduras found that households with improved latrines had lower geometric mean concentration (MPN/100mL) of total coliforms [138] in both existing and study-introduced toys compared to households with unimproved sanitation. However these studies did not have enough power to assess the effect of a range of confounding variables that may affect the association between faecal contamination and sanitation access.

\textit{1.2.2.3 Neighbourhood sanitation coverage}

Infectious diarrhoea is transmitted in both public and private domains [18]. So, improved sanitation may reduce the transmission of infectious diarrhoea in two ways. As described in section 1.2.2.1 of this literature review there may be a direct benefit to a household in improving their household sanitation. Additionally there may be an external benefit for that household which arises, due to their neighbours accessing sanitation as this results in a lower probability of human contact with human excreta [101]. An important question often debated in the context of
improving sanitation in low-income settings is whether the benefits of sanitation critically depend on neighbourhood-level sanitation coverage (“herd effect”) [139].

Several studies were identified that assessed the effect of community sanitation coverage on health. A few studies have looked at whether the level of community sanitation coverage has an effect on health by studying sanitation facilities which are connected to sewer systems or septic tanks in urban contexts [140-144]. A study conducted in 45 urban wards in Dar es Salam, found limited change in cholera incidence as the percentage of the ward’s residents connected to a septic tank or sewage system increased (Incidence rate ratio: 1.01; 95% CI: 0.95–1.07). The authors suggest that the lack of association could be due to a narrow range of access to sanitation at the ward level (sanitation coverage) [141]. Another study conducted in an urban area of Dhaka found that among the four wards studied, the ward which had more than 60% of toilets connected to a sewer system or septic tank had 1.25 less DALYs/household/per year compared to a ward in which 95% of residents practiced open defecation or used a hanging latrine [145]. While these studies show the importance of community sanitation access, they cannot fully elucidate the relationship between neighbourhood-level sanitation coverage and faecal contamination or on health outcomes.

A study implemented a city-wide sanitation intervention in Salvador, Brazil which aimed to raise the level of sewerage coverage from 26% to 80%. After the intervention implementation there was a 22% reduction in diarrhoea prevalence (95% CI: 19-26) [142, 143]. In the multivariate model, adjustment for changes in community sewerage coverage explained 100% of risk reduction while changes in household level sanitation related variables explained only 17% of the risk reduction [143]. This finding suggests that that the pathogen transmission reduced by the programme was mainly in the public domain, suggesting that achieving community-wide access to improved sanitation, in addition to household access, is likely to be critical for effective reduction of faecal contamination and diarrhoeal incidence reduction. However, this study was conducted in urban areas with sewage connections, a sanitation technology not feasible in most low-income rural settings.
In rural settings with predominantly onsite sanitation the impact of neighbourhood sanitation may be different.

Studies conducted in rural contexts with predominantly onsite sanitation facilities have also highlighted that neighbourhood sanitation coverage may be important. First a study conducted in rural Zimbabwe assessed the effect of latrine coverage at the community level, on diarrhoea morbidity. In the community with 62% latrine coverage children experienced 68% lower diarrhoea morbidity compared with the children from the community that had no sanitation access. However the study had a relatively small sample size and compared only two communities. A second study conducted in coastal Ecuador analysed data from four years of active diarrhoeal-disease surveillance data across 21 communities. Villages were categorised based on diarrhoea prevalence as ‘low’ (<0.6%); ‘low-medium’ (0.6%-2.2%); ‘medium-high’ (2.2 %-< 5.2%) and ‘high’ (5.25-100%). The study found that higher levels of improved sanitation were associated with lower diarrhoea prevalence in regions categorised as low risk. This study showed that the association between community sanitation coverage and diarrhoea risk may vary depending on the level of disease in the surrounding villages. These studies provide insufficient evidence of the benefits of externality associated with increased community-level sanitation access.

The studies which were conducted in rural settings indicate that high levels of sanitation coverage within a community may provide additional externality benefits in terms of reducing diarrhoea. For example one study used data from an Indian nationwide survey of rural households. The findings suggest that community-level improved sanitation coverage is associated with a 37% additional reduction in diarrhoea prevalence, in addition to a reduction due to household level improved sanitation coverage. A second study that used demographic and health survey data suggests that children from villages with higher open defecation rates were stunted, controlling for the effect of household level sanitation practices. These findings have so far not been replicated in other settings. Depending on the status of disease in a specific context the effect of risk factors such as lack of
sanitation may have a variable effect. Moreover, most of these studies have used secondary data such as DHS. As acknowledged earlier, the classification of sanitation facilities in DHS may be prone to misclassification bias as the questions used in DHS do not capture the function of sanitation facilities in separating faeces from the environment.

1.2.2.4 Other determinants of household faecal contamination and diarrhoea

In 2012, worldwide 297,000 diarrhoea deaths were estimated to be caused by inadequate hand hygiene [53]. In a study conducted in India, the caregiver’s self-reported practices of washing hands with soap before meals (OR=0.85, 95% CI 0.76 to 0.94) or after defecation (OR=0.86, 95% CI 0.80 to 0.93) were inversely associated with child stunting, after adjusting for all potential confounders [61]. A recent systematic review identified individually randomized controlled trials (RCTs) and cluster-RCTs that compared the effects of hand washing interventions, on diarrhoea episodes in children and adults with no intervention. The study found that hand washing promotion among communities in low and middle income countries (LMICs) prevents around one-quarter of diarrhoea episodes (rate ratio 0.72, 95% CI 0.62 to 0.83) [148]. In six out of eight trials identified in this review, soap was provided free alongside hand washing education, and the overall average effect size was larger than in the two trials which did not provide soap.

Findings from observational studies suggest that washing hands with soap is effective in removing microorganisms from hands [106, 149-151]. For example a study conducted in Tanzania among 334 households found that children’s hands reported washed within the past hour have an average of 0.3 log10 CFU / 2 hands less *E. coli* (EC) (t=-3.31, df=832, P=0.001) and 0.2 log10 CFU / 2 hands less Faecal Streptococci (FS). (t=-3.82, df=836, P<0.001) compared with children’s hands reported not washed within the past hour [106]. More over in this study visible dirt observed on the subject’s palm, finger pads, or underneath their nails was significantly related to higher level of both EC and FS on hands. Similarly a second study conducted in Zimbabwe among 80 families found that washing hands with
soap was more effective in reducing faecal indicator bacteria level on hands compared to traditional hand washing [150].

Similarly findings from intervention studies suggest that washing hands with soap is effective in reducing microorganisms from hands [149, 152, 153]. For example, a study conducted in karachi, Pakistan found that, compared to mothers who received no hand-washing intervention, mothers who received soap, would be expected to have 65% fewer thermotolerant coliform bacteria on their hands (95% CI 40%, 79%) and mothers who received soap, a safe water storage vessel, hypochlorite for water treatment, and instructions to wash their hands with soap and chlorinated water would be expected to have 74% fewer (95% CI 57%, 84%) [154]. It is possible that differences in faecal indicator bacteria among the groups reflected underlying divergences in their neighbourhoods rather than the affect of the assigned interventions. However, in this study neighbourhood characteristics likely to affect hand cleanliness and hand washing, was adjusted in the multivariate analysis.

In 2012, globally 502,000 diarrhoea deaths were estimated to be caused by inadequate drinking water [53]. A systematic review conducted by Clasen and colleagues suggests that, water disinfection products for use at the household level may reduce diarrhoea by around one quarter (home chlorination products: RR 0.77, 95% CI 0.65 to 0.91; flocculation and disinfection sachets: RR 0.69, 95% CI 0.58 to 0.82). and point-of-use filtration systems probably reduce diarrhoea by around a half (RR 0.48, 95%CI 0.38 to 0.59)[155]., This findings suggests that water quality is an important determinant of diarrhoeal diseases.

1.2.2.5 Faecal contamination, transmission pathways and link with diarrhoea

1.2.2.5.1 Water

A range of indicators, including FIB, pathogenic microorganisms (viruses and bacteria), Coliphages and species specific faecal markers [117] have been used to assess faecal contamination of drinking water [107-110, 113-116, 118-120, 156-183].
However, the evidence associating faecal contamination of water with health outcomes is inconsistent. Those reporting a linkage between faecal contamination and health outcomes have mostly used FIB to assess faecal contamination. Findings from these observational (large sample size) and intervention studies conducted in both high and low-income countries suggest that the presence of FIB (faecal coliforms, *E. coli*, faecal streptococci and enterococci) in water may be associated with adverse health outcomes [163, 177, 182-186]. However, a few observational and intervention studies did not find the level of FIB in stored water to be associated with adverse health outcomes [106, 117, 168, 178]. The studies which did not find the faecal contamination of water to be associated with health outcomes were weakened by the fact that they had a limited sample size (N>335) to detect differences in health outcome. Moreover presence of FIB in recreational water was found to be associated with gastrointestinal illness in high-income country contexts [187, 188]. So it can be argued that there is a reasonable amount of evidence suggesting that the presence of FIB in water may predict health risk.

### 1.2.2.5.2 Hands

The available literature suggests that the presence of FIB on children’s and caregiver’s hands are common [132, 165, 173, 189-192] and plays a significant role in transmission of infectious gastrointestinal illness. In a domestic environment with high microbial contamination, hands that are effectively de-contaminated by washing are often quickly re-contaminated [189, 193, 194] by coming into contact with different vectors in the household environment and through different household activities. In day care centres contamination of hands was found to be correlated with the contamination of inanimate objects [131]. Several small scale studies have identified the level of FIB on hands to be associated with diarrhoea [106, 122, 130-132, 195-197]. However, the evidence is generally weak because of limited sample sizes and is often not consistent between countries. For example studies conducted in Bangladesh [114] and Thailand found the presence of FIB in children’s and mothers hands to be associated with higher rates of diarrhoea [197]. However, a study conducted in Karachi by Luby and colleagues suggests that
presence of thermo tolerant coliform on hands was not associated with diarrhoea when measured using finger imprints. In this same study the presence of faecal coliforms were measured using a hand rinse technique and this was found to be associated with diarrhoea [122]. The studies conducted in Thailand [197] and Bangladesh [114] also used similar finger imprinting techniques to assess hand contamination and found the faecal contamination of hands to be associated with diarrhoea. However both of these studies used larger agar plates which allowed a larger hand surface area to be cultured compared to the study in Karachi. This suggests that culturing a larger surface area of the hand may provide a more accurate and useful assessment of faecal contamination on hands.

There is limited evidence about the association between the faecal contamination of hands and diarrhoea. The literature indicates that measuring hand contamination at random could be considered as a potential indicator of the faecal contamination that may be prevalent in household environment. However since hand contamination is highly variable, it may require large sample sizes to capture variation in factors contributing to hand contamination [122].

1.2.2.5.3 Home hygiene (surface/fomite)

There is some evidence from high [198-209] and low-income countries [123, 128, 165, 173, 210] that the microbial contamination of household surfaces and fomites are common and plays a significant role in the transmission of enteric pathogens. However most of these were descriptive studies, with small sample sizes. These studies have mostly described the levels of general microbial contamination or faecal contamination in the household environment but did not link faecal contamination on surfaces and fomites with health outcomes.

1.2.2.5.4 Toys

Evidence suggests that children’s toys have a high degree of FIB and can be a potential source of transmission of enteric pathogens [124, 125, 130-132, 211]. There is also some evidence from small scale observational studies, suggesting that the degree of faecal contamination on hands may be associated with the faecal
contamination of toys [125, 131]. However, there is very limited evidence of faecal contamination of toys being associated with diarrhoea in low-income countries.

1.2.2.6 Microbial indicators of faecal contamination:

1.2.2.6.1 Comparison of indicators of faecal contamination

The literature from high and low income countries suggests that, a range of indicators including faecal indicator bacteria (FIB), pathogenic microorganisms (bacteria and viruses) have been used to assess faecal contamination [106, 116, 119, 122, 124, 157, 181, 209, 212-215]. A range of microbial source tracking (MST) methods (genotypic, phenotypic, and chemical) have also been used to identify sources (human/non-human) of faecal pollution in the environment [106, 117, 157, 204, 216-218]. However, all indicators of faecal contamination have some advantages and disadvantages in term of their use to assess faecal contamination in epidemiological studies.

Links between species specific faecal markers in environmental samples and health is yet to be established [106, 216, 217, 219-221]. Moreover the presence of human specific faecal markers identified using MST methods has been found to be a poor predictor of pathogenic bacteria [213, 219]. MST methods are time consuming, labour-intensive, and expensive (require costly laboratory equipment) [220]. As a result this may have limited feasibility in assessing the impact of large scale sanitation/hygiene programme in low income country context.

Pathogenic microorganisms (bacteria and viruses) that are associated with faecal contamination and can cause diarrhoea tend to be found in low concentrations in the environment and there are a large number of them. So it is difficult to monitor them in environmental samples [217, 220, 222] and can be costly in the context of low income country setting if the primary purpose is large scale programme evaluation.

FIB are rapidly detected, easily enumerated, have survival characteristics that are similar to those of the pathogens of concern. There is some evidence that presence of FIB can be associated with the presence of pathogenic microorganisms [217, 219, 222] and Bacteroidales faecal marker [223]. More over concentration of
FIB in hand and drinking water was found to be associated with health outcome [114, 122, 163, 167, 170, 177, 180-184, 197, 224-226] in the context of both high and low income countries. In a systematic review in high income country context, higher concentration of FIB bacteria in recreational water was found to be associated with higher relative risk of gastrointestinal illness (GI) in areas with known sources of human faecal contamination [187]. However FIB (faecal coliform, *E. coli*, faecal streptococci, enterococci) are found in faeces of all warm blooded animal [106, 216, 217, 222] and can be naturally found in the environment [227-230]. But there is also evidence from small scale observational studies suggesting that concentration of FIB in hands and toy may be associated with sanitation [106-116].

So use of FIB could be considered as a feasible option to assess faecal contamination in low income country context to predict health risk, although they cannot be used to track source of faecal contamination (human/animal). However the extent to which they represent health risk may vary and some may be more faecal specific than others. In this study level of faecal indicator bacteria will be assessed in hands and toys considering feasibility of measuring in low income country context.

1.2.2.6.2 Comparison of common faecal indicator bacteria used to assess faecal contamination

There is very limited evidence of the performance of four most commonly used faecal indicator bacteria (faecal coliform, *E. coli*, faecal streptococci, enterococci) if found in hands and toys to be associated with health outcome as well as sanitation. Most of the literature on faecal indicator bacteria is related to drinking water or recreational water.

1.2.2.6.2.1 Faecal coliform

Evidence from observational studies conducted in the context of both high and low income countries suggests that concentration of faecal coliform in hands may be associated with higher risk of diarrhoeal illness [122, 130-132, 163, 183, 186]. However there is no evidence of concentration of faecal coliform in hands to be associated with sanitation. But level of faecal coliform in toys was found to be
associated with better quality sanitation [124, 125] in two small scale observational studies conducted in Bangladesh. But we do not know if level of faecal coliform in toys is associated with better health outcome. One of the important limitations of faecal coliform is that faecal coliform can also include some species that can have a non-faecal origin (e.g., Klebsiella pneumonia) [226-231]. So concentration of faecal coliform may not represent exposure to human faeces only but if found to be associated with better sanitation, it can provide indication of how better sanitation might contribute in preventing faecal contamination of the household environment.

So concentration of faecal coliform in hands and toy may better predictor of sanitation but may not be good predictor of health and faecal contamination.

1.2.2.6.2.2 E. coli

E. coli is more faecal specific than faecal coliform [217, 226, 231] and recommended as indicator for recent faecal contamination in water [232] from human and animal. While there is some evidence to suggest that level of E. coli in drinking water and recreational water is associated with health outcome [163, 177, 182-187, 233], there is very limited evidence of level of E. coli in hands and toys to be associated with sanitation or health outcome. However a study conducted in 334 households in Tanzania, found that level of E. coli in mothers and children’s hands was not associated with prevalence of gastrointestinal symptoms although this study measured gastrointestinal symptoms in one season only. Moreover in this study level of E. coli in children’s and mothers hands were not associated with sanitation level (JMP definition) [106]. There was no evidence found about level of E. coli in toy to be associated with health outcome, however studies conducted in Bangladesh with limited sample size found that level of E. coli in toy was not associated with sanitation level [125].

So concentration of E. coli in hands and toy might be good predictor of faecal contamination but may not be good predictor of sanitation.

1.2.2.6.2.3 Faecal streptococci

Faecal streptococci survive longer in the environment than faecal coliforms and E. coli [220, 226, 234]. There is limited evidence of level of faecal streptococci in
hands and toys to be associated with health outcome as well as sanitation. In observational studies conducted in Thailand and Tanzania level of faecal streptococci in hands was found to be associated with health outcome [106, 197]. Moreover in the study conducted in Tanzania level of faecal streptococci in hands were found to be associated with sanitation level. However in Bangladesh level of faecal streptococci in toy was not found to be associated with sanitation level in a study with limited sample size [124].

So level or faecal streptococci in hands may be good predictor of health and faecal contamination but may not be good predictor of sanitation.

1.2.2.6.2.4 Enterococci

Enterococci are more faecal specific [217, 220] than faecal streptococci. A study conducted by Pinto and colleagues has found majority of enterococci (84%) found in variety of polluted water source to be true faecal species [235]. Level of enterococci in drinking and recreational water was found to be better predictor of diarrhoeal risk compared to faecal streptococci [185, 187, 188, 236]. In a study conducted in France, level of enterococci in water was found to be correlated with level of Bacteroidales faecal marker [223]. Another study conducted in Tanzania found higher concentration of enterococci in water to be associated with presence of E. coli virulence genes (ECVG) [219]. However there is lack of evidence of the presence of enterococci in hands and toys to be associated with health outcome and sanitation.

So concentration of enterococci in hand and toys might be the best predictor of faecal contamination while its association with sanitation and health is yet to be explored.

Taken together these findings suggests that, there is limited evidence comparing the utility of faecal coliform, E. coli, faecal streptococci and enterococci as indicator of faecal contamination on hands and toys in relation to linkage between both sanitation and health. Concentration of E. coli and enterococci is better predictor of faecal contamination (water) and health, compared to faecal coliform and faecal streptococci. But there is limited evidence of concentration of E. coli and
enterococci in hands and toys to be associated with sanitation as well as health. There is some evidence suggesting concentration of faecal streptococci in hands may be associated with sanitation level, while concentration of faecal streptococci in toys may not be. Although faecal coliforms are not faecal specific but concentration of faecal coliform in hands and toys were found to be associated with sanitation. Since this study aims to assess faecal contamination of hands and toys in relation to sanitation, faecal coliform (found to be linked with sanitation) and enterococci (most faecal specific) can be considered as potential indicator of faecal contamination. As concentration of \textit{E. coli} and faecal streptococci in hands and toys were not found associated with sanitation level in small scale studies conducted in low income country context.

1.2.2.7 Summary of literature review and gap in knowledge

The findings from the literature review suggest that access to private improved sanitation may be associated with modest reductions in diarrhoeal disease but the effect may vary depending on the country, rural or urban environments and seasonality. Sharing a sanitation facility may be associated with higher diarrhoea risk but depending on the context the effect may vary. Most of the existing studies assessing sanitation quality and health outcomes were observational and had important methodological limitations. Many of the existing studies could not capture the seasonal variation of diarrhoea. Moreover many of the existing studies used reported data and standard questionnaires used by JMP/DHS to assess sanitation. This approach assesses only the presence of sanitation technology rather than its functionality, which can lead to potentially inaccurate categorisations of latrines. As a result these studies are prone to misclassification bias.

There are limited numbers of studies that have looked at the effect of sanitation on household faecal contamination. Understanding of faecal-oral disease transmission pathways in relation to sanitation has largely focused on drinking water. The available evidence suggests that both hands and toys could be considered as potential indicators of household faecal contamination. However the findings are based on observational studies and there is heterogeneity in the effect of sanitation
in preventing faecal contamination. The inconsistencies in findings across different studies may be explained by the difference in indicator organism chosen as outcome, variation in methodology of sample collection and the differences in context. Important limitations of existing studies include that many are underpowered to understand the role of confounding factors. Further studies with large enough sample sizes to allow adjustment for possible confounders are needed to see if faecal contamination of hands and toys are associated with sanitation.

There is a reasonable amount of evidence suggesting that the presence FIB in water may predict health risk although there are some inconsistencies in findings across different studies. There is limited evidence linking the faecal contamination of hands with diarrhoea but hand contamination measured at random could be considered as a potential indicator of faecal contamination in household environment. However since hand contamination is highly variable, it may require large sample sizes to capture variation in factors contributing to hand contamination. There is limited evidence to suggest that faecal contamination of surfaces, soil, fomites and toys are associated with increased diarrhoea.

Neighbourhood-level sanitation may provide important externality benefits in reducing diarrhoea disease transmission. But the effect is likely to be different in rural and urban contexts. There is limited evidence to suggest that the level of neighbourhood sanitation coverage has an effect on health outcomes. The literature on the role of neighbourhood sanitation coverage in reducing household faecal contamination is even more limited.

From the literature review presented above, a few important gaps in evidence in relation to improving sanitation coverage in the context of low-income countries can be highlighted. There is limited evidence of the comparative benefits of different levels of onsite sanitation facilities as defined by JMP in terms of reducing faecal contamination of hands and toys and protecting health. There is also limited knowledge about role of sanitation coverage in the neighbouring households on environmental faecal contamination and health. Important limitations of the
studies which have assessed faecal contamination include limited sample sizes and lack of understanding of the role of confounding factors.

1.3 Study aims and objectives

The present study assessed whether faecal contamination of hands and toys is associated with level of sanitation access in a rural setting with predominantly onsite sanitation. The study used sentinel toy and hand contamination as indicators of household environmental contamination in rural areas of Bangladesh. The study collected data from a sample size large enough to capture variability in the degree of faecal contamination comparing households with different level of sanitation. A range of potential household factors (water, sanitation and hygiene related) and neighbourhood level factors was measured to see how they modify or confound the association between sanitation and faecal contamination.

1.3.1 Aim

The aim of the study was to further our understanding of the importance of sanitation quality and coverage, in protecting health.

1.3.2 Specific Objectives

1. To assess the association between different types of onsite sanitation provision (as defined by the JMP and the Govt of Bangladesh) in the household and faecal contamination of the household environment.

2. To assess the association between neighbourhood sanitation coverage and faecal contamination of the household environment.

3. To assess the association between different types of onsite sanitation provision (as defined by the JMP and the Govt of Bangladesh) in the household and the occurrence of diarrhoeal disease in children younger than five years of age.

1.3.3 Research questions

1. Is access to better onsite sanitation (as defined by the JMP and the Govt of Bangladesh) in the household, associated with a lower level of faecal contamination of the household environment?
2. Is higher coverage of improved latrine in the neighbourhood, associated with lower level of faecal contamination of the household environment?

3. Is access to better onsite sanitation provision (as defined by the JMP and the Govt of Bangladesh) in the household, associated with lower reported diarrhoea among children less than five years of age in rural Bangladesh?

**1.3.4 Impact of the study**

This study will help develop a better understanding of the impact of different type of onsite sanitation in reducing environmental faecal contamination and diarrhoea, and of the effect of sanitation coverage in the neighbourhood on environmental faecal contamination. As a result this will add to the evidence base on health impact of sanitation facility. The evidence could help inform policymakers as to what type of onsite sanitation facilities should be promoted in low-income settings such as Bangladesh. This will also help improve the evidence base regarding the classification of sanitation facilities that is used for international monitoring.

**1.4 Thesis components**

The thesis consists of six chapters. The contents of each chapter are summarized below.

Chapter 1: Background and literature review

- Background to the thesis
- Comprehensive literature review
- Aim and objectives of the thesis

Chapter 2: Comparing measures of household faecal contamination in rural Bangladesh

This chapter presents data on children’s exposure to household faecal contamination and data from piloting several measures of household faecal contamination to inform decisions regarding indicator of household faecal
contamination, to be used in the next chapters. This chapter includes a ready for submission manuscript, which describes the main results.

Chapter 3: A cross sectional study of the association between sanitation type and faecal contamination of the household environment in rural Bangladesh

This chapter compares the relevance of different classifications of improved sanitation used for international monitoring in term of reducing microbiological contamination of household environment. This chapter includes a manuscript submitted for publication, which describes the main results.

Chapter 4: Effect of neighbourhood sanitation coverage on faecal contamination of the household environment in rural Bangladesh

This chapter explores the role of neighbourhood sanitation coverage on household faecal contamination as measured through toy ball and children’s hands. This chapter includes a ready for submission manuscript, which describes the main results.

Chapter 5: A cross sectional study to explore the association between sanitation type and diarrhoeal disease.

This chapter compares the relevance of different classifications of improved sanitation used for international monitoring in term of reducing diarrhoea among children less than five years of age using previous data from a programme evaluation conducted in Bangladesh. This chapter includes a ready for submission manuscript, which describes some of the main results.

Chapter 6: Discussion

This last chapter provides a summary of the results from all the chapters, provides an overall interpretation of the results, discusses notable strengths and limitations of the research and finally provides recommendation for policy and future research.

Chapter 7: Appendices that include details of microbiological sample collection and processing; and data collection tools
1.5 References


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Chapter 2: Comparing measures of household faecal contamination in rural Bangladesh

2.1: Introduction to the chapter

This chapter includes the first of the four manuscripts presenting results of the studies conducted for this thesis. The results presented in this manuscript are from the pilot study that was conducted to identify suitable sites on which to measure indicators of household faecal contamination.

2.2 Role of the authors in the research paper

Tarique M.N. Huda (TH): TH is the first author of the research paper. He had the primary role of designing the study, overseeing the field work, cleaning and analyzing the data, interpreting the results and drafting the manuscript.

Amy J. Pickering (AP): AP provided guidance on the microbiological sample collection protocol; provided feedback on analysis and interpretation of the data and reviewed the draft manuscript.

Stephen P. Luby (SL): SL provided guidance on design of the study and reviewed the draft manuscript.

Leanne Unicomb (LU): LU provided guidance during data collection in Bangladesh and reviewed the draft manuscript.

Wolf-Peter Schmidt (WS): WS contributed to the conception of the study, defining the research questions, provided guidance on design of the study; reviewed the data analysis and the draft manuscript.

Zahid H. Mahmud (ZM): ZM reviewed the protocol for the microbiological sample processing in the lab, helped with supervision of the sample processing in the lab and reviewed the draft manuscript.

Probir K. Ghosh (PG): PG reviewed the data analysis strategy and the draft manuscript.

Adam Biran (AB): AB was the executive author for this manuscript. He contributed to the conception of the study, contributed in defining the research questions, approved the overall study design, data/sample collection protocols and reviewed the draft manuscript.
2.3 Research paper cover sheet

Since this thesis is 'Research Paper' style thesis, the following cover sheet is being included in accordance with the regulations, mentioned in the LSHTM Research Degree Handbook guidance.

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**RESEARCH PAPER COVER SHEET**

**PLEASE NOTE THAT A COVER SHEET MUST BE COMPLETED FOR EACH RESEARCH PAPER INCLUDED IN A THESIS.**

**SECTION A – Student Details**

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<td>Principal Supervisor</td>
<td>Adam Biran</td>
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<tr>
<td>Thesis Title</td>
<td>Role of Sanitation in preventing faecal contamination of the domestic environment and protecting health: An observational study.</td>
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*If the Research Paper has previously been published please complete Section B, if not please move to Section C*

**SECTION B – Paper already published**

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**SECTION C – Prepared for publication, but not yet published**

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<td>Tarique M N Huda, Wolfi-Peter Schmidt, Amy J. Pickering, Leanne Unicomb, Zahid Hayat Mahmud, Stephen P. Luby and, Adam Biran</td>
</tr>
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**SECTION D – Multi-authored work**

| For multi-authored work, give full details of your role in the research included in the paper and in the preparation of the paper. (Attach a further sheet if necessary) | I had the primary role of designing the study, overseeing the field work, analysing the data, and drafting the manuscript |

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Improving health worldwide www.lshtm.ac.uk
2.4 Abstract

The objectives of this study were a) to identify potentially suitable (relevant to local context and standardized) sites at which to measure indicators of household faecal contamination and b) to compare different measures of household faecal contamination in terms of feasibility of assessment and variation across different households.

We conducted three-hour observations in ten households with at least one child less than five years of age to identify surfaces and objects that came in contact with the children. Children’s hands came into contact with earth floors, including living room, entrance of main house, yard, and kitchen. Children played with a wide range of objects of different sizes and shapes. Only in half of the households were children playing with commercially available toys.

To assess household faecal contamination, a microbiologist collected samples from mother’s hands, child’s hands, toy balls (so called ‘sentinel toys’ provided by the study), the floor of entrance to the main house and a composite floor sample (collected from middle of yard, bedroom of the child and the kitchen) from 20 households (five samples per household). A microbiologist enumerated presumptive faecal coliforms (FC) and presumptive E. coli (EC) using the membrane filtration technique. The results are presented in terms of colony forming unit (CFU) per 100 cm² sampling area.

The coefficient of variation (CV) of FC count among both the floor samples (CV=0.16-0.17) was lower compared to hand rinse samples (mother’s hands=0.47 and children’s hands=0.41) and sentinel toy ball (CV=0.60). The coefficient of
variation (CV) of EC count among both the floor samples (CV=0.17-0.20) was lower compared to hands (mother’s hands=0.44 and children’s hands=0.48). The median level of FC on children’s hands from households with access to improved latrine was lower compared to households with access to unimproved latrines (1.94 vs. 2.67; log_{10} CFU). The median level of FC in sentinel toy samples collected from households with improved latrine were lower compared to samples collected from unimproved latrines (1.32 vs. 2.10; log_{10} CFU).

Contamination of children’s hands and study-provided sentinel toys can be used as indicator of children’s exposure to household faecal contamination, as these measures can be identified and sampled reliably across different households, capture variation and are feasible to measure.

**Key words:** faecal contamination, sentinel toy, hands, and Bangladesh

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1 Since the sample size was small and the sample was selected purposively significance level was not presented. As, the differences could be due to selection bias.
2.5 Introduction

Diarrhoea-causing enteric pathogens pass from one host to another through the environment before reaching a new host. For young children, the environment is the home and its immediate vicinity [1, 2]. Containing contamination at the sanitation point is one way to prevent faeces and their associated pathogens from contaminating the household environment [2-5]. To assess the effectiveness of sanitation interventions in reducing contamination within the household environment, we need suitable indicators of faecal contamination of the household environment.

Within the household environment there may be multiple sources of children’s exposure to faecal contamination, including hands, objects, surfaces, food and drinks [1, 2]. Research assessing household faecal contamination has conventionally focused on hands, food, and drinking water [6-40]. However, contaminated household surfaces and inanimate objects can also play an important role in transmission of enteric pathogens [41-44] and microbial contamination of household surfaces, inanimate objects, and soil, as transmission pathways has been relatively understudied [34, 44-51]. One major difficulty in measuring household surfaces and inanimate objects is identifying a standard surface or object to sample across different study households. Moreover, the extent to which young children come into contact with particular household surfaces or objects is not well known [47] and is likely to be context-specific for the most part.

A useful indicator of household faecal contamination should be relevant to the context, standard across different households, capture variation and be feasible to measure. Depending on the social, cultural and environmental context of a particular household and behaviour of the children in that household, the importance of a particular transmission pathway in transmitting enteric pathogens may vary. So the first objective of the study was to explore where the children under five are potentially exposed to faecal contamination in the household environment, in the context of rural areas of Bangladesh. This understanding will then further help to identify potentially suitable (relevant to context and standard) sites at which to
measure indicators of household faecal contamination. If contamination level on a transmission pathway is very high and there is no variation across different households, we are less likely to capture any difference between two groups of households separated by sanitation characteristics. So the second objective of this pilot study was to compare different measures of household faecal contamination in terms of feasibility of assessment and variation in the level of contamination across different household.

2.6 Methods

We conducted an observational, cross-sectional study between July and September 2012 in eight rural areas of Bangladesh. The field workers identified study villages from a list of villages that were part of an impact assessment implemented by icddr,b [52] and were situated within four hours travel time from Dhaka (in order to facilitate transporting microbiological samples on the day of collection). The study was conducted in two phases. During phase one the field workers conducted semi-structured observations to identify surfaces and objects that commonly came in contact with children’s hands and mouth. Then in phase two the field workers conducted a cross-sectional survey (household questionnaire survey and microbiological sample collection) to assess the suitability of measures of children’s exposure to faecal contamination. To assess suitability of the measures of exposure to faecal contamination we compared the variation in levels of presumptive faecal coliform and the practical experience of collecting and processing the samples in the laboratory with the local resources available.

Ethics

Participation was on the basis of written, witnessed, informed consent. The study protocol received ethical approval from Ethical Review Committee (ERC) of London School of Hygiene and Tropical Medicine (LSHTM) and icddr,b.
2.7 Phase 1: Identifying suitable measures of household faecal contamination

2.7.1 Observation

The purpose of the observations was to collect descriptive data to identify and list the surfaces and objects that a child under five years of age may touch with their hands or mouth.

The field team consisted of two male research officers trained in collecting observation data from rural Bangladesh. They received 2 days training on ethics, observation methods, study objectives and the observation guideline developed for the study. The first author supervised the field workers and was with them in the field during the entire data collection period. At the end of each data collection day the first author reviewed the transcripts.

The field workers conducted observations in ten households from four villages from four sub-districts (Muktagacha, and Fulbaria from Mymensingh district; Roypura and Narshingdi Sadar from Narshingdi district). From each village the observers purposively selected at least one household with a child who was under six months of age, one household with a crawling child and one household with a walking child from a list of households provided by a previous health impact study [52].

The field workers conducted the observations in the morning (9 a.m.-12 a.m.) using a detailed observation guideline. They first visited the entire household premises and noted a detailed description of the household setting and the presence of animal or human faeces. The field workers observed the focal children for the entire period. They recorded the surfaces or object that came in contact with the focal child’s hands or mouth. For each of these events the observers noted the site of child’s activities within the household and the immediate vicinity. The observers collected narrative field notes using pen and paper. The first author then reviewed the narrative field notes to list the surfaces or objects that came in contact with child’s hands and mouth. Then for each surface or object the frequency of contact
with children’s hands and mouth was extracted to identify the common surface or object.

**2.7.2 Findings from observation**

Observed children spent time in the child’s bedroom, inside and around the kitchen, in the courtyard and in neighbouring households, as well as in public places such as shops. All the households selected for semi-structured observation had mud floors in the child’s bedroom, kitchen and yard. In four out of 10 households a cowshed was attached to the main house.

The children came into contact with soil in the front yard (common open area surrounded by multiple households that form a compound owned by several related nuclear families), back yard (smaller private household yard, usually situated between the main house and the water and sanitation facilities), bedroom, and in the indoor and outdoor kitchen within the household as well as in the neighbouring households. For example in one of the households, the child played with vegetables on the floor of the kitchen while the mother was cooking. The children were also found to be in contact with surfaces of furniture, doors, walls, hands and bodies of other children and caregivers. In two households, children were playing with poultry and goats.

During the observations the children were found to be playing with a range of objects, including cooking utensils, natural objects (tree branches, leaves) and miscellaneous household objects of different size and shape. In four out of ten households, children were found to be playing with commercially-available toys. The commercial toys that were found in these households included a marble made of glass, a bamboo flute, wooden spinning, plastic doll, fabric doll and football (Table 2.1). In these households, children were found to be putting a range of objects (toys, clothes, fingers utensils, soil) in their mouths. In half of the households (n=5), children were found to put their own hands in their mouths while playing. In one instance a child was found crawling in the yard and putting mud in her mouth. In most of the houses children’s hands came into contact with caregiver’s hands and in three households children put caregiver’s finger in their mouth.
2.7.3 Potential measures of household faecal contamination

Children under five years of age came into contact with soil from different parts of the household floor and were observed to consume soil. These findings are in line with reports from previous studies conducted in Zimbabwe and Bangladesh [53, 54], reiterating that the surface of floors may play an important role in transmission of infectious disease in these settings. However, we found from our observational data that it was difficult to identify one single specific part of the floor surfaces that would be most important in disease transmission. We therefore chose multiple floor surfaces with reference to a household landmark that can be easily identified across different study households. These multiple floor samples together contributed to a composite indicator of floor contamination, with the assumption that the amount of environmental exposure to contamination is likely to be an average of contamination levels measured from different floor surfaces.

The children touched a range of objects of different size, shape and material during their daily activities so it is difficult to identify one standard object that could be used as a measure of household environmental contamination. Children are more likely to be exposed to contamination on toys in comparison to a particular surface and fomite. The commercially-available toys in these households were of different size and shape, were not common across all households and many households had no toys. This makes existing household toys unsuitable for measuring microbiological faecal contamination across different households. Several previous studies have introduced standardised toy balls as an indicator of household faecal contamination [47, 49-51, 55]. Therefore, contamination on study-introduced toy ball can be used as an indicator of household faecal contamination.

Hands are a closer indicator of level of contamination that a child may encounter in comparison to household surfaces and fomites. It is easy to sample hands across different study households. Several small-scale studies have assessed the association between level of faecal indicator bacteria on children’s and mother’s hands and diarrhoea [19, 26, 31-38]. Therefore, contamination on hands can be used as an indicator of household faecal contamination.
There can be several sources of children’s exposure to household faecal contamination. Considering relevance to local context and the ability to collect standard sample across different households, we collected samples from children’s and mother’s hands; study-introduced toy balls; and a floor sample from the entrance of main house, middle of the living room, middle of a general yard, and the middle of the kitchen.

2.8 Phase 2: Comparing measures of household faecal contamination

2.8.1 Methods for cross-sectional survey

The household questionnaire survey and microbial assessment was conducted in four villages from four sub-districts of Comilla and Pabna districts (different villages from those used for observation). The field workers purposively selected ten households with improved latrines and ten households with unimproved latrines from a list of households provided by a previous study [52]. They categorised sanitation facilities using the current UNICEF/WHO Joint Monitoring Programme (JMP) definition of improved (individual pit latrine with a slab or better) and unimproved, based on spot-check of sanitation facilities.

2.8.1.1 Household questionnaire survey

The field workers, conducted a verbally-administered questionnaire survey, along with spot-checks of household facilities [52, 56-58]. The initial questionnaires were developed based on the study research questions and directed acyclic graph developed for the study. The questionnaire was then reviewed by one of the authors (AB) as a quality assurance procedure, including checking for ambiguous or potentially leading questions. The questionnaire included questions about household possessions, parental education, water, and sanitation and hygiene behaviour. The questionnaire was developed in English and then translated in Bengali. Based on the questionnaire a data collection application was developed to collect data using handheld computers. The questionnaire and the data collection application was pilot tested in the field for comprehensibility prior to final data collection. Questions were
amended, reworded or replaced following piloting. The data collection application was then updated based on the changes in the questionnaire and feedback on the application from the pre-testing.

The data collectors were trained on the use of questionnaire, ethics and interview techniques. Once the class room training was over there was practice data collection in the field before the actual data collection. The first author supervised the data collectors in the field. The first author visited all the study households to collect data on the key water sanitation and hygiene facilities so that the data collected by the data collectors can be cross checked. At the end of data collection in each household the data collectors reviewed the questionnaire to check for completeness of data. All the completed questionnaires were reviewed by the first author completeness before data entry.

2.8.1.2 Microbial assessment

A microbiologist collected samples from mother’s hands, children’s hands, sentinel toy balls (details given below), floor of the entrance to the main house and a composite floor sample (collected from middle of yard, bedroom of a child less than five and the kitchen) in each household (Table 2.2). A total of 100 environmental samples from 20 households (five samples per household) were collected.

2.8.1.2.1 Hand contamination sample collection

A sample was collected from both hands of the primary caregiver and the child under five years of age on the same day as the initial household questionnaire survey following a similar technique used in previous studies [22, 29]. A microbiologist rinsed the hands for 30 seconds, one after another in a Whirl-pak bag (Nasco, Fort Atkinson, WI) containing 200 ml sterile Ringer’s solution (A solution that includes sodium chloride, potassium chloride, calcium chloride di-hydrate, and sodium lactate). The mother/child was instructed to rub the fingers with palm for 15 seconds. Then the microbiologist massaged the inserted hand from the outside of the bag for an additional 15 seconds.
2.8.1.2.2 Sentinel toy sample collection

A sterile non-porous plastic ball (20 cm circumference) (Picture 1) was given to each study household on the day of the initial household questionnaire survey. The mother was instructed to let her child to play with the toy ball with his/her usual playmates and at the usual sites. The microbiologist returned to the household 23-25 hours later and rinsed the ball in a Whirl-Pak bag filled with 200 ml ringer’s solution for 30 seconds, fully immersed, using methodology described previously [47].

2.8.1.2.3 Floor/yard sample collection

The first floor sample was collected from the earthen floor entrance of the main house. One side of a pre-hydrated sponge (3.6 cm wide, 7.6 cm long and 1.5 cm thick) was twice rubbed over 100 cm$^2$ sampling area, marked with a sterile aluminium stencil frame, and then placed back into the Whirl-Pak bag (Whirl-Pak Speci-Sponge bag, Nasco, Fort Atkinson, WI). For the composite floor sample the microbiologist identified middle of the yard, under five child’s bed room and kitchen, based on a visual estimate. Then, one half of one side of a sponge was swiped over 100 cm$^2$ sampling area twice so that sample from each of the three sites could be collected using the same sponge.

2.8.1.2.4 Quality control

A sample Whirl-Pak bag with 200 ml of Ringer’s solution and a pre-hydrated sponge was opened at the household during sample collection and then closed without collecting any sample. This way a field blank was collected every sample collection day to ensure sample rinse bags were free of indicator organisms and not contaminated during the field sampling process.
2.8.1.2.5 Sample processing

The closed Whirl-Pak bags, with the collected samples, were placed immediately into a cold box, maintained at a temperature of ≤10°C. The samples were transported to the Environmental Microbiology Laboratory of icddr,b. The samples were processed to detect presumptive faecal coliforms (FC), using mFC media and presumptive *Escherichia coli* (EC) using MI media (BD Difco, Franklin Lakes, NJ), via membrane filtration technique (EPA method) [59, 60] and drop plate technique [61, 62].

2.8.1.2.6 Enumeration of faecal coliforms (FC) and *E. coli* (EC)

The microbiologist filtered 50 ml to 1 ml (Table 2.3) of liquid recovery media, depending on turbidity and type of the sample, through a 0.22 µm Millipore (Billerica, MA) membrane filter using a vacuum pump. In the majority of cases only one volume was filtered. The plates were then incubated at a temperature of 44.5 ± 0.2°C for 24 ± 2 hours for faecal coliforms and at 35 ± 2°C for 24 hours for *E. coli*. The microbiologist then counted the blue and greenish-blue-coloured colonies on the mFC agar as presumptive faecal coliforms and the deep blue-coloured colonies on the MI agar plate as presumptive *E. coli*. If fewer than 500 characteristic colonies were present, the result was reported as number of CFU per 200 ml of recovery media.

If the samples processed via membrane filtration on the first day produced no detectable colonies, a higher concentration was filtered on the second day using samples stored at 4°C temperature. If there were no target colonies found in the plates on both the days, then the microbiologists reported 0 CFU/200 ml of recovery media. For each sample, droplets of the original recovery media, 10⁻¹ and 10⁻² dilutions of the recovery media, was also plated on the first day at a total volume of 100 µl in case the results from the membrane filtration appeared too numerous to count (TNTC) [61, 62]. To monitor the quality, test negative controls were tested for contamination for each set of agar media. Every day one laboratory blank was tested for contamination. For mFC agar *Escherichia coli* ATCC-13706 was used as positive control and *Staphylococcus aureus* ATCC-25923 was used as negative control. For
MI agar Escherichia coli ATCC-13706 was used as positive control and Staphylococcus aureus ATCC-25923 was used as negative control.

The detection limits ranged from 2 [0.5 for 0 CFU for a maximum of 50 ml filtered; so 0.5*(200/50)=2] to 1,000,000 CFU [maximum 500 CFU detection limit for a minimum of 100µl of 10^{-2} dilutions; so 500*(200000/100)=1000000] per 200 ml recovery media (Table 2.3).

2.8.2 Statistical analysis

For standardization purposes, all data are presented in terms of bacterial counts per 100 square centimetres surface area. Since the distribution of the bacterial counts were found to be not normally distributed, they were transformed into log base 10 [63]. Before the log transformation we replaced the 0 values with 0.5. Then we calculated arithmetic mean and median of the log_{10} transformed counts of FC and EC. To assess variation we also compared mean and median level of contamination between household with improved latrine and unimproved latrine. To test the association between faecal contamination (FC and EC counts) and sanitation type we used Wilcoxon rank-sum test [63]. We also calculated the coefficient of variation (SD/Mean) to achieve an indication of the dispersion of the data. To assess the correlation between levels of faecal contamination across different samples we calculated Pearson’s correlation coefficient and associated significance level.

2.8.3 Results of cross sectional survey (Phase 2)

All households reported having access to a latrine. Among these 35% had access to a pit latrine with a slab and a further 25% had a pit latrine with a slab but with a visible broken pit lining allowing leakage of faeces. A quarter of all the latrines had visible faeces on the slab or floor. Forty percent of the households reported sharing the latrine with other households. In 60% of the households the focal child was reported to defecate in the open, in and around the household. The majority (85%) of households had animal faeces present within the household premises (Table 2.6). Nineteen out of the 20 households had soap available for handwashing.
Hand contamination

Mother’s hands recorded a mean of $2.79 \log_{10}$ [Standard deviation (SD) =1.33] FC and $1.96 \log_{10}$ (SD= 0.86) CFU of EC. Compared to mother’s hands, children’s hands had lower levels of mean FC (Mean= 2.30 $\log_{10}$; SD=0.94) and EC (Mean=1.72; SD= 0.82). The median levels of FC and EC in mother’s hands from households with access to improved and unimproved sanitation were similar$^2$ (for FC 2.57 vs. 2.65 $\log_{10}$ CFU and for EC 1.90 vs. 2.02 $\log_{10}$ CFU). The median level of FC on children’s hands from households with access to improved latrine was lower compared to households with access to unimproved latrines (1.94 vs. 2.67 $\log_{10}$ CFU). However the median level of EC in children’s hands from households with access to improved latrine and unimproved latrine were similar (1.89 vs. 1.72 $\log_{10}$ CFU). Hand rinse samples had higher coefficient of variation (CV) in FC count (CV for children’s hands=0.47 and mother’s hands=0.47) compared to floor samples (CV for entrance of main house=0.16 and composite floor sample=0.17) (Table 2.4).

Household floor/yard contamination

The floor samples collected from the entrance of the main house had a mean of $5.84 \log_{10}$ CFU of FC (SD=0.91, N=20) and $5.38 \log_{10}$ CFU of EC (SD=0.91). The mean level of FC (Mean=5.43 $\log_{10}$ CFU; SD=0.92) and EC (Mean=4.66, SD=0.91) found in composite floor samples was lower than$^3$ the floor samples collected from the entrance of the living room (Table 2.4). The coefficient of variation among both the floor samples was lowest among all the five types of samples for both FC and EC (CV=0.16-0.18) (Table 2.4).

Sentinel toy ball

The samples collected from the sentinel toy balls had $2.22 \log_{10}$ CFU of presumptive faecal coliforms on average (SD=1.39). The median level of FC in

$^2$ Since the sample size was small and the sample was selected purposively significance level was not presented. As, the differences could be due to selection bias.

$^3$ Since the sample size was small and the sample was selected purposively significance level was not presented. As, the differences could be due to selection bias.
sentinel toy samples collected from households with improved latrine were lower (1.32 log$_{10}$ CFU) compared to households with unimproved latrines (2.10 log$_{10}$ CFU). Toys had most variation (CV=0.60) in FC counts in comparison to all other environmental samples (Table 2.4). FC contamination level in sentinel toys was positively correlated with FC contamination level of children’s hands ($r=42$, $P=0.07$) and composite floor sample ($r=0.31$, $P=0.19$) (Table 2.5).

2.9 Discussion on indicators of microbial faecal contamination of the household environment

In this study hands, floor surfaces and objects were assessed for the presence of faecal indicator bacteria, with the purpose of identifying a suitable measure of household faecal contamination to assess the effect of sanitation. All samples showed faecal indicator bacteria, even among households with an onsite latrine. This indicates that a child and a mother could be exposed to faecal contamination via multiple transmission pathways. Children practiced open defecation in these setting [64, 65], which could also contribute to household faecal contamination, even in the presence of a functional latrine. There was frequent movement of animals within the households and the majority of household had some sort of animal faeces present during the survey. Therefore, animal faeces are likely to contribute to the faecal contamination of the household environment and environmental samples collected for this study.

In our study, earthen floor samples had the lowest coefficients of variation, thus requiring a large sample to detect associations with sanitation, making it an unsuitable indicator. However, the sample size was small and therefore limited variation could be due to chance alone. Nonetheless, the probability of a child coming into contact with a particular household surface is unknown making it difficult to estimate the health risk posed by a particular surface.

Contamination on mothers’ hands and children’s hands had higher level of variation than soil samples. Hand rinse samples were more suitable to process via membrane filtration, compared to soil samples. Therefore, hand contamination could be a potential indicator of household faecal contamination. In this study there
was more variation recorded between households with improved and unimproved sanitation in the level of presumptive faecal coliform contamination on children’s hands in comparison to mother’s hands. Mothers’ hands showed a higher level of faecal indicator bacteria than children’s hands. Previous studies have suggested variation in women’s hand contamination is due to the activity immediately prior to sample collection [22, 39]. So the higher level of contamination in mothers’ hands may be because of contamination of mothers’ hands while doing household activities. Although mothers wash their hands more frequently than children (with water only) they may also touch contaminated surfaces/objects more frequently. In our study we found that children put their hands in their mouth frequently while playing. Therefore, contamination of children’s hands may be a relevant and a useful indicator of the amount of children’s exposure to faecal contamination.

In our study, sentinel toys demonstrated the highest CV among the five samples tested. If there is a difference in levels of faecal contamination comparing household with access to improved and unimproved latrines, this indicator is likely to capture it. Moreover, contamination levels in sentinel toys was positively correlated with contamination level of children’s hands, indicating that contamination level in the sentinel toys could be a useful proxy for child exposure. A reduction in the microbiological contamination levels on toys is a proximal indicator of household faecal contamination that a child may encounter in comparison to other exposure pathways such as surfaces and object. Toy balls might be more directly exposed to the household environment than water. As a result, the contamination level on the toy ball (the sentinel toy) might be a suitable indicator of a child’s exposure to household faecal contamination. The sentinel toy method has been used in previous studies of sanitation in Bangladesh [47] and in India [55].

This study had some important limitations. Faecal contamination was measured using faecal indicator bacteria (FIB). There is evidence from small-scale observational studies suggesting that presence of FIB on hands and toys may be associated with household sanitation [12-21, 34]. Presence of FIB may have non-human origin and does not necessarily signify risks to human health [34, 66-68] [69-72]. More over presence of FIB may not be correlated with presence of viruses that
may originate in human faeces. It is important to note that here presence of FIB is used to imply human faecal contamination. This makes presence of FIB bacteria an imprecise outcome indicator for sanitation. As a consequence, the confidence intervals of the estimates presented are likely to be wider, making the results less likely to be statistically significant. even if in reality a difference exists [73]. Using markers of human specific pathogens as indicator of human faecal contamination could help us better understand the association between sanitation and human faecal contamination in future studies.

This study was conducted in low-income rural Bangladeshi households with multiple source of household faecal contamination in which children are exposed to earthen surfaces in the household and immediate vicinity. However, the children’s exposure to faecal contamination may be different in urban contexts or in high-income countries. In particular, the contamination of surfaces may have different levels of importance or different levels of variation. However, at least in similar settings contamination of children’s hands and sentinel toy ball is likely to be as useful as in this context. The experience of this study and its findings can therefore be used in other contexts, with similar environmental and social contexts.

The findings from this small-scale study suggest that children are likely to be exposed to faecal contamination from different household surfaces and objects but that identifying a standard surface or object for measurement across different households is difficult. Since the contamination level of soil demonstrated low variation across different households, a larger sample size will be required in studies to capture the difference in contamination level. Children’s hands and study-introduced sentinel toys are standard across different households and are more feasible to collect and process using membrane filtration. Moreover, there is more variation in level of faecal contamination on hands and sentinel toys in comparison to earthen surfaces. Therefore children’s hands and study-introduced sentinel toys could be used to assess child exposure to household faecal contamination. Although this study was undertaken in a small number of households, it provides important insight as to the feasibility and relevance of alternative measures of household faecal
contamination. Future studies of environmental contamination would benefit from undertaking a feasibility study of the measures of environmental contamination.
2.10 Acknowledgement: This research was made possible with UK Aid from the Department of International Development (DFID) as part of the SHARE research programme (www.SHAREresearch.org). However, the views expressed do not necessarily reflect DFID’s official policies. No funding bodies had any role in study design, data collection and analysis, decision to publish or preparation of the manuscript. The study was also partially funded by Water, Sanitation and Hygiene research group at icddr,b, Dhaka, Bangladesh. The author acknowledges the contributions of the study participants, icddr,b administration, field and laboratory research staff. The authors also thank the Research Advisory Committee, the examiners, and the environmental Health Group at London School of Hygiene and tropical Medicine (LSHTM). The author specially thanks Sarker Masud Parvez, from ICDDR,B for his support during data collection in Bangladesh.
2.11 References


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Table 2.1: Surfaces and objects that came in contact with children’s hands and mouth during structured observation conducted in rural Bangladeshi households (HH), July-August 2012

<table>
<thead>
<tr>
<th>Surface/Object that came in contact with hand</th>
<th>No of Households (HH) where event was observed (N=10)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Soil from floor in</td>
<td></td>
</tr>
<tr>
<td>Bed room</td>
<td>5</td>
</tr>
<tr>
<td>Yard adjacent to entrance of main house</td>
<td>3</td>
</tr>
<tr>
<td>General yard</td>
<td>3</td>
</tr>
<tr>
<td>Kitchen</td>
<td>2</td>
</tr>
<tr>
<td>Furniture/door/walls/fence</td>
<td></td>
</tr>
<tr>
<td>(Bamboo pillars, wooden, plastic chair, wooden chair, bed)</td>
<td>6</td>
</tr>
<tr>
<td>Bed linen/towel</td>
<td>4</td>
</tr>
<tr>
<td>Cooking utensils or household objects</td>
<td></td>
</tr>
<tr>
<td>(mug, plastic bottle, jug, plastic hand fan, drinking glass, spoon, Badna, plastic bottle, plastic food storage box)</td>
<td>7</td>
</tr>
<tr>
<td>Formal toys</td>
<td></td>
</tr>
<tr>
<td>(glass marble, bamboo flute, wooded latim*, nail cutter, plastic doll, fabric doll, football)</td>
<td>4</td>
</tr>
<tr>
<td>Natural objects</td>
<td></td>
</tr>
<tr>
<td>(Tree branches, leaves, crop residue, produce brought for cooking, fire wood, fruits)</td>
<td>9</td>
</tr>
<tr>
<td>Miscellaneous objects</td>
<td></td>
</tr>
<tr>
<td>(Pen, sandals, nail cutter, screw driver)</td>
<td>5</td>
</tr>
<tr>
<td>Hands and body of other children</td>
<td>7</td>
</tr>
<tr>
<td>Hands and body of caregiver</td>
<td>8</td>
</tr>
<tr>
<td>Hands and body of neighbours</td>
<td>3</td>
</tr>
<tr>
<td>Domestic animal (chicken, duck and goat)</td>
<td>2</td>
</tr>
<tr>
<td>Clothes of care giver</td>
<td>5</td>
</tr>
<tr>
<td><strong>Objects that a child put in mouth (non-food item)</strong></td>
<td></td>
</tr>
<tr>
<td>Soil</td>
<td>1</td>
</tr>
<tr>
<td>Caregivers’ clothes</td>
<td>1</td>
</tr>
<tr>
<td>Own clothes</td>
<td>1</td>
</tr>
<tr>
<td>Toys (doll)</td>
<td>1</td>
</tr>
<tr>
<td>Tree branch, leaves, crop residue</td>
<td>7</td>
</tr>
<tr>
<td>Own fingers</td>
<td>5</td>
</tr>
<tr>
<td>Finger of sibling</td>
<td>1</td>
</tr>
<tr>
<td>Fingers of caregivers</td>
<td>3</td>
</tr>
<tr>
<td>Uncooked vegetable/fruit (Produce)</td>
<td>4</td>
</tr>
<tr>
<td>Utensils (glass, plastic bottle)</td>
<td>2</td>
</tr>
<tr>
<td>Miscellaneous (Pen)</td>
<td>1</td>
</tr>
</tbody>
</table>

*A traditional wooden toy
† A small water vessel made of plastic or aluminium or copper used to transfer/carry water to the latrines.
(http://en.wikipedia.org/wiki/Lota_(vessel))
Table 2.2: Summary of environmental samples collected from Rural Bangladesh, 2012

<table>
<thead>
<tr>
<th>Type of sample</th>
<th>Sample collection method</th>
<th>Indicator bacteria</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mother’s hands</td>
<td>Rinsing both hands in 200 ml ringer’s solution</td>
<td>E. coli Faecal coliform</td>
</tr>
<tr>
<td>(N=20)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Children’s Hands</td>
<td>Rinsing both hands in 200 ml ringer’s solution</td>
<td>E. coli Faecal coliform</td>
</tr>
<tr>
<td>(N=20)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sentinel toy</td>
<td>Rinsing standard toy ball in 200 ml of ringer’s solution, 24 hours after supplied.</td>
<td>Faecal coliform*</td>
</tr>
<tr>
<td>(N=20)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Floor of entrance</td>
<td>Sponging 100 sq cm surface using a pre-hydrated sponge</td>
<td>E. coli Faecal coliform</td>
</tr>
<tr>
<td>of living room</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(N=20)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Composite-floor</td>
<td>Sponging 100 sq cm from 3 surface area using one pre-hydrated sponge (Middle of yard, middle of living room and middle of kitchen)</td>
<td>E. coli Faecal coliform</td>
</tr>
<tr>
<td>(N=20)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*Since a study conducted in Bangladesh did not find E. coli level in sentinel toy to be associated with sanitation type we have not measured E. coli level for sentinel toy [51]
Table 2.3: Showing the percentage of samples with various detection limits for each type of sample (N=20)

<table>
<thead>
<tr>
<th>Method</th>
<th>Amount filtered or drop plated</th>
<th>Detection limit†</th>
<th>Mother’s hands (%)</th>
<th>Children’s hands (%)</th>
<th>Sentinel toy</th>
<th>Entrance of living room</th>
<th>Composite floor sample</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Lower</td>
<td>Upper</td>
<td>EC</td>
<td>FC</td>
<td>EC</td>
<td>FC</td>
</tr>
<tr>
<td>100 µl of 10^{-2} dilution</td>
<td>100000</td>
<td>100000000</td>
<td>10%</td>
<td>5%</td>
<td></td>
<td>45%</td>
<td>35%</td>
</tr>
<tr>
<td>Drop</td>
<td>10000</td>
<td>10000000</td>
<td></td>
<td></td>
<td></td>
<td>20%</td>
<td>35%</td>
</tr>
<tr>
<td>100 µl of 10^{-1} dilution</td>
<td>1000</td>
<td>1000000</td>
<td>25%</td>
<td>20%</td>
<td>30%</td>
<td>10%</td>
<td>30%</td>
</tr>
<tr>
<td>Drop plate technique</td>
<td>1 ml filtration</td>
<td>100</td>
<td>100000</td>
<td>30%</td>
<td>10%</td>
<td>35%</td>
<td>5%</td>
</tr>
<tr>
<td></td>
<td>2 ml filtration</td>
<td>50</td>
<td>500000</td>
<td>50%</td>
<td>15%</td>
<td>45%</td>
<td>20%</td>
</tr>
<tr>
<td>Membrane filtration</td>
<td>5 ml filtration</td>
<td>20</td>
<td>20000</td>
<td>50%</td>
<td>15%</td>
<td>45%</td>
<td>20%</td>
</tr>
<tr>
<td></td>
<td>10 ml filtration</td>
<td>10</td>
<td>10000</td>
<td>5%</td>
<td>25%</td>
<td>25%</td>
<td>5%</td>
</tr>
<tr>
<td></td>
<td>20 ml filtration</td>
<td>5</td>
<td>50000</td>
<td>15%</td>
<td>10%</td>
<td>10%</td>
<td>15%</td>
</tr>
<tr>
<td></td>
<td>50 ml</td>
<td>2</td>
<td>20000</td>
<td>0</td>
<td>5%</td>
<td>5%</td>
<td>10%</td>
</tr>
</tbody>
</table>

*E. coli (EC), Faecal coliform (FC)*
† For lower detection limit we counted 0.5 for no characteristic colony per plate and for upper detection limit we considered 500 colonies per plate to countable.
Table 2.4: Mean log_{10}-transformed colony forming units (CFU) of presumptive faecal coliforms and *Presumptive E. coli* per 100 cm² of environmental sample (N=20), rural Bangladesh 2012

<table>
<thead>
<tr>
<th>Type of environmental sample</th>
<th>All households (HHs) N=20</th>
<th>HHs with Improved latrine N=10</th>
<th>HHs with unimproved latrine N=10</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean (SD)</td>
<td>Median</td>
<td>CV*</td>
</tr>
<tr>
<td>Faecal coliform</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mother’s hands</td>
<td>2.79 (1.33)</td>
<td>2.58</td>
<td>0.47</td>
</tr>
<tr>
<td>Children’s hands</td>
<td>2.30 (0.94)</td>
<td>2.50</td>
<td>0.41</td>
</tr>
<tr>
<td>Sentinel toy</td>
<td>2.22 (1.39)</td>
<td>1.62</td>
<td>0.63</td>
</tr>
<tr>
<td>Entrance of main house</td>
<td>5.84 (0.91)</td>
<td>5.91</td>
<td>0.16</td>
</tr>
<tr>
<td>Composite Floor‡</td>
<td>5.43 (0.92)</td>
<td>5.54</td>
<td>0.17</td>
</tr>
<tr>
<td>E. coli</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mother’s hands</td>
<td>1.96 (0.86)</td>
<td>2.02</td>
<td>0.44</td>
</tr>
<tr>
<td>Children’s hands</td>
<td>1.72 (0.82)</td>
<td>1.81</td>
<td>0.48</td>
</tr>
<tr>
<td>Entrance of main house</td>
<td>5.38 (0.91)</td>
<td>5.51</td>
<td>0.17</td>
</tr>
<tr>
<td>Composite floor‡</td>
<td>4.66 (0.91)</td>
<td>4.60</td>
<td>0.20</td>
</tr>
</tbody>
</table>

* Coefficient of variation (SD/Mean)
† Association between faecal coliform counts and sanitation type using Wilcoxon rank sum test
‡ Composite floor: Sample collected from middle of the yard, bed room of <5 child and kitchen by microbiologist based on visual estimate using one sponge.
Table 2.5: Correlation of presumptive faecal coliform (FC) and *Presumptive E. coli* (EC) contamination among samples collected from different sampling sites in rural Bangladeshi households (N=20).

<table>
<thead>
<tr>
<th>Variable 1</th>
<th>Variable 2</th>
<th>Faecal coliform (FC)</th>
<th>E. coli (EC)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>r</td>
<td>P value</td>
</tr>
<tr>
<td>Composite Floor</td>
<td>Entrance of main house</td>
<td>0.29</td>
<td>0.21</td>
</tr>
<tr>
<td>Composite Floor</td>
<td>Sentinel toy</td>
<td>0.31</td>
<td>0.19</td>
</tr>
<tr>
<td>Composite Floor</td>
<td>children’s hands</td>
<td>-0.15</td>
<td>0.54</td>
</tr>
<tr>
<td>Composite Floor</td>
<td>Mother’s hands</td>
<td>-0.30</td>
<td>0.20</td>
</tr>
<tr>
<td>Entrance of main house</td>
<td>Sentinel toy</td>
<td>0.07</td>
<td>0.76</td>
</tr>
<tr>
<td>Entrance of main house</td>
<td>children’s hands</td>
<td>-0.13</td>
<td>0.57</td>
</tr>
<tr>
<td>Entrance of main house</td>
<td>Mother’s hands</td>
<td>-0.23</td>
<td>0.33</td>
</tr>
<tr>
<td>Sentinel toy</td>
<td>Children’s hands</td>
<td>0.42</td>
<td>0.07</td>
</tr>
<tr>
<td>Sentinel toy</td>
<td>Mother’s hands</td>
<td>0.01</td>
<td>0.97</td>
</tr>
<tr>
<td>Children’s hands</td>
<td>Mother’s hands</td>
<td>0.48</td>
<td>0.03</td>
</tr>
</tbody>
</table>
Table 2.6: Characteristics of the participating households, Comilla and Pabna districts, Bangladesh, August/September 2012.

<table>
<thead>
<tr>
<th>Characteristics</th>
<th>All participating households (HH)</th>
<th>HHs with improved latrine</th>
<th>HHs with unimproved latrine</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>n</td>
<td>Percent or Mean</td>
<td>n</td>
</tr>
<tr>
<td>General</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mean Number of HH residents</td>
<td>20</td>
<td>5</td>
<td>10</td>
</tr>
<tr>
<td>Mean Number of children age &lt;5 years</td>
<td>20</td>
<td>1.1</td>
<td>10</td>
</tr>
<tr>
<td>Mean age (months) of children &lt;5 years</td>
<td>20</td>
<td>38.8</td>
<td>10</td>
</tr>
<tr>
<td>Mother of youngest child lacked formal education</td>
<td>7</td>
<td>35%</td>
<td>6</td>
</tr>
<tr>
<td>Father of youngest child lacked formal education</td>
<td>11</td>
<td>55%</td>
<td>8</td>
</tr>
<tr>
<td>Occupation of the father of the youngest child</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Farmer</td>
<td>9</td>
<td>45%</td>
<td>5</td>
</tr>
<tr>
<td>Labourer</td>
<td>5</td>
<td>25%</td>
<td>-</td>
</tr>
<tr>
<td>Salaried employee</td>
<td>1</td>
<td>5%</td>
<td>3</td>
</tr>
<tr>
<td>Business owner</td>
<td>5</td>
<td>25%</td>
<td>2</td>
</tr>
<tr>
<td>Proportion who owned</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>House</td>
<td>20</td>
<td>100%</td>
<td>10</td>
</tr>
<tr>
<td>Wardrobe</td>
<td>6</td>
<td>30%</td>
<td>3</td>
</tr>
<tr>
<td>Table</td>
<td>17</td>
<td>85%</td>
<td>8</td>
</tr>
<tr>
<td>Chair</td>
<td>19</td>
<td>95%</td>
<td>10</td>
</tr>
<tr>
<td>Bed</td>
<td>9</td>
<td>45%</td>
<td>3</td>
</tr>
<tr>
<td>Inexpensive cot</td>
<td>15</td>
<td>75%</td>
<td>10</td>
</tr>
<tr>
<td>Watch/clock</td>
<td>12</td>
<td>60%</td>
<td>5</td>
</tr>
<tr>
<td>Bicycle</td>
<td>6</td>
<td>30%</td>
<td>3</td>
</tr>
<tr>
<td>Mobile Phone</td>
<td>18</td>
<td>90%</td>
<td>9</td>
</tr>
<tr>
<td>Television</td>
<td>5</td>
<td>25%</td>
<td>3</td>
</tr>
<tr>
<td>Refrigerator</td>
<td>0</td>
<td>-</td>
<td>0</td>
</tr>
<tr>
<td>Goat</td>
<td>9</td>
<td>45%</td>
<td>4</td>
</tr>
<tr>
<td>Cow</td>
<td>16</td>
<td>85%</td>
<td>8</td>
</tr>
<tr>
<td>Chicken</td>
<td>16</td>
<td>85%</td>
<td>8</td>
</tr>
<tr>
<td>Mean acres of agricultural land</td>
<td>20</td>
<td>0.9</td>
<td>10</td>
</tr>
<tr>
<td>Mean acres of non-agricultural land</td>
<td>20</td>
<td>0.2</td>
<td>10</td>
</tr>
<tr>
<td>House construction</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tin roof</td>
<td>19</td>
<td>95%</td>
<td>10</td>
</tr>
<tr>
<td>Cement floor</td>
<td>2</td>
<td>10%</td>
<td>0</td>
</tr>
<tr>
<td>Mean number of rooms</td>
<td>20</td>
<td>1.9</td>
<td>10</td>
</tr>
<tr>
<td>Electrical connection</td>
<td>16</td>
<td>80%</td>
<td>7</td>
</tr>
<tr>
<td>Cooking Fuel</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Wood</td>
<td>4</td>
<td>20%</td>
<td>3</td>
</tr>
<tr>
<td>Crop residue</td>
<td>13</td>
<td>65%</td>
<td>4</td>
</tr>
<tr>
<td>Cow dung</td>
<td>2</td>
<td>10%</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>--------------------------</td>
<td>--------</td>
<td>------</td>
<td>--------</td>
</tr>
<tr>
<td><strong>Kerosene</strong></td>
<td>1</td>
<td>5%</td>
<td>1</td>
</tr>
<tr>
<td><strong>Water source for drinking</strong></td>
<td><strong>Shallow tube-well</strong></td>
<td>19</td>
<td>95%</td>
</tr>
<tr>
<td><strong>Type of latrine facility used by the household</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Flush latrine connected to</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>septic tank</td>
<td>1</td>
<td>5%</td>
<td></td>
</tr>
<tr>
<td>offset pit</td>
<td>6</td>
<td>30%</td>
<td></td>
</tr>
<tr>
<td>somewhere else</td>
<td>1</td>
<td>5%</td>
<td></td>
</tr>
<tr>
<td>Pit latrine with slab</td>
<td>7</td>
<td>35%</td>
<td></td>
</tr>
<tr>
<td>Pit latrine with slab but the pit is leaking</td>
<td>5</td>
<td>25%</td>
<td></td>
</tr>
<tr>
<td><strong>User of latrine facility</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Individual</td>
<td>12</td>
<td>60%</td>
<td></td>
</tr>
<tr>
<td>Shared</td>
<td>8</td>
<td>40%</td>
<td></td>
</tr>
<tr>
<td><strong>Visible faeces on latrine slab</strong></td>
<td>5</td>
<td>25%</td>
<td></td>
</tr>
<tr>
<td><strong>Animal faeces present within the household</strong></td>
<td>17</td>
<td>85%</td>
<td></td>
</tr>
<tr>
<td><strong>Defecation site for &lt;5 children</strong>*</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Potty/Nappy</td>
<td>4</td>
<td>20%</td>
<td></td>
</tr>
<tr>
<td>Latrine</td>
<td>4</td>
<td>20%</td>
<td></td>
</tr>
<tr>
<td>Open within the household</td>
<td>8</td>
<td>40%</td>
<td></td>
</tr>
<tr>
<td>Open in the nearby bush</td>
<td>4</td>
<td>20%</td>
<td></td>
</tr>
</tbody>
</table>

*Household
Chapter 3: A cross sectional study of the association between sanitation type and faecal contamination of the household environment in rural Bangladesh

3.1 Introduction to the chapter

This chapter compares different classifications of improved sanitation used for international monitoring in terms of their effectiveness at reducing microbiological contamination of household environment. This chapter includes a submitted manuscript which describes the main results of the study conducted for this thesis.

3.2: Role of the authors in the research paper

Tarique M.N. Huda (TH): TH is the first author of the research paper. He had the primary role of designing the study, overseeing the field work, cleaning and analyzing the data, interpreting the results and drafting the manuscript.

Wolf-Peter Schmidt (WS): WS contributed to the conception of the study, defining the research questions, provided guidance on design of the study; reviewed the data analysis and the draft manuscript.

Amy J. Pickering (AP): AP provided guidance on the microbiological sample collection protocol; provided feedback on analysis and interpretation of the data and reviewed the draft manuscript.

Zahid H. Mahmud (ZM) and Md. Sirajul Islam: ZM and SI reviewed the protocol for the microbiological sample processing in the lab, helped with supervision of the sample processing in the lab and reviewed the draft manuscript.

Md. S. Rahman: SR helped with supervision of data collection in the field, data cleaning and reviewed the draft manuscript.

Stephen P. Luby (SL): SL provided guidance on design of the study and reviewed the draft manuscript.

Adam Biran (AB): AB was the executive author for this manuscript. He contributed to the conception of the study, contributed in defining the research questions, approved the overall study design, data/sample collection protocols and reviewed the draft manuscript.
3.3 Research paper cover sheet

Since this thesis is 'Research Paper' style, the following cover sheet is being included in accordance with the regulations as mentioned in the LSHTM Research Degree Handbook guidance.

RESEARCH PAPER COVER SHEET

PLEASE NOTE THAT A COVER SHEET MUST BE COMPLETED FOR EACH RESEARCH PAPER INCLUDED IN A THESIS.

SECTION A – Student Details

<table>
<thead>
<tr>
<th>Student</th>
<th>Tariqae Mohammad Nurul Huda</th>
</tr>
</thead>
<tbody>
<tr>
<td>Principal Supervisor</td>
<td>Adam Biran</td>
</tr>
<tr>
<td>Thesis Title</td>
<td>Role of Sanitation in preventing faecal contamination of the domestic environment and protecting health: An observational study.</td>
</tr>
</tbody>
</table>

If the Research Paper has previously been published please complete Section B, if not please move to Section C

SECTION B – Paper already published

Where was the work published?

When was the work published?

If the work was published prior to registration for your research degree, give a brief rationale for its inclusion

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*If yes, please attach evidence of retention. If no, or if the work is being included in its published format, please attach evidence of permission from the copyright holder (publisher or other author) to include the work.

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Please list the paper’s authors in the intended authorship order:


Stage of publication

Submitted for publication

SECTION D – Multi-authored work

For multi-authored work, give full details of your role in the research included in the paper and in the preparation of the paper. (Attach a further sheet if necessary)

I had the primary role of designing the study, overseeing the field work, analysing the data, and drafting the manuscript
Title: A cross sectional study of the association between sanitation type and faecal contamination of the household environment in rural Bangladesh

Authors: Tarique M N Huda¹, Wolf-Peter Schmidt¹, Amy J. Pickering², Zahid Hayat Mahmud³, Md. Sirajul Islam³, Md. S. Rahman³, Stephen P. Luby² and, Adam Biran¹

¹London School of Hygiene and Tropical Medicine, London, UK
²Stanford University, Stanford, California, USA
³International Centre for Diarrhoeal Disease Research (icddr,b), Bangladesh

3.4 Abstract

A cross-sectional study was conducted to assess the association between different types of sanitation facilities and faecal contamination in the household environment. Households with a child aged 6-24 months (target child) were enrolled for the study. Sanitation facilities in 454 households in rural Bangladesh were assessed. Sanitation was categorised using; a) The Millennium Development Goal (MDG) definition of improved (Individual pit latrine with a slab or better) and unimproved; b) the proposed Sustainable Development Goal (SDG) definition of improved (pit latrine with a slab or better used by up to five households) and unimproved. In each household an identical toy ball was given to the target child. After 24 hours the balls were rinsed to enumerate faecal coliforms, using the membrane filtration technique as an indicator of household faecal contamination.

Households with individual improved sanitation (MDG) had lower faecal coliform contamination than households with unimproved sanitation [adjusted difference in means -0.31 log₁₀ colony forming units (CFU)/toy ball: 95% CI -0.61, -0.01]. Households with improved (SDG) sanitation used by up to five households had a similar level of faecal coliform contamination to households with access to unimproved sanitation. Shared sanitation facilities of otherwise improved technology were more likely to be dirtier compared to private facilities. Households with no visible faeces on the latrine slab at the time of assessment had less contamination than households with visible faeces on the latrine slab (adjusted difference in means -0.38 log₁₀ CFU/toy ball; 95% CI: -0.77, 0.02)
A sanitation facility used by an individual household may be better at reducing household faecal contamination compared to shared facilities.

**Key words:** sanitation, faecal contamination, faecal coliform, Bangladesh

### 3.5 Introduction

Inadequate sanitation is an important risk factor for poor health especially in low and middle income countries [1-5]. In addition to its link with diarrhoea morbidity [2, 5-15] and mortality [2, 5, 16, 17], inadequate sanitation is associated with the risk of trachoma,[2, 18, 19] helminthiases [2, 20, 21] and schistosomiasis [4].

The WHO/UNICEF Joint monitoring Programme (JMP) for water supply and sanitation categorised sanitation as improved or unimproved to monitor progress towards Millennium Development Goal (MDG) 7, target 10 which addressed sanitation coverage [22-24]. The JMP defines improved sanitation as access to a pit latrine with a slab, ventilated improved pit latrine or a flush/pour-flush latrine, (Table 1)[23, 25]. For the MDG shared facilities, otherwise of improved technology are considered unimproved because of concerns regarding cleanliness, maintenance and access [23, 26]. However, the implications of using a shared facility are likely to be different in the urban and rural context. In crowded, urban areas of most low-income countries, shared facilities might be the only viable option to avoid open defecation and in rural areas households with family ties often share a facility to keep costs down [23]. The JMP is revising its definition to monitor the progress towards sanitation for the post-2015 Sustainable Development Goals (SDG). In the revised definition, there is discussion as to whether to consider sanitation facilities of otherwise improved technology, shared among no more than five households or 30 persons, whichever is fewer, as improved [25].

Although these standard definitions proposed by the JMP allow comparable data among countries and across time, [22] they may differ from the criteria used by national governments [25]. For example the Government of Bangladesh (GoB) categorises sanitation as hygienic or unhygienic. The GoB definition of hygienic
excludes pit latrines with a slab (Table 1)[27] and allows sharing by a maximum of two households. There is very limited empirical evidence to judge the extent to which improved or hygienic sanitation facilities achieve their purpose in separating faeces from the environment [14, 28, 29].

Few studies have explored the effect on health of access to different levels of sanitation as classified by JMP, [16, 29, 30]. Findings from Indonesia suggested that lack of improved sanitation was associated with higher reported diarrhoea (OR=1.23, 95% CI=1.18-1.29) [16]. A recent systematic review identified 21 studies that compared health outcomes associated with shared versus individual household latrines [29]. However, most of these studies did not adequately address potential confounding and did not allow the effect of different types of shared sanitation to be distinguished. An analysis of Demographic and Health surveys (DHS) from 51 countries found shared, improved sanitation facilities to be associated with adverse health outcomes [30]. However, this finding was not consistent across all countries, suggesting that environmental, social and economic contexts are also important.

There is evidence from a small number of observational studies that access to flush or pour flush latrines connected to a piped sewer system or septic tank or pit and composting latrines are associated with lower risk of diarrhoea [31-35]. However, from these studies it is not known whether pit latrines with a slab (improved, as defined by the JMP) provide similar protection from diarrhoea.

Safe disposal of faeces is expected to create a barrier to multiple faeco-oral disease transmission pathways [36]. However there is limited evidence about the relative impact of improved and unimproved sanitation (JMP definition) on specific transmission pathways. [37-40]. The current approaches to measure level of environmental exposure to faecal contamination includes sampling for contamination in drinking water [37-39, 41-43], on hands [39], and on household surfaces[37, 40]. However most of these studies did not use the JMP definition or had limited sample size.

Toys used by young children may have a high level of faecal contamination and play an important role in diarrhoeal disease transmission [44-47]. Children are
more likely to be exposed to contamination on toys in comparison to other surfaces and fomites. Hands may be a closer indicator of level of contamination that the child may encounter. However, hand contamination [48] data are likely to be more variable because of variation in handwashing practices. Compared to hands, toy balls are less subject to washing. Toy balls might be more directly exposed to the household environment than stored water. As a result, the contamination level on the toy ball (the sentinel toy) might be a useful indicator of a child’s exposure to household faecal contamination [49]. The sentinel toy method has been used in previous studies of sanitation in Bangladesh [49] and in India [50]. While these studies demonstrated the feasibility of using toy balls as a measure of household faecal contamination, sanitation was not categorised using the JMP definition.

A study conducted in Peru found that improved sanitation, as defined by the JMP (MDG definition), was associated with lower levels of faecal indicator bacteria (E. coli) [51] in toys compared to households that lacked improved sanitation. A second study conducted in Honduras also found that households with improved latrines had lower levels of total coliforms [52] on toys. However these studies had limited sample size and so could not assess the effect of a range of confounding variables that may affect the association between faecal contamination and sanitation access.

In this study we assessed the association between sanitation facility type and microbial faecal contamination of the household environment. We assessed faecal contamination using the sentinel toy method where by an identical toy ball (the ‘sentinel toy’) was given to a child in each participating household and microbial contamination of the balls was subsequently measured.

3.6 Methods

An observational, cross-sectional study was conducted between September and October 2013, in rural areas of Mymenshingh and Narshingdi districts of Bangladesh. The study was conducted in villages that were participating in the Sanitation, Hygiene Education, and Water supply in Bangladesh (SHEWA-B) health impact study described elsewhere [53].
3.6.1 Household selection

First a list of study villages enrolled in the SHEWA-B health impact study situated in Mymensingh and Narshingdi districts was collected. Using the list a simple random sample of 46 villages was selected using the random number generator in Microsoft Excel. Fieldworkers identified 10 households in each village by using a random walk algorithm. A household was considered eligible if it included a child aged between 6 and 24 months residing at the house (target child) on the day of the visit, had no more than one latrine and was more than 50 meters from any other selected household. Field workers entered the village and identified the beginning of its main road by asking the local inhabitants. From the starting point they searched for the closest eligible household. After selecting the first study household they looked for the next eligible household. The distance between households was measured using a handheld global positioning system (GPS) unit “Garmin Etrex legend H” (GARMIN)[54].

3.6.2 Data and sample collection

Data were collected using a questionnaire survey and environmental spot-check. To assess faecal contamination of household environments the enumerators also collected microbiological samples. These methods are outlined below.

3.6.2.1 Training of field staff

All enumerators received seven days training on overall study objectives; study protocol; consent process; interview and spot-check techniques; use of data collection instruments; collection and handling of microbiological samples; and quality control approaches. The training also included practice data and microbiological sample collection in the field followed by feedback session.

3.6.2.2 Questionnaire survey

The enumerators used a verbally administered, structured questionnaire survey to collect information from the primary caregivers (usually the mothers) of the target children. The initial questionnaires were developed based on the study research questions and directed acyclic graph developed for the study. The questionnaire was then reviewed by one of the authors (AB) as a quality assurance
procedure including checking for ambiguous or potentially leading questions. The questionnaire included questions about household possessions, parental education, water, and sanitation and hygiene behaviour. The questionnaire was developed in English and then translated in Bengali. Based on the questionnaire a data collection application was developed to collect data using hand held computers. The questionnaire and the data collection application was pilot tested in the field for comprehensibility prior to final data collection. Questions were amended, reworded or replaced following piloting. The data collection application was then updated based on the changes in the questionnaire and feedback on the application from the pre-testing.

3.6.2.3 Environmental spot-check

The environmental check included a visual inspection of the house and compound. A compound in rural Bangladesh is comprised of a few households, often owned by members of an extended family who usually share a yard and water and sanitation facilities. The enumerators conducted visual inspections of water, sanitation and hygiene related infrastructure using a checklist. The enumerators recorded the features related to infrastructure and cleanliness at the time of visit. They also visually checked around the house and compound for presence of animal and human faeces and recorded the number and type of faeces observed. The field workers inspected the hands and nails of the target child for visible dirt.

3.6.2.4 Microbiological sample collection

3.6.2.4.1 Sample collection

Fieldworkers, trained in collection and handling of microbiological samples, supplied an identical, sterile, rubber toy ball (sentinel toy ball) with a 20 centimetre circumference (Picture 3.1) to the target child in every study household. The primary caregiver was told that the child should be allowed to play with the toy ball in his/her usual play

Picture 3.1: Sentinel toy ball.
sites and with his/her usual playmates. The fieldworkers returned to the households approximately 23 to 25 hours after supplying the toy balls. They rinsed the balls in a Whirl-pak bag (19×38 cm) filled with 200 ml of Ringer’s solution for 30 seconds [49]. The field workers transported the samples to the Environmental Microbiology Laboratory of icddr,b within 15-18 hours of collection, maintaining a temperature of 4–10 °C in a cool box.

3.6.2.4.2 Enumeration of faecal coliforms

The samples were stored at 2-8°C and were analysed by a microbiologist within 24 hours of collection to detect faecal coliforms. Five millilitres (ml) of the recovery medium that bathed the toy ball was collected and filtered through a 0.22 µm Millipore (Billerica, MA) membrane filter. The membrane filter was then placed on to modified faecal coliform (mFC) agar plates. The plates were incubated at 44.5 ± 0.2°C for 22-26 hours and the blue and greenish-blue coloured colonies on the mFC agar were then counted as presumptive faecal coliforms following standard procedures [55, 56].

If no colonies were found, 50 ml of recovery media was filtered on the following day from the stored sample and the culturing process was repeated. If the characteristic colony counts from the 1st day were more than 500 per plate, 5 ml of 10 times diluted sample was taken and the filtration and culturing process was repeated [57]. Hundred µl of original, 10 times diluted and 100 times diluted samples were also inoculated onto mFC media following the drop plate technique to quantify samples from which the colonies on the membrane filters from the 2nd day also appears too numerous to count .The results were expressed as colony forming units (CFU) per 200 ml of recovered media that bathed the toy ball.

3.6.2.5 Quality control/Quality assurance

During development of the data collection application, auto skips were included in appropriate places. Validation rules were set-up to prevent incorrect data entry. Options were included to notify the user should they try to input incompatible data. Manual typing was minimized by setting choice list for responses.
Options for reviewing the full questionnaire and answer at a glance through data collection app was provided.

All the completed questionnaires were checked by the enumerators for completeness before leaving the household. The field supervisors reviewed all the data on the day of collection and discussed any ambiguities with the enumerator concerned. The first author randomly checked data from at least one household collected by each enumerator in 50% (20/40) of the village clusters, to check for completeness of data and provided feedback on the quality of the data. In each village cluster the field supervisor observed the data collection process in a random selection of at least 5% of households (6 HH per village) and conducted repeat interviews in a (different) random selection of 5% of households (6 HH per village), making sure that the data collection of each enumerator was assessed at least once in each village cluster. The field supervisor visited the sanitation facilities in all the study households and cross checked with the enumerators to make sure the sanitation facilities were coded with minimal error. The first author visited 50% (20/40) of the village clusters to monitor quality of data. In each of these villages the data collection process was observed in a random selection of at least 5% of households (6 HH per village) and a repeat spot-check was conducted in a (different) random selection of at least 5% of households (6 HH per village), making sure that the data collection of each enumerator was assessed at least once in each village.

The first author performed random observation of the microbial sample collection process in at least 25% (3/10 HH per village) in 50% (20/40) of the village clusters to check for adherence to protocol. One field blank per 9 samples was collected to ensure sample rinse bags are free of indicator organisms and were not getting contaminated during the field sampling process. In the laboratory the samples were received and checked for the physical quality of sample. Every 10th sample was run in duplicate. Test negative controls were tested for contamination for each set of agar media. For mFC agar *Escherichia coli* ATCC-13706 is used as positive control and *Staphylococcus aureus* ATCC-25923 is used as negative control. Every day laboratory blanks were run to check for quality of laboratory methodology. The laboratory techniques were observed by the first author once every week to make
sure that the protocol for processing in the laboratory was followed. The bacterial
counts were reviewed once every week to look for any outliers.

3.6.3 Human subject protection

The study protocol was approved by the Ethical Review of icddr,b and the
London School of Hygiene and Tropical Medicine (LSHTM), United Kingdom. Written,
inform consent was taken from the primary caregiver of the child.

3.6.4 Sample size calculation

Results of a pilot study conducted in 20 households found that in households
with access to improved latrines the mean faecal coliform count was $2.33 \log_{10} \text{CFU}$
per toy ball. The ratio of households with unimproved latrines to households with
improved latrines was expected to be 1.5 in the sample selected regardless of the
latrine access status based on an earlier study in a similar setting [53]. Assuming a
design effect of 2, comparing 180 households with improved latrines and 270
household with unimproved latrines with at least 80% power, the study was
estimated to be able to detect a minimum difference of $-0.65 \text{mean} \log_{10} \text{CFU}$ of
faecal coliforms per sentinel toy ball. Allowing for a 2% loss to follow up the
necessary sample size was estimated to be 460 households.

3.6.5 Data analysis

Sanitation technologies were first categorised as: a) improved (flush/pour
flush latrines and pit latrines with slab as in table 1), b) unimproved (pit latrines
without slab, hanging latrines, flush/pour flush latrines connected to open water
bodies) and c) no facility, following the JMP categorisation [58]. Sanitation access
was then categorised considering technology type as well as sharing status, as a
binary variable following 1) definition used for MDG: referred to as improved-MDG
and unimproved MDG; 2) post-2015 JMP definition proposed for the SDGs: referred
to as improved-SDG and unimproved-SDG; and 3) GoB definition referred to as
hygienic and unhygienic (Table 1). In all 3 definitions “no facility” was considered as
unimproved/unhygienic.
Principal component analysis (PCA) with 23 household characteristics was used to assess household wealth [59, 60] (Table 2), excluding water and sanitation. The means, frequencies and score coefficients were calculated and the correlation matrix of 23 variables was used to calculate sample weights [59, 61, 62].

During the interview, if the data collectors observed no visible dirt on the hands and nails of the target child, the child was considered to have clean hands. During the spot-check, a household was considered to have a clean latrine if the enumerators found no visible faeces on the slab/floor and pan of the latrine. Disposal of faeces of children under 3 years of age was categorised as safe (defecation into a latrine, disposal of stool into a latrine or buried) and unsafe as proposed by JMP [63].

If the faecal coliform concentration was zero it was replaced with 0.5 (half the detection limit) and then faecal coliform concentrations were transformed using logarithm to the base of 10. The difference in log_{10} transformed arithmetic mean CFU of faecal coliforms comparing households with different types of sanitation using a linear regression model was calculated. To account for clustering effect at village level a generalised least squares (GLS) random-effects model was used that explicitly allowed the average outcome to vary between village clusters [64-68].

Univariable analyses was, conducted to estimate the crude effect of the primary exposure variables and potential confounding variables on the main outcome (faecal coliform count) adjusting for the effect of village level clustering. The multivariable analysis included the primary exposure, primary outcome and potential confounders. A causal diagram was developed to decide which variable should be included as a potential confounder, excluding variables on the same causal pathway as the exposure variables (Figure 2) [68, 69]. All the potential variables that were associated with the exposure and the outcome in the univariable analysis were included in the final multivariable model. The models were tested for normality of residuals and homoscedasticity. We implemented three multivariate models, one for each of the three definitions of sanitation type (Table 3.1) as primary exposure. Two separate models were also implemented to understand the sanitation factors
associated with faecal contamination among subgroup of households that had
access to an improved sanitation technology (ignoring sharing).

3.7 Results

Out of 468 households visited eight were excluded because of having more
than one latrine. Out of 460 households enrolled for the study the sentinel toys from
six households could not be sampled. Data are therefore presented from 454 (99%)
households.

Among the 454 households there were on average 5.6 persons per household
with on average 1.3 children under the age of 5 years. The majority of households
(75%) owned poultry, 41% owned a cow and 23% owned a goat. Most of the
households (95%) reported having access to a latrine. Among them, 53% (n=230)
reported sharing the latrine with at least one other household. On average a latrine
was used by 1.99 households or 7.6 individuals (Table 3.2).

Only 22% of households reported disposing of faeces of children under three
years of age in a latrine. Enumerators observed human faeces around the house in
13% of the households. Among the 409 (90%) households with access to a latrine
with a slab, enumerators classified 35% of the latrines as clean (Table 3.3).

The most common type of latrine was a pit latrine with a slab but no water-
seal (n=189, 42%). About half (51%) of the 230 households that reported using a
shared latrine reported sharing the facility with only one other household. Only eight
households shared a latrine among more than five households.

Less than half (45%) of the households accessed improved sanitation
technology and 25% of the households visited had access to individual, improved
sanitation (MDG definition). Using the definition of sanitation type as proposed for
the SDGs, 205 households (45%) had access to improved (SDG) sanitation shared by
a maximum of five households. One in five (n=85, 19%) households had access to
hygienic sanitation (GoB) used by a maximum of two households (Table 3.3).
3.7.1 Faecal contamination of toy balls

Among the 454 sentinel toys sampled, 49 (11%) of the samples were below the detection limit for faecal coliforms. On average there were 2.09 (SD=1.37) log$_{10}$ CFU/toy ball of faecal coliforms with a median of 2.08 log$_{10}$ CFU/toy.

The levels of faecal coliforms in samples collected from Narshingdi district were higher than those collected from Mymenshingh district (difference in mean=0.36 log$_{10}$CFU/toy ball; 95% CI: 0.07, 0.65). With each one hour increase in time of sample collection (as the day progressed) there was 0.17 log$_{10}$ decrease in level of faecal contamination (Table 3.3 and 3.4).

Samples collected from households belonging to the richest wealth quintile had lower faecal coliform contamination than households from the poorer wealth quintiles. Samples collected from households where the mother had some formal education had lower level of faecal contamination than those households where the mother had no formal education (Table 3.3).

3.7.2 Improved sanitation and faecal contamination

Samples collected from households with access to improved sanitation technology (JMP technology, ignoring sharing) had similar levels of faecal coliforms as those from households with unimproved sanitation. Toy balls from households using shared sanitation facilities had higher levels of faecal coliform contamination than private facilities (unadjusted, difference in mean=0.19 log$_{10}$ CFU/toy ball; 95% CI: -0.07, 0.45) (Table 3.3).

Toy rinse samples from households with improved individual sanitation (MDG definition) had less contamination with faecal coliforms (mean=1.84 log$_{10}$CFU/toy ball) than households with unimproved sanitation (difference in mean=-0.36 log$_{10}$CFU/toy ball, 95% CI: -0.65, -0.07, P=0.02) (Table 3). After adjusting for potential confounders the difference in mean was reduced to 0.31 log$_{10}$ CFU/toy ball (95% CI: -0.61, -0.01), and the strength of statistical association became weaker (P value=0.04) (Table 3.4).
The level of faecal contamination in toys was similar in households with improved sanitation (SDG definition) used by a maximum of five households and those with unimproved sanitation (difference in mean= -0.07 log_{10}CFU/toy ball, 95% CI: 0.33, 0.18) (Table 3). In multivariable analysis the results remained similar (Table 3.4).

3.7.3 Hygienic sanitation (GoB definition) and faecal contamination

Households with access to hygienic sanitation (GOB definition) used by a maximum of two households had less faecal coliform contamination (difference in mean=-0.45, 95% CI -0.77, -0.13; P<0.01) than households with unhygienic or no access to latrines (Table 3). Access to hygienic sanitation remained associated with less faecal coliform contamination (difference in mean= -0.34 log_{10}CFU/toy ball; 95% CI: -0.68, 0.01) after adjusting for all the confounding variables. The reduction was statistically significant (P value=0.05) (Table 3.4).

3.7.4 Sanitation characteristics and faecal contamination (sub group analysis)

Households with improved flush/pour flush latrines had less (statistically significant) faecal contamination than those with improved but non-flush technologies (difference in mean -0.45, 95% CI: -0.81, -0.09, P value=0.02). In the adjusted analysis the difference of mean was reduced and the statistical evidence weakened considerably (difference in mean -0.27, 95% CI: -0.67, 0.13, P value=0.19) (Table 3.5).

Toy ball samples collected from households with private improved sanitation had less faecal contamination than those with access to improved sanitation shared by 2-5 households (Difference in mean -0.49 log_{10} CFU/toy ball, 95% CI: 0.13, 0.85, P=0.01). In the adjusted analysis the difference in mean was somewhat smaller and the strength of association became weaker (difference in mean -0.45 log_{10}CFU/toy ball; 95% CI: -0.05, 0.75; P=0.08) (Table 3.5).

Toy ball samples from households with access to improved and clean latrines had less faecal contamination (difference in mean -0.36 log_{10} CFU/toy ball; 95% CI: -
0.73, -0.00; P=0.05) compared to dirty improved latrines. In the adjusted analysis the difference in faecal coliform contamination changed slightly with slightly weaker strength of association (difference in mean -0.38 log\textsubscript{10} CFU/toy ball; 95% CI: -0.77, 0.02; P=0.06) (Table 3.5).

Toy ball samples collected from households with private flush/pour-flush latrines had less faecal contamination (difference in mean -0.69 log\textsubscript{10} CFU/toy ball; 95% CI: -1.06, -0.31), compared to those with access to shared flush/pour-flush or non-flush latrines. In multivariate analysis adjusting for potential confounders the difference in mean was slightly smaller (difference in mean=-0.55 log\textsubscript{10} CFU/toy ball; 95% CI -1.00, -0.11; P=0.02) yet statistically significant (Table 3.5).

### 3.7.5 Faecal contamination of toy balls and other household characteristics

Households in which enumerators observed any goat faeces on the household premises had more contamination with faecal coliforms than those without (difference in mean 0.36 log\textsubscript{10} CFU/toy ball; 95% CI: 0.06, 0.67; P value=0.02). In multivariate analysis adjusting for potential confounders the difference in mean was slightly smaller (difference in mean=0.31 log\textsubscript{10} CFU/toy ball; 95% CI: 0.02, 0.61; P=0.04) yet statistically significant (Table 4). Households in which enumerators observed more than ten piles of cow dung on the household premises had more contamination with faecal coliforms than those with no cow dung at the time of visit (difference in mean=0.36 log\textsubscript{10} CFU/toy ball; 95% CI: -0.05, 0.77; P value=0.08). In multivariate analysis adjusting for potential confounders the difference in mean was slightly bigger (difference in mean=0.40 log\textsubscript{10} CFU/toy ball; 95% CI: 0.00, 0.79; P=0.05) yet statistically significant (Table 3.4).

Toy ball samples collected from households with a water drainage system had less contamination than those without, (difference in mean=-0.24 log\textsubscript{10} CFU/toy ball; 95% CI: -0.50, 0.0.01; P=0.06) (Table 3.3). In multivariate analysis adjusting for potential confounders the difference in mean was slightly bigger (difference in mean=-0.32 log\textsubscript{10} CFU/toy ball; 95% CI: -0.58, -0.06; P=0.02) and with greater strength of association it was statistically significant (Table 3.4).
Presence of a convenient handwashing place with soap and water was not associated (small and statistically insignificant reduction) with faecal contamination of toy ball (Table 3.3). In households in which the target children’s hands and nails looked visibly clean, the toy balls had less faecal contamination than those with visibly dirty hands (difference in mean=-0.35 log_{10} CFU/toy ball; 95% CI: -0.69, -0.01; P=0.05) (Table 3.3). In multivariate analysis adjusting for potential confounders the difference in mean was slightly bigger (difference in mean=-0.26 log_{10} CFU/toy ball; 95% CI: -0.06, 0.09; P=0.15) but the difference was not statistically significant (Table 3.4).

3.8 Discussion

In this observational study we assessed the association between sanitation type and microbiological faecal contamination. We found no difference in indicators of faecal contamination on sentinel toys between households with access to improved-SDG and unimproved sanitation. When shared facilities were excluded from the definition of improved sanitation (MDG definition), access to improved sanitation was associated with lower levels of faecal contamination compared to households with access to unimproved sanitation after adjusting for potential confounding factors. Although 0.05 log_{10} CFU/toy ball difference in faecal contamination observed in this study was due to confounding factors there were still statistically significant differences in levels of household faecal contamination that could be due to the protective effect of access to improved-MDG sanitation.

Since this was an observational study the findings are prone to confounding due to important household characteristics. In this study a directed acyclic graph was developed to identify the potential confounding factors (Figure 3.1). The confounding factors considered were presence of animal faeces, presence of appropriate water and solid waste disposal system, visible cleanliness of hands and nail (proxy for hand hygiene), household wealth, mother’s education, study site and time of data collection among others. Findings from observational studies suggest that washing hands with soap is effective in removing microorganisms from hands [39, 70-72] and there for an important determinant of household faecal
contamination. In this study presence of soap and water at a handwashing station was not associated with faecal contamination of toy ball in the univariable analysis. So this was not included as a potential confounder to be included in the multivariable analysis. But since visible cleanliness of hand was associated with faecal contamination of hand, this was used a proxy for hand hygiene and included in the multivariate analysis as a potential confounder.

In this study sanitation was measured before faecal contamination. The association of improved sanitation (MDG) with faecal contamination in the unadjusted analysis is consistent with findings from earlier studies conducted in Honduras [52], Peru [51], and Bangladesh [38, 49]. Although in contrast, in a study conducted in Tanzania improved sanitation was not found to be associated with faecal indicator bacteria level on hand-contact surfaces in latrines [40]. However, the geographical context was different and most importantly the exposure pathway measured was different. Studies conducted in Kenya and Indonesia that attempted to adjust for the effect of several confounding factors found improved sanitation (MDG) to be associated with lower levels of both faecal indicator bacteria [39] and diarrhoea [16].

However in this observational study we cannot establish causality because there are many unmeasured household and child characteristics that may influence faecal contamination. In this study lower faecal contamination of the toy ball was also associated with absence of animal faeces, mother’s education, and presence of appropriate water drainage and study site. In this study wealth was associated with lower faecal contamination of the toy ball in the unadjusted analysis, so is an important confounder. Therefore wealth was included in the multivariate analysis to adjust or its effect. But Faecal contamination of the household environment is actually influenced by underlying, unmeasured, broader, social, economical, cultural and environmental differences [30, 73]. The confounding factors considered in this study are only proxy for these underlying unmeasured broader factors. It is possible that access to an improved latrine and absence of animal faeces, mother’s education, and presence of appropriate water drainage are all proxy measures of these unmeasured differences and hence associated with faecal contamination. A
two-arm, randomised, controlled trial in which households in one arm receive improved sanitation and households in the other arm receive unimproved sanitation could help better understand this issue.

Our data suggest that the observed differences in indicators of faecal contamination on sentinel toys between households with access to improved-MDG and unimproved sanitation may be attributed to factors related to use rather than the sanitation infrastructure. When we categorised latrines based on technology alone, ignoring sharing, and access to latrines considered as improved was not associated with any reduction in household faecal contamination in comparison to those households with access to unimproved sanitation. There can be several possible explanations for this finding.

First it is possible that the sanitation facilities considered as improved by the JMP are not any more effective in confining faeces than the facilities considered as unimproved. The main infrastructural difference between improved and unimproved sanitation facilities is the presence of a slab. Even in the presence of a slab flies can act as a vector to transmit organisms originating in the faeces and contaminate household environment [74]. In our subgroup analysis, improved sanitation with a water-seal was associated with a greater reduction in faecal contamination than improved sanitation with a slab but without a water-seal. Presence of a water-seal may prevent flies breeding within the latrine and may reduce fly numbers and thereby provide protection from one route of faecal contamination. Our findings are in line with those from previous studies conducted in Ghana where households with a dry pit latrine or no latrine had higher odds of having *E. coli* contamination of stored water than those with a water-seal latrine, even after adjustment for other sanitation related and socio-demographic characteristics [43]. There is also evidence that access to improved sanitation with a water-seal is associated with less diarrhoea morbidity [34, 35] [31]. This may suggest that access to sanitation facilities with a water-seal provides better protection from faecal contamination than non-flush latrines. Alternatively, the difference observed in this observational study could be due to confounding by socio-economic status.
Second, in these settings a household could be exposed to faecal contamination even in the presence of a sanitation facility that successfully separates human faeces from the environment due to other routes of contamination such as unsafe disposal of child’s faeces [40, 75], lack of exclusive use of sanitation facilities, lack of improved sanitation facilities in the neighbourhood, and the presence of animal faeces. Moreover, lack of proper management of faecal sludge from onsite sanitation facilities may also contribute to contamination that access to household sanitation cannot prevent. This may suggest that provision of sanitation infrastructure alone as a strategy to reduce household faecal contamination may not be sufficient. In the presence of a sanitation system that is effective in separating human faeces from human contact hands can still be contaminated with faeces during anal cleansing. So washing hands with soap is necessary to reduce household faecal contamination.

When a subgroup analysis was conducted among households with access to improved sanitation, it was found that sharing was associated with higher levels of faecal contamination although with small sample size in the subgroup the statistical evidence was weak. Previous studies have also reported adverse health outcomes associated with shared sanitation facilities [29, 30]. While in contrast, shared sanitation was found to be protective against faecal contamination of hand-contact surfaces within a latrine in rural Tanzania [40]. However, in this study the mechanism by which sharing a latrine prevents faecal contamination is unclear. The findings related to the effects of shared sanitation in previous studies are inconsistent and context-specific [30, 76].

Shared sanitation facilities may not be as effective in separating faeces from the environment as individual latrines for several reasons. First, shared facilities may be dirtier and may wear out or break more quickly than private latrines due to higher use rates. In our study shared facilities were more likely to have faeces present on the latrine floor (data not shown). However, our data suggest that sharing may lead to higher faecal contamination independent of cleanliness of latrine suggesting that other mechanisms may also play an important role.
Second, the need to share a latrine may result in lower rate of use per user. As a result some users may intermittently use suboptimal sanitation including open defecation. Moreover, families who report sharing a facility may not actually have access to a latrine but because of social desirability they report using their neighbour’s latrine. As a result, when shared facilities are grouped together with individual facilities the protective effect of improved sanitation technologies is diluted.

Third, people who use share facilities are likely to be poorer and headed by people with no formal education [77]. Socioeconomic status and lack of parents formal education has been linked with higher level of faecal contamination in this study as well as in a previous study [49]. Although in our study sharing was associated with higher faecal contamination independent of wealth status and mother’s education there may be residual confounding due to unmeasured social, environmental and cultural factors that may influence faecal contamination in this context. The mechanism of how shared sanitation increases health risk needs to be understood in more detail in future research.

Our estimated minimum detectable difference in mean faecal coliform counts used for the power calculation was higher than the difference we found from our data. This suggests that our study had low statistical power. Nevertheless, the fact that access to individual improved sanitation is associated with lower levels of faecal contamination even after adjusting for common confounding, which is also consistent with findings from previous studies, may suggest an independent link between sanitation type (MDG) and faecal contamination.

In this study there was a trend of reduction of faecal coliforms as the day progressed (Table 3.4). This could have been due to increasing sunlight causing sunlight induced die-off of pathogens in the environment as well as on the toy ball [78]. It is also possible that as the day progressed the children played less with the toy. It is important to note that this could be a potential confounding factor in the association between sanitation type and faecal contamination of the toy ball. This is why this factor was included in the multivariate analysis.
An important limitation of this study is the use of faecal indicator bacteria to assess faecal contamination as they are not human specific. This random measurement error could introduce bias due to misclassification of the outcome. As a consequence the confidence intervals of the estimates presented are likely to be wide making the results less likely to receive statistical support even if in reality a difference exists [79]. Further study with a larger sample size could increase our understanding of the role of improved sanitation in reducing household faecal contamination [79]. Using molecular markers of human specific pathogens as indicators of faecal coliform could help reduce this bias in future studies. Presence of faecal indicator bacteria does not necessarily mean health risks. However there is evidence to suggest that presence of faecal coliforms in environmental samples may be associated with diarrhoeal illness [44-46, 80-83]. In this study the presence of faecal coliforms was associated with sanitation type after adjusting for the effect of presence of animal faeces in consistence with findings from similar settings [38, 84].

The findings from this observational study suggest that improved sanitation used by individual households may be better in reducing household faecal environmental contamination than shared facilities. Sanitation facilities with a water-seal might also be better in reducing faecal contamination of the household environment than dry pit latrines with a slab but no water-seal. However, further studies with experimental design and larger sample sizes are required to understand if this association is causal. In addition to sanitation infrastructure, cleanliness of latrines should be considered an important indicator for sanitation monitoring. Even in the context of rural areas in which sanitation facilities are shared by acquaintances shared facilities may be dirtier than individual latrines. An intervention to improve and monitor latrine cleanliness particularly for shared sanitation may be useful. Shared facilities may pose health risks due to many factors other than cleanliness. Further studies are needed to better understand the mechanism by which shared facilities pose health risks if any. Moreover, to reduce household faecal contamination washing hands with soap after anal cleansing has to be ensured.
3.9 Acknowledgements: This research was made possible with UK Aid from the Department of International Development (DFID) as part of the SHARE research programme (www.SHAREresearch.org). However, the views expressed do not necessarily reflect DFID’s official policies. No funding bodies had any role in study design, data collection and analysis, decision to publish or preparation of the manuscript. The study was also partially funded by Water, Sanitation and Hygiene research group at icddr,b, Dhaka, Bangladesh. However the views expressed do not necessarily reflect the Departments, official policy. The authors acknowledge the contributions of the study participants, icddr,b admin, field and lab research staff. The authors also thank the research advisory committee the environmental health group at LSHTM. The author specially thanks Dr. Leanne Unicomb from ICDDR,B for her guidance during data collection in Bangladesh.
3.10 References


55. CDC, *Microbiological Indicator Testing in Developing Countries: A Fact Sheet for the Field Practitioner*. 2010, Centre for Disease Control and Prevention.


80. Abu Amr, S.S. and M.M. Yassin, *Microbial contamination of the drinking water distribution system and its impact on human health in Khan Yunis Governorate, Gaza*


Table 3.1: Comparing definitions of sanitation proposed by WHO/UNICEF Joint monitoring programme for water supply and sanitation (JMP) and the Government of Bangladesh (GoB) [25, 27]

<table>
<thead>
<tr>
<th>Latrine characteristics</th>
<th>Improved JMP</th>
<th>Improved MDG</th>
<th>Improved SDG*</th>
<th>Hygienic GOB</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sanitation technology</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Flush or pour-flush latrine to Sewerage pipe/Septic tank/Pit</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>Pit latrine with slab and lid/flap</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>Ventilated Improved Pit latrine</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>Composting latrine</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td><strong>Pit latrine with slab</strong></td>
<td><strong>x</strong></td>
<td><strong>x</strong></td>
<td><strong>x</strong></td>
<td><strong>x</strong></td>
</tr>
<tr>
<td>Number of households using latrine facility</td>
<td>Not considered</td>
<td>1</td>
<td>Up to 5</td>
<td>Up to 2</td>
</tr>
</tbody>
</table>

*As a part of the process of identifying targets and indicators for global monitoring post-2015 there was proposal to change the definition of improved sanitation to include share sanitation of otherwise improved technology as improved [25]. This is why this definition is referred to as SDG definition.*
Figure 3.1: Directed acyclic graph showing the variables that were measured and included in the multivariable analysis

Study site: Broad geographical, social and cultural context

1. Lack Access to improved sanitation

3. Less HH wealth

4. Lack parent’s education

5. Other Sanitation:
   - Inap. child’s faeces disposal
   - Faeces in the latrine slab
   - Open faeces in the yard

6. Presence of animal faeces

7. Household Hygiene:
   - Inap. solid waste disposal
   - Inap. water drainage

8. Unimproved Water source

9. Visible cleanliness of hands and nails

10. Presence of soap and water at HW station

11. Access to Unimproved sanitation in Neighbourhood

12. Animal faeces in Neighbourhood

13. Time of sample collection

Potential confounders

Unmeasured variables

Variables in causal pathway

Faecal contamination of vehicles and vectors (fomites, flies, tracking by people, objects, animals)

HH Faecal contamination (Surface/soil, water, field)
Table 3.2: Household characteristics (n=454)

<table>
<thead>
<tr>
<th>Variable (n)</th>
<th>n</th>
<th>Percent or mean</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean Number of HH residents</td>
<td>454</td>
<td>5.6</td>
</tr>
<tr>
<td>Mean Number of children age &lt;5 y</td>
<td>454</td>
<td>1.3</td>
</tr>
<tr>
<td>Mother with no formal education</td>
<td>78</td>
<td>17%</td>
</tr>
<tr>
<td>Father with no formal education †</td>
<td>135</td>
<td>30%</td>
</tr>
<tr>
<td>Father’s occupation</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Farmer</td>
<td>103</td>
<td>23%</td>
</tr>
<tr>
<td>Day labour, Rickshaw puller</td>
<td>100</td>
<td>22%</td>
</tr>
<tr>
<td>House construction</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tin roof †</td>
<td>438</td>
<td>96%</td>
</tr>
<tr>
<td>Cement floor †</td>
<td>73</td>
<td>16%</td>
</tr>
<tr>
<td>Brick walls †</td>
<td>69</td>
<td>15%</td>
</tr>
<tr>
<td>Mean number or rooms †</td>
<td>454</td>
<td>2.0</td>
</tr>
<tr>
<td>Household with electric connection †</td>
<td>309</td>
<td>68%</td>
</tr>
<tr>
<td>Proportion who owned</td>
<td></td>
<td></td>
</tr>
<tr>
<td>House †</td>
<td>430</td>
<td>95%</td>
</tr>
<tr>
<td>Wardrobe †</td>
<td>189</td>
<td>42%</td>
</tr>
<tr>
<td>Bicycle †</td>
<td>109</td>
<td>24%</td>
</tr>
<tr>
<td>Mobile phone †</td>
<td>378</td>
<td>83%</td>
</tr>
<tr>
<td>Black and white television †</td>
<td>36</td>
<td>8%</td>
</tr>
<tr>
<td>Colour television †</td>
<td>109</td>
<td>24%</td>
</tr>
<tr>
<td>Sewing machine †</td>
<td>52</td>
<td>11%</td>
</tr>
<tr>
<td>Refrigerator †</td>
<td>44</td>
<td>10%</td>
</tr>
<tr>
<td>Motor cycle †</td>
<td>22</td>
<td>5%</td>
</tr>
<tr>
<td>Mean number of items owned</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tables †</td>
<td>454</td>
<td>1</td>
</tr>
<tr>
<td>Chairs †</td>
<td>454</td>
<td>2.2</td>
</tr>
<tr>
<td>Watches/clocks †</td>
<td>454</td>
<td>0.6</td>
</tr>
<tr>
<td>Beds †</td>
<td>454</td>
<td>0.9</td>
</tr>
<tr>
<td>Inexpensive sleeping cots †</td>
<td>454</td>
<td>1.3</td>
</tr>
<tr>
<td>Acres of agricultural land †</td>
<td>453</td>
<td>0.52</td>
</tr>
<tr>
<td>Acres of non-agricultural land †</td>
<td>451</td>
<td>0.13</td>
</tr>
<tr>
<td>Owned any domestic animal</td>
<td>375</td>
<td>83%</td>
</tr>
<tr>
<td>Owned any goat</td>
<td>104</td>
<td>23%</td>
</tr>
<tr>
<td>Owned any cow</td>
<td>186</td>
<td>41%</td>
</tr>
<tr>
<td>Owned any poultry</td>
<td>341</td>
<td>75%</td>
</tr>
<tr>
<td>Access to improved water source for drinking</td>
<td>454</td>
<td>100%</td>
</tr>
<tr>
<td>Have access to a latrine</td>
<td>431</td>
<td>95%</td>
</tr>
<tr>
<td>Have access to a shared latrine</td>
<td>230</td>
<td>53%</td>
</tr>
<tr>
<td>Mean number of household sharing a latrine facility</td>
<td>431</td>
<td>1.99</td>
</tr>
<tr>
<td>Mean number of individuals sharing a latrine facility</td>
<td>431</td>
<td>7.6</td>
</tr>
<tr>
<td>Ownership of latrine (n=437)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

1 If sample size is different it is presented next to the variable in the table.
<table>
<thead>
<tr>
<th>Ownership Type</th>
<th>Number</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Individual ownership</td>
<td>247</td>
<td>57%</td>
</tr>
<tr>
<td>Shared ownership</td>
<td>114</td>
<td>26%</td>
</tr>
</tbody>
</table>

*Number with presented category
†Included to calculate wealth quintile.
Table 3.3: Univariable relationship between water, sanitation, and hygiene related variables and log$_{10}$ transformed faecal coliform CFU/toy ball (n=454)

<table>
<thead>
<tr>
<th>Exposures</th>
<th>n $^\dagger$ (%)</th>
<th>Mean (SD)</th>
<th>Median</th>
<th>Diff. in mean $^\dagger$ (95% CI)</th>
<th>P value $^\dagger$</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Sanitation type</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>JMP technology type</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Improved</td>
<td>205 (45)</td>
<td>2.06 (1.33)</td>
<td>1.90</td>
<td>-0.06 (-0.32, 0.20)</td>
<td>0.64</td>
</tr>
<tr>
<td>Unimproved (Baseline)</td>
<td>226 (50)</td>
<td>2.10 (1.41)</td>
<td>2.08</td>
<td>0.09 (-0.49, 0.69)</td>
<td>0.75</td>
</tr>
<tr>
<td>Open</td>
<td>23 (5)</td>
<td>2.23 (1.45)</td>
<td>2.08</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>MDG</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Improved</td>
<td>113 (25)</td>
<td>1.84 (1.23)</td>
<td>1.60</td>
<td>-0.36 (-0.65, -0.07)</td>
<td>0.02</td>
</tr>
<tr>
<td>Unimproved</td>
<td>341 (75)</td>
<td>2.17 (1.41)</td>
<td>2.20</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>SDG</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Improved</td>
<td>205 (45)</td>
<td>2.06 (1.33)</td>
<td>1.90</td>
<td>-0.07 (-0.33, 0.18)</td>
<td>0.58</td>
</tr>
<tr>
<td>Unimproved</td>
<td>249 (55)</td>
<td>2.12 (1.41)</td>
<td>2.08</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>GOB</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hygienic</td>
<td>85 (19)</td>
<td>1.76 (1.21)</td>
<td>1.60</td>
<td>-0.45 (-0.77, -0.13)</td>
<td>&lt;0.01</td>
</tr>
<tr>
<td>Unhygienic</td>
<td>369 (81)</td>
<td>2.17 (1.40)</td>
<td>2.08</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Sharing status</strong> $^\dagger$ (N=431)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Shared</td>
<td>230 (53)</td>
<td>2.17 (1.45)</td>
<td>2.08</td>
<td>0.19 (-0.07, 0.45)</td>
<td>0.15</td>
</tr>
<tr>
<td>Individual</td>
<td>201 (47)</td>
<td>1.98 (1.28)</td>
<td>1.90</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Number of person using a sanitation facility (N=431)</strong> $^\dagger$</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Up to 6</td>
<td>218 (51)</td>
<td>2.18 (1.42)</td>
<td>2.14</td>
<td>0.16 (-0.10, 0.42)</td>
<td>0.22</td>
</tr>
<tr>
<td>More than 6</td>
<td>213 (49)</td>
<td>2.01 (1.31)</td>
<td>1.90</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Increase in number of person using the sanitation facility $^\dagger$ (N=431)</strong></td>
<td></td>
<td></td>
<td></td>
<td>0.00 (-0.3, 0.04)</td>
<td>0.83</td>
</tr>
<tr>
<td><strong>Other sanitation and hygiene characteristics</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>&lt;3 Child faeces disposal (n=454)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Safe</td>
<td>98 (22)</td>
<td>1.95 (1.35)</td>
<td>1.90</td>
<td>-0.23 (-0.54, 0.07)</td>
<td>0.14</td>
</tr>
<tr>
<td>Unsafe</td>
<td>356 (78)</td>
<td>2.13 (1.38)</td>
<td>2.08</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cleanliness of sanitation facility (N=409)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Clean</td>
<td>142 (35)</td>
<td>1.94 (1.21)</td>
<td>1.90</td>
<td>-0.25 (-0.53, 0.03)</td>
<td>0.08</td>
</tr>
<tr>
<td>Dirty</td>
<td>267 (65)</td>
<td>2.16 (1.45)</td>
<td>2.08</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Presence of open human faeces in/around household premises</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Presence of any goat faeces</td>
<td>103 (23)</td>
<td>2.36 (1.46)</td>
<td>2.38</td>
<td>0.36 (0.06, 0.67)</td>
<td>0.02</td>
</tr>
<tr>
<td>Number of cow dung pile</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>No cow dung</td>
<td>264 (58)</td>
<td>2.04 (1.38)</td>
<td>1.90</td>
<td></td>
<td>0</td>
</tr>
<tr>
<td>1 to 10 cow dung</td>
<td>136 (30)</td>
<td>2.08 (1.37)</td>
<td>2.20</td>
<td>0.04 (-0.25, 0.32)</td>
<td>0.79</td>
</tr>
<tr>
<td>More than 10 cow dung</td>
<td>54 (12)</td>
<td>2.37 (1.35)</td>
<td>2.45</td>
<td>0.36 (-0.05, 0.77)</td>
<td>0.08</td>
</tr>
<tr>
<td>Presence of any poultry faeces</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>-------------------------------</td>
<td>---</td>
<td>---</td>
<td>---</td>
<td>---</td>
<td>---</td>
</tr>
<tr>
<td>No faeces</td>
<td>92 (20)</td>
<td>1.97 (1.23)</td>
<td>1.90</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>1 to 10 piles</td>
<td>224 (49)</td>
<td>2.12 (1.46)</td>
<td>2.14</td>
<td>0.15 (-0.19, 0.49)</td>
<td>0.38</td>
</tr>
<tr>
<td>More than 10 piles</td>
<td>138 (30)</td>
<td>2.13 (1.30)</td>
<td>2.08</td>
<td>0.17 (-0.20, 0.53)</td>
<td>0.38</td>
</tr>
<tr>
<td>Visibly clean hands and nails vs. unclean</td>
<td>71 (16)</td>
<td>1.81 (1.34)</td>
<td>1.90</td>
<td>-0.35 (-0.69, -0.01)</td>
<td>0.05</td>
</tr>
<tr>
<td>Presence of convenient HW place with soap and water</td>
<td>95 (21)</td>
<td>2.00 (1.19)</td>
<td>1.90</td>
<td>-0.15 (-0.46, 0.17)</td>
<td>0.36</td>
</tr>
<tr>
<td>Presence of appropriate water drainage system</td>
<td>261 (57)</td>
<td>1.99 (1.36)</td>
<td>1.90</td>
<td>-0.24 (-0.50, 0.01)</td>
<td>0.06</td>
</tr>
<tr>
<td>Appropriate Solid waste disposal</td>
<td>11 (2)</td>
<td>1.59 (2.00)</td>
<td>1.90</td>
<td>-0.47 (-0.29, 0.34)</td>
<td>0.26</td>
</tr>
<tr>
<td><strong>Other variables</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Wealth quintile</td>
<td>0.02</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lowest</td>
<td>91 (20)</td>
<td>2.22 (1.43)</td>
<td>2.20</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lower middle</td>
<td>91 (20)</td>
<td>1.98 (1.23)</td>
<td>1.90</td>
<td>-0.24 (-0.65, 0.14)</td>
<td>0.21</td>
</tr>
<tr>
<td>Middle</td>
<td>91 (20)</td>
<td>2.42 (1.35)</td>
<td>2.44</td>
<td>0.19 (-0.20, 0.59)</td>
<td>0.34</td>
</tr>
<tr>
<td>Upper Middle</td>
<td>91 (20)</td>
<td>2.03 (1.57)</td>
<td>1.90</td>
<td>-0.21(-0.60, 0.19)</td>
<td>0.31</td>
</tr>
<tr>
<td>Upper</td>
<td>90 (20)</td>
<td>1.81 (1.22)</td>
<td>1.70</td>
<td>-0.48 (-0.88, -0.08)</td>
<td>0.02</td>
</tr>
<tr>
<td>Household belongs to upper wealth quintile</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Yes</td>
<td>90 (20)</td>
<td>1.81 (1.22)</td>
<td>1.70</td>
<td>-0.41(-0.72, -0.09)</td>
<td>0.01</td>
</tr>
<tr>
<td>No</td>
<td>364 (80)</td>
<td>2.16 (1.40)</td>
<td>2.08</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mother with formal education vs. (no formal education)</td>
<td>376 (83)</td>
<td>2.03 (1.36)</td>
<td>1.90</td>
<td>-0.33 (-0.66, 0.00)</td>
<td>0.05</td>
</tr>
<tr>
<td>Change in time of data collection by hour as the day progress</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Study site (District)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Narshingdi</td>
<td>238 (52)</td>
<td>2.26 (1.38)</td>
<td>2.20</td>
<td>0.36 (0.07, 0.65)</td>
<td>0.01</td>
</tr>
<tr>
<td>Mymensingh</td>
<td>216 (48)</td>
<td>1.90 (1.34)</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

1 Number with presented category
2 Adjusting for clustering at village
3 Among those who has access to a latrine (N=431)
### Table 3.4: Multivariable relationship between water sanitation and hygiene related variables and log10 transformed faecal coliform CFU per toy ball (Total N=454)

<table>
<thead>
<tr>
<th>Variables (n)</th>
<th>A. MDG</th>
<th></th>
<th>B. SDG</th>
<th></th>
<th>C. GOB</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Diff. mean* (95% CI)</td>
<td>P Value†</td>
<td>Diff. mean* (95% CI)</td>
<td>P Value†</td>
<td>Diff. mean* (95% CI)</td>
<td>P Value†</td>
</tr>
<tr>
<td>Sanitation type</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(Improved/hygienic) (113/85) Vs unimproved/unhygienic</td>
<td>-0.31 (-0.61, -0.01)</td>
<td><strong>0.04</strong></td>
<td>-0.01 (-0.26, 0.25)</td>
<td>0.95</td>
<td>-0.34 (-0.68, 0.005)</td>
<td>0.05</td>
</tr>
<tr>
<td>Presence of any goat faeces (103) Vs absence of any goat faeces</td>
<td>0.31 (0.02, 0.61)</td>
<td><strong>0.04</strong></td>
<td>0.32 (0.02, 0.62)</td>
<td><strong>0.03</strong></td>
<td>0.30 (0.002, 0.60)</td>
<td><strong>0.05</strong></td>
</tr>
<tr>
<td>Presence of cow dung</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>No cow dung (264)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Up to 10 piles (136)</td>
<td>0.08 (-0.21, 0.36)</td>
<td>0.60</td>
<td>0.09 (-0.20, 0.37)</td>
<td>0.55</td>
<td>0.08 (-0.21, 0.36)</td>
<td>0.60</td>
</tr>
<tr>
<td>More than 10 piles (54)</td>
<td>0.40 (0.00, 0.79)</td>
<td><strong>0.05</strong></td>
<td>0.42 (0.02, 0.82)</td>
<td><strong>0.04</strong></td>
<td>0.40 (0.01, 0.79)</td>
<td><strong>0.05</strong></td>
</tr>
<tr>
<td>Presence of appropriate water drainage (261) Vs absence of appropriate water drainage</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hands and nails looked visibly clean (71) Vs Hands and nails looked visibly dirty</td>
<td>-0.26 (-0.06, 0.09)</td>
<td>0.15</td>
<td>-0.27 (-0.62, 0.08)</td>
<td>0.13</td>
<td>-0.26 (-0.60, 0.09)</td>
<td>0.15</td>
</tr>
<tr>
<td>Household belongs to upper wealth quintile (90) Vs lower wealth quintile</td>
<td>-0.18 (-0.52, 0.16)</td>
<td>0.31</td>
<td>-0.30 (-0.63, 0.03)</td>
<td>0.08</td>
<td>-0.19 (-0.53, 0.15)</td>
<td>0.26</td>
</tr>
<tr>
<td>Mother’s with form education (376) Vs mothers with no formal education</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Change in time of data collection by hour as the day progress</td>
<td>-0.16 (-0.27, -0.06)</td>
<td><strong>0.002</strong></td>
<td>-0.16 (-0.26, -0.05)</td>
<td><strong>0.003</strong></td>
<td>-0.16 (-0.27, -0.06)</td>
<td><strong>0.002</strong></td>
</tr>
<tr>
<td>Study site Narshingdi district (238) vs. Mymensingh</td>
<td>0.52 (0.25, 0.78)</td>
<td>&lt;0.01</td>
<td>0.50 (0.23, 0.78)</td>
<td>&lt;0.01</td>
<td>0.52 (0.25, 0.79)</td>
<td>&lt;0.01</td>
</tr>
<tr>
<td>---</td>
<td>---</td>
<td>---</td>
<td>---</td>
<td>---</td>
<td>---</td>
<td>---</td>
</tr>
</tbody>
</table>

- **Difference in mean**
- † Adjusting for the effect of all the other variables in the model
- ‡ Number with presented category
Table 3.5: Relationship between sanitation and log_{10} transformed faecal coliform CFU per toy ball, among households with access to improved sanitation technologies as defined by JMP (N=205) (subgroup analysis).

<table>
<thead>
<tr>
<th>Sanitation characteristics among household with improved sanitation technology.</th>
<th>n (%)</th>
<th>Descriptive</th>
<th>Univariable*</th>
<th>Multivariable†</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Sanitation technologies (n=205)</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Flush/pour-flush</td>
<td>97 (47)</td>
<td>1.83</td>
<td>1.27</td>
<td>1.60</td>
</tr>
<tr>
<td>Non flush/pour-flush‡</td>
<td>108 (53)</td>
<td>2.27</td>
<td>1.34</td>
<td>2.20</td>
</tr>
<tr>
<td><strong>Sharing status (n=205)</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Private/individual</td>
<td>113 (55)</td>
<td>1.84</td>
<td>1.23</td>
<td>1.60</td>
</tr>
<tr>
<td>Shared by 2-5 HH</td>
<td>92 (45)</td>
<td>2.33</td>
<td>1.39</td>
<td>2.30</td>
</tr>
<tr>
<td><strong>&lt;3 Child’s faeces disposal practices</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Safe</td>
<td>54 (26)</td>
<td>2.03</td>
<td>1.27</td>
<td>1.90</td>
</tr>
<tr>
<td>Unsafe</td>
<td>151 (74)</td>
<td>2.07</td>
<td>1.35</td>
<td>1.90</td>
</tr>
<tr>
<td><strong>Cleanliness of latrine</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Clean</td>
<td>92 (45)</td>
<td>1.87</td>
<td>1.08</td>
<td>1.90</td>
</tr>
<tr>
<td>Dirty</td>
<td>113 (55)</td>
<td>2.22</td>
<td>1.48</td>
<td>2.08</td>
</tr>
<tr>
<td><strong>Presence of open faeces in and around HH</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Open faeces</td>
<td>20 (10)</td>
<td>2.21</td>
<td>1.49</td>
<td>1.90</td>
</tr>
<tr>
<td>No open faeces</td>
<td>185 (90)</td>
<td>2.05</td>
<td>1.31</td>
<td>1.90</td>
</tr>
<tr>
<td><strong>Considering technology and sharing status</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Individual flush/pour flush</td>
<td>66 (32)</td>
<td>1.60</td>
<td>1.14</td>
<td>1.60</td>
</tr>
<tr>
<td>Shared flush/pour flush or Non flush</td>
<td>139 (68)</td>
<td>2.28</td>
<td>1.34</td>
<td>2.20</td>
</tr>
</tbody>
</table>

* Adjusting for clustering at village
† Adjusting for all other variable in the table as well as presence of cow/goat, visible cleanliness of hands, wealth, mothers education and study site/district, time of sample collection, water waste disposal.
‡ This includes pit latrine without slab which is considered improved according to JMP but unhygienic technology according to GOB.
§ Separate multivariate model Adjusting for child, faeces disposal, cleanliness of latrine, presence of open faeces, presence of cow/goat, visible cleanliness of hands, wealth, mothers education and study site/district, time of sample collection, water waste disposal.
Chapter 4: Effect of neighbourhood sanitation coverage on faecal contamination of the household environment in rural Bangladesh.

4.1 Introduction to the chapter

This chapter explores the role of neighbourhood sanitation coverage on faecal contamination of the target household as measured through toy ball and children’s hands. This chapter includes a ready for submission manuscript, which describes some of the main results.

4.2: Role of the authors in the research paper

Tarique M.N. Huda (TH): TH is the first author of the research paper. He had the primary role of designing the study, overseeing the field work, cleaning and analyzing the data, interpreting the results and drafting the manuscript.

Wolf-Peter Schmidt (WS): WS contributed to the conception of the study, defining the research questions, provided guidance on design of the study; reviewed the data analysis and the draft manuscript.

Amy J. Pickering (AP): AP provided guidance on the microbiological sample collection protocol; provided feedback on analysis and interpretation of the data and reviewed the draft manuscript.

Leanne Unicomb (LU): LU provided guidance during data collection in Bangladesh and reviewed the draft manuscript.

Zahid H. Mahmud (ZM) and Md. Sirajul Islam: ZM and SI reviewed the protocol for the microbiological sample processing in the lab, helped with supervision of the sample processing in the lab and reviewed the draft manuscript.

Stephen P. Luby (SL): SL provided guidance on design of the study and reviewed the draft manuscript.

Adam Biran (AB): AB was the executive author for this manuscript. He contributed to the conception of the study, contributed in defining the research questions, approved the overall study design, data/sample collection protocols and reviewed the draft manuscript.
### 4.3 Research paper cover sheet

**Student:** Tarique Mohammad Nurul Huda  
**Principal Supervisor:** Adam Biran  
**Thesis Title:** Role of Sanitation in preventing fecal contamination of the domestic environment and protecting health: An observational study.

**SECTION A – Student Details**  

<table>
<thead>
<tr>
<th>Student</th>
<th>Tarique Mohammad Nurul Huda</th>
</tr>
</thead>
<tbody>
<tr>
<td>Principal Supervisor</td>
<td>Adam Biran</td>
</tr>
<tr>
<td>Thesis Title</td>
<td>Role of Sanitation in preventing fecal contamination of the domestic environment and protecting health: An observational study.</td>
</tr>
</tbody>
</table>

If the Research Paper has previously been published please complete Section B, if not please move to Section C

**SECTION B – Paper already published**

<table>
<thead>
<tr>
<th>Where was the work published?</th>
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</tr>
</thead>
<tbody>
<tr>
<td>When was the work published?</td>
<td></td>
</tr>
<tr>
<td>If the work was published prior to registration for your research degree, give a brief rationale for its inclusion</td>
<td></td>
</tr>
<tr>
<td>Have you retained the copyright for the work?</td>
<td>Choose an item.</td>
</tr>
<tr>
<td>Was the work subject to academic peer review?</td>
<td>Choose an item.</td>
</tr>
</tbody>
</table>

*If yes, please attach evidence of retention. If no, or if the work is being included in its published format, please attach evidence of permission from the copyright holder (publisher or other author) to include this work.

**SECTION C – Prepared for publication, but not yet published**

<table>
<thead>
<tr>
<th>Where is the work intended to be published?</th>
<th>American Journal of Tropical Medicine and Hygiene</th>
</tr>
</thead>
<tbody>
<tr>
<td>Please list the paper’s authors in the intended authorship order:</td>
<td>Tarique M.N. Huda, Wolf-Peter Schmidt, Amy J. Pickering, Leanne Unicomb, Zahid Hayat Mahmud, Stephen P. Luby and Adam Biran</td>
</tr>
<tr>
<td>Stage of publication</td>
<td>Not yet submitted</td>
</tr>
</tbody>
</table>

**SECTION D – Multi-authored work**

| For multi-authored work, give full details of your role in the research included in the paper and in the preparation of the paper. (Attach a further sheet if necessary) | I had the primary role of designing the study, overseeing the field work, analysing the data, and drafting the manuscript |

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Effect of neighbourhood sanitation coverage on faecal contamination of the household environment in rural Bangladesh

Authors: Tarique M N Huda¹, Wolf-Peter Schmidt¹, Amy J. Pickering², Leanne Unicomb³, Zahid Hayat Mahmud³, Stephen P. Luby² and, Adam Biran¹

1 London School of Hygiene and Tropical Medicine, London, UK
2 Stanford University, Stanford, California, USA
3 International Centre for Diarrhoeal Disease Research, Bangladesh (icddr,b), Dhaka, Bangladesh

4.4 Abstract

Enteric pathogens can be transmitted within the household and the surrounding neighbourhood. The objective of this study was to understand the effect of neighbourhood level sanitation coverage on faecal contamination of the household environment in rural Bangladesh. Spot-check observations of sanitation facilities was conducted in neighbouring households within a 20 meter radius of target households with children aged 6-24 months. Following the Millennium Development Goal (MDG) definition sanitation facilities were defined as improved (a private pit latrine with a slab or better) or unimproved. Faecal coliforms (FC) on children’s hands and sentinel toy balls were measured and used as indicators of household-level faecal contamination.

We visited 1,784 neighbouring households surrounding 454 target households. Twenty two percent of these neighbouring households had access to a private improved latrine. On average, sentinel toy balls had 2.09 (SD=1.37) log_{10} colony forming units (CFU) of FC/toy ball and children’s hands had 2.25 (SD=1.14) log_{10} CFU of FC/two hands. Access to 100% private improved sanitation coverage in the neighbourhood was associated with a small but statistically insignificant difference in contamination of sentinel toy ball (difference in mean: -0.09 log_{10} CFU/toy ball; 95% CI: -0.56, 0.38; P=0.70) and children’s hands (difference in mean: -0.20 log_{10} CFU/two hands; 95% CI: -0.45, 0.14; P=0.25).
Improved sanitation coverage in the neighbourhood had limited measurable effect on faecal contamination of the target household environment. Other household and community level factors may be more important in reducing faecal contamination of the household environment.

**Key words:** Neighbourhood, sanitation, faecal coliform, hands, sentinel toys

### 4.5 Introduction

Enteric pathogens excreted within faeces can be transmitted through contaminated food and drink, person to person (hand to mouth), or contact with a fomite and flies either through contaminated food and utensils or landing directly on children [1-4]. In rural areas of densely populated countries households live very close to each other. Members of neighbouring households often share a yard along with basic water and sanitation infrastructure [5]. This allows frequent movement of adults and children between households within the neighbourhood [6] resulting in enteric pathogens being transmitted within households [7] and the surrounding community [8].

Sanitation facilities that separate faeces from the environment are expected to create a primary barrier to break the chain of transmission of enteric pathogens [1, 2]. There may be two source of benefit of sanitation in reducing transmission of enteric pathogens. There may be a direct benefit to a household due to improving household sanitation. There may be also an external benefit due to immediate neighbour’s access to sanitation that result in a lower probability of human contact with human excreta [9]. We have limited empirical evidence to understand whether the benefits of sanitation at household level critically depend on sanitation coverage across the neighbourhood [10].

Several studies were identified that assessed the effect of community sanitation coverage on health. A few studies have looked at the effect of community coverage of sanitation facilities connected to sewer systems or septic tanks in urban contexts [11-16]. These studies show the importance of community sanitation
access, but they do not clarify the role of neighbourhood sanitation on target households in reducing faecal contamination and related health outcomes.

A study conducted in Brazil assessed the effect on child diarrhoea of a city-wide intervention to improve sewerage coverage. Following the intervention there was a 22% reduction in the longitudinal prevalence of diarrhoea. Household-level sanitation-related variables (indoor latrine, household excreta disposal) explained only 17% of the heterogeneity of the effect of programme. Whereas, neighbourhood sanitation coverage through sewerage connection explained 100% of the heterogeneity in the effect of the programme [14]. This suggests that in this setting the neighbourhood level sanitation access was more important than household level sanitation access in reducing diarrhoeal disease transmission. However the study was conducted in urban areas with sewage connections, a sanitation technology not feasible in most low income rural settings. As of 2010, 60% of global urban residents reported using facilities linked to sewers compared to only 12% in rural areas [17]. Most sanitation facilities in rural areas of low income countries are onsite (pit latrines, septic tanks and other household level technologies that do not involve sewerage). In 2010 64% of the global rural population reported using onsite sanitation facilities [17]. In rural settings with predominantly onsite sanitation the impact of neighbourhood sanitation may be different.

Studies conducted in rural contexts with predominantly onsite sanitation facilities have also highlighted that neighbourhood sanitation coverage may be important. First a study conducted in rural Zimbabwe assessed the effect of latrine coverage at the community level, on diarrhoea morbidity. A community where 62% of the children lived in a household with a latrine experienced 68% lower diarrhoea morbidity compared to the children living in a community with no sanitation [10]. However the study had a relatively small sample size and compared only two communities. A second study conducted in coastal Ecuador analysed data from four years of active diarrhoeal-disease surveillance data across 21 communities. Villages were categorised based on diarrhoea prevalence as “low” (<0.6%); “low-medium” (0.6%-2.2%); “high-medium” (2.2 %-< 5.2%) and “high” (5.25-100%). The data
suggests that the overall increase in percentage of village level improved sanitation was associated with higher diarrhoea prevalence in the context of low regional risk of diarrhoea [18]. This study showed that the association between community sanitation coverage and diarrhoea risk may vary depending on the level of disease in the surrounding villages. This suggests that disease dynamics is influenced by disease status of neighbouring communities. However from these studies we cannot understand the benefits of externality due to sanitation access in the neighbourhood. Another important limitation of this study was that it looked at the effectiveness of water treatment and sanitation without considering hand washing with soap.

Studies conducted in the rural context suggest that neighbourhood sanitation may provide additional externality benefits [9] in terms of reducing diarrhoea. For example, a study used data from an Indian nationwide survey of rural households. The findings suggest that community level improved sanitation coverage is associated with a 37% additional reduction in diarrhoea prevalence, in addition to reduction due to household level improved sanitation coverage [9]. A second study that used demographic and health survey (DHS) data suggests that children from villages with higher open defecation rate were shorter controlling for effect of household level sanitation practices [19]. However these studies did not control for the effect of handwashing practices on health. Moreover these findings have so far not been replicated in other settings. Depending on the status of disease in a specific context the effect of risk factors like lack of sanitation may have variable effect [20, 21]. The classification of sanitation facilities in demographic and health surveys may be prone to misclassification bias as the questions used in DHS do not capture the function of sanitation facilities in separating faeces from environment.

The objective of this study was to assess the association between neighbourhood sanitation coverage and microbial faecal contamination at the household-level so that informed decisions can be made regarding the focus of sanitation interventions and how we monitor global progress.
4.6 Methods

An observational, cross-sectional study was conducted between September and October 2013, in rural areas of Mymenshingh and Narshingdi districts of Bangladesh. The study was conducted in villages that were participating in the Sanitation, Hygiene Education, and Water supply in Bangladesh (SHEWA-B) health impact study described elsewhere [22]. Verbally administered questionnaire surveys, spot-check of sanitation facilities and microbial assessment of children’s hands and sentinel toy ball (described below).

4.6.1 Neighbouring household selection

The study was conducted in rural areas of Mymenshingh and Narshingdi districts of Bangladesh between September and October 2013. The enumerators systematically selected 454 target households with a child aged 6-24 months, from a simple random sample of villages enrolled for a health impact study as described elsewhere [23]. All neighbouring households within a 20 metre radius of the entrance to the living room of each target household were enrolled in this study. The cut-off point of a 20 meter radius was arbitrary, based on logistical convenience and resources available for data collection rather than scientific evidence. During the pilot study (Chapter 2) high population density was found and within a 20 meter radius 4-10 neighbouring households were found. In this manuscript the term “neighbourhood” refers to these immediate neighbouring households. The distance between households was measured using a handheld global positioning system (GPS) unit “Garmin Etrex legend H” (GARMIN)[24]. Target households were separated by a distance of at least 50 meters ensuring that none of the neighbouring households was counted for more than one target household.

4.6.2 Data collection tools

Neighbourhood and target household surveys: The enumerators used a verbally administered, structured questionnaire and spot-check observation to collect information about household possessions; water, sanitation and hygiene related behaviour and facilities in target households [23] (Chapter 3). The
information on training of enumerators and quality control during data collation are described elsewhere (Chapter 3). Enumerators used a shorter version of this procedure to collect information about human and animal faeces disposal practices in the neighbouring households. Data were recorded using a tablet computer.

4.6.3 Microbiological sample collection

We used contamination of toys and hands by faecal indicator bacteria as an indicator of faecal contamination of the household environment.

Hand rinse: Prior to administering the household survey the field team rinsed both the hands of the target child, (aged 6-24 months) from each target household. Hands were rinsed for 30 seconds each, in a Whirl-Pak bag (19×38 cm) (Nasco, Fort Atkinson, WI) filled with 200 ml of Ringer’s solution [25].

Sentinel toy ball rinse: Standard sized (20 cm circumference) sentinel toy balls given to children to play with were collected after 24 hours and rinsed in a Whirl-pak bag (19×38 cm) filled with 200 ml of Ringer’s solution for 30 seconds following methods used previously [26].

All samples were transported in a cool box to the Environmental Microbiology Laboratory of icddr,b laboratory within 15-18 hours of collection maintaining the temperature of 4–10 °C.

4.6.4 Enumeration of faecal coliforms

The enumeration procedure for faecal coliforms is described in detail elsewhere [23]. Presumptive faecal coliforms were enumerated using a membrane filtration technique with modified faecal coliform (mFC) agar plates, within 24 hours of collection [27, 28]. The results were calculated as colony forming units (CFU) present per 200 ml of recovered media that bathed the toy balls or hands.

4.6.5 Ethics

Written informed consent was taken from the primary caregiver of the child aged 6-24 months before enrolling for the study (Appendix 3). The study protocol
was approved by the ethical review committee of icddr,b, Bangladesh and London School of Hygiene and Tropical Medicine (LSHTM), United Kingdom.

4.6.6 Operational definitions of variables used in the analysis

Our analysis included the following variables, household access to improved sanitation, neighbourhood sanitation coverage, household wealth, latrine cleanliness, hand cleanliness, appropriate child faeces disposal and faecal coliform counts from hands and sentinel toys. These variables are defined below.

Access to improved sanitation: We categorised access to improved sanitation using 2 different definitions used by the WHO/UNICEF Joint Monitoring Programme (JMP) for water supply and sanitation [30]. Definition 1 was used for monitoring progress towards the Millennium Development Goal (MDG). We refer to this as the MDG definition. Definition 2 was that proposed for future monitoring of progress towards the post-2015 Sustainable Development Goal (SDG) [30]. We refer to this as the SDG definition. The key difference between these definitions is that MDG does not include any shared sanitations in the definition of improved whereas the proposed SDG does include some types of shared sanitation within the definition of improved provided they are shared by no more than five households.

Following the MDGs we categorised flush/pour flush latrines and pit latrines with slabs as improved provided these were not shared between households. Unimproved sanitation included pit latrines without slabs, hanging latrines, flush/pour flush latrines with no connection to a sewer or septic tank; no facility; and any shared facilities. We also defined improved sanitation following the SDG definition where shared facilities of otherwise improved technology (flush/pour flush latrines and pit latrines with slabs) if shared by a maximum of five households as improved [17]. So for the SDG definition unimproved sanitation included pit latrines without slabs, hanging latrines, flush/pour flush latrines connected to open; no facility; and improved technologies shared by more than five households.

Neighbourhood sanitation coverage: We calculated neighbourhood sanitation coverage as the proportion of neighbouring households with access to
improved (MDG and SDG definitions) latrines. We treated the neighbourhood improved (MDG and SDG) sanitation coverage variable in 2 different forms: a) continuous and b) binary (100% and < 100%).

**Household wealth:** To assess the wealth of target households we used principal component analysis (PCA) with 23 household characteristics [31, 32] excluding sanitation and water access. We calculated the means, frequencies and score coefficients and used the correlation matrix of the 23 variables to calculate sample weights [31, 33, 34]. We initially divided the wealth score into quintiles (lower, lower middle, middle, upper middle and upper). Then we recoded the wealth score as a binary variable rich (upper wealth quintile) or poor (lower, lower middle, middle and upper middle wealth quintiles).

**Hand cleanliness:** If the trained enumerators observed no visible dirt on the hands or under the nails of the target child then the child was considered to have clean hands.

**Latrine cleanliness:** We considered a household to have a clean latrine if the enumerators observed no faeces on the slab/floor and pan of the latrine at the time of visit.

**Safe child’s faeces disposal:** The faeces of children (below 3 years of age) were considered to be disposed safely if they were reported to be disposed inside a latrine [35].

### 4.6.7 Data analysis

We first converted the faecal coliform concentrations to their base 10 logarithms for calculating means. A faecal coliform level of <1 was replaced with the value 0.5 (half the detection limit) before the conversion. We calculated the difference in log_{10} transformed arithmetic means CFU of faecal coliforms comparing households with different levels of sanitation coverage in the neighbourhood using a linear regression model. To account for the clustering effect at village level we used a
generalised least squares (GLS) random-effects model explicitly allowing the average outcome to vary between village clusters [36-40]

We conducted univariable analyses to estimate the crude effect of the primary exposure variables and potential confounding variables on the main outcome, adjusting for the effect of village level clustering. For the multivariable analysis, adjusting for potential confounders, we used causal diagrams to decide which variables to include as potential confounders, excluding variables on the same causal pathway as the exposure variables (Figure 4.1). We decided *a priori* to include mother’s education and wealth as confounders even if they were not associated with the outcome in this study. We included all potential confounders in the multivariable model if they were associated with the exposure and outcome in the univariable analysis [40, 41]. We also tested for normality of residuals and homoscedasticity of the models.

We generated separate multivariable models for toy contamination and hand contamination as outcomes. For each of the outcomes we used 2 different forms for neighbourhood improved (MDG and SDG) sanitation coverage variable (continuous and binary).

### 4.7 Results

#### 4.7.1 Neighbourhood characteristics

The 454 target households visited had a mean of four neighbouring households within a 20 metre radius. Twenty two target households had no neighbouring household within a 20 metre radius and an additional four target households had one neighbouring household but none of the family members of those neighbouring households were present during data and sample collection.

We visited 1,948 neighbouring households of 454 target households. We could not collect data on sanitation status from 165 neighbouring households (8%) because of absence or refusal so we have data on sanitation status from 1,784 neighbouring households. These neighbouring households had five members on
average and 35% (n=684) had at least one child under 5 years of age. Two thirds of neighbouring households reported that the children under 5 years of age defecated in the open in or around the household. Among 432 households with one or more children under 3 years of age, 22% reported that they disposed of the child’s faeces in a latrine. The majority (n=1431, 80%) of the neighbouring households had animal faeces present within the household premises at the time of observation. Among these, 24% (n=467) had more than 10 piles of open poultry faeces, and 11% (n=213) had more than 10 piles of cow dung, while 16% (n=321) had goat faeces present (Table 4.1).

Among the neighbouring households, 1,682 (94%) reported having access to a latrine. Almost all of the households with latrine access had a worn path to the latrine suggesting regular use. Almost all of these households (99%) reported using the latrine within the 24 hours preceding spot-checks. Among all the neighbouring households 60% (n=1012) reported access to a shared latrine. About 22% of the households had a flush or pour flush latrine with a septic tank or a pit, while, 24% households reported to have access to a pit latrine without flush technology. Twenty two percent of the households had access to a private improved latrine (MDG). While 42% had access to improved latrine (SDG) shared by a maximum of 5 households. There were 1615 households that had a latrine with a slab. Seventeen percent of these latrines were visibly clean (Table 4.1). Shared latrines were more likely to be dirty than individual latrines (182/969=19% vs. 90/646=14%, P value=0.01)

4.7.2 Target household characteristics

A quarter (25%) of the target households had access to private improved sanitation(MDG) while 45% of the target households had access to an improved latrine, as defined by JMP for the SDG (Table 4.2). Characteristics of the target households have been presented in more detail elsewhere [23].

Almost half of the target households (n=220, 49%) were from neighbourhoods with no improved (MDG) sanitation access. Nine percent of the
target households (n=39) were from neighbourhoods with 100% improved (MDG) sanitation coverage (Table 4.2).

**4.7.3 Faecal contamination of sentinel toy ball**

Among the 454 sentinel toys 49 (11%) of the rinse samples were below the detection limit for faecal coliforms. No samples had faecal coliform levels that were above the detection limit. On average there were 2.09 (SD=1.37) log_{10} CFU/toy ball with a median of 2.08 log_{10} CFU/toy ball.

Toy ball samples collected from target households in neighbourhoods with no private, improved (MDG) sanitation access had 2.04 (SD=1.47) log_{10} CFU/toy ball on average. There was minimal change in the level of toy ball contamination associated with each 1% increase in the private, improved (MDG) sanitation coverage in the neighbourhood. Toy ball samples collected from households in neighbourhoods with less than 100% improved (MDG) sanitation coverage had somewhat lower levels of contamination than households in neighbourhoods with 100% improved (MDG) sanitation coverage (difference in mean: -0.19 log_{10} CFU/toy ball; 95% CI: -0.64, 0.27), but differences of this magnitude are consistent with random variation (P=0.42). After adjusting for potential confounding household and neighbourhood characteristics the findings remained unchanged (Table 4.2).

In restricted analysis among 113 target households with access to unimproved sanitation a higher proportion of access to improved sanitation in the neighbourhood was not associated with any reduction in faecal contamination of the toy ball in the target households. Even access to 100% improved sanitation coverage in the neighbourhood was only associated with minimal reduction in faecal contamination of the toy ball (difference in mean -0.06: 95% CI:-0.62, 0.50) compared to household with less than 100% improved sanitation access.

There was minimal change in the level of toy ball contamination associated with each 1% increase in the improved (SDG) sanitation coverage in the neighbourhood. Toy ball samples collected from households in neighbourhoods with
less than 100% improved (SDG) sanitation coverage had somewhat similar levels of contamination as households in neighbourhoods with 100% improved (SDG) sanitation coverage. Coverage of shared sanitation in the neighbourhood was not associated with any statistically significant change in level of faecal contamination of the toy ball (Table 4.2).

4.7.4 Faecal contamination of hands

Among the hand rinse samples taken from 454 children under 2 years of age, 6% (n=28) of the samples were below the detection limit for faecal coliforms. On average children’s hands had 2.25 (SD 1.14) log_{10} CFU/two hands with a median of 2.20 log_{10} CFU/two hands. Contamination of hands was weakly correlated with contamination of the toy balls (r=0.19, P=0.44). A one log_{10} increase in level of faecal coliform per two hands was associated with 0.24 log_{10} increase in level of faecal coliform per sentinel toy ball (95% CI: 0.12, 0.34) (Figure 4.4).

In households from neighbourhoods with no improved (MDG) sanitation access there were on average 2.29 (SD=1.12) log_{10} CFU/two hands. With each 1% increase in neighbourhood improved sanitation coverage there was a reduction of 0.17 log_{10} CFU of faecal coliform contamination (95% CI: -0.50, 0.16). This reduction could be due to chance (P=0.32). Households in neighbourhoods with 100% improved (MDG) sanitation coverage had similar levels of hand contamination as those in neighbourhoods with <100% coverage (difference in mean -0.11; 95% CI: -0.48, 0.26) (Table 4.3).

In the restricted analysis among target households with access to unimproved (MDG) sanitation a higher proportion of access to improved sanitation in the neighbourhood was not associated with any reduction in faecal contamination of children’s hands in the target household (Data not shown).

With each 1% increase in neighbourhood improved (SDG) sanitation access there was a reduction of 0.15 log_{10} CFU of faecal coliform contamination (95% CI: -0.43, 0.13). This reduction could be due to chance (P=0.29) (Table 4.3). With each 1%
increase in neighbourhood shared sanitation coverage was an increase of 0.26 log_{10} CFU of faecal coliform contamination (95% CI: -0.43, 0.13) per two hands. Although the statistical evidence was weak (P=0.07). In the adjusted analysis the estimates and the strength of the statistical evidence remained similar.

In the multivariate analysis, hand contamination was similar in target households with access to private, improved sanitation and unimproved sanitation (difference in mean: 0.12; 95% CI -0.14, 0.38). Children, who were playing in the half hour preceding hand rinse sample collection, had more faecal contamination than children who were inactive (for example sleeping) (difference in mean=0.29 log_{10} CFU/two hands, 95% CI: 0.04, 0.54). Children with visibly clean hands had lower faecal coliform contamination than children with dirty hands (difference in mean=-0.56 log_{10} CFU/two hands, 95% CI: -0.84, -0.27). Presence of soap and water in the handwashing station was not associated with faecal coliform level in children’s hands. Household wealth and mother’s education were not associated with faecal contamination of the children’s hands (Table 4.3).

### 4.8 Discussion

In rural areas of Bangladesh with predominantly onsite sanitation, access to improved (MDG) sanitation in neighbouring households was associated with small and statistically insignificant reductions in faecal indicator bacteria in the domestic environment. For both measures of household faecal contamination (children’s hands and toys) this finding was consistent. Even 100% improved (MDG) sanitation coverage was not associated with significant reduction in contamination level. The association between neighbourhood sanitation coverage and faecal contamination was similar when improved sanitation was defined using the SDG definition proposed by JMP. Access to private improved (MDG) sanitation in the target household was associated with lower level of faecal contamination of the sentinel toy ball. But access to improved sanitation as defined for SDG was not associated with any reduction in faecal contamination.
These findings suggest that improved sanitation access in the neighbourhood may not be sufficient to prevent faecal contamination of the domestic environment. Other household and community-level factors may also be necessary. This does not imply that neighbourhood sanitation is not important in reducing faecal contamination.

There are several possible explanations as to why neighbourhood sanitation coverage was not associated with levels of faecal contamination of children’s hands and toys. Firstly, it is possible that household sanitation access is more important than neighbourhood coverage in reducing faecal contamination within the target household. Since children under two years of age are likely to spend most time within the household premises the hand/toy ball contamination are most likely to represent the contamination level of the household’s domestic environment. In our study as well as in previous small-scale studies conducted in Bangladesh [26, 42] and Tanzania [43] household-level access to improved sanitation was found to be associated with lower contamination of toy balls [26, 42] and hands [43].

Secondly there are other routes of contamination, such as poor cleanliness of the latrine, presence of animal faeces or unsafe disposal of children’s faeces, that neither target household nor neighbourhood sanitation access prevent. In this study presence of soap and water at a convenient handwashing location was not associated with lower level of faecal contamination but visible cleanliness of hands were associated with level of faecal contamination of children’s hands and toys. A previous study conducted in Tanzania among 334 households found that washing hands with soap within the past hour was associated with lower level of faecal contamination [43]. More over in Tanzania study visible dirt observed on the subject’s palm, finger pads, or underneath their nails was significantly related to higher level both of EC and FS on hands. So handwashing practice may be more important than neighbourhood sanitation access. There may also be important community-level social, geographical, economical, cultural and or environmental factors that we did not capture in our study since we found sentinel toys in
Narshingdi district had higher level of contamination compared to children’s toys in Mymensingh district even after adjusting for potential confounding factors.

Thirdly, it is possible that we were unable to detect a difference in faecal contamination associated with neighbourhood sanitation due to low statistical power. Previous studies have found contamination level in toys and hands [26] to be highly variable and so requiring a large sample size to evaluate group differences. The sample size calculation for this study was not determined considering neighbourhood level sanitation coverage as the primary exposure. Future research with a larger sample size might help to better understand this phenomenon.

Previous studies have identified neighbourhood sanitation coverage as important in reducing diarrhoeal disease transmission [10, 14, 44]. This apparent contradiction to the findings of the present study might arise if children visiting neighbouring households are exposed to faecal pathogens in the neighbouring households. Or other household members bring in contamination from neighbouring households. It is also possible that other more important transmission pathways (e.g. water or food) that operate at household as well as neighbourhood level and that could not be captured by assessing faecal contamination of toy balls and hands.

An important limitation of this study is use of faecal indicator bacteria to assess faecal contamination as they are not human specific. This random measurement error can introduce bias due to misclassification of outcome. As a consequence the confidence intervals of the estimates presented are likely to be wider making the results less likely to be statistically significant even if in reality they are statistically significant [45]. For example, having 100% improved sanitation access in the neighbourhood was associated lower but statistically insignificant reduction in level of faecal contamination. So, further study with larger sample size could help better understand the role of neighbourhood sanitation[45]. Using molecular markers of human specific pathogens as indicator of faecal coliform could help reduce this bias in future studies.
Finally, our definition of neighbourhood may be problematic. The cut-off point of a 20 meter radius was arbitrary, based on logistical convenience and high population density in this context rather than scientific evidence. So our conclusion may be conservative given small radius. Selecting a larger radius might have resulted in a different conclusion. Moreover, there may be issues with generalisability of these findings. Bangladesh has high water tables and high number of domestic animal, as a result Bangladesh may have many determinants of household faecal contamination that are not impacted on by neighbourhood sanitation practices.

Neighbourhood coverage with improved sanitation within 20 meters of households in rural Bangladesh had no effect on faecal contamination of the household environment measured as indicator bacteria on children’s hands and toys. Household sanitation access is probably more important than neighbourhood sanitation coverage in reducing faecal contamination of domestic environment. Intervention studies with appropriate sample size might help us better understand the impact of neighbourhood sanitation coverage on faecal contamination of household environments.
4.9 Acknowledgements: This research was made possible with UK Aid from the Department of International Development (DFID) as part of the SHARE research programme (www.SHAREresearch.org). However, the views expressed do not necessarily reflect DFID’s official policies. The study was also partially funded by Water, Sanitation and Hygiene research group at icddr,b, Dhaka, Bangladesh. No funding bodies had any role in study design, data collection and analysis, decision to publish or preparation of the manuscript.; However the views expressed do not necessarily reflect the Department’s, official policy. The authors acknowledge the contributions of the study participants; and icddr,b admin, field and lab research staff. The author is thankful to Dr. Amal Krishna Halder, Dr. Md. Mahbubur Rahman, Sharker Masud Parvez from icddr,b for logistic support during the field activities. The authors also thank the research advisory committee; the examiners, the EHG group at LSHTM. The author specially thanks Ben Arnold and Jade Benjamin-Chung from UC Berkeley, USA and Jane Bruce from LSHTM for statistical advice.
4.10 References


23. Huda, T.M.N., et al., A cross sectional study of the association between sanitation type and faecal contamination of the household environment in rural Bangladesh.


27. CDC, Microbiological Indicator Testing in Developing Countries: A Fact Sheet for the Field Practitioner. 2010, Centre for Disease Control and Prevention.


Figure 4.1: Directed acyclic graph (DAG) showing the variables measured and included in the multivariable analysis.
Table 4.1: Neighbourhood household (NH) characteristics (n=1784)*

<table>
<thead>
<tr>
<th></th>
<th>n</th>
<th>% or mean</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean number of household (HH) member</td>
<td>1,784</td>
<td>4.6</td>
</tr>
<tr>
<td>Proportion of HH with a &lt;5 child</td>
<td>684</td>
<td>35%</td>
</tr>
<tr>
<td>Proportion of HH with access to a latrine</td>
<td>1,672</td>
<td>94%</td>
</tr>
<tr>
<td>Proportion of HH with worn path to latrine (N=1682)</td>
<td>1,666</td>
<td>99%</td>
</tr>
<tr>
<td>Sanitation access according to technology (Ignoring sharing)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Open defecation</td>
<td>102</td>
<td>5.7%</td>
</tr>
<tr>
<td>Pit latrine without slab, hanging latrine and pit latrine</td>
<td></td>
<td></td>
</tr>
<tr>
<td>with a slab but broken pit</td>
<td>858</td>
<td>48%</td>
</tr>
<tr>
<td>Pit latrine with a slab</td>
<td>436</td>
<td>24%</td>
</tr>
<tr>
<td>Flush/pour flush latrine with septic tank or pit</td>
<td>388</td>
<td>22%</td>
</tr>
<tr>
<td>Proportion of HH that privately owns a latrine (N=1682)</td>
<td>862</td>
<td>51%</td>
</tr>
<tr>
<td>Proportion of HH with access to a shared latrine (N=1682)</td>
<td>1,012</td>
<td>60%</td>
</tr>
<tr>
<td>Mean number of individuals using a latrine</td>
<td>1,682</td>
<td>8</td>
</tr>
<tr>
<td>Mean number of HH sharing a latrine</td>
<td>1,012</td>
<td>2.9</td>
</tr>
<tr>
<td>Sanitation access according JMP (MDG) classification</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Private Improved</td>
<td>389</td>
<td>22%</td>
</tr>
<tr>
<td>Unimproved</td>
<td>1,395</td>
<td>78%</td>
</tr>
<tr>
<td>Access to Improved (JMP-SDG) sanitation</td>
<td>816</td>
<td>42%</td>
</tr>
<tr>
<td>Proportion of HH with dirty latrine (N=1,615)</td>
<td>272</td>
<td>17%</td>
</tr>
<tr>
<td>Reported &lt;5 child faeces defecation site</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Open: filed/bush/yard/floor</td>
<td>390</td>
<td>57%</td>
</tr>
<tr>
<td>Potty</td>
<td>80</td>
<td>12%</td>
</tr>
<tr>
<td>Nappy</td>
<td>69</td>
<td>10%</td>
</tr>
<tr>
<td>In a latrine</td>
<td>145</td>
<td>21%</td>
</tr>
<tr>
<td>Safe child’s faeces disposal (N=432)</td>
<td>93</td>
<td>22%</td>
</tr>
<tr>
<td>Proportion of HH where children aged 5-18 not using a latrine</td>
<td>601</td>
<td>34%</td>
</tr>
<tr>
<td>Number of piles of poultry faeces found in or around HH</td>
<td></td>
<td></td>
</tr>
<tr>
<td>No faeces</td>
<td>613</td>
<td>31%</td>
</tr>
<tr>
<td>1-10 piles</td>
<td>868</td>
<td>45%</td>
</tr>
<tr>
<td>10&gt; piles</td>
<td>467</td>
<td>24%</td>
</tr>
</tbody>
</table>

* n=1784
Number of pile of cow dung found in or around HH

<table>
<thead>
<tr>
<th>No faeces</th>
<th>1,323</th>
<th>68%</th>
</tr>
</thead>
<tbody>
<tr>
<td>1-10 piles</td>
<td>412</td>
<td>21%</td>
</tr>
<tr>
<td>10&gt; piles</td>
<td>213</td>
<td>11%</td>
</tr>
</tbody>
</table>

Goat faeces found in or around HH

<table>
<thead>
<tr>
<th>Present</th>
<th>1,627</th>
<th>84%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Absent</td>
<td>321</td>
<td>16%</td>
</tr>
</tbody>
</table>

*If sample size is different it is presented next to the variable in the table*
Figure 4.2: Scatter plot and fitted line showing relationship between proportion of neighbouring households (NH) with improved (JMP-MDG) sanitation access and log$_{10}$ transformed CFU of faecal coliform per toy ball.

Figure 4.3: Scatter plot and fitted line showing relationship between proportion of neighbouring households (NH) with improved (JMP-MDG) sanitation access and log$_{10}$ transformed CFU of faecal coliform per two hands of children.
Table 4.2: Relationship between neighbourhood (NH) sanitation and log_{10} transformed faecal coliform CFU/toy ball (n=454 households)

<table>
<thead>
<tr>
<th>Exposures</th>
<th>n* (%)</th>
<th>Mean (SD)†</th>
<th>Median</th>
<th>Univariable Difference in mean‡ (95% CI§)</th>
<th>P value‡</th>
<th>Multivariable Difference in mean†† (95% CI††)</th>
<th>P value††</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Primary Exposure: NH Sanitation coverage (MDG)</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1a. Increase in improved sanitation coverage in the NH (Continuous)</td>
<td>454</td>
<td>2.09 (1.37)</td>
<td>2.08</td>
<td>-0.06 (-0.47, 0.34)</td>
<td>0.75</td>
<td>0.06 (-0.37, 0.49)</td>
<td>0.79</td>
</tr>
<tr>
<td>1c. Improved sanitation coverage in the NH</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>100% coverage</td>
<td>39 (9)</td>
<td>1.93 (1.20)</td>
<td>1.90</td>
<td>-0.19 (-0.64, 0.27)</td>
<td>0.42</td>
<td>-0.09 (-0.56, 0.38)</td>
<td>0.70</td>
</tr>
<tr>
<td>&lt;100% coverage</td>
<td>415 (91)</td>
<td>2.11 (1.39)</td>
<td>2.08</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Primary Exposure: NH Sanitation type (SDG)</strong></td>
<td></td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1a. Increase in improved sanitation coverage in the NH (Continuous)</td>
<td>454</td>
<td>2.09 (1.37)</td>
<td>2.08</td>
<td>0.12 (-0.22, 0.46)</td>
<td>0.48</td>
<td>0.18 (-0.17, 0.52)</td>
<td>0.31</td>
</tr>
<tr>
<td>1b. Improved sanitation coverage in the NH</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>100% coverage</td>
<td>365 (80)</td>
<td>2.10 (1.40)</td>
<td>2.08</td>
<td>-0.07 (-0.39, 0.24)</td>
<td>0.65</td>
<td>0.03 (-0.35, 0.29)</td>
<td>0.86</td>
</tr>
<tr>
<td>&lt;100% coverage</td>
<td>89 (20)</td>
<td>2.06 (1.29)</td>
<td>1.90</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1c. Increase in NH shared sanitation access (cont.)</td>
<td>444**</td>
<td></td>
<td></td>
<td>0.12 (-0.23, 0.46)</td>
<td>0.52</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Other household variables††</strong></td>
<td></td>
<td></td>
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<td></td>
</tr>
<tr>
<td>2a. Improved (JMP-MDG) sanitation access target HH¶</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Improved</td>
<td>113 (25)</td>
<td>1.84 (1.23)</td>
<td>1.60</td>
<td>-0.36 (-0.65, -0.07)</td>
<td>0.02</td>
<td>-0.34 (-0.63, -0.00)</td>
<td><strong>0.05</strong></td>
</tr>
<tr>
<td>Unimproved</td>
<td>341 (75)</td>
<td>2.17 (1.41)</td>
<td>2.20</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2b. Improved (JMP-SDG) sanitation access target HH¶</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>205 (45)</td>
<td>2.06 (1.33)</td>
<td>1.90</td>
<td>-0.07 (-0.33, 0.18)</td>
<td>0.58</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Improved</td>
<td>249 (55)</td>
<td>2.12 (1.41)</td>
<td>2.08</td>
<td></td>
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<td>----------</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Unimproved</td>
<td></td>
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<td></td>
<td></td>
</tr>
</tbody>
</table>

3. Number of goat faeces pile in compound

<table>
<thead>
<tr>
<th>Category</th>
<th>Number (Percentage)</th>
<th>Average</th>
<th>SD</th>
<th>95% CI</th>
<th>Lower CI</th>
<th>Upper CI</th>
</tr>
</thead>
<tbody>
<tr>
<td>No faeces</td>
<td>312 (69)</td>
<td>2.02 (1.34)</td>
<td>1.90</td>
<td>-</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1 to 10 piles</td>
<td>95 (21)</td>
<td>2.15 (1.32)</td>
<td>2.20</td>
<td>0.16 (-0.15, 0.48)</td>
<td>0.30</td>
<td></td>
</tr>
<tr>
<td>&gt; 10 piles</td>
<td>47 (10)</td>
<td>2.43 (1.62)</td>
<td>2.20</td>
<td>0.45 (0.02, 0.87)</td>
<td>0.04</td>
<td></td>
</tr>
</tbody>
</table>

4. Presence of any goat faeces in HH (Vs absence of any goat faeces)

<table>
<thead>
<tr>
<th>Number (Percentage)</th>
<th>Average</th>
<th>SD</th>
<th>95% CI</th>
<th>Lower CI</th>
<th>Upper CI</th>
</tr>
</thead>
<tbody>
<tr>
<td>312 (69)</td>
<td>2.36 (1.46)</td>
<td>2.38</td>
<td>0.36 (0.06, 0.67)</td>
<td>0.02</td>
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5. Number of cow dung pile in compound

<table>
<thead>
<tr>
<th>Category</th>
<th>Number (Percentage)</th>
<th>Average</th>
<th>SD</th>
<th>95% CI</th>
<th>Lower CI</th>
<th>Upper CI</th>
</tr>
</thead>
<tbody>
<tr>
<td>No cow dung</td>
<td>198 (44)</td>
<td>2.07 (1.37)</td>
<td>1.90</td>
<td>0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1 to 10 cow dung</td>
<td>165 (36)</td>
<td>2.09 (1.34)</td>
<td>2.08</td>
<td>0.03 (-0.25, 0.32)</td>
<td>0.83</td>
<td></td>
</tr>
<tr>
<td>&gt; cow dung</td>
<td>90 (20)</td>
<td>2.15 (1.45)</td>
<td>2.36</td>
<td>0.11 (-0.23, 0.46)</td>
<td>0.53</td>
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</tbody>
</table>

6. Number of cow dung pile in household

<table>
<thead>
<tr>
<th>Category</th>
<th>Number (Percentage)</th>
<th>Average</th>
<th>SD</th>
<th>95% CI</th>
<th>Lower CI</th>
<th>Upper CI</th>
</tr>
</thead>
<tbody>
<tr>
<td>No cow dung</td>
<td>264 (58)</td>
<td>2.04 (1.38)</td>
<td>1.90</td>
<td>0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1 to 10 cow dung</td>
<td>136 (30)</td>
<td>2.08 (1.37)</td>
<td>2.20</td>
<td>0.04 (-0.25, 0.32)</td>
<td>0.79</td>
<td></td>
</tr>
<tr>
<td>&gt; cow dung</td>
<td>54 (12)</td>
<td>2.37 (1.35)</td>
<td>2.45</td>
<td>0.36 (-0.05, 0.77)</td>
<td>0.08</td>
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</tr>
</tbody>
</table>

7. Number of poultry faeces piles in the compound

<table>
<thead>
<tr>
<th>Category</th>
<th>Number (Percentage)</th>
<th>Average</th>
<th>SD</th>
<th>95% CI</th>
<th>Lower CI</th>
<th>Upper CI</th>
</tr>
</thead>
<tbody>
<tr>
<td>≤10 piles</td>
<td>233 (51)</td>
<td>2.10 (1.37)</td>
<td>2.08</td>
<td>-0.01 (-0.26, 0.25)</td>
<td>0.96</td>
<td></td>
</tr>
<tr>
<td>&gt; piles</td>
<td>221 (49)</td>
<td>2.08 (1.38)</td>
<td>2.08</td>
<td>-0.15 (-0.26, 0.25)</td>
<td>0.96</td>
<td></td>
</tr>
</tbody>
</table>

8. Number of poultry faeces piles in HH

<table>
<thead>
<tr>
<th>Category</th>
<th>Number (Percentage)</th>
<th>Average</th>
<th>SD</th>
<th>95% CI</th>
<th>Lower CI</th>
<th>Upper CI</th>
</tr>
</thead>
<tbody>
<tr>
<td>No faeces</td>
<td>92 (20)</td>
<td>1.97 (1.23)</td>
<td>1.90</td>
<td>0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1 to 10 piles</td>
<td>224 (49)</td>
<td>2.12 (1.46)</td>
<td>2.14</td>
<td>0.15 (-0.19, 0.49)</td>
<td>0.38</td>
<td></td>
</tr>
<tr>
<td>&gt; 10 piles</td>
<td>138 (30)</td>
<td>2.13 (1.30)</td>
<td>2.08</td>
<td>0.17 (-0.20, 0.53)</td>
<td>0.38</td>
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</tr>
</tbody>
</table>

9. Presence of appropriate water drainage (Vs absence of appropriate water drainage)

<table>
<thead>
<tr>
<th>Number (Percentage)</th>
<th>Average</th>
<th>SD</th>
<th>95% CI</th>
<th>Lower CI</th>
<th>Upper CI</th>
</tr>
</thead>
<tbody>
<tr>
<td>261 (58)</td>
<td>1.99 (1.36)</td>
<td>1.90</td>
<td>-0.24 (-0.50, 0.01)</td>
<td>0.06</td>
<td></td>
</tr>
</tbody>
</table>

-0.33 (-0.59, -0.07) | 0.01 |
<p>| | | | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
</table>
| 10. Presence of appropriate solid waste disposal system  
(Vs absence of appropriate solid waste disposal system) | 11 | 1.59 (2.00) | 1.90 | -0.47 (-0.29, 0.34) | 0.26 |
| 11. Hands/nails looked visibly clean  
(Vs hands/nails visibly dirty) | 71 (16) | 1.81 (1.34) | 1.90 | -0.35 (-0.69, -0.01) | 0.05 |
| 12. HW place with soap and water  
(Vs no soap and/or water) | 95 (21) | 2.00 (1.19) | 1.90 | -0.15 (-0.46, 0.17) | 0.36 |
| 13. Mother with any formal education  
(Vs mothers with no formal education) | 376 (83) | 2.03 (1.36) | 1.90 | -0.33 (-0.66, 0.00) | 0.05 |
| 14. Household belongs to upper (richest) wealth quintile  
(Vs poorer quintiles) | 90 (20) | 1.81 (1.22) | 1.70 | -0.41 (-0.72, -0.09) | 0.01 |
| 15. Change in time (hour) of sample collection as the day progress | | | | -0.17 (-0.27, -0.06) | 0.002 |
| 16. Study site  
Narshingdi district | 238 (52) | 2.26 (1.38) | 2.20 | 0.36 (0.07, 0.65) | 0.01 |
| Mymensing district | 216 (48) | 1.90 (1.34) | | | |
| 17. Increase in number of neighbouring household | | | | 0.002 (-0.05, 0.05) | 0.92 |

*Number with presented category  
† Standard Deviation (SD)  
§ Adjusting for clustering at village  
¶ Confidence interval  
|| The estimates and associated 95% confidence intervals for the other household variables presented here are from the multivariable model with variable 1a (increase in improved sanitation coverage in the NH (as the primary outcome).  
¶ Household  
**Excluding target households that had at no neighbouring households with access to a latrine
Figure 4.4: Scatter plot showing log10 transformed faecal coliform contamination of children’s hands and toys in rural Bangladesh. Here CV refers to covariance.
Table 4.3: Relationship between community level water sanitation and hygiene related variables and log_{10} transformed faecal coliform CFU/two hands of children under 2 years of age in rural Bangladesh (n=454 households)

<table>
<thead>
<tr>
<th>Exposures</th>
<th>n^* (%)</th>
<th>Mean (SD)</th>
<th>Median</th>
<th>Univariable Difference in mean (95% CI)</th>
<th>P value</th>
<th>Multivariable Difference in mean (95% CI)</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>NH improved (MDG) sanitation coverage</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1a. Increase improved sanitation coverage in the NH (Continuous)</td>
<td>454</td>
<td>2.25 (1.14)</td>
<td>2.20</td>
<td>-0.17 (-0.50, 0.16)</td>
<td>0.32</td>
<td>-0.20 (-0.55, 0.14)</td>
<td>0.25</td>
</tr>
<tr>
<td>1b. Improved sanitation coverage in the NH</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>100% coverage</td>
<td>39 (9%)</td>
<td>2.17 (1.09)</td>
<td>2.08</td>
<td>-0.11 (-0.48, 0.26)</td>
<td>0.55</td>
<td>-0.18 (-0.56, 0.21)</td>
<td>0.35</td>
</tr>
<tr>
<td>&lt;100% coverage</td>
<td>415 (91%)</td>
<td>2.25 (1.15)</td>
<td>2.30</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>NH improved (SDG) sanitation coverage</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1a. Increase in improved sanitation coverage in the NH (Continuous)</td>
<td>454</td>
<td>2.25 (1.14)</td>
<td>2.20</td>
<td>-0.15 (-0.43, 0.13)</td>
<td>0.29</td>
<td>-0.14 (-0.42, 0.14)</td>
<td>0.34</td>
</tr>
<tr>
<td>1b. Improved sanitation coverage in the NH</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>100% coverage</td>
<td>365 (80%)</td>
<td>2.22 (1.18)</td>
<td>2.20</td>
<td>0.05 (-0.21, 0.31)</td>
<td>0.70</td>
<td>0.04 (-0.23, 0.30)</td>
<td>0.78</td>
</tr>
<tr>
<td>&lt;100% coverage</td>
<td>89 (20%)</td>
<td>2.33 (0.99)</td>
<td>2.20</td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>1c. Increase in NH shared sanitation access (cont.)</td>
<td>444</td>
<td></td>
<td></td>
<td>0.26 (-0.02, 0.55)</td>
<td><strong>0.07</strong></td>
<td>0.27 (-0.01, 0.56)</td>
<td><strong>0.06</strong></td>
</tr>
<tr>
<td><strong>Other confounding variables</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2a. Improved sanitation access in the target HH**, Improved</td>
<td>113 (25)</td>
<td>2.23 (1.14)</td>
<td>2.20</td>
<td>-0.01 (-0.25, 0.23)</td>
<td>0.95</td>
<td>0.12 (-0.14, 0.38)</td>
<td>0.38</td>
</tr>
<tr>
<td>2b. Improved (JMP-SDG) sanitation access target HH**</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Improved</td>
<td>Unimproved</td>
<td>Unimproved</td>
<td>Unimproved</td>
<td>Unimproved</td>
<td>Unimproved</td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>249 (55)</td>
<td>205 (45)</td>
<td>2.27 (1.17)</td>
<td>2.20</td>
<td>-0.06 (-0.28, 0.15)</td>
<td>0.55</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

3. Number of goat faeces piles in compound

| No faeces | 312 (69%) | 2.19 (1.16) | 2.20 | - |
| 1 to 10 piles | 95 (21%) | 2.30 (1.12) | 2.20 | 0.09 (-0.17, 0.36) | 0.50 | 0.08 (-0.18, 0.34) | 0.57 |
| > 10 piles | 47 (10%) | 2.48 (1.09) | 2.86 | 0.29 (-0.06, 0.64) | **0.11** | 0.18 (-0.17, 0.54) | 0.28 |

4. Presence of any goat faeces in HH** (Vs absence of any goat faeces)

| No faeces | 103 (23) | 2.38 (1.11) | 2.45 | 0.15 (-0.10, 0.40) | 0.23 |

5. Number of cow dung piles in the compound

| No cow dung | 198 (44%) | 2.23 (1.14) | 2.20 | - |
| 1 to 10 cow dung | 165 (36%) | 2.19 (1.13) | 2.20 | -0.05 (-0.29, 0.18) | 0.66 |
| > cow dung | 90 (20%) | 2.35 (1.19) | 2.45 | 0.13 (-0.16, 0.41) | 0.37 |

6. Number of cow dung piles in the HH**

| No cow dung | 264 (58) | 2.15 (1.13) | 2.20 | |
| 1 to 10 cow dung | 136 (30) | 2.31 (1.18) | 2.34 | 0.14 (-0.10, 0.37) | 0.25 | 0.14 (-0.09, 0.37) | 0.23 |
| > cow dung | 54 (12) | 2.57 (1.07) | 2.87 | 0.46 (0.13, 0.80) | **0.01** | 0.42 (0.08, 0.76) | **0.02** |

7. Number of poultry faeces piles in the compound

| ≤10 piles | 233 (51%) | 2.24 (1.17) | 2.20 | - |
| > piles | 221 (49%) | 2.25 (1.12) | 2.27 | -0.02 (-0.22, 0.19) | 0.87 |

8. Number of poultry faeces piles in HH**

| No faeces | 92 (20) | 2.09 (1.23) | 1.98 | |
| 1 to 10 piles | 224 (49) | 2.30 (1.14) | 2.20 | 0.10 (-0.18, 0.38) | 0.48 |
| More than 10 piles | 138 (30) | 2.27 (1.10) | 2.30 | 0.12 (-0.19, 0.42) | 0.46 |

9. Presence of appropriate water drainage (Vs absence of appropriate water drainage)

| 261 (43%) | 2.22 (1.14) | 2.20 | 0.03 (-0.19, 0.24) | 0.81 |

10. Presence of appropriate solid waste disposal system (Vs absence of)

<p>| 11 (2.4%) | 2.17 (1.39) | 2.20 | -0.00 (-0.67, 0.67) | 0.99 |</p>
<table>
<thead>
<tr>
<th>Question</th>
<th>Cases</th>
<th>Mean</th>
<th>SD</th>
<th>Effect Size 95% CI</th>
<th>Adjusted Effect Size 95% CI</th>
<th>p-Value</th>
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<tbody>
<tr>
<td>11. Hands/nails looked visibly clean (Vs Hands/nails looked visibly dirty)</td>
<td>71 (16%)</td>
<td>1.74 (1.33)</td>
<td>1.60</td>
<td>-0.61 (-0.89, -0.33)</td>
<td>&lt;0.001 -0.56 (-0.84, -0.27)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>12. HW place with soap and water (Vs no soap and/or water)</td>
<td>95 (21)</td>
<td>2.28 (1.19)</td>
<td>2.30</td>
<td>0.10 (-0.16, 0.35)</td>
<td>0.47</td>
<td></td>
</tr>
<tr>
<td>13. Target child washed hands within half an hour preceding hand rinse sample collection (Vs did not wash hands)</td>
<td>64 (14%)</td>
<td>2.20 (1.22)</td>
<td>2.14</td>
<td>-0.03 (-0.33, 0.27)</td>
<td>0.86</td>
<td></td>
</tr>
<tr>
<td>14. Child was active in the preceding half an hour (playing) (Vs sleeping)</td>
<td>361 (80%)</td>
<td>2.32 (1.12)</td>
<td>2.30</td>
<td>0.36 (0.10, 0.61)</td>
<td>&lt;0.01 0.29 (0.04, 0.54)</td>
<td>0.02</td>
</tr>
<tr>
<td>15. Mother with any formal education (Vs no formal education)</td>
<td>376 (83%)</td>
<td>2.24 (1.14)</td>
<td>2.20</td>
<td>0.001 (-0.27, 0.28)</td>
<td>0.99 0.10 (-0.18, 0.37)</td>
<td>0.49</td>
</tr>
<tr>
<td>12. Household belongs to upper (richest) wealth quintile (Vs poorer quintiles)</td>
<td>90 (20%)</td>
<td>2.07 (1.17)</td>
<td>2.20</td>
<td>-0.17 (-0.43, 0.09)</td>
<td>0.21 -0.10 (-0.38, 0.17)</td>
<td>0.46</td>
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<tr>
<td>13. Change in time (hour) of sample collection as the day progress</td>
<td>-0.11 (-0.20, 0.02)</td>
<td>0.01</td>
<td>-0.12 (-0.21, -0.03)</td>
<td>0.01</td>
<td></td>
<td></td>
</tr>
<tr>
<td>14. Study site Narshingdi district Mymensing district</td>
<td>238 (52%)</td>
<td>2.21 (1.15)</td>
<td>2.20</td>
<td>-0.08 (-0.37, 0.22)</td>
<td>0.61</td>
<td></td>
</tr>
<tr>
<td>15. Increase in number of neighbouring HH</td>
<td>-0.02 (-0.06, 0.02)</td>
<td>0.31</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

* Number with presented category
† Standard Deviation (SD)
‡ Adjusting for clustering at village
§ Confidence interval
|| Excluding target households that had no neighboring households with access to a latrine.
¶ The estimates and associated 95% confidence intervals for the other household variables presented here are from the multivariable model with variable 1a (increase in improved sanitation coverage in the NH (as the primary outcome)).
** Household
†† A separate multivariate model among subset of target households, using NH sanitation coverage (categorical) as primary exposure and all the other common household variables presented in the table.
Chapter 5: A cross sectional study to explore the association between sanitation type and diarrhoeal disease.

5.1 Introduction to the chapter

This chapter compares the different classifications of improved sanitation used for international monitoring in terms of reducing diarrhoea among children less than five years of age using existing data from a programme evaluation conducted in Bangladesh. This chapter includes a ready for submission manuscript, which describes results from the secondary data analysis that was conducted as part of the PhD thesis.

5.2: Role of the authors in the research paper

Tarique M.N. Huda (TH): TH is the first author of the research paper. He had the primary role of developing the concept for secondary data analysis, reviewing the literature, cleaning and analyzing the data, interpreting the results and drafting the manuscript.

Leanne Unicomb (LU): LU reviewed the concept for secondary data analysis and manuscript drafts.

Amal K. Halder (AKH): AKH was part of the team that collected the data used for this secondary data analysis. He contributed by reviewing the draft manuscripts.

Wolf-Peter Schmidt (WS): WS contributed in refining the research questions; reviewed the data analysis and the draft manuscript.

Probir K. Ghosh (PKG): PKG reviewed the data analysis strategy and the draft manuscript.

Richard B. Johnston (RBJ): RBJ was involved in the conception of the study that generated the data for this secondary data analysis. He contributed by reviewing the draft manuscript.

Adam Biran (AB): AB contributed in defining the research questions for the secondary data analysis, supported the first author during the literature review, reviewed the data analysis, helped with interpretation of data and reviewed the draft manuscript.
Stephen P. Luby (SL): SL was the executive author for this manuscript. He was the Principal investigator for the study that generated the data for this secondary data analysis. He contributed in defining the research questions for the secondary data analysis, reviewed the data analysis, helped with interpretation of data and reviewed the draft manuscript.
5.3 Research paper cover sheet

RESEARCH PAPER COVER SHEET

PLEASE NOTE THAT A COVER SHEET MUST BE COMPLETED FOR EACH RESEARCH PAPER INCLUDED IN A THESIS.

SECTION A – Student Details

<table>
<thead>
<tr>
<th>Student</th>
<th>Tarique Mohammad Nurul Huda</th>
</tr>
</thead>
<tbody>
<tr>
<td>Principal Supervisor</td>
<td>Adam Biran</td>
</tr>
<tr>
<td>Thesis Title</td>
<td>Role of Sanitation in preventing fecal contamination of the domestic environment and protecting health: An observational study.</td>
</tr>
</tbody>
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If the Research Paper has previously been published please complete Section B, if not please move to Section C

SECTION B – Paper already published

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<th>Where was the work published?</th>
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<tr>
<th>If the work was published prior to registration for your research degree, give a brief rationale for its inclusion</th>
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<table>
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<tr>
<th>Have you retained the copyright for the work?*</th>
<th>Choose an item.</th>
<th>Was the work subject to academic peer review?</th>
<th>Choose an item.</th>
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*If yes, please attach evidence of retention. If no, or if the work is being included in its published format, please attach evidence of permission from the copyright holder (publisher or other author) to include this work.

SECTION C – Prepared for publication, but not yet published

<table>
<thead>
<tr>
<th>Where is the work intended to be published?</th>
<th>American Journal of Tropical Medicine and Hygiene</th>
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<table>
<thead>
<tr>
<th>Please list the paper’s authors in the intended authorship order:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tarique M N Huda, Wolf-Peter Schmidt, Amy J. Pickering, Leanne Unicomb, Zahid Hayat Mahmud, Stephen P. Luby and, Adam Biran</td>
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</table>

<table>
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<th>Stage of publication</th>
<th>Not yet submitted</th>
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</table>

SECTION D – Multi-authored work

<table>
<thead>
<tr>
<th>For multi-authored work, give full details of your role in the research included in the paper and in the preparation of the paper. (Attach a further sheet if necessary)</th>
<th>I had the primary role of designing the study, overseeing the field work, analysing the data, and drafting the manuscript</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
</tr>
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</table>
Title: A cross sectional study to explore the association between sanitation type and diarrhoeal disease.

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5.4 Abstract

This secondary data analysis aimed to assess the relationship between sanitation type, and diarrhoeal disease using data collected as part of a programme evaluation. The evaluation was conducted in Bangladesh to assess the impact of a large-scale water, sanitation and hygiene education programme implemented by the government of Bangladesh with technical support from UNICEF Bangladesh, between 2007 and 2011.

Field workers interviewed the primary caregivers of children under five years of age and performed a spot check of sanitation facilities. Those households with at least one child<3 years of age (N=995 households) were also visited by a female community monitor, monthly for 24 months to collect data on reported diarrhoea in the preceding 2 days. We first categorised sanitation facilities based on UNICEF/WHO Joint Monitoring Programme (JMP) technology type, as “improved” (latrine with a water seal connected to sewer/septic tank/pit, pit latrine with a slab), “unimproved” (pit latrine without slab, hanging latrines) and “no facility”. We then further classified sanitation facilities according to JMP sanitation ladder with 4 categories: “private improved, shared improved, unimproved and no facility”.

Children from households with access to unimproved sanitation had similar prevalence of diarrhoea as those with a private improved sanitation (Prevalence=11.1 vs. 10.2; adjusted PR=1.001; 95% CI: 0.80, 1.25). Children belonging to households with access to shared improved sanitation had similar prevalence of
diarrhoea (11.6%) as those with access to private improved sanitation (adjusted PR=1.01; 95% CI: 0.90, 1.13). Households with visible faeces on the slab had higher prevalence of diarrhoea compared to those with no faeces on the slab (Adjusted PR=1.09; 95% CI=0.96, 1.25).

Children from households with an appropriate solid waste disposal system had lower risk of diarrhoea (PR=0.74, 95% CI: 0.61, 0.89) compared to those without appropriate solid waste disposal. Adjusting for other variables in the multivariate model did not change the effect estimate. Presence of soap and water in a handwashing station was only weakly associated with lower diarrhoea risk (PR=0.91; 95% CI: 0.82, 1.02; P=0.12). Children from households with an appropriate solid waste disposal system had lower (statistically significant) risk of diarrhoea (PR=0.74, 95% CI: 0.61, 0.89) compared to those without appropriate solid waste disposal system. Adjusting for other variables in the multivariate model did not change the effect estimate.

Household level provision of onsite sanitation facilities considered as improved for international monitoring does not prevent diarrhoea disease in context where diarrhoea is endemic. Sharing a sanitation facility does not appear to be a risk factor for diarrhoeal disease in the context where sanitation facilities are shared among relatives or neighbours who know each other. In addition presence of soap and water at the designated handwashing station and storing water in a covered container was not associated with any reduction in diarrhoea prevalence. However presence of an appropriate solid waste disposal system was associated with reduction in the prevalence if diarrhoea.

**Key words:** Improved sanitation, diarrhoea, shared sanitation, children
5.5 Introduction

Diarrhoeal diseases are among the top five causes of death in children under five years of age [1, 2]. Although there has been a decline in the incidence of diarrhoea there were still 1.7 billion episodes of diarrhoea in 2010, in 139 low and middle income countries [3]. Diarrhoea is also a risk factor for pneumonia [4, 5]. Repeated episodes of early childhood diarrhoea have a lasting influence on the physical growth, cognitive function and school performance [6-9].

Most cases of diarrhoea are transmitted through the faecal oral route [10]. Appropriate human excreta disposal systems, generally referred to as sanitation, are expected to break the chain of transmission by separating faeces from the environment [11, 12]. In 2012, 280,000 diarrhoea deaths were estimated to be caused by inadequate sanitation [13]. A recent systematic review suggests that interventions to improve sanitation were associated with a 28% reduction in diarrhoeal disease [14]. In recognition of the need for action on sanitation, Millennium Development Goal (MDG) 7, target 10 was to “halve, by 2015, the proportion of people without sustainable access to basic sanitation”[15, 16].

The WHO/UNICEF Joint monitoring Programme (JMP) for water supply and sanitation is the official United Nations mechanism tasked with monitoring towards the MDG related to water and sanitation. Access to sanitation is monitored using the indicator “proportion of population with access to improved sanitation.” [16-18]. The terminology used for the MDG target is “basic sanitation” but JMP refers to basic sanitation as “improved sanitation”. According to JMP, improved sanitation refers to “facilities that ensure hygienic separation of human excreta from human contact”[19, 20]. The JMP improved sanitation technologies include: latrine with a water seal connected to a sewer system or septic tank, and pit; ventilated improved pit latrine; composting latrine and pit latrine with slab. However sanitation facilities are not counted towards MDG coverage and are considered “unimproved” if they are shared [20], because of concerns regarding cleanliness, maintenance of the facility and access [21]. In addition, JMP also uses a four rung-ladder of sanitation, defined by a hierarchy of predefined sanitation technologies that allows monitoring.
progress without changing the MDG definition [22]. The sanitation technologies on
the higher rung of the ladder are believed to be better at hygienically separating
faeces from the environment and thereby reducing health risk [17, 22]. Ideally for
international monitoring sanitation would be classified on the basis of evidence for
its relative effectiveness in delivering health benefits, but this evidence base is
generally weak [23-26].

Findings from a few observational studies suggest that access to latrines with
water seals connected to a piped sewer system, septic tank/pit and composting
latrines are associated with lower risk of diarrhoea [25, 27-30]. However, from these
studies we do not know if pit latrines with a slab but without a water seal will
provide similar protection.

Several observational studies have used data from demographic health
surveys (DHS) to assess the effect of improved sanitation on diarrhoea risk. Studies
conducted in Indonesia [31] and Malawi, found that children from households with
access to a private improved sanitation facility had lower odds of diarrhoea [32]
compared to those with no sanitation facility. A study conducted by Fuller and
colleagues used 217 Demographic and Health Surveys from 74 countries, found that
access to improved sanitation was associated with reduced prevalence of diarrhoea
[Prevalence Ratio (PR): 0.93 95% CI; 0.92-0.95] [33]. But the effect of sanitation on
diarrhoea varied between countries and across time suggesting that the
environmental, social and geographical context plays important role. The questions
used for DHS to capture the data on latrine classification are focused on the design
of the latrine rather than the functionality of the latrine [34]. For example a pit
latrine with a slab may be considered as improved by JMP because of the design. But
if there is a leakage in the pit, the faeces will come out of the pit and contaminate
the environment. So this latrine cannot be considered to hygienically separate faeces
from the environment and thereby JMP should not consider it as improved. But, the
DHS questionnaire does not include questions to capture this information [35]. As a
result these national surveys likely include substantial measurement error of
exposure.
There is also evidence from large nationwide surveys that access to private improved (MDG) sanitation is associated with less diarrhoea [36, 37]. These large surveys are prone to substantial measurement error in categorising sanitation facilities due to reliance on report by the respondent and lack of detailed questions to assess the functionality of the latrine in confining faeces. Moreover in these large nationwide surveys data on reported diarrhoea is collected at one point in time that cannot capture the seasonality of diarrhoea. However diarrhoeal diseases follow seasonal variation [38] and sanitation may have a variable effect depending on the season. This is why longitudinal prevalence of diarrhoea estimated through repeated measures has been identified as a preferable indicator of diarrhoea for low income high risk populations [39, 40]. A nationwide study conducted in rural Indonesia suggested that lack of improved latrines was associated with higher reported diarrhoea (OR=1.23, 95% CI: 1.18-1.29) [26] and under 5 child mortality (OR = 1.29, 95% CI = 1.25–1.31). This study used the JMP definition and collected longitudinal diarrhoea data to capture variation in seasonality. However this finding has not been replicated in other low income country contexts.

We have identified some studies that have looked at the effect of sharing a latrine on diarrhoea. A recent systematic review conducted to compare health outcomes associated with shared sanitation versus individual household sanitation reported increased adverse health outcomes associated with shared sanitation. However most of the studies included in the review did not adequately address potential confounding and did not allow the effect of different types of shared sanitation (Improved/unimproved) to be distinguished [24]. An analysis of DHSs from 51 countries reported a 10% reduction in diarrhoea among households with private sanitation facilities compared to households with shared sanitation [23]. The study also reported heterogeneity in the effect of shared sanitation across countries. A multicounty case control study conducted in 7 low income country sites in sub-Saharan Africa and South Asia found families of children with moderate to severe diarrhoea more commonly used shared facilities than control families (47.5% vs. 41.2% OR=1.2; 95% CI 1.1-1.3) overall [41]. But these findings were not consistent in all the 7 countries. Suggesting that local context plays an important role. More over
within the same country sharing may have variable effect in rural and urban context or depending on whether sanitation is shared by neighbours or acquaintances or by public. We have limited data to understand the context in which shared sanitation is as effective in separating human faeces from human contact as private sanitation.

The objective of the present study was to assess the association between sanitation type and diarrhoeal disease among children <5 years of age using data collected as part of an evaluation of a water, sanitation and hygiene intervention project [42-44]. The findings of this study will help us to understand the relevance of different classifications of sanitation used for international monitoring.

5.6 Methods

The data used in this secondary analysis was collected as part of an evaluation of the sanitation, hygiene education and water supply in Bangladesh (SHEWA-B) programme. The methods of the programme evaluation including household enrolment, assessment of exposure and outcome, human subject protection has been described elsewhere [42-44]. However for the convenience of the reader some of these are described briefly.

5.6.1 Study population

The study population of this secondary data analysis were the households with children <5 years of age in rural Bangladesh where a large health impact study was being implemented. The SHEWA-B programme selected the specific intervention sub-districts with lower than average performance in term of health and social indicators because of the perceived need and the absence of other active programs addressing water, sanitation and hygiene in these communities. The control areas of the SHEWA-B health impact study were selected from similar geographical and socioeconomic status as the intervention areas [42-44].

5.6.2 Household enrolment

The SHEWA-B health impact study team selected fifty intervention unions using probability proportional to population size. Fifty control unions were also selected using probability proportional to population size of the union.
The SHEWA-B health impact study team collected a list of all the villages from the union council. From each of the selected unions a village was selected randomly from the list of villages in that union. The field workers visited the village and identified the centre of the village by asking the residents. They then identified an eligible household nearest to the centre point and sought consent for an interview. A household was considered to be eligible if they had at least one child <5 years of age. To enrol the next household, the field workers skipped the next two closest households, and then looked for the next closest eligible household. The first 10 households with a child <3 years of age were also requested to participate in a monthly disease surveillance [42-44].

5.6.3 Assessment of household sanitation

In 2007, the SHEWA-B health impact study field workers conducted a face to face interview with the primary caregivers of children <5 years of age to fill out a structured questionnaire survey. The field workers were trained in data collection using the assessment tool, how to conduct interviews, and human subject protection. Before the actual data collection the field workers conducted practice interviews outside the study areas.

The questionnaire survey included questions regarding demographic information, household possessions and behaviour related to water sanitation and hygiene. Then fieldworkers also conducted a spot check of the household water, sanitation and hygiene related infrastructure to record the quality and upkeep of the facility. The initial questionnaires were developed based on the indicators for the evaluation. The questionnaire was then reviewed by the principle investigator of the evaluation as a quality assurance procedure including checking for ambiguous or potentially leading questions. The questionnaire was developed in English and then translated in Bengali. The questionnaire was pilot tested in the field for comprehensibility prior to final data collection. Questions were amended, reworded or replaced following piloting.
A field supervisor was responsible for ensuring the quality of data collected in the field. For at least 5% of the surveys the field worker observed the data collectors and conducted repeat interviews. Each field facilitator was observed to make sure the questions were asked as intended. At the end of data collection each data collector reviewed the completed forms, before leaving the house to check for completeness. At the end of a data collection day, the enumerators cross-checked each other’s completed questionnaire in the presence of the field supervisor for any inconsistency in data.

5.6.4 Assessment of diarrhoea

The SHEWA-B health impact study team recruited a female community member with at least eight years of formal education and trained them as a community monitor in each of the study villages. The community monitor was trained in use of the data collection tool, interview technique and human subject protection. The community monitor visited each of the enrolled households after the initial questionnaire survey, every month for 24 months, starting from October 2007. They collected information on episodes of diarrhoea among all children <5 years of age in a household, during the 2 days preceding the interview. Diarrhoea was defined as the passage of 3 or more loose or watery stools in the 24 hours period preceding the interview [45]. The questionnaire was designed following the same steps as the questionnaire for household assessment.

A field supervisor monitored the collection of data by the community monitors. The community monitors reviewed the completed data collection forms before leaving the respondents household. Every month the field supervisor reviewed the completed data collection forms to check for consistency and completeness of data. Then before entering the data a research officer reviewed the completed data collection forms for consistency and completeness.

5.6.5 Operational definitions of variables used in the secondary data analysis

We categorised the primary exposure variable, sanitation access in four different ways based on information collected through the survey. First, we
categorised sanitation facilities as “improved” or “unimproved” as defined by JMP based on technology type (Table 1). Second, we further categorised improved sanitation facilities based on whether the facility used water seal technology. Thus we classified all households in four technology categories: a) improved with a water seal, b) improved without a water seal, c) unimproved facility, and d) open defecation. If during visual inspection, a sanitation facility was found to have a water seal but the seal was broken then it was considered as an improved facility without water seal. Third, we categorised sanitation facilities according to the four categories of the JMP sanitation ladder: a) improved private facilities b) improved shared facilities c) unimproved facilities (pit latrine without a slab or hanging latrine) d) no facilities. Fourth, we categorised sanitation facilities based on the MDG definition where improved private facilities were considered “improved” and the rest of the categories in the ladder were considered “unimproved” (Table 1). A latrine was considered to be dirty if the field workers could see faeces in the commode or slab/floor.

A household was considered to have appropriate water drainage if it had either a drain (constructed with or without concrete and cement) or a soak pit in order to dispose of household waste water. A household was considered to have appropriate solid waste disposal if it had a drum or a specific pit and the waste was found to be disposed in such a way that no waste was observed outside the pit or drum. A household was considered to have appropriate drinking water storage if the field workers found all drinking water containers fully covered at the time of rapid observation. A household was considered to have a proper handwashing facility if water and soap was found in a convenient hand washing station.

To assess the household wealth, we used principal component analysis (PCA) with 23 household characteristics (Table 2) [43, 46-48] excluding water and sanitation infrastructure.

5.6.6 Sample size calculation

We analysed data collected from 1000 SHEWA-B health impact study households. Since the intervention had very limited impact on diarrhoea prevalence
in the first two years of implementation we included both the intervention and control households [49]. We assumed 95% confidence and a design effect of 2.5 and had 86% power to detect 30% (12% to 8%) difference in diarrhoea prevalence among 1.4 children per HH when comparing 400 households with improved latrines to 600 households with other type of latrines.

5.6.7 Human subject protection

All study participants of SHEWA-B health impact study provided written informed consent. The Government of Bangladesh Department of Public Health Engineering and UNICEF approved the evaluation. icddr,b administration provided an expedited approval of the study [43]. The hard copies of the questionnaire were stored in a locked cabinet at the icddr,b head office and were only available to the study officials. The electronic data were kept in a password protected computer and were accessed by the study officials only.

5.6.8 Data analysis

We calculated the prevalence ratio (PR) of reported diarrhoea among children <5 years of age comparing households with different type of sanitation access using a log-binomial model [50]. To calculate 95% confidence intervals (CI) adjusting for clustering at the village level and repeated observations of diarrhoea in a single household we used generalised estimating equation (GEE) [51] with a robust standard error estimator with the village as the cluster variable.

We conducted univariable analysis to estimate the crude effect of the primary exposure variables and potential confounding variables on the main outcome, adjusting for the effect of village level clustering. We used causal directed acyclic graph (DAG) [52-54] to decide which variable to be included as a potential confounder, excluding variables on the same causal pathway as the exposure variable [55]. All the potential confounding variables that were associated with the outcome and exposure in the univariable analysis were included in the multivariable model [53, 56]. We also considered some forced-in variables (age, gender, wealth, and mother’s education) to be included in the model. For the multivariable model
we included the main exposure, outcome, forced-in and all the confounders together. We calculated the variance inflation (VIF) factor for all the variables in the model to assess multicollinearity [57-59]. We implemented separate multivariate models for the four definitions of sanitation type as primary exposure.

5.7 Results

5.7.1 General household characteristics

Among the 1000 households enrolled in the study who completed the initial questionnaire survey, the field team collected at least one measure of diarrhoea symptoms from 1272 children belonging to 995 households. Twenty nine percent of the mothers reported to have some formal education. More than half of the fathers were farmers or daily wage earners. The most common source of drinking water were shallow tube-wells (81%) (Table 5.2).

Most (92%) of the households reported having access to a latrine. More than half of the households individually owned a latrine. Among the households who reported access to any latrine, 44% (n=400) reported sharing the facility with at least 1 other household (Table 5.2). The most common type of latrine accessed by these households was a pit latrine with a slab (n=553, 56%) More than 90% of the households had access to an improved source of water for drinking. Thirty one percent of these households individually owed a water source (Table 5.3). About 50% of these households had access to soap and water at a convenient place. About a quarter of these households stored water in a covered container.

5.7.2 Diarrhoea prevalence

Over 24 months time period, on average the community monitors visited children 22 times with the majority (67%, 863) of them visited 24 times. In total the field team completed 27, 843 monthly child visits, diarrhoea was reported in 26,097 of the child visits. In the 26,097 child visits, the primary caregiver reported that their child had diarrhoea in the preceding 2 days in 2,804 monthly child visits (10.7%).

Male children had nine percent higher diarrhoea prevalence compared to female children (95% CI: 0%, 20%; P=0.05). In the multivariate analysis the estimate
remained the same although the strength of the statistical evidence became slightly weaker (adjusted PR=1.09; 95% CI: 1.00, 1.19; P=0.06). Children under 2 years of age had increased risk of diarrhoea than older children (PR=1.43; 95% CI: 1.26, 1.63; P<0.001). Adjusting for other variable changed the effect estimate only slightly.

Children whose mother had formal education had 13% lower risk of diarrhoea (PR=0.87; 95% CI: 0.77, 0.98). In multivariable analysis the effect was attenuated slightly but the 95% confidence limit included the null (adjusted PR=0.89 95% CI: 0.78, 1.01; P=0.07). Children belonging to upper middle wealth quintile had lower prevalence of diarrhoea compared to children in poorest quintile (PR= 0.85; 95% CI: 0.72, 1.01) (Table 5.4). In the multivariate analysis the estimate changed towards the null and the strength of the statistical evidence became much weaker (PR= 0.91; 95% CI: 0.75, 1.09).

5.7.3 Sanitation technology type

Twenty three percent of households had access to an improved sanitation facility with a water seal and 56% had access to an improved sanitation facility without a water seal (Table 5.3). Children from households with access to an improved sanitation facility without a water seal had a 14% higher prevalence of diarrhoea compared to children from households with access to an improved sanitation facility with a water seal (95% CI: -2%, 33%) (Table 5.4 and 5.5). In the multivariate analysis the estimate of diarrhoea risk was slightly lower and the strength of the statistical evidence became weaker (PR=1.11; 95% CI: 0.94, 1.30, P=0.12). In reference to the households with access to an improved sanitation facilities with a water seal access to an improved sanitation facilities without a water seal and access to unimproved sanitation facility (PR=1.10; 95% CI 0.86, 1.40; P=0.46) was associated with similar reduction in the prevalence of diarrhoea (Table 5.5).

Children belonging to households with access to improved sanitation technology had only 5% reduced risk of diarrhoea compared to those with access to unimproved sanitation technology (excluding open defecation) (PR=1.05; 95% CI
0.82, 1.25) (Table 5.4, 5.5). But the 95% confidence interval included null. In the multivariate analysis most of this small effect size was eliminated by confounders.

5.7.4 JMP sanitation ladder

Less than half (43%) of the households had access to private improved sanitation where about 36% of households had access to a shared improved sanitation. Children from households with access to a private improved sanitation had diarrhoea on 10% of the monthly visits. Children belonging to households with access to a shared improved sanitation had only 4% increased risk of diarrhoea compared to those with access to private improved sanitation (PR=1.04; 95% CI: 0.93, 1.17) (Table 5.4, 5.5). But the 95% confidence interval included null. In the multivariate analysis, adjusting for the effect of confounders like; children’s gender, age, presence of soap and water at a convenient location, presence of solid waste disposal system, mother’s education and wealth, most of this small effect size was eliminated (PR=1.01; 95% CI: 0.90, 1.13) by confounders (Table 5.5).

5.7.5 MDG classification

The prevalence of diarrhoea among children <5 years of age in households with access to private improved sanitation was 10.2% and in households with access to unimproved sanitation the prevalence was 11.2%. The mean diarrhoea prevalence over the 24 months in households with access to improved sanitation as defined by MDG, was only 5% lower than households with access to unimproved sanitation facilities (PR=1.05; 95% CI: 0.94, 1.18)(Table 5.4 and Table 5.5). However, the 95% confidence interval included null. In the multivariate analysis most of this small effect size was eliminated by confounders (Table 5.4 and Table 5.5).

5.7.6 Other sanitation characteristics

The mean diarrhoea prevalence among children from households with access to any type of shared sanitation facilities was 11.7%. The children from households with access to shared sanitation facilities had 6% higher diarrhoea prevalence compared to those with access to private sanitation facilities (PR=1.06; P=0.27).
However, the difference observed could be due to chance alone. (Table 5.4 and Table 5.5).

Among households with access to improved sanitation technology as defined by JMP, households with access to a dirty improved sanitation had 15% higher diarrhoea prevalence compared to those with clean improved sanitation (PR: 1.15; 95% CI: 1.01, 1.30; P=0.04). In the adjusted analysis the prevalence ratio was smaller and was not statistically significant (PR: 1.09; 95% CI: 0.96, 1.25; P=0.20) (Table 5.6).

5.7.7 Other household characteristics

Children from households with an appropriate solid waste disposal system had lower risk of diarrhoea (PR=0.74, 95% CI: 0.61, 0.89) compared to those without appropriate solid waste disposal system. Adjusting for other variables in the multivariate model did not change the effect estimate. Presence of soap and water in a handwashing station was associated with 9% lower prevalence of diarrhoea but the association was not statistically significant (PR=0.91; 95% CI: 0.82, 1.02; P=0.12). Children from households who stored water in a covered container had lower prevalence of diarrhoea but the reduction was not statistically significant (PR=0.94; 95% CI: 0.84, 1.05; P=0.25). Children who were exclusively breast fed as reported by the mother in the past 24 hours had lower prevalence of diarrhoea compared children who were not exclusively breastfed. But the difference was not statistically significant (PR=0.92; 95% CI: 0.72, 1.17; P=0.50).

5.8 Discussion

The proportion of the rural Bangladeshi population living in the study area, with access to MDG defined improved sanitation was below 50%, which is slightly lower than the national estimate of 52% in 2007 [60]. This could be due to the study area being chosen for its lower than national average performance in term of water sanitation coverage [61].

The objective of the study was to assess the association between sanitation type and diarrhoea. We classified sanitation using three classifications (JMP
technology, MDG, JMP sanitation ladder) used for international monitoring. None of the classifications of household level sanitation explained differences in diarrhoea prevalence that was independent of confounding child and household characteristics. Neither technology types that were considered as improved nor sharing of a sanitation facility was associated with diarrhoea prevalence independent of confounding. Other household and child characteristics that were associated with diarrhoea risk independent of effect of other variables included female gender, lower age and absence of appropriate solid waste disposal, and lack of mother’s education. Taken together these findings suggest that in the context of rural areas with predominantly onsite sanitation, household provision of sanitation may not be causally associated with any reduction in diarrhoea risk among children under 5 years of age. The fact that none of the classifications of sanitation used for international monitoring explained difference in diarrhoea risk that is independent of confounding and the fact that other sanitation factors like cleanliness of latrines were associated with modest and statistically insignificant reduction in diarrhoea may suggest that in this context other determinants of childhood diarrhoea such as open defecation by children, lack of cleanliness of latrine, lack of sanitation in the neighbourhood, presence of animal faeces, lack of handwashing with soap, poor food hygiene, drinking water quality and nutritional status may be more important.

Previous studies that have evaluated the relationship between improved sanitation technology (ignoring sharing) access and diarrhoea have shown conflicting results [26, 33]. The heterogeneity in the effect of improved sanitation technology across different studies and surveys could be due to difference in the degree of measurement error or due to difference in various factors related context of the study. In the study conducted in Indonesia [26] latrine categorisation was based on self-reports rather than visual inspection. Even the standard questionnaire used in DHS has the potential to cause misclassification bias as a latrine is judged based of the design of the facility rather than function of the latrine in separating faeces from the environment. For example, a latrine might have a pit latrine with a water seal but if the pit is broken from the back it will contaminate the environment [62]. This misclassification bias due to measurement error would influence the measure of
association toward the null. However in this study the categorisation of latrine was done based on visual inspection rather than self-report to minimise misclassification bias. The source of heterogeneity could also be due to different contexts. A multi-country analysis of the effect of improved sanitation technologies on diarrhoea found that in some contexts access to improved sanitation was protective while in some there was no association while in some, there was a harmful effect [26].

In our study context access to improved sanitation technologies may not be associated with diarrhoea for two important reasons related to study context. First, in our study context diarrhoea is endemic, so the population is likely to have some level of immunity to common circulating pathogens. This may attenuate the relationship between improved sanitation access and diarrhoea [63].

Second there may be other sources of household faecal contamination like open defecation by children, lack of cleanliness of latrine, lack of sanitation in the neighbourhood and presence of animal faeces that are important in reducing diarrhoeal disease but access to improved sanitation cannot prevent them. In addition lack of proper faecal sludge management could also contribute to faecal contamination of the community and there by contribute in diarrhoea disease transmission that household access to sanitation could not capture in this study. So even if improved sanitation technologies are effective in confining faeces if used, access to improved sanitation may still not be associated with reduced diarrhoea.

Moreover it is possible that in this context other transmission pathways like hands, food and drinking water are more important determinants of diarrhoea disease. Although in this analysis storing drinking water in a covered container was not associated with diarrhoea but in similar setting microbiological quality of drinking water was associated with diarrhoea [64]. Furthermore, in a recent systematic review it was found that intervention to improve water quality at point of use may reduce diarrhoea by at least around a quarter [65]. In our study presence of soap and water was associated with small and statistically insignificant reduction in diarrhoea. But evidence from a recent systematic review suggests that handwashing promotion among communities in low and middle income countries (LMICs)
prevents around one-quarter of diarrhoea episodes [66]. Exclusive breast feeding has been recommended as an important diarrhoea prevention strategy [67, 68]. But in this study exclusive breast feeding was also not associated with reduction in diarrhoea. Take together these findings suggest that this setting diarrhoea disease can only be prevented by interventions that address more than one transmission pathway. A recent study has identified that during the past ten years sanitation or water have only been effective in reducing diarrhoea if they were combined [33]. Further studies to look at the combined effect of these factors on faecal contamination and diarrhoea would be informative.

The MDG classification of sanitation combines the technology type as well as sharing status. It is possible that sharing of latrines does not pose any additional risk. As a result categorisation of shared facilities as unimproved might account for no association between improved sanitation as defined by MDG and diarrhoea. However in this study when shared facilities were also considered as improved access to improved sanitation had no effect on the prevalence of diarrhoea that is independent of confounding. This may suggest that sharing is less likely to dilute the effect of sanitation on diarrhoea. The evidence in the existing literature linking access to shared sanitation and diarrhoea is inconsistent [23, 24, 69]. In some countries sharing a latrine has been found to be associated increased risk of diarrhoea (not always statistically significant), in some other countries sharing was associated with reduced risk of diarrhoea [24], and in some countries there was no relationship between sharing and diarrhoea [23, 24, 69]. This heterogeneity among countries suggests that the specific social economic and environmental context matters.

Sharing a latrine may have harmful effects because of issues related to cleanliness, maintenance, over use or lack of full time access. These factors are likely to vary depending on the relationship between families sharing the facilities and interaction between them. It is possible that in the context where the people are related or know each other sharing poses less risk because there is less problems with maintenance, access and over use. Although in this study the shared facilities were more likely to be dirty but dirty latrines were more likely to be poorer. The
relationship between shared facilities and cleanliness of latrine was confounded by wealth (Data not shown). So in this context the cleanliness of latrine is less likely to be due to sharing. Households or people sharing the latrine in rural Burundi was not found to be influential [60] in the cleanliness of the latrine. But in urban India sharing a latrine among non-family members were found to be dirtier [61]. It is beyond the scope of this study to fully explain the mechanism by which sharing poses increased risk or setting shared sanitation is safe. Further studies looking at shared facilities comparing different management arrangement of shared facilities will be helpful.

In this study we found that access to an improved and clean latrine was associated with a modest reduction in diarrhoea, with some evidence of confounding. Although the statistical evidence to support this association was weak. It is important to note that this study was not powered to conduct this subgroup analysis. Cleanliness of latrines have been linked with increased bacterial pathogens, latrine use [70, 71], diarrhoea outbreaks [72, 73] and reduced absence from school [74]. Cleanliness might improve use and thereby reduce contamination and prevent diarrhoea. Latrine cleanliness might also be a proxy for general cleanliness and hygiene of the household that are important in reducing transmission of infectious diarrhoea. Although in this observational study we cannot establish causality our findings suggest that latrine cleanliness should be considered as an important component of sanitation interventions.

Our analysis suggests that access to latrines with water seal is associated with more than a 14% reduction in diarrhoea, although the 95% confidence limits included the null. The multivariable analysis suggests that this weak statistical association was confounded by household and child characteristics. Although confounders explained some of the difference it did not explain all of the difference. In this study sanitation was measured before diarrhoea so reverse causality is less likely to affect the estimates. Latrines with water seals prevent flies from coming out of latrines. Presence of flies in the latrine has been found to be associated with diarrhoea [75]. Although, the reduction could be due differences in socio-economic status, between the households with and without presence of flies. The study by Fink and colleagues found children living in households with latrines with water seals
had lower odds of diarrhoea than children in households with basic/improved pit latrine or no latrine. So taken together these findings suggest that access to improved sanitation with water seal technologies might be better in reducing diarrhoea independent of confounding. In this observational study we cannot establish causality as there may be residual confounding due to unmeasured confounding factors. Moreover we did not measure fly density to understand the underlying mechanism by which flush latrines with water seals prevent diarrhoea disease transmission. Further studies with randomised intervention trial might help us better understand this issue.

Appropriate solid waste disposal was found to be associated with lower prevalence of diarrhoea in this study as well as in other studies conducted in different contexts [76, 77]. This may suggest that in this setting, factors like waste disposal might be playing important role in reducing diarrhoeal disease transmission.

Our analysis has some important limitations. This analysis used data from both intervention and control households. It is possible that the intervention area had more improved sanitation and less diarrhoea and there by attenuating the effect of sanitation on diarrhoea. However the intervention did not have any effect on diarrhoea or access to sanitation [61], moreover in our analysis intervention status did not change the effect of sanitation on diarrhoea when adjusted for one variable at a time (Data not shown).

It is possible that households with access to improved sanitation as defined by the MDG were still exposed to diarrhoea causing pathogens from the faecal material of their neighbour [78] if their neighbours have unimproved or no access to a latrine. Infectious diseases are transmitted in both private and public domain [79, 80]. But we do not have data on neighbourhood sanitation to disentangle the effect of improved sanitation given the neighbourhood context. However these findings emphasize that household sanitation access alone may not be a good predictor of diarrhoeal disease in this context.
An important limitation of this study is lack of data on microbiological drinking water quality [64] and nutritional [81-83] status of the child. These are important determinant of diarrhoea and could be a potential confounder. Future studies should collect data on these important determinants of diarrhoea.

The findings from this analysis suggest that in the context where diarrhoea is endemic access to improved onsite sanitation may not be sufficient in reducing diarrhoea disease transmission among children less than five years of age. Additional sanitation related factors such as latrine cleanliness, child faeces disposal, presence of water seal may be necessary in separating human faeces from human contact. Future research to see how these sanitation factors interact with each other in reducing diarrhoeal disease transmission might help us to decide the focus of future sanitation intervention and indicators of international monitoring of sanitation. In rural context where sanitation facility is shared among neighbours or extended family members sharing may not pose additional risk of diarrhoea. However apart from concerns related to health risk associated with shared sanitation there are concerns from a human rights perspective that has to be considered if shared facilities are to be considered as improved for the Sustainable Development Goals. Intervention to improve sanitation may not be sufficient in reducing diarrhoea, so we may need to combine intervention to improve hand hygiene, food hygiene, water quality and nutritional status. Future studies to see combined effect of intervention may be relevant for policy makers to decide how sanitation can be combined with other interventions to achieve maximum health benefit.
5.9 Acknowledgements: The authors acknowledge the contributions of the study participants, icddr,b admin, field and lab research staff. The authors also thank the research advisory committee, the examiners, the Environmental Health Group (EHG) at London School of Hygiene and Tropical Medicine (LSHTM). The author specially thanks Mahfuza Islam from icddr,b for data management in Bangladesh and Jane Bruce from LSHTM for statistical advice. The SHERWA-B programme evaluation was funded by by the United Kingdom Department for International Development (DFID) through UNICEF Bangladesh, grant number GR00540. icddr,b acknowledges with gratitude the commitment of DFID and UNICEF to its research efforts. The first author was supported by the UK Aid from the Department of International Development (DFID) through SHARE research programme (www.SHAREresearch.org). However, the views expressed do not necessarily reflect DFID’s official policies. No funding bodies had any role in study design, data collection and analysis, decision to publish or preparation of the manuscript.
5.10 References


64. Luby, S.P., et al. *Microbiological contamination of drinking water associated with subsequent child diarrhoea*. 2015 (Accepted for publication, Undergoing revision ).


Figure 5.1: Directed acyclic graph (DAG) showing general child level/household level; water, sanitation, and hygiene related exposure variables and diarrhoea disease transmission.
### Table 5.1: Classification of sanitation used for international monitoring [20].

<table>
<thead>
<tr>
<th>MDG</th>
<th>JMP sanitation ladder</th>
<th>JMP technology type*</th>
<th>Technology type*</th>
<th>Sanitation technology</th>
</tr>
</thead>
<tbody>
<tr>
<td>Open</td>
<td>Open defecation</td>
<td>Open defecation</td>
<td></td>
<td>- Defecation in fields, forests, bushes, bodies of water or other open spaces, or disposal of human faeces with solid waste.</td>
</tr>
<tr>
<td>Unimproved</td>
<td></td>
<td>Unimproved</td>
<td></td>
<td>- Facilities that do not ensure hygienic separation of human excreta from human contact. Unimproved facilities include:</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>- pit latrines without a slab or platform</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>- hanging latrines/Bucket latrines.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>- flush or pour-flush latrine/latrine to open</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>- pit latrine with a slab but with a leakage in the pit lining</td>
</tr>
<tr>
<td>Shared</td>
<td>Improved</td>
<td>Improved with water seal</td>
<td></td>
<td>- Facilities that ensure hygienic separation of human excreta from human contact. They include:</td>
</tr>
<tr>
<td>Unimproved</td>
<td></td>
<td></td>
<td></td>
<td>- Improved-flush or pour-flush latrine/latrine to:</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>- piped sewer system</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>- septic tank</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>- pit latrine</td>
</tr>
<tr>
<td>Private</td>
<td>Improved</td>
<td>Improved without water seal</td>
<td></td>
<td>- Improved-Non flush pit latrine with slab</td>
</tr>
</tbody>
</table>

*Ignoring sharing of facility
Table 5.2: Household characteristic in rural Bangladesh, 2007 (N=995).

<table>
<thead>
<tr>
<th>Variable</th>
<th>n</th>
<th>Percent or mean</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean Number of household (HH) residents</td>
<td>995</td>
<td>5.6</td>
</tr>
<tr>
<td>Mean Number of children age &lt;5 years</td>
<td>995</td>
<td>1.3</td>
</tr>
<tr>
<td>Female &lt;5 children</td>
<td>505</td>
<td>51</td>
</tr>
<tr>
<td>Mothers with no formal education</td>
<td>286</td>
<td>29</td>
</tr>
<tr>
<td>Fathers with no formal education</td>
<td>347</td>
<td>35</td>
</tr>
<tr>
<td>Father’s occupation</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Farmer/homemaker</td>
<td>247</td>
<td>25</td>
</tr>
<tr>
<td>Day labour, Rickshaw puller</td>
<td>288</td>
<td>29</td>
</tr>
<tr>
<td>Skilled worker</td>
<td>93</td>
<td>9.5</td>
</tr>
<tr>
<td>Working abroad</td>
<td>68</td>
<td>6.8</td>
</tr>
<tr>
<td>Salaried employee</td>
<td>109</td>
<td>11</td>
</tr>
<tr>
<td>Business owner</td>
<td>176</td>
<td>18</td>
</tr>
<tr>
<td>House construction</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tin roof†</td>
<td>905</td>
<td>91</td>
</tr>
<tr>
<td>Cement floor †</td>
<td>88</td>
<td>8.8</td>
</tr>
<tr>
<td>Brick walls†</td>
<td>98</td>
<td>10</td>
</tr>
<tr>
<td>Mean number of rooms †</td>
<td>996</td>
<td>2.2</td>
</tr>
<tr>
<td>Household with electric connection †</td>
<td>459</td>
<td>46</td>
</tr>
<tr>
<td>Proportion who owned</td>
<td></td>
<td></td>
</tr>
<tr>
<td>House †</td>
<td>930</td>
<td>93</td>
</tr>
<tr>
<td>Wardrobe †</td>
<td>286</td>
<td>29</td>
</tr>
<tr>
<td>Radio †</td>
<td>210</td>
<td>21</td>
</tr>
<tr>
<td>Bicycle †</td>
<td>258</td>
<td>26</td>
</tr>
<tr>
<td>Mobile phone †</td>
<td>309</td>
<td>31</td>
</tr>
<tr>
<td>Black and white television †</td>
<td>190</td>
<td>19</td>
</tr>
<tr>
<td>Colour television †</td>
<td>90</td>
<td>9.1</td>
</tr>
<tr>
<td>Sewing machine †</td>
<td>62</td>
<td>6.2</td>
</tr>
<tr>
<td>Refrigerator †</td>
<td>23</td>
<td>2.3</td>
</tr>
<tr>
<td>Motor cycle †</td>
<td>23</td>
<td>2.3</td>
</tr>
<tr>
<td>Mean number of items owned</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tables †</td>
<td>995</td>
<td>1.1</td>
</tr>
<tr>
<td>Chairs †</td>
<td>995</td>
<td>2.2</td>
</tr>
<tr>
<td>Watches/clocks †</td>
<td>995</td>
<td>1.4</td>
</tr>
<tr>
<td>Beds †</td>
<td>995</td>
<td>0.9</td>
</tr>
<tr>
<td>Inexpensive sleeping cots †</td>
<td>995</td>
<td>1.3</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>--------------------------------</td>
<td>--------</td>
<td>-----</td>
</tr>
<tr>
<td>Mean acres of agricultural land</td>
<td>995</td>
<td>0.88</td>
</tr>
<tr>
<td>Mean acres of non-agricultural land</td>
<td>995</td>
<td>0.19</td>
</tr>
<tr>
<td>Have access to a latrine</td>
<td>918</td>
<td>92</td>
</tr>
<tr>
<td>Have shared access to a latrine</td>
<td>400</td>
<td>44</td>
</tr>
<tr>
<td>Individually owned a latrine</td>
<td>518</td>
<td>56</td>
</tr>
<tr>
<td>Source of water for drinking</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Shallow tube well</td>
<td>805</td>
<td>81</td>
</tr>
<tr>
<td>Deep tube well</td>
<td>96</td>
<td>10</td>
</tr>
<tr>
<td>Individually owned source of drinking water</td>
<td>306</td>
<td>31</td>
</tr>
<tr>
<td>Cooking Fuel</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Wood</td>
<td>249</td>
<td>25</td>
</tr>
<tr>
<td>Crop residue/grass</td>
<td>611</td>
<td>61</td>
</tr>
<tr>
<td>Dung</td>
<td>127</td>
<td>13</td>
</tr>
</tbody>
</table>

†Included to calculate wealth quintile.
Table 5.3: Distribution of latrine characteristics in rural Bangladesh according to different classification of sanitation (N=995).

<table>
<thead>
<tr>
<th>Classification</th>
<th>Sanitation Type</th>
<th>n</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>JMP sanitation technology type</td>
<td>Improved</td>
<td>786</td>
<td>79</td>
</tr>
<tr>
<td></td>
<td>Unimproved</td>
<td>132</td>
<td>13</td>
</tr>
<tr>
<td></td>
<td>No facility</td>
<td>77</td>
<td>8</td>
</tr>
<tr>
<td>Sanitation technology type (Modified JMP)</td>
<td>Improved with a water seal</td>
<td>233</td>
<td>23</td>
</tr>
<tr>
<td></td>
<td>Improved without a water seal</td>
<td>553</td>
<td>56</td>
</tr>
<tr>
<td></td>
<td>Unimproved</td>
<td>132</td>
<td>13</td>
</tr>
<tr>
<td></td>
<td>No facility</td>
<td>77</td>
<td>8</td>
</tr>
<tr>
<td>JMP sanitation ladder</td>
<td>Private improved</td>
<td>425</td>
<td>43</td>
</tr>
<tr>
<td></td>
<td>Shared improved</td>
<td>361</td>
<td>36</td>
</tr>
<tr>
<td></td>
<td>Unimproved</td>
<td>132</td>
<td>13</td>
</tr>
<tr>
<td></td>
<td>Open defecation</td>
<td>77</td>
<td>8</td>
</tr>
<tr>
<td>MDG sanitation type</td>
<td>Improved</td>
<td>425</td>
<td>43</td>
</tr>
<tr>
<td></td>
<td>Unimproved</td>
<td>570</td>
<td>57</td>
</tr>
</tbody>
</table>
Table 5.4: Univariable relationship between sanitation, water and hygiene related variables and diarrhoea among children < 5 years of age in rural Bangladesh, 2007-2009 (N=26,097)*.

<table>
<thead>
<tr>
<th>Exposure *</th>
<th>No. (%)</th>
<th>No. (%) monthly visits with diarrhoea</th>
<th>PR†</th>
<th>95% CI‡§</th>
<th>P value§</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>monthly visit with this exposure</td>
<td>With exposure</td>
<td>Without exposure</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sanitation type</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Based on technologies (N=24,029)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Improved with a water seal</td>
<td>5,984 (25)</td>
<td>589 (9.8)</td>
<td>589 (9.8)</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Improved without a water seal</td>
<td>14,464 (60)</td>
<td>1,624 (11.2)</td>
<td>589 (9.8)</td>
<td>1.14</td>
<td>0.98, 1.33</td>
</tr>
<tr>
<td>Unimproved</td>
<td>3,581 (14)</td>
<td>397 (11.1)</td>
<td>589 (9.8)</td>
<td>1.16</td>
<td>0.92, 1.46</td>
</tr>
<tr>
<td>JMP technologies (N=24,029)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Improved</td>
<td>20,448 (85)</td>
<td>2,213 (10.8)</td>
<td>2,213 (10.8)</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Unimproved</td>
<td>3,581 (15)</td>
<td>397 (11.09)</td>
<td>2,213 (10.8)</td>
<td>1.05</td>
<td>0.86, 129</td>
</tr>
<tr>
<td>JMP sanitation ladder (N=26,097)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Private improved</td>
<td>11,213 (43)</td>
<td>1,142 (10.2)</td>
<td>1,142 (10.2)</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Shared improved</td>
<td>9,235 (35)</td>
<td>1,071 (11.6)</td>
<td>1,142 (10.2)</td>
<td>1.04</td>
<td>0.93, 1.17</td>
</tr>
<tr>
<td>Unimproved</td>
<td>3,681 (14)</td>
<td>397 (11.1)</td>
<td>1,142 (10.2)</td>
<td>1.07</td>
<td>0.87, 1.33</td>
</tr>
<tr>
<td>Open defecation</td>
<td>2,068 (8)</td>
<td>194 (9.4)</td>
<td>1,142 (10.2)</td>
<td>1.08</td>
<td>0.88, 1.32</td>
</tr>
<tr>
<td>MDG (N=26,097)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Improved</td>
<td>11,213 (43)</td>
<td>1,142 (10.2)</td>
<td>1,142 (10.2)</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Unimproved</td>
<td>14,884 (57)</td>
<td>1,662 (11.2)</td>
<td>1,142 (10.2)</td>
<td>1.05</td>
<td>0.94, 1.18</td>
</tr>
<tr>
<td>Other sanitation variables</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dirty latrine (N=20,448)</td>
<td>12,634 (61)</td>
<td>720 (9.2)</td>
<td>1,493 (11.8)</td>
<td>1.15</td>
<td>1.01, 1.30</td>
</tr>
<tr>
<td>Sharing of latrine (N=24,029)</td>
<td>10,192 (42)</td>
<td>1,190 (11.7)</td>
<td>1,420 (10.3)</td>
<td>1.06</td>
<td>0.96, 1.17</td>
</tr>
</tbody>
</table>
### Child defecation site

<table>
<thead>
<tr>
<th>Description</th>
<th>N</th>
<th>Mean (SD)</th>
<th>Median</th>
<th>Min</th>
<th>Max</th>
<th>OR</th>
<th>CI</th>
</tr>
</thead>
<tbody>
<tr>
<td>In a latrine</td>
<td>3,712 (13)</td>
<td>329 (9.6)</td>
<td>329 (9.55)</td>
<td>0.90</td>
<td>0.66, 1.22</td>
<td>0.49</td>
<td></td>
</tr>
<tr>
<td>In potty/nappy</td>
<td>1,630 (6)</td>
<td>131 (9.0)</td>
<td>329 (9.55)</td>
<td>0.90</td>
<td>0.66, 1.22</td>
<td>0.49</td>
<td></td>
</tr>
<tr>
<td>No specific place (open)</td>
<td>22,501 (81)</td>
<td>2,344 (11.1)</td>
<td>329 (9.55)</td>
<td>1.18</td>
<td>1.03, 1.36</td>
<td>0.02</td>
<td></td>
</tr>
</tbody>
</table>

### Household and child characteristics (N=26,097)

<table>
<thead>
<tr>
<th>Description</th>
<th>N</th>
<th>Mean (SD)</th>
<th>Median</th>
<th>Min</th>
<th>Max</th>
<th>OR</th>
<th>CI</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mother’s education &gt;0 years</td>
<td>19,712 (71)</td>
<td>1,843 (10.1)</td>
<td>961 (12.4)</td>
<td>0.87</td>
<td>0.77, 0.98</td>
<td>0.03</td>
<td></td>
</tr>
<tr>
<td>Father’s Education &gt;0 years</td>
<td>18,185 (65)</td>
<td>1,676 (9.9)</td>
<td>1,128 (12.3)</td>
<td>0.92</td>
<td>0.82, 1.03</td>
<td>0.16</td>
<td></td>
</tr>
<tr>
<td>Presence of water and soap at handwashing station</td>
<td>14,335 (52)</td>
<td>1,392 (10.3)</td>
<td>1,412 (11.2)</td>
<td>0.91</td>
<td>0.82, 1.02</td>
<td>0.12</td>
<td></td>
</tr>
<tr>
<td>Store drinking water in fully covered container</td>
<td>5,938 (21)</td>
<td>516 (9.5)</td>
<td>1,305 (11.2)</td>
<td>0.94</td>
<td>0.84, 1.05</td>
<td>0.25</td>
<td></td>
</tr>
<tr>
<td>Has appropriate solid waste disposal system</td>
<td>845 (3)</td>
<td>66 (8.1)</td>
<td>2,738 (10.8)</td>
<td>0.75</td>
<td>0.63, 0.89</td>
<td>0.001</td>
<td></td>
</tr>
<tr>
<td>Appropriate water drainage system</td>
<td>11,762 (42)</td>
<td>1,081 (9.7)</td>
<td>1,723 (11.5)</td>
<td>0.94</td>
<td>0.82, 1.07</td>
<td>0.32</td>
<td></td>
</tr>
<tr>
<td>Exposed to WATSAN intervention</td>
<td>13,015 (50)</td>
<td>1,418 (10.9)</td>
<td>1,386 (10.6)</td>
<td>1.08</td>
<td>0.78, 1.49</td>
<td>0.63</td>
<td></td>
</tr>
<tr>
<td>Male child</td>
<td>12,687 (49)</td>
<td>1,377 (10.9)</td>
<td>1,427 (10.6)</td>
<td>1.09</td>
<td>1.00, 1.20</td>
<td>0.05</td>
<td></td>
</tr>
<tr>
<td>Number of &lt; 5 child in a house</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1 child &lt;5 years of age</td>
<td>16,994 (65)</td>
<td>1,746 (10.3)</td>
<td></td>
<td>1.05</td>
<td>0.93, 1.20</td>
<td>0.41</td>
<td></td>
</tr>
<tr>
<td>2 child &lt;5 years of age</td>
<td>7,785 (30)</td>
<td>853 (11.0)</td>
<td>1,746 (10.3)</td>
<td>1.09</td>
<td>0.78, 1.53</td>
<td>0.62</td>
<td></td>
</tr>
<tr>
<td>3 child &lt;5 years of age</td>
<td>1,092 (4)</td>
<td>173 (15.8)</td>
<td>1,746 (10.3)</td>
<td>1.94</td>
<td>1.53, 2.47</td>
<td>&lt;0.001</td>
<td></td>
</tr>
<tr>
<td>4 child &lt;5 years of age</td>
<td>226 (1)</td>
<td>32 (14.2)</td>
<td>1,746 (10.3)</td>
<td>1.09</td>
<td>0.98, 1.21</td>
<td>0.12</td>
<td></td>
</tr>
<tr>
<td>Number of &lt; 5 child continuous</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>&gt;1 &lt;5 child in same household</td>
<td>9,103 (35)</td>
<td>1,058 (11.6)</td>
<td>1,746 (10.3)</td>
<td>1.07</td>
<td>0.95, 1.23</td>
<td>0.25</td>
<td></td>
</tr>
<tr>
<td>Age &lt;2 years</td>
<td>9,614 (37)</td>
<td>1,287 (13.4)</td>
<td>1,517 (9.2)</td>
<td>1.43</td>
<td>1.26, 1.63</td>
<td>&lt;0.001</td>
<td></td>
</tr>
<tr>
<td>Year 2 surveillance (vs. Year 1)</td>
<td>13,410 (51)</td>
<td>1,094 (8.2)</td>
<td>1,710 (13.5)</td>
<td>0.61</td>
<td>0.51, 0.71</td>
<td>&lt;0.001</td>
<td></td>
</tr>
<tr>
<td>Month since initiation of surveillance</td>
<td>0.97</td>
<td>0.96, 0.98</td>
<td>&lt;0.001</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>---------------------------------------</td>
<td>------</td>
<td>------------</td>
<td>--------</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Exclusive breast feeding last 24 hours (N=8,889)</td>
<td>904 (10)</td>
<td>114 (12.6)</td>
<td>1,079 (13.5)</td>
<td>0.92</td>
<td>0.72, 1.17</td>
<td>0.50</td>
<td></td>
</tr>
<tr>
<td>Wealth index quintile</td>
<td>0.01</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Poorest</td>
<td>5,232 (20)</td>
<td>562 (10.7)</td>
<td>562 (10.7)</td>
<td>1.0</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lower middle</td>
<td>5,221 (20)</td>
<td>725 (13.9)</td>
<td>562 (10.7)</td>
<td>1.15</td>
<td>0.95, 1.38</td>
<td>0.15</td>
<td></td>
</tr>
<tr>
<td>Middle</td>
<td>5,220 (20)</td>
<td>588 (11.3)</td>
<td>562 (10.7)</td>
<td>1.07</td>
<td>0.89, 1.27</td>
<td>0.45</td>
<td></td>
</tr>
<tr>
<td>Upper middle</td>
<td>5,222 (20)</td>
<td>445 (8.5)</td>
<td>562 (10.7)</td>
<td>0.85</td>
<td>0.72, 1.01</td>
<td>0.07</td>
<td></td>
</tr>
<tr>
<td>Richest</td>
<td>5,202 (20)</td>
<td>448 (9.3)</td>
<td>562 (10.7)</td>
<td>0.95</td>
<td>0.77, 1.16</td>
<td>0.59</td>
<td></td>
</tr>
</tbody>
</table>

*Some variable has different denominators. In those cases denominators are presented next to the name of the variable in column 1.
†Prevalence Ratio
‡95% Confidence Interval
§Adjusting for clustering at village level
|| Water Sanitation and Hygiene intervention
Table 5.5: Multivariable relationship between sanitation, water and hygiene related variables and diarrhoea among children under 5 years of age in rural Bangladesh 2007-2009 (N=26,097).

<table>
<thead>
<tr>
<th>Exposure*</th>
<th>Crude† prevalence ratio (95% confidence interval)</th>
<th>P value†</th>
<th>Adjusted‡ prevalence ratio (95% confidence interval)</th>
<th>P value‡</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Sanitation type: technologies‡§ (N=24,029)</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Improved with a water seal</td>
<td>1</td>
<td>1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Improved without a water seal</td>
<td>1.14 (0.98, 1.33)</td>
<td>0.09</td>
<td>1.11 (0.94, 1.30)</td>
<td>0.21</td>
</tr>
<tr>
<td>Unimproved: Pit latrine without slab/hanging latrine</td>
<td>1.16 (0.92, 1.46)</td>
<td>0.21</td>
<td>1.10 (0.86, 1.40)</td>
<td>0.46</td>
</tr>
<tr>
<td>Sharing a latrine (Vs non-shared latrines)</td>
<td>1.06 (0.96, 1.117)</td>
<td>0.27</td>
<td>1.05 (0.95, 1.16)</td>
<td>0.35</td>
</tr>
<tr>
<td>Male child (Vs female child)</td>
<td>1.09 (1.00, 1.20)</td>
<td>0.05</td>
<td>1.11 (1.01, 1.21)</td>
<td><strong>0.04</strong></td>
</tr>
<tr>
<td>&lt;2 years of age (Vs 2 years and above)</td>
<td>1.43 (1.26, 1.63)</td>
<td>&lt;0.001</td>
<td>1.42 (1.25, 1.62)</td>
<td><strong>&lt;0.001</strong></td>
</tr>
<tr>
<td>Presence water and soap at handwashing station (Vs no soap and/or water)</td>
<td>0.91 (0.82, 1.02)</td>
<td>0.12</td>
<td>0.95 (0.84, 1.07)</td>
<td>0.38</td>
</tr>
<tr>
<td>Has appropriate solid waste disposal system (Vs no solid waste disposal system)</td>
<td>0.75 (0.63, 0.89)</td>
<td>0.001</td>
<td>0.78 (0.65, 0.95)</td>
<td><strong>0.01</strong></td>
</tr>
<tr>
<td>Mother’s education &gt;0 years (s any formal education)</td>
<td>0.87 (0.77, 0.98)</td>
<td>0.03</td>
<td>91 (79, 1.03)</td>
<td>0.15</td>
</tr>
<tr>
<td><strong>Wealth index quintile</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Poorest</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lower middle</td>
<td>1.15 (0.95, 1.38)</td>
<td>0.15</td>
<td>1.15 (0.94, 1.40)</td>
<td>0.19</td>
</tr>
<tr>
<td>Middle</td>
<td>1.07 (0.89, 1.27)</td>
<td>0.45</td>
<td>1.08 (0.89, 1.31)</td>
<td>0.42</td>
</tr>
<tr>
<td>Upper middle</td>
<td>0.85 (0.72, 1.01)</td>
<td>0.07</td>
<td>0.89 (0.72, 1.09)</td>
<td>0.25</td>
</tr>
<tr>
<td>Richest</td>
<td>0.95 (0.77, 1.16)</td>
<td>0.59</td>
<td>1.04 (0.80, 1.35)</td>
<td>0.79</td>
</tr>
<tr>
<td><strong>Sanitation type: JMP technology‡§ (N=24,097)</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Unimproved technology (vs. Improved technology)</td>
<td>1.05 (0.86, 1.29)</td>
<td>0.61</td>
<td>1.01 (0.82, 1.25)</td>
<td>0.89</td>
</tr>
</tbody>
</table>
### Sanitation type: JMP sanitation ladder (N=26,097)

<table>
<thead>
<tr>
<th>Sanitation Type</th>
<th>Prevalence Ratio</th>
<th>p Value</th>
<th>95% CI</th>
<th>Odds Ratio</th>
<th>p Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Private Improved</td>
<td>1</td>
<td></td>
<td>1</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Shared Improved</td>
<td>1.04 (0.93, 1.17)</td>
<td>0.476</td>
<td>1.01 (0.90, 1.13)</td>
<td>0.90</td>
<td></td>
</tr>
<tr>
<td>Unimproved</td>
<td>1.07 (0.87, 1.33)</td>
<td>0.514</td>
<td>1.001 (0.80, 1.25)</td>
<td>0.99</td>
<td></td>
</tr>
<tr>
<td>Open defecation</td>
<td>1.08 (0.88, 1.32)</td>
<td>0.469</td>
<td>1.00 (0.81, 1.23)</td>
<td>0.98</td>
<td></td>
</tr>
</tbody>
</table>

### Sanitation type: MDG (N=26,097)

<table>
<thead>
<tr>
<th>Sanitation Type</th>
<th>Prevalence Ratio</th>
<th>p Value</th>
<th>95% CI</th>
<th>Odds Ratio</th>
<th>p Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Unimproved sanitation (vs. private improved sanitation)</td>
<td>1.05 (0.94, 1.18)</td>
<td>0.377</td>
<td>1.00 (0.89, 1.13)</td>
<td>0.94</td>
<td></td>
</tr>
</tbody>
</table>

* Among households that has access to any latrine.
† Adjusting for clustering at village level. P value for comparing prevalence of diarrhoea among households grouped according to different household characteristics.
‡ Adjusting for clustering at village level and all the other variable presented in the table
§ Separate multivariate model for each classification of sanitation as primary exposure variable.
Table 5.6: Multivariable relationship between sanitation, water and hygiene related variables and diarrhoea among children under 5 years of age, restricted to household with access to improved technology as defined by JMP (N=20,448).

<table>
<thead>
<tr>
<th>Exposure</th>
<th>Crude prevalence ratio (95% confidence interval)</th>
<th>P value*</th>
<th>Adjusted prevalence ratio (95% confidence interval)</th>
<th>P value†</th>
</tr>
</thead>
<tbody>
<tr>
<td>Improved latrine with water seal (vs. latrine without water seal)</td>
<td>1.16 (0.99, 1.35)</td>
<td>0.06</td>
<td>1.09 (0.92, 1.29)</td>
<td>0.33</td>
</tr>
<tr>
<td>Shared improved latrine (vs. Private improved latrine)</td>
<td>1.04 (0.93, 1.18)</td>
<td>0.46</td>
<td>1.00 (0.89, 1.13)</td>
<td>0.94</td>
</tr>
<tr>
<td>Dirty latrine (Vs clean latrine)</td>
<td>1.15 (1.01, 1.30)</td>
<td>0.04</td>
<td>1.09 (0.96, 1.25)</td>
<td>0.20</td>
</tr>
<tr>
<td>Male child (Vs female child)</td>
<td>1.13 (1.02, 1.25)</td>
<td>0.02</td>
<td>1.12 (1.01, 1.24)</td>
<td>0.03</td>
</tr>
<tr>
<td>&lt;2 years of age (Vs 2-5 years of age)</td>
<td>1.44 (1.25, 1.66)</td>
<td>&lt;0.001</td>
<td>1.45 (1.26, 1.67)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Presence of water and soap at handwashing station (Vs absence of sop and/or water)</td>
<td>0.93 (0.81, 1.05)</td>
<td>0.24</td>
<td>0.94 (0.83, 1.07)</td>
<td>0.35</td>
</tr>
<tr>
<td>Has appropriate solid waste disposal system (Vs no solid waste disposal)</td>
<td>0.71 (0.59, 0.86)</td>
<td>0.001</td>
<td>0.71 (0.58, 0.87)</td>
<td>0.001</td>
</tr>
<tr>
<td>Mother’s education &gt;0 years (Vs any formal education)</td>
<td>0.89 (0.74, 0.99)</td>
<td>0.04</td>
<td>0.89 (0.76, 1.04)</td>
<td>0.14</td>
</tr>
<tr>
<td>Wealth index quintile</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Poorest</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lower middle</td>
<td>1.13 (0.92, 1.39)</td>
<td>0.25</td>
<td>1.14 (0.92, 1.41)</td>
<td>0.24</td>
</tr>
<tr>
<td>Middle</td>
<td>1.07 (0.87, 1.29)</td>
<td>0.55</td>
<td>1.12 (0.92, 1.38)</td>
<td>0.25</td>
</tr>
<tr>
<td>Upper middle</td>
<td>0.83 (0.67, 1.01)</td>
<td>0.07</td>
<td>0.90 (0.72, 1.13)</td>
<td>0.37</td>
</tr>
<tr>
<td>Richest</td>
<td>0.94 (0.76, 1.18)</td>
<td>0.61</td>
<td>1.04 (0.79, 1.37)</td>
<td>0.78</td>
</tr>
</tbody>
</table>

*Adjusting for clustering at village level using generalised estimating equation (GEE) [51] with a robust standard error estimator with the village as the cluster variable
† Adjusting for clustering at village level and all the other variable presented in the table
Chapter 6: Discussion

This chapter summarizes the key findings, discusses strengths and limitations, explains how this research has contributed to the knowledge base in the sector and considers the implications for policy and future research.

The aim of the study was to further our understanding of the importance of sanitation quality and coverage, in protecting health. A cross sectional study to assess the association between sanitation quality and microbiological faecal contamination of households was conducted. To explore the effect of neighbourhood sanitation coverage on faecal contamination of the household environment sanitation coverage among neighbouring households within 20 metres of a target household we measured. An analysis to assess the relationship between type of sanitation facility and childhood diarrhoea using secondary data from a health impact evaluation was conducted. In carrying out this study the issue of identifying feasible and valid indicators of faecal contamination had to be confronted. Following a pilot of several methods contamination of sentinel toys and children’s hands by indicator organisms as indicators of household faecal contamination was ultimately used. The thesis thus additionally contributes to the knowledge base relating to what type of microbiological indicator and site should be considered in measuring household faecal contamination in the rural low-income country context.

International monitoring of sanitation helps to understand needs of countries, informs policy and facilitates implementation of policies to improve services. Worldwide there is a wide variety of sanitation facilities [1]. This variation can affect not only user experience but also the extent to which faeces are contained and contamination prevented [2-5]. For international monitoring of sanitation this variation is a challenge. The WHO/UNICEF Joint monitoring Programme (JMP) categorizes sanitation facilities as improved and unimproved based on the technology used by the household. For the Millennium Development Goal (MDG) target related to sanitation, shared facilities are considered unimproved regardless of the sanitation category [6, 7]. Now that the MDG era is coming to an end the
related indicators and definitions are being modified for monitoring progress towards the post 2015 Sustainable Development Goals (SDGs). There is discussion about whether to consider improved but shared sanitation categories as improved facilities for the SDG target if the facility is shared by a limited number of households (five households or 30 people). Ideally, for international monitoring sanitation would be classified on the basis of evidence for its relative effectiveness in isolating human excreta from the environment and delivering health benefits, but this evidence base is weak.

Sanitation quality was classified using a variety of existing definitions used for international monitoring, as the intention was also to comment on the public health significance of these definitions. To define sanitation quality, four different definitions of sanitation were used that considered the technology categorisation and number of households using the facility. The categorisation included: a) JMP technology classification of ‘improved’ and ‘unimproved’; b) segregated JMP improved technology classification of ‘improved with water seal’ and ‘improved without water seal’; c) JMP sanitation ladder with four groups including ‘private improved’ ‘shared improved’ ‘unimproved’ and ‘open defecation’; and d) Binary MDG classification of ‘private improved’ and ‘unimproved’ (Figure 6.1) [6, 7].

6.1 Key findings

Households with flush or pour flush latrines connected to pits or tanks and households with basic pit latrines with slabs (JMP improved) had no less faecal contamination than those with poorer quality latrines (JMP unimproved). However, households with private (not shared) flush or pour flush latrines connected to pits or tanks or with private pit latrines with slabs had somewhat lower levels of contamination than households with access to poorer quality and/or shared sanitation, independent of potentially confounding household characteristics.

Increasing neighbourhood coverage with good quality (JMP improved) sanitation (flush or pour flush latrines connected to pits or tanks or basic pit latrines with slabs) or good quality (JMP improved), private sanitation was not associated with a decrease in faecal contamination in target households.
Other household characteristics that were associated with higher levels of faecal contamination on sentinel toys included cleanliness of latrine, presence of animal faeces, having a mother with no formal education, lacking an appropriate water drainage system and study site. Contamination of children’s hands was associated with visible cleanliness of hands and child’s activity prior to sample collection. However contamination of children’s hands was not associated with any of the variables related to sanitation (household sanitation access or coverage in the neighbourhood).

There was no association between sanitation characteristics (either technology or sharing) and diarrhoea prevalence in children less than five years of age.

Other household characteristics that were associated with lower diarrhoea prevalence included having a mother with any formal education, and having an appropriate solid waste disposal system.

6.2 Interpretations of key findings

In this rural context, with multiple source of household faecal contamination, variation in sanitation infrastructure did not explain variation in faecal contamination or diarrhoeal disease. Neighbourhood level sanitation coverage was not found to be an important determinant of household faecal contamination. Private use and cleanliness of latrine was associated with lower faecal contamination. But these factors were not associated with any reduction in the prevalence of diarrhoeal disease. Taken together these findings suggest that onsite sanitation access may have limited effect in hygienically separating human faeces from human contact and thereby reducing transmission of diarrhoea-causing enteric pathogens. There may be several possible explanations for limited effectiveness of sanitation access. First, there may be other sanitation-related factors (such as cleanliness of latrine, presence of water seal and safe child’s faeces disposal) that are necessary in hygienically separating human excreta from human contact and reducing transmission of diarrhoea-causing enteric pathogens. Second, ensuring separation of human excreta from human contact at household level is not sufficient in reducing
transmission of diarrhoea causing enteric pathogens. Other routes of transmission like food, drinking water and hands may need to be targeted simultaneously. In addition nutritional status may also need to be improved. Third, it also possible that the measure of household faecal contamination used in the study is not a good indicator of the reduction in household faecal contamination associated with sanitation.

The reason access to improved (JMP) sanitation is not associated with reduced faecal contamination and diarrhoea is possibly because firstly, access to sanitation alone is not sufficient to separate human faeces from human contact. In this study, even access to sanitation facilities with a water seal was no better at reducing faecal contamination and diarrhoea compared to improved sanitation facilities without water seal. Presence of a water seal may prevent flies from breeding within the latrine and may reduce fly numbers and thereby provide protection from one route of faecal contamination within household environment [8]. This may provide additional evidence that provision of sanitation infrastructure may not be enough to prevent household faecal contamination and diarrhoea. The limited impact of provision of improved (JMP) sanitation on faecal contamination and diarrhoea found in this study is supported by a recent study that presents a pooled estimate of Demographic and Health Surveys (DHS) conducted between 2003 and 2013 [9], though in contrast, a study conducted in Indonesia found improved sanitation (JMP) to be protective against diarrhoea [10]. But the inconsistency in the findings could be due to difference in country context [9] or due to variation in important confounders such as soap use for handwashing and water quality.

Similarly, a study conducted in Kenya found access to improved (JMP) sanitation to be associated with reduction in faecal contamination of hand contact surfaces within the toilet but the same study found the level of faecal contamination in the toilet was not correlated with faecal contamination of household surfaces [11]. In this study, household faecal contamination was measured using the sentinel toy method, which is more likely to capture the contamination within the household rather than the latrine.

There may be several sources of household faecal contamination, such as poor cleanliness of the toilet, poor maintenance of facility, unsafe disposal of
children’s faeces [11, 12] that access to good quality sanitation alone cannot prevent. In this study, private use was associated with lower contamination of sentinel toys, even after adjusting for the effect of wealth, mother’s education, presence of animal faeces, presence of appropriate water and solid waste disposal system, visible cleanliness of hands and nail (proxy for hand hygiene), study site and time of data collection, among others. Findings from observational studies suggest that washing hands with soap is effective in removing microorganisms from hands [39, 70-72] and therefore an important determinant of household faecal contamination. In this study presence of soap and water at a handwashing station was not associated with faecal contamination of toy ball in the univariable analysis. So this was not included as a potential confounder to be included in the multivariable analysis. But since visible cleanliness of hand was associated with faecal contamination of hand, this was used a proxy for hand hygiene and included in the multivariable analysis as a potential confounder. However, in this observational study we cannot exclude the possibility that there may be residual confounding due to unmeasured household characteristics (such as general cleanliness of the household, family members attitude and practices towards cleanliness of the household, general hygiene practices of the household members) that may influence faecal contamination. These factors are difficult to measure but may be important predictors of household faecal contamination.

In this study lower faecal contamination of the toy ball was also associated with absence of animal faeces, mother’s education, and presence of appropriate water drainage and study site. In this study wealth was associated with lower faecal contamination of the toy ball in the unadjusted analysis, so it is an important confounder. Therefore wealth was included in the multivariate analysis to adjust or its effect. But Faecal contamination of the household environment is actually influenced by underlying, unmeasured, broader, social, economical, cultural and environmental differences [30, 73]. The confounding factors considered here are only proxy for these underlying unmeasured broader factors. It is possible that access to an improved latrine and absence of animal faeces, mother’s education, and presence of appropriate water drainage are all proxy measures of these unmeasured
differences and hence associated with faecal contamination. A two-arm, randomised, controlled trial in which households in one arm receive improved sanitation with private use and households in the other arm receive improved sanitation with shared use, could help better understand this issue.

Sharing a latrine may have a harmful effect due to issues related to cleanliness, maintenance, over use or lack of fulltime access. Moreover cleanliness of latrine was also associated with lower contamination of sentinel toys. In this study, sanitation access (exposure) was measured prior to outcome (faecal contamination) measurement so reverse causality is less likely to be an issue. Nonetheless the findings suggest that these factors related to maintenance and use of sanitation facilities, may be important in hygienically separating human faeces from human contact. These factors were also found to be important predictors of diarrhoea in previous studies [2, 3, 13-16].

Although in this study private use and cleanliness of latrine were associated with reduction in faecal contamination, these factors were not associated with reduced diarrhoea prevalence. This may be because the faecal contamination and health outcome studies were conducted in slightly different settings and at different times. Therefore some of the difference in effect could be due to social, cultural and environmental differences between the study site and time, as observed in previous studies of sanitation [9, 16]. Moreover, the inconsistency could be due to the degree of measurement error in assessing sanitation. Depending on the degree of measurement error, the misclassification bias would lead to underestimation of the effect of sanitation on faecal contamination or diarrhoea. In addition, the indicator organisms are only weakly associated with presence of enteric pathogens [17, 18]. As a result, presence of indicator organisms is likely to be weakly associated with diarrhoea disease. Moreover in the context of this study, the population is likely to develop some degree of immunity to common circulating enteric pathogens. This may attenuate the relationship between microbiological indicators of faecal contamination and diarrhoea [19]. Therefore, even if sanitation may be associated with contamination by indicator organisms, it may not be associated with diarrhoea. It is possible that in this context none of these factors are sufficient alone to prevent
faecal contamination to a degree that would prevent diarrhoea. Maybe a combination of these factors is necessary. In a previous study conducted in Bangladesh it was found that households that had access to sanitation facilities with a water seal and had no visible faeces in the premises had lower level of household faecal contamination [20].

The second reason for the limited effect of sanitation access may be that in this setting other routes of transmission are more important. In similar setting microbiological quality of drinking water was associated with diarrhoea [21]. Furthermore, in a recent systematic review it was found that intervention to improve water quality at point of use may reduce diarrhoea by at least around a quarter [22]. In the study presented in chapter five, presence of soap and water was associated with small and statistically insignificant reduction in diarrhoea. But evidence from a recent systematic review suggests that handwashing promotion among communities in low and middle income countries (LMICs) prevents around one-quarter of diarrhoea episodes [23]. Exclusive breast feeding has been recommended as an important diarrhoea prevention strategy [24-26]. Malnutrition has been also identified as important determinant of diarrhoea [27-29] although in the secondary data analysis presented in chapter six data on nutritional status was not included. Take together these findings suggest that in this setting, diarrhoea disease can only be prevented by interventions that address more than one transmission pathways. A recent study has identified that during the past ten years sanitation or water have only been effective in reducing diarrhoea if they were combined [9]. Further studies to look at the combined effect of these factors on faecal contamination and diarrhoea would be informative.

In this study, household waste disposal was found to be associated with 25% reduction of diarrhoea with limited effect of confounding. This finding is consistent with two previous studies [31, 32]. However the mechanism by which household waste disposal reduces diarrhoeal disease risk is not well known. It is possible that solid waste disposal is a proxy indicator for general cleanliness of the household member and household, which could not be captured in this observational study. Although in the observational study causality could not be established but the
findings highlight the importance of considering factors other than sanitation in reducing transmission of diarrhoea causing enteric pathogens.

The third reason for the limited effect of sanitation on faecal contamination observed in this study could be the choice of measure of household faecal contamination. Toy contamination has been found to be associated with several sanitation-related factors including, household sanitation, presence of animal faeces, cleanliness of children’s hands and presence of an appropriate water drainage system, suggesting that the level of toy ball contamination is likely to be a reasonable proxy of household sanitation and hygiene. Previous studies have also found toy ball contamination to be linked to household sanitation [20, 33, 34]. A reduction in the microbiological contamination levels on toys is a proximal indicator of household contamination that a child may encounter in comparison to other exposure pathways such as surface and fomites. Toy balls might be more directly exposed to the household environment than water. Hands may be a closer indicator of level of contamination that the child may encounter however, hand contamination [35] data are likely to be more variable because of variation in handwashing practices. In this study, hand contamination was not found to be associated with any of the variables related to sanitation, suggesting that random hand contamination may not be a good indicator of household sanitation. Compared to hands, toy balls are less subject to frequent washing. Further studies with experimental study design might help us to better understand the utility of sentinel toys as a proxy for household faecal contamination.

6.3 Strengths and Limitations of the research

In this thesis, access to sanitation was the primary exposure of interest, so it was important to minimize any misclassification of sanitation as improved or unimproved due to error in coding sanitation facilities during data collection. The standard core questionnaire used by the JMP was used to collect data on sanitation status [36]. However there are concerns about reliability of these questions as there are many types of sanitation facilities available [36, 37]. In this study additional questions were added to the survey to cross check functionality of the sanitation
facilities. Moreover prior to the main data collection, the set of questionnaires to assess sanitation access was assessed for Inter-observer reliability. The questions to assess sanitation status were found to be highly reliable in the inter-observer reliability study. In addition extensive training on coding of sanitation with several field practices was provided, to ensure that all the data collectors could code the latrines correctly and reliably across different households. During the data collection, the principal investigator (Tarique Huda) and the field supervisors observed the data collection process in a random selection of at least 5% of households (6 HH per village) and conducted repeat spot-check in a (different) random selection of 5% of households (6 HH per village), to cross-check the coding of latrines extensively.

An important limitation of this study was the use of faecal indicator bacteria (FIB) to assess faecal contamination because presence of FIB may not be correlated with presence of viruses that may originate in human faeces. But presence of Clophilages indicate the presence of enteric viruses, and Clostridium perfringens, an obligate anaerobe, indicates presence of parasitic protozoan and enteric viruses [38]. So may be monitoring a suite of indicator organisms is more likely to be predictive of risk to human health.

Another important limitation of using FIB is that, FIB may have non-human origin and does not necessarily signify risks to human health [39-42] [43-46]. In a cross-sectional study conducted in India assessed faecal exposure via community water sources (N = 123) and in the home (N = 137) using human- and nonhuman-associated Bacteroidales microbial source tracking (MST) markers and faecal coliforms (FCs). Animal faecal markers were widely detected in both public and domestic domains, indicating ubiquitous risks of exposure to animal faeces and Zoonotic pathogens [47]. This makes presence of FIB bacteria an imprecise outcome indicator for sanitation. As a consequence the confidence intervals of the estimates becomes wider, making the results less likely to be statistically significant even if a true difference exists [48]. A range of microbial source tracking (MST) methods (genotypic, phenotypic, and chemical) are available that can be used to identify human/non-human sources of faecal pollution in the household environment [39,
40, 42, 49-52]. But MST methods are time consuming, labour-intensive, and expensive (require costly laboratory equipment) [53]. As a result this may have limited feasibility in assessing the impact of large scale sanitation/hygiene programme in low income country context.

[20]

It is possible that the overall level of faecal coliforms on the toy balls and hands might represent faecal coliforms originating from both human and animal faeces. Nevertheless in this study presence of faecal coliforms was associated with lack of access to flush latrine and inadequate latrine cleanliness (Chapter 3) after adjusting for the effect of presence of animal faeces, consistent with findings from similar settings [54]. There is evidence from small-scale observational studies suggesting that presence of FIB on hands and toys may be associated with household sanitation [42, 55-64]. Although our estimates may not represent the true contribution of sanitation in reducing human faecal contamination of toy balls, it could give some indication of reduction from overall faecal contamination.

6.4 Policy implications of the research

Based on the findings of this observational study conducted in rural areas in which diarrhoea is endemic, no conclusive recommendation regarding changes to policy in relation to classification of sanitation used for international monitoring can be provided.

Nevertheless, findings from observational study presented in this thesis add to the evidence base that does not support the inclusion of shared facilities as ‘improved’. Although in this study sharing a latrine was not associated with additional risk of diarrhoea, the shared latrines were found to be dirtier than individual latrines and associated with higher faecal coliform contamination. This suggests that even in a context in which a sanitation facility is shared among extended families or among acquaintances, there may still be concerns related to maintenance and use. Further research needs to be undertaken to understand the context in which shared sanitation is safe before considering shared sanitation as improved for international monitoring.
Apart from concerns related to health risk there other factors related to privacy and access, particularly for women and young children that also need to be considered. For example, in rural areas of Bangladesh families sharing the facilities may not have shared ownership. As a result, non owning families may not have continuous access to the latrine. But this scenario may be different for shared urban toilets in rented houses or public toilets. Sharing may have different implication in rural and urban areas, even if it is shared by families who know each other. For example, sharing a latrine among families that are renting their house in urban areas may have different level of access compared to household who share a latrine owned by an extended family member.

For the MDGs the definition of ‘improved sanitation’ focused on the provision of hardware. In the study reported here a limited effect of sanitation infrastructure on faecal contamination of the household environment was found. This may suggest that other sanitation, related factors such as maintenance of sanitation facility, use by all household members including children and faecal sludge management should be considered if intervention to improve sanitation is expected to provide maximum reduction in health risk.

Future interventions to prevent diarrhoea may need to target additional transmission routes such as food, water and hands.

The current sets of questions in national surveys to collect information on sanitation do not include questions to elucidate whether there is leakage in the latrine pit/tank. Therefore, future questions on sanitation could include the option for visual inspection of sanitation facility to collect detailed information on the sanitation infrastructure in order to minimise measurement error.

6.5 Conclusions

The experience of working towards achieving the Millennium Development Goals (MDG) related to sanitation have provided the international community with an opportunity to generate important knowledge regarding the strength and limitations of defining and monitoring access to sanitation. Now that the world has
adopted the Sustainable Development Goals (SDG), evidence-based changes in the definition of improved sanitation will shape how low income countries improve the health of their populations by ensuring adequate sanitation. The findings of this thesis provide further evidence of limited effectiveness of sanitation infrastructure in reducing household faecal contamination and diarrhoea in contexts in which diarrhoea is endemic. The thesis provides further evidence that contamination of study-introduced toy balls could be used as a proxy indicator of household faecal contamination if found to be associated with health outcome in future studies. The findings of this thesis also add to existing knowledge by providing evidence of the potential adverse effects of access to shared sanitation on household faecal contamination in the context of rural areas in which latrines are shared among neighbours or acquaintances. Although this thesis has important limitations (such as using faecal indicator bacteria which are likely to be an imprecise measure of human faecal contamination as primary outcome) in the absence of convincing evidence that shared sanitation provides similar protection to individual latrines, shared facilities can only be considered improved if issues with maintenance can be tackled effectively. More research needs to be undertaken to understand the challenges of ensuring hygienic sanitation for un-served and underserved population, how to address these challenges. We also need to increase research efforts to integrate sanitation, water quality, handwashing and nutritional interventions and to understand better ways to monitor the impact of these interventions on ensuring better health and quality of life.
6.6 References


21. Luby, S.P., et al. Microbiological contamination of drinking water associated with subsequent child diarrhoea. 2015 (Accepted for publication, Undergoing revision ).
52. Mattioli, M.C., et al., *Enteric pathogens in stored drinking water and on caregiver’s hands in Tanzanian households with and without reported cases of child diarrhea*. PLoS ONE, 2014. 9(1).


Figure 6.1: Comparing classification of sanitation used for international monitoring. Note: JMP classification does not consider sharing status but for all the other definition sharing by different number of households are considered in the definition. For the classification 2, 3 and 4 some of the shared facilities are also considered to be unimproved even if the toilet is of improved technology. * The WHO/UNICEF Joint monitoring Programme (JMP) for water supply and sanitation, † Millennium Development Goal definition related to sanitation, ‡ Sustainable Development Goal definition of sanitation

<table>
<thead>
<tr>
<th>No. of Using (HH)</th>
<th>1 Household</th>
<th>2-5 HHs</th>
<th>6 or more HHs</th>
<th>Open defecation</th>
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<tr>
<td>2. JMP* Technology</td>
<td>Private Improved</td>
<td>Shared Improved</td>
<td>Unimproved</td>
<td>Open defecation</td>
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<td></td>
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<td>Defecation in fields, forests, bushes, bodies of water or other open spaces</td>
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<td>3. MDG †</td>
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Improved
- With water seal
  - Flush or pour-flush latrine to:
    o piped sewer system
    o septic tank
    o pit latrine with slab
  - Ventilated Improved pit latrine
  - Composting latrine
- Without water seal
  - Pit latrine with slab

Unimproved
- Flush or pour-flush latrine to:
  o Else where
- Unimproved pit latrines without a slab/platform
- Hanging latrines/Bucket latrines.
- flush or pour-flush latrine to open
- pit latrine with a slab but with a leakage in the pit

Open defecation
- Defecation in fields, forests, bushes, bodies of water or other open spaces
Appendix 1: Search terms used for comprehensive literature review.

### Table 7.1: Search terms and strategy for Embase conducted on 15th October 2015

<table>
<thead>
<tr>
<th>Search strategy</th>
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<tr>
<td>1. Sanitation/ or environmental sanitation/ or sewage/ or sewage disposal/</td>
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<tr>
<td>2. (sanita* or latrine* or toilet* or water closet or privy or sewer* or sewage or septic tank or ((excreta or faeces or feces or stool or faecal or fecal) adj disposal)).ab,ti.</td>
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<td>3. diarrhea/dm, ep, pc or Enterobacteriaceae infection/ or Enterobacteriaceae/</td>
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<td>4. (diarrh<em>ea or diarrh</em>eal disease* or waterborne infection* or waterborne illness* or dysenter* or cholera or shigell* or cryptosporid* or salmonell* or escherichia or campylobacter or cyclospor* or giardia* or rotavirus).ab,ti.</td>
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<tr>
<td>5. Microbial contamination/ or bacterium contamination/ or enterobacteriaceae/ or coliform bacterium/ or faecal coliform/ or Escherichia coli/ or Streptococcus/ or Enterococcus/ or enterococcaceae/</td>
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<td>6. (((micro* or bacteria* or environment* or fecal or faecal or household or domestic or home or water or hand or floor or surface or soil or toy or produce) adj3 (contamina* or pollut* or hygiene)) or (water adj3 quality) or ((fecal or faecal or total or thermotolerant) adj3 coliform) or Escherichia coli or E coli or streptococ* or enterococ* or Enterobacteriaceae or heterotrophic plate count bacteria).ab,ti.</td>
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<tr>
<td>7. (quality or coverage or type or ladder or level or commun* or categor* or neighbourhood or neighborhood).ab,ti.</td>
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<tr>
<td>8. ((sanita* or latrine* or toilet* or water closet or privy or sewer* or sewage or septic tank or ((excreta or faeces or feces or stool or faecal or fecal) adj disposal)) adj (quality or improv* or hygienic or coverage or type or ladder or level or commun* or categor* or neighbourhood or neighborhood)).ab,ti.</td>
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<tr>
<td>9. ((quality or improv* or hygienic or coverage or type or ladder or level or commun* or categor* or neighbourhood or neighborhood) adj (sanita* or latrine* or toilet* or water closet or privy or sewer* or sewage or septic tank or ((excreta or faeces or feces or stool or faecal or fecal) adj disposal))).ab,ti.</td>
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<td>10. (1 or 2) and (3 or 4)</td>
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<td>14. JMP.mp.</td>
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Appendix 2: Consent form and guideline for 3 hours observation

Informed consent form for 3 hours semi-structured observation

Project title: Role of sanitation in preventing contamination of the domestic environment and protecting health.

Investigator: Tarique Md. Nurul Huda

Part I: Information Sheet

Introduction

Hello (Assalamualaikum/Nomoshkar). My name is ________ and I work with the ICDDR,B (Cholera Hospital) in Dhaka. I am here to invite you to take part in a research study. You are free to decide whether or not to be in the study.

Purpose of the research:

The purpose of the study is to understand, whether latrine quality is linked with household environmental contamination. This will help us understand how to improve health of under-5 children.

Procedure:

We are interested in the health of <5 children. Because you have a child under the age of 5, we would like to invite you to participate in this study. If you agree to participate in the study I will observe the activities of your child <5. I will also observe your general household activities. I will spend 3 hours in your household. I will stay in your household from 9 AM-11 AM. During the observation, you can carry on your usual daily routine, as if I was not present. I will not obstruct any of your daily activities. I also wish to ask you for the permission to take pictures. I might take pictures of different activities within your household. I will show you the pictures. If you agree, these pictures might be used as illustration of my observations in future presentations. If you do not want your face to be visible on the pictures, I will blur your face. This way nobody will be able to recognize you. I will also take some notes on paper.

Benefits:

There is no immediate benefit to you from this study. The study will help us better understand conditions in Bangladesh. This information may help to improve child health in future.

Costs and Compensation:

There is no cost to you for being in this study. You will not receive anything for being in the study.

Risks:

There is no risk from being in the study. We will only collect information. My presence in your home for several hours may be uncomfortable for you. But we do not expect any harm to come to you or your family because of the study.
Privacy:

We assure that the privacy of information identifying you will be strictly maintained. The information identifying you will only be accessible to me, my research team, the ethical Review Committee. Any information that is gathered about you and your family will be kept anonymous. All paper documents will be kept in a locked cabinet at ICDDR,B. The research team will have sole access to the locked cabinet. All digital data with personal identifiers will be maintained on secure systems protected by passwords. Your name and identity will not be used in reporting and presenting study findings, or in their publication in journals. We will use the information only for the purpose of research. In case of future use of the information collected from the study anonymous information may be supplied to other researchers. But this will not compromise with your privacy and anonymity.

Voluntary participation:

You are free to decide whether or not to be in the study. You are free to leave the study at any time. You do not have to give any reason for leaving the study. You will not lose any benefits for leaving the study. If you do take part in the study, you are free to refuse to answer any question. You do not have to give any reason for refusing to answer any questions.

Persons to Contact

If you have any question about this research study you may contact Mr. Tarique Md. Nurul Huda (Study Coordinator). His mobile number is 01772362311. His office number is 988-1761.

If you have questions about your right in the study, you may call Mr. M A Salam Khan, Committee coordination secretariat at 9886498. His office is located at 68, Shaheed Tajuddin Ahmed Sarani Mohakhali, Dhaka 1212.

Part II: Consent Form

The nature of the study has been explained to me. I have had the opportunity to ask questions about it. I understand what will be required of me and what will happen to me, if I take part. I understand that my participation in this study is voluntary. I understand that I do not have to answer any questions if I do not want. I understand that I can leave the study freely at any time. I understand that these conditions also apply to any children for whom I give consent to participate in the study. I do agree to quotations from my participation in the study to be included anonymously in reports about the study

☐ I agree to participate in the study (tick)

☐ I do agree to quotations from my participation in the study to be included anonymously in reports about the study.

☐ I give my consent for pictures of me and my household facilities to be taken and used.

☐ I give my consent for all household members below the age of 18 years and for whom I am the parent of guardian to participate in the study. (Tick)
Name of the main caregiver

Age _______ Years

_________________________________________  ___________________

Signature of the Investigator or his representative    Date
Observation guideline

**Project title:** Role of sanitation in preventing contamination of the domestic environment and protecting health.

**Objective of the observation:** To understand, where the <5 children are potentially exposed to pathogens that are washed or carried into their environment (Household surfaces /fomite)

Household identification

Date of observation ⏰/🏞/🏞 Time of Starting (24 hrs)⏰:⏰

**Observation:**

1. Get an idea about the setting of the household and compound?
2. Get an idea about the cleanliness of different parts of the household/compound?
3. Get an idea about the daily routine of the child? What the child does in different time of the day?
4. Get an idea about animal movement in the household?
5. Get an idea about the place for different household activities?
6. Observe where the child spends his time? Where does the child go?
7. During different activities (During playing, roaming around) of the child what surfaces come in contact with the child’s hands?
   a. How often?
   b. What is the general cleanliness status of the place/surface?
   c. Where is the place in respect to latrine, tube well
   d. What else happens in that place to get an idea about how clean that place is?
      i. Is it a place for defecation, cleaning, and other household activity?
      ii. Is there animal moving around, presence of animal faeces nearby?
8. During the observation time what objects comes in contact with the child’s hands and mouth?
9. Collect information of the object the child comes in contact/play with
   a. Identify/describe the place/object specifically
   b. How much time the child spends there?
   c. What else comes in contact with that object?
10. Use of cow dung in the households and in the cooking. How is child come in contact with any cow dung?

Time of finishing (24 hrs)⏰:⏰
Appendix 3: Consent form and questionnaire for household questionnaire survey

Informed consent form for Household questionnaire survey

Project title: Role of sanitation in preventing contamination of the domestic environment and protecting health.

Part I: Information Sheet

Introduction

Hello (Assalamualaikum/Nomoshkar). My name is ________ and I work with the ICDDR,B (Cholera Hospital) in Dhaka. I am here to invite you to take part in a research study. You are free to decide whether or not to be in the study.

Purpose of the research:

The purpose of this study is to understand whether latrine quality is linked with household environmental contamination. This will help us understand how to improve health of children.

Procedure:

We are enrolling households with at least one child aged between 6 and 24 months. If you agree to participate in the study I will visit different parts of your household. At the end of observation i will ask some questions about your household routine and practices. It will take around 2 hours. I will also ask about your child’s health. I will take some notes on a tablet computer.

I also wish to ask you for the permission to take pictures. I might take some pictures of different facilities and activities of your household. I will show you the pictures that I will take. If you agree, these pictures might be shown as illustration in future presentations. If you do not want your face to be visible on the pictures I will blur your face, so that nobody can recognize you.

I will ask you to rinse your hands in a liquid of plastic bag. I will also ask your child to rinse his/her hands, similarly in a liquid of plastic bag. I will demonstrate the hand rinse procedure. After that I will take the plastic bags with the hands rinse liquid in it. We will test the hand rinse liquid in a lab. We are interested to see if there is any harmful germ in it.

Today, I will give your child a toy ball to play with. I will leave the ball overnight with your child. Tomorrow, I will come back to your household same time as today. I will rinse the ball in a liquid of plastic bag. After taking the toy rinse liquid I will return the ball to you for your child to keep.

When I return to rinse the ball after 24 hours, I will also ask you some question about what happened to the ball within the last 24 hours.
Benefits:

There is no immediate benefit to you from this study. The study will help us better understand conditions in Bangladesh. This information may help to improve child health in future.

Costs and Compensation:

There is no cost to you for being in this study. You will not receive anything for being in the study.

Risks:

There is no risk from being in the study. We will only collect information. My presence in your home for several hours may be uncomfortable for you. But we do not expect any harm to come to you or your family because of the study.

Privacy:

We assure that the privacy of information identifying you will be strictly maintained. The information identifying you will only be accessible to me, my research team, the ethical Review Committee. Any information that is gathered about you and your family will be kept anonymous. All paper documents will be kept in a locked cabinet at ICDDR,B. The research team will have sole access to the locked cabinet. All digital data with personal identifiers will be maintained on secure systems protected by passwords. Your name and identity will not be used in reporting and presenting study findings, or in their publication in journals. We will use the information only for the purpose of research. In case of future use of the information collected from the study anonymous information may be supplied to other researchers. But this will not compromise with your privacy and anonymity.

Voluntary participation:

You are free to decide whether or not to be in the study. You are free to leave the study at any time. You do not have to give any reason for leaving the study. You will not lose any benefits for leaving the study. If you do take part in the study, you are free to refuse to answer any question. You do not have to give any reason for refusing to answer any questions.

Persons to Contact

If you have any question about this research study you may contact Mr. Tarique Md. Nurul Huda (Study Coordinator). His mobile number is 01772362311. His office number is 988-1761.

If you have questions about your right in the study, you may call Mr. M A Salam Khan, Committee coordination secretariat at 9886498. His office is located at 68, Shaheed Tajuddin Ahmed Sarani Mohakhali, Dhaka 1212.

Part II: Consent Form

The nature of the study has been explained to me. I have had the opportunity to ask questions about it. I understand what will be required of me and what will happen to me, if I take part. I understand that my participation in this study is voluntary. I understand that I do not have to answer any questions if I do not want. I
understand that I can leave the study freely at any time. I understand that these conditions also apply to any children for whom I give consent to participate in the study. I do agree to quotations from my participation in the study to be included anonymously in reports about the study.

☐ I agree to participate in the study (*tick*)

☐ I do agree to quotations from my participation in the study to be included anonymously in reports about the study.

☐ I give my consent for pictures of me and my household facilities to be taken and used.

☐ I give my consent for all household members below the age of 18 years and for whom I am the parent of guardian to participate in the study. (*Tick*)

Name of the main caregiver ________________________________
Age__________Years

________________________________________  _________________
Signature of the Investigator or his representative    Date
HOUSEHOLD CROSS SECTIONAL SURVEY

Project title: Sanitation and faecal contamination of the domestic environment

Note: Ask these questions to the mother or the main caregiver of the child.

[এই প্রশ্নগুলো বাচ্চার মাকে অথবা মূল পরিচারকারীকে জিজ্ঞেস করুন]

PART A: QUESTIONNAIRE

Section 1. Questionnaire identification

1.1 খানা নং (Household ID): ........................................................................................................

(Please follow the specific code sheet)

1.2 ইন্সট্রুমেন্ট টাইপ [Instrument Type] (Code: Cross Sectional Survey=A1): ................................................................. A 1

1.3 ক্লাস্টার নং[Cluster number (starting point number)]: .................................................................

1.4 জেলা নাম এবং কোড (District name & district geocode): .................................................................

1.5 উপজেলা নাম এবং কোড (Upazila name & code): ........................................................................

1.6 ইউনিয়নের নাম (Union name):

1.7 ঠিকানা (Address):

add1 খানা প্রধানের নাম [Name of household head]: ........................................................................

add2 খানা প্রধানের পিতা/শ্বারীর নাম [Father’s/ husband’s name of HH head]: ........................................

add3 বাড়ির নাম [Bari Name]: ............................................................................................................

add4 আমার নাম [Village]: ..................................................................................................................

add5 বাড়ির অবস্থান (নির্দিষ্ট করুন) [Location (specify)]: ........................................................................

1.8 FRA নাম এবং কোড (FRA name & code): ................................................................................

1.9 তথ্য সংগ্রহের তারিখ (Date of data collection): DD/MM/YYYY

1.10 তথ্য সংগ্রহ শুরু সময় (24 N:UV) [Time of Starting (24 hrs)]: HH:MM

1.11 শোভার ঘরের প্রবেশ মুখের জিআইএস কোডিফিনেট নির্দিষ্ট করুন [GIS coordinates of the entrance of the living room].

<table>
<thead>
<tr>
<th>Latitude</th>
<th>Longitude</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Section 2. Respondent and household demographics

2.1 [Name of respondent:] .................................................................

2.2 [Status of main respondent] .........................................................

2.3 (வெளி) [Age of main respondent: (in years) DK=999] ..................

2.4 [Sex of head of household (1=Male, 0=Female)] .........................

2.5 [Is the household head differently able? (1=Yes, 0=No)] ..............

2.6 [Age of household head: (in years) DK=999] .................................

2.7 [Education of mother of the target child (Years of education completed, DK=999)] .............................................

2.8 [Education of father of the target child (Years of education completed, DK=999)] ........................................

2.9 [Main occupation of father of the target] ........................................

Occupation Code:

1. Farmer/Cultivator
2. Homemaker
3. Agri-labor
4. Non-agri labor
5. Salaried job (Govt./Private/NGO)
6. Mason (Rajmistr)
7. Carpenter
8. Van/Rickshaw puller
9. Fisherman
10. Boatman
11. Poultry/livestock rearer
12. Homeopath
13. Spiritual healer/kabiraj/Ojha
14. Professional practitioner (Doctor/lawyer)
15. Imam/priest
16. Retired service holder
17. Student
18. Unemployed
2.10. How many people in total live in your household at present? ...................................................................................................

(Note: Household would be defined as cooking in the same pot regardless of number of living house/room.)

2.11. How many children less than five years old live in your household?

2.11.1 Include the information of the target child first. Then, list rest of the <5 children’s (youngest to old) information. Make sure you also keep a list of the child with the ID in your note book as the ID will be needed later in the questionnaire.

<table>
<thead>
<tr>
<th>A. Child Name</th>
<th>B. Date of birth (DD/MM/YY)</th>
<th>C. Age in months</th>
<th>D. Gender [Male=1] [Female=0]</th>
<th>E. Motor milestone</th>
</tr>
</thead>
<tbody>
<tr>
<td>[Child Name]</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

- Motor milestone:
  0 = Bed mobility
  1 = Can crawl
  2 = Can walk with assistance
  3 = Walk independently

2.11.x Male

2.11.y Female

2.15. [Blacksmith] [Goldsmith] [Potter (soil smith)] [Shoe polisher/maker] [Shopkeeper] [Vendor (Feriwala/hawker)]

2.17. Petty trader (capital <=10000) [Business, capital >10000]

2.19. Tailor [Cottage industry]

32. Domestic maid / servant [Died/untraced] [Labor]

37. Teacher [Staying abroad] [Business, capital >10000]

38. Tribal potters [Teacher] [Died/untraced] [Died/untraced]

39. Business, capital <=10000 [Petty trader, capital <=10000]

40. Tailor [Cottage industry] [Petty trader, capital <=10000] [Teacher] [Died/untraced] [Died/untraced]

41. Husband [Cottage industry] [Petty trader, capital <=10000] [Teacher] [Died/untraced] [Died/untraced]

42. Teacher [Cottage industry] [Petty trader, capital <=10000] [Teacher] [Died/untraced] [Died/untraced]

43. Teacher [Cottage industry] [Petty trader, capital <=10000] [Teacher] [Died/untraced] [Died/untraced]

44. Teacher [Cottage industry] [Petty trader, capital <=10000] [Teacher] [Died/untraced] [Died/untraced]

45. Teacher [Cottage industry] [Petty trader, capital <=10000] [Teacher] [Died/untraced] [Died/untraced]

46. Teacher [Cottage industry] [Petty trader, capital <=10000] [Teacher] [Died/untraced] [Died/untraced]

47. Teacher [Cottage industry] [Petty trader, capital <=10000] [Teacher] [Died/untraced] [Died/untraced]

48. Teacher [Cottage industry] [Petty trader, capital <=10000] [Teacher] [Died/untraced] [Died/untraced]

49. Teacher [Cottage industry] [Petty trader, capital <=10000] [Teacher] [Died/untraced] [Died/untraced]

50. Teacher [Cottage industry] [Petty trader, capital <=10000] [Teacher] [Died/untraced] [Died/untraced]
Independent walking

1.
2.
3.
4.
5.

2.12 How many households are there in your compound (Bari) (DK=999?)

[(Note: Bari is comprised of a group of usually 5-12 households that share a common courtyard or have linked courtyard and are usually blood relatives.)]

Section 3. Respondent's Hand washing practices

3.1 When do you wash your hands with soap? (This is an open-ended question)

[After noting down the answers of this open-ended question, check appropriate code to the boxes below]

- Yes...1, No...0

3.1.1 Before preparing food

3.1.2 Before eating

3.1.3 After eating

3.1.4 Before feeding a child

3.1.5 After cleaning child's anus

3.1.6 After disposal of child feces

3.1.7 After defecation

3.1.8 After handling cow-dung

3.1.9 After returning from outside compound

3.1.10 After cooking

3.1.11 After dish/crockery washing
3.1.12 After cutting/cleaning fish...
3.1.13 After cleaning yard/household...
3.1.14 After contacting with dirt...
3.1.15 Before serving food...
3.1.16 Never
3.1.777 Others (Specify)

3.2 Do you have soap available for hand washing?

Code: হাজা [Yes] .................1
      না [No] ..........................0
      জানানা [DK] .......................

Skip Note: 3.2 এর উত্তর ০ বা ৯৯৯ হলে ৩.৪ নং প্রশ্নে চলে যান। [If the answer to question 3.2 is 0 or 999 go to question 3.4]

3.3 When do you think it is important to wash hands with soap? Open ended question. Multiple answers are allowed here.

Note: উভয় সত্তিক এখানেই পড়লে অন্যান্য যে জন্য না, উভয় সত্তিক উত্তর বলতে পারে সেভারে তাকে সহায়তা করতে হবে লেখন, আরও কিছু আছে কিনা বা অন্য কিছু ... [Don't read the answer, encourage by asking if there is anything else until he/she mentions there in nothing else and check all mentioned?]

      হাজা [Yes] .................................................1
      না [No] .................................................0

3.4 Before preparing food
3.4.1 Before preparing food
3.4.2 Before eating
3.4.3 After eating
3.4.4 Before feeding a child
3.4.5 After cleaning child’s anus

3.4.6 After disposal of child feces:

3.4.7 After defecation

3.4.8 After handling cow-dung

3.4.9 After returning from outside compound

3.4.10 After cooking

3.4.11 After dish/crockery washing

3.4.12 After cutting/cleaning fish

3.4.13 After cooking yard/household

3.4.14 After contacting with dirt

3.4.15 Before serving food

3.4.16 Others (Specify)

3.5 What have you done in the last half an hour? (Note: Do not read the answers. Probe, anything else? (Multiple answer possible)

1. Prepared food

2. Ate foods

3. Fed the child

4. Cleaned child anus

5. Disposed child’s faeces

6. Defecated

7. Handled cow dung

8. Handled agricultural products/crops

9. Returned from outside compound

10. Washed dishes

11. Cleaned household
12. Handled animals [Handled animals] ...............................................................□
13. Washed clothes [Washed clothes] ........................................................................................................□
777. Other: specify [Other: specify] ...........................................................................................................□

3.6 Did you wash your hand(s) within last half hour? ........................................

  Ḥা [Yes] ........................................1
  না [No]. ..............................0 (3.10-এ ফি কর্ন) [(Skip to question no 3.10)]

3.8 How many time(s) did you wash your hand(s) within last half hour? ....

  1. Right hand ..........................................................................................................................□
  2. Left hand .............................................................................................................................□
  3. Both hands ..........................................................................................................................□

3.9 What did you use to clean hands within last half an hour? (Use the code for

  cleansing agents)]........................................................................................................

  1. Bar soap
  2. Powdered detergent
  3. Only water
  4. Laundry soap
  5. Ash
  6. Mud
  7. Liquid soap
  777. Other (Specify) [Other (Specify)]

3.10 What did your child do within the last half hour? ........................................

  উল্লেখ করেছে [Mentioned] ......................1
  উল্লেখ করেনি [Not mentioned] .............2

  1. Slept
  2. Ate
  3. Played
  4. Defecated

  777. Others (Specify) [Others (Specify)] .................................................................................
3.11 Did he/she wash hand(s) within last half an hour?

[Yes] ..................................................1
[No] ..................................................0
[DK] ................................................999

(Skip to question no 3.10.b)

3.13 How many time(s) did he/she wash hand(s) within last half an hour?

1. Right hand
2. Left hand
3. Both hands

3.14 What did he/she use to clean hands after the following event(s) within last half an hour?

1. Bar soap
2. Powdered detergent
3. Only water
4. Laundry soap
5. Ash
6. Mud
7. Liquid soap
777. Other (Specify)

3.10.b What did the child do since starting of the interview?

[Mentioned] ........................1
[Not mentioned] ...................2

[Slept] .................................
2. খাবার খেয়েছে [Ate] ..............................................................................
3. খেলা করেছে [Played] ..............................................................................
4. মাল্টোগ করেছে [Defecated] ..............................................................................
777. অন্যান্য (লিখুন) [Others (Specify)] .............................................

3.11.b ইন্টারভিউ শুরু করার পর থেকে শিশুটি (টার্গেট শিশু) কি হাত মৌচায় করেছে? [Did he/she wash hand(s) since starting of the interview?]

 hindi [Yes] ..........................................................1

 না [No].........................................................0 (১১.৬ তে যান) [(Skip to question no 11.6)

 জানিনা [DK].................................999 (১১.৬ তে যান) [(Skip to question no 11.6)

3.13.b ইন্টারভিউ শুরু করার পর থেকে শিশুটি (টার্গেট শিশু) কতবার হাত মৌচায় করেছে? [How many time(s) did he/she wash hand(s) since starting of the interview?]

 1. শুধু ডান হাত [Right hand] .................................................................
 2. শুধু বাম হাত [Left hand] .................................................................
 3. উভয় হাত [Both hands] ......................................................................

3.14.b ইন্টারভিউ শুরু করার পর থেকে শিশুটি (টার্গেট শিশু) হাত মৌচায় করার জন্য কি ব্যবহার করেছে? (পরিকারকের কোড ব্যবহার করন) What did he/she use to clean hands after the following event(s) since starting of the interview? (Use the code for the cleansing agents).................................................................

 1. গোসলের সাবান [Bar soap]
 2. ডিস্ট্রাক্টেড ডোঁজা [Powdered detergent]
 3. মস্ত পানি [Only water]
 4. কাপড় থেকে সাবান [Laundry soap]
 5. ছায়া [Ash]
 6. মাটি [Mud]
 7. তরল সাবান [Liquid soap]
 777. অন্যান্য (লিখুন) [Other (Specify)]

11.6 আমি কি (কাছার নাম) হাতগুলো দেখতে পারি? (যদি একই খানাতে ৫ বছরের নীচে একাকী বাচ্চা থাকে এবং তাদের প্রতিটারের তথ্য লিপিবদ্ধ করেন) [May I please look at (Child's name) hands (if more than one under-5 children living in a household than observed and collect information on all of the children <5 )]

 ময়লা স্পটিভাবে দেখা যাচ্ছিল [Visible dirt].................................................................1

 ময়লা স্পটিভাবে দেখা না গেল অপরিচিতক্রান্ত ছিল [Unclean appearance] .................2
[Instruction to data collector: Read to the mother the following instruction. I will now request you to help me to rinse your child’s hands in this bag (Show the mother the whirl-pak bag so that she can show the child). Please follow my instructions. (Demonstrate the mother hand rinse technique and ask her to help the child rinse hands following the standard operating procedure for hand rinse) Please take all the samples following the standard operating procedures (SOP).]

3.15 Is Collection of hands rinse sample complete?

[Yes] ........................................1
[No] .........................................0

[Toy Ball collection: Instruction to data collector: Give the child the sentinel ball and tell the mother that he can play with the ball and you will come back tomorrow to rinse the ball in a similar bag used for hand and will return the Ball.]
3.16 টার্কেট শিশুকে বল সরবরাহ করা হয়েছে কি? [Is ball supplied to the child?]

.............................................

ঃ [Yes] .................................1

না [No]......................................0

3.17 বল সরবরাহ করার সময় [Time of supplying the toy ball].............................................

3.19 গত দুই সপ্তাহের মধ্যে সর্বশেষ কতদিন আগে বৃষ্টি হয়েছিল?(১৪ দিনের মধ্যেবৃষ্টিহলে ৮৮৮ কোড করুন) [When was the most recent time it rained in the past 2 weeks?(Code 888 if it did not rain within 14 days)]

...............................................................

[days ago]

Section 4: Faeces disposal

4.1 আপনার খানার সদস্যরা পায়নামা করার জন্য সাধারণত কোথায় যায়? (Note: উত্তরদাতাকে উত্তরগোলো পড়ে শোনান) [Where do the members of your household usually go for defecation? (Note: Read out the responses to the respondent)]...............................................................................................

1. খোলা জঙ্গল [Open bush]
2. খোলা মাঠ [Open field]
3. খোলা জায়গায়, নদী/পুকুর/লেকের পাশে [Open, by the side of river/pond/lake]
4. পাথরহাট [In a toilet]

4.2 আপনি সাধারণত কোথায় পায়নামা করেন?(জ্যাম্বেক উত্তরদাতাকে উত্তরগোলো পড়ে শোনান) [Where do you usually defecate?]

..........................................................................................................

1. খোলা জঙ্গল[Open bush]
2. খোলা মাঠ[Open field]
3. খোলা জায়গায়, নদী/পুকুর/লেকের পাশে [Open, by the side of river/pond/lake]
4. পাথরহাট [In a toilet]

4.3 আপনার খানার অন্যান্য ধরে বয়স (১৮+) সদস্যরা সাধারণত কোথায় পায়নামা করেন? (Note: উত্তরদাতাকে উত্তরগোলো পড়ে শোনান) [Where do other adults (18+) in the household usually defecate?]

.........................................................................................

1. খোলা জঙ্গল[Open bush]
2. খোলা মাঠ[Open field]
3. খোলা জায়গায়, নদী/পুকুর/লেকের পাশে [Open, by the side of river/pond/lake]
### 4. পায়োখানায় [In a toilet]

4.4 আপনার ঘরের <৩ বছর শিশু (টিয়েটারে শিশু) সাধারণত কোথায় পায়োখানা করেন? (২.১১ নং প্রশ্ন থেকে শিশুর নাম ব্যবহার করুন) [Where do the <3 child in the household usually defecate? (Use name of the child from question 2.11)]

| 1. পট্টি [Potty] |
| 2. নাপ্পি/ডায়াপার [Nappy / diaper] |
| 3. উঠানে (পট্টি ছাড়া) [In the courtyard (without potty)] |
| 4. ঘরের ভিতরে (পট্টি ছাড়া) [Inside the house (without potty)] |
| 5. পায়োখানায়/টিয়েটারে [In Toilet / Latrine] |
| 6. কোপ-ঝড়ে/জমলে [Bush / forest / field] |
| 7. কোন নির্দিষ্ট জায়গায় নয় [No specific place] |
| 8.77 | 777. অন্যান্য (কোন লিখিত নয়) [Other (specify)] |
| 9.77 | 888. অন্যান্য নয় [Not Applicable] |
| 10.99 | 999. জানি না / নির্দিষ্ট নয় [Don’t know / Not sure] ঘরের অন্য কেউ জানে কি না দেখুন [Probe to see if someone in the HH knows] |

### 4.5 আপনার ঘরের ৩-৫ বছরের শিশু সাধারণত কোথায় পায়োখানা করেন? [Where do the children aged 3-5 years usually defecate?]

| 1. পট্টি [Potty] |
| 2. নাপ্পি/ডায়াপার [Nappy / diaper] |
| 3. উঠানে (পট্টি ছাড়া) [In the courtyard (without potty)] |
| 4. ঘরের ভিতরে (পট্টি ছাড়া) [Inside the house (without potty)] |
| 5. পায়োখানায়/টিয়েটারে [In Toilet / Latrine] |
| 6. কোপ-ঝড়ে/জমলে [Bush / forest / field] |
| 7. কোন নির্দিষ্ট জায়গায় নয় [No specific place] |
| 8.77 | 777. অন্যান্য (কোন লিখিত নয়) [Other (specify)] |
| 9.77 | 888. অন্যান্য নয় [Not Applicable] |
| 10.99 | 999. জানি না / নির্দিষ্ট নয় [Don’t know / Not sure] ঘরের অন্য কেউ জানে কি না দেখুন [Probe to see if someone in the HH knows] |
4.6 Where do the children above 5 (up to 18 years) usually defecate?

1. Potty
2. Nappy / diaper
3. In the courtyard (without potty)
4. Inside the house (without potty)
5. In Toilet / Latrine
6. Bush / forest / field
7. No specific place
8. Other
9. Not Applicable
10. Don’t know / Not sure

4.7 Where did you defecate the last time?

1. Open bush
2. Open field
3. Open, by the side of river/pond/lake
4. In a toilet

4.8 When was the last time your youngest child / infant (<3 years) defecated?

1. Today
2. Yesterday
3. 2 or more days ago
4. Cannot remember
5. Refused
6. Not Applicable
4.9  Where did the child (<3 years) defecate the last time? [Do Not Read Responses]

1. Potty
2. Nappy / Diaper
3. In the courtyard (without potty)
4. Inside the house (without potty)
5. In Toilet / Latrine
6. Bush / forest / field
7. No specific place
8. Other (specify)

4.10 What was done with the faeces? [Do Not Read Responses]

1. Left there
2. Put / rinsed into toilet or latrine
3. Put / rinsed into drain or ditch
4. Rinsed near tubewell/pond
5. Thrown into the bush / forest / field
6. Thrown into garbage
7. Thrown into a specific pit for child’s faeces
8. Buried
9. Other (specify)

4.11 How did you handle the faeces? [Do Not Read Responses]

1. Hands only/bare hands
2. Hands cloth / paper / leaves / straw
3. Local agricultural hoe/instrument
4. Sani-scoop
5. Did nothing
777. Other (specify)

999. Don’t know / not sure

4.12 When was the last time your youngest child/infant (3-5) defecated?

1. Today
2. Yesterday
3. 2 or more days ago
4. Cannot remember
5. Cannot remember

888. Not Applicable

4.13 Where did the child 3 –5 years defecate the last time?

1. Potty
2. Nappy / diaper
3. In the courtyard (without potty)
4. Inside the house (without potty)
5. In Toilet / Latrine
6. Bush / forest / field
7. No specific place
777. Other (specify)

888. Not Applicable

999. Don’t know / not sure [Probe to see if someone in the HH knows]
4.14  What was done with the faeces? [Do Not Read Responses]

1. Left there
2. Put / rinsed into toilet or latrine
3. Put / rinsed into drain or ditch
4. Rinse near tubewell/pond
5. Thrown into the bush / forest / field
6. Thrown into garbage
7. Thrown into a specific pit for child's faeces
8. Did nothing
9. Other (specify)

4.15  How did you handle the faeces? [Do Not Read Responses]

1. Hands only/bare hands
2. Hands and cloth / paper / leaves / straw
3. Local agricultural hoe/instrument
4. Sani-scoop
5. Did nothing
6. Other (specify)

4.16  Where did the child above 5 years (up to 18 years) defecate the last time? [Do Not Read Responses]

1. Potty
2. Nappy / diaper
3. In the courtyard (without potty)
4. Inside the house (without potty)
5. In Toilet / Latrine
6. Bush / forest / field
7. कोन निर्दिष्ट जागरण नय [No specific place]
777. अन्याय (वर्तना निर्धन्यु) [Other (specify)]
888. अजोम नय [Not Applicable]
999. जानि ना / निर्दिष्ट नय [Don’t know / Not sure] खानार अन्य केउ जाने कि ना देखून [Probe to see if someone in the HH knows]

4.17 परिकर पायाखाना बाबहलेर उपकारित फ कि कि? (एटा एकटा उम्मक प्रश्न) [Note: उत्तरतुला कोशमा/बबे पड़ॉ अनाला घाने ना, उत्तरतुला याते गर्न उल्लस बने रे ले भाये ताके सह्यात करतेहे हबे नेमन, आया किदु आठे किना बा अन्य किदु (कुमी: अन्यायाते 7 लिखन: ) [What are the benefits of using clean toilet? Note: Don’t read the answer, encourage by asking if there is anything else until he/she mentions there in nothing else and check all mentioned?]

उल्हेख करेफे [Mentioned]..........................1
उल्हेख करनि [Not mentioned]......................0

1. डायरिया कम हा [Less diarrhoea]..........................................................□
2. असुक-बिकिचुक कम हा (निर्दिष्ट कोन रोग सर नाम बने) [Less illness (type of illness not specified)]□
3. रोग जीवाचू कम [Less germs]..........................................................□
4. अलेदा गण्द (Smell better)........................................................................□
5. बेंची पोपनीयता [More Privacy]..........................................................□
6. सामाजिक बांधला[Social Status ]..........................................................□
777. अन्याय: निर्दिष्ट करेल लिखन [Other: specify]...............................................□
999. जानि ना
[DK]...........................................................................................................□

4.18 अपनार जाना मतेहे, गड़ 24 दंडतयं एउतेह खाना प्राकृतिक कोन सरद स्थल जागरण शोला जागरणा करेफे कि?
[Do you know if any adult in you household had to defecated open with last 24 hours?] ......................□□

हाँ [Yes].................................................................1
ना [No]..........................................................................0
जाणि ना [DK]........................................................................999

4.19 अपनार जाना मतेहे, गड़ 7 दिन एउतेह खाना प्राकृतिक कोन सरद स्थल जागरणा करेफे कि?
[Do you know if any adult in your household had to defecate open with last 7 days?]..............................□□

हाँ [Yes].................................................................1
ना [No]..........................................................................0
4.20 Among the Households in your compound how many has access to a latrine? (জানি না [DK]=999)

4.21 Among the Households in your compound individually uses a latrine?

Section 5: Household asset

5.1. Does your household (or any member of your household) have:

ঃঃ (Yes)....1, না (No)....0, জানি না (DK)....999

<table>
<thead>
<tr>
<th>a. বিদ্যুত [Electricity]</th>
<th>.................................................................</th>
</tr>
</thead>
<tbody>
<tr>
<td>b. আলমীরা/ওয়ার্ডরব্র [Number of Almirah or wardrobe]</td>
<td>.................................................................</td>
</tr>
<tr>
<td>c. সেতু [Number of tables]</td>
<td>........................................................................</td>
</tr>
<tr>
<td>d. চেয়ার/স্টুল [Number of chair or bench]</td>
<td>........................................................................</td>
</tr>
<tr>
<td>e. হাত ঘড়ি/সেলার ঘড়ি [Number of watch or clock]</td>
<td>........................................................................</td>
</tr>
<tr>
<td>f. ধাট [Number of khat]</td>
<td>........................................................................</td>
</tr>
<tr>
<td>g. টোকি [Number of chouki]</td>
<td>........................................................................</td>
</tr>
<tr>
<td>h. রেডিও [A radio that is working]</td>
<td>........................................................................</td>
</tr>
<tr>
<td>i. টেলিভিশন (শাখা/কালো) [A B/W television that is working]</td>
<td>........................................................................</td>
</tr>
<tr>
<td>j. টেলিভিশন (রঙ) [A color television that is working]</td>
<td>........................................................................</td>
</tr>
<tr>
<td>k. রেফ্রিজারেটর [Refrigerator]</td>
<td>........................................................................</td>
</tr>
<tr>
<td>l. সাইকেল (নলা সাইকেল নয়) [A bicycle (used for commercial purposes not toy for children)]</td>
<td>........................................................................</td>
</tr>
<tr>
<td>m. মটর সাইকেল [A motorcycle]</td>
<td>........................................................................</td>
</tr>
<tr>
<td>n. সেলাই মেশিন [A sewing machine]</td>
<td>........................................................................</td>
</tr>
<tr>
<td>o. মেবাইল ফোন (রঙ) [Number of Mobile phones]</td>
<td>........................................................................</td>
</tr>
<tr>
<td>p. ল্যান্ড ফোন [A land phone]</td>
<td>........................................................................</td>
</tr>
</tbody>
</table>

5.2. How many rooms the households have (exclude bathroom and Kitchen)?

5.3 Status of living house

<table>
<thead>
<tr>
<th>নিজের বাড়ি [Self-owned]</th>
<th>.................................................................</th>
</tr>
</thead>
<tbody>
<tr>
<td>ভাড়া বাড়ি [Rental]</td>
<td>........................................................................</td>
</tr>
<tr>
<td>সরকারী জমি [Govt. land]</td>
<td>........................................................................</td>
</tr>
</tbody>
</table>
Skip Note-5.1: যদি কোড ২ নাহি, তবে ৫.৫ - এত্যন [If answer is not 2 then skip to 5.5]

5.4 যদি ৫.৩ - এর উপর ২ হয় (ভাড়া বাড়ি), তবে বসতিবাড়িটির আয়তন কি ২০০ বর্গফুটের কম? [If 5.3 answer is 2 (rental) then do the area is less than 200 sq.
ft.?]

Code: হাঁ [Yes]................................................1

না [ No]..................................................0

5.5. আপনার খানায় রাত্রির জন্য প্রধানত কি ধরনের তালালনী ব্যবহার করা হয়? [What type of fuel does your household mainly use for
cooking?]

কাঠ [Wood] .......................................................01

শস্যের অশিক্তিশাস্ত্র/হাস [Crop residue / grass ] .................02

কাঠা গোলায় [Dung cakes ] ........................................03

কয়লা [Coal / coke / lignite ] ........................................04

কাঠ কয়লা [Charcoal ] ..............................................05

কোয়ালিন [Kerosene ] ..............................................06

বিদ্যুৎ [Electricity ] .....................................................07

তরল গ্যাস/প্রাকৃতিক গ্যাস [Liquid gas / gas ] ......................08

গ্যাস [Bio-gas/LPG gass] ...........................................09

অন্যান্য[Other] .........................................................777

(বর্ণনা লিখুন) [Specify other] ________________________________

জানি না [Don’t know ] .................................................999

5.6 আপনার খানায় সদস্যদের কি কোন বসতিস্তম্ভ আছে? [Does your household own any homestead
land?]

Code: হাঁ [Yes]......................................................1

না [ No]. .............................................................0

বলতে রাজি হামনি [Refused]...........................................666

জানি না [Don’t know].................................................999

Skip Note: ৫.২যদি ৫.৬ ন প্রশ্নের উত্তর ০/৬৬৬/৯৯৯ হয়, তবে ৫.৮ নং প্রশ্নে চলে যান। [If Answer of 5.6 is 2/666/999, skip to 5.8]

1 We need to set up a cut off area (200 sq feet) by practical demonstration during training and train
FRAs according so that they can assess easily by observing the household whether the household area
is less than 200 sq feet or not.
5.7 (৫.৬) এর উপর হ্যা হলে, খানার সদস্যদের বসতিবাড়িতে মোট কয়টুকু জমি আছে (ডেসিমেল)? [How much homestead land (decimal) does your household own?]

জমির পরিমাণ কলে না পারলে ১৯৯৯৯ বলন [If Answer of 5.7 is Don’t know please insert 99999]

পরিমাণ [AMOUNT] __________ (একক নির্দিষ্ট করে লিখুন) [SPECIFY UNIT]__________

পরিমাণ [AMOUNT] __________ (একক নির্দিষ্ট করে লিখুন) [SPECIFY UNIT]__________

5.8 আপনার খানার সদস্যদের কি বসতিভূমি ছাড়া অন্য কোন জমি আছে? [Does your household own any land, other than homestead land]..........

........................................................................................................

Code:  

হ্যা [Yes]..............................................................1

না [ No]. ...............................................................0

বলতে রাজি হয়নি [Refused]..........................................666

জানি না [Don’t know]...............................................999

Skip Note: যদি ৫.৮নং প্রশ্নের উত্তর ০/৬৬৬/৯৯৯ হয়, তবে ৫.১০নং প্রশ্ন চলে যান। [If Answer of 5.8 is 0/666/999, skip to 5.10]

5.9 (৫.৭) হ্যা হলে, খানার সদস্যদের বসতিবাড়ি বাদে মোট কয়টুকু জমি আছে (ডেসিমেল)? [How much land (decimal) does your household own (other than the homestead land)?]

জমির পরিমাণ কলে না পারলে ১৯৯৯৯ বলন [If Answer of 5.9 is Don’t know please insert 99999]

পরিমাণ [AMOUNT] __________ (একক নির্দিষ্ট করে লিখুন) [SPECIFY UNIT]__________

পরিমাণ [AMOUNT] __________ (একক নির্দিষ্ট করে লিখুন) [SPECIFY UNIT]__________

5.10 আপনার মতে সামাজিক গ্রেডসফোটে আপনার খানাটির অবস্থান কি রকম? [How would you describe your economic status]..........................................................................................................................
5.11 Do you use cow dung in the floor of living room?

- Yes ................................................. 1
- No .................................................. 0

5.12 Do you use cow dung in the floor of kitchen room?

- Yes ................................................. 1
- No .................................................. 0

5.13 Do you use cow dung for cooking?

- Yes ................................................. 1
- No .................................................. 0

5.14 Do you have any domestic animal?

- Yes ................................................. 1
- No .................................................. 0

5.15 If yes what type (how many)?

1. Goat .............................................
2. Cow .............................................
3. Chicken ......................................
4. Duck ..........................................  
5. Cat ..............................................
6. Pigeon ........................................
7. Dog .............................................
777. Other ........................................

[Specify other] __________________________

5.16 Have you observed any animal that is not domestic in your household within last 24 hours?

- Yes ................................................. 1
- No .................................................. 0
Section 6: Reported diarrhea

Note: Identify all <5 child in the household according to ID given in question 2.11 and record answer to the following questions for each child.

6.1 Has the child had diarrhoea during the past two days? [Has the child had diarrhoea during the past two days?]

Diarrhoea is the passage of unusually loose or watery stools, usually at least three times in a 24 hour period. However, it is the consistency of the stools rather than the number that is most important. Frequent passing of formed stools is not diarrhoea. Babies fed only breast milk often pass loose, "pasty" stools; this also is not diarrhoea. Mothers usually know when their children have diarrhoea and may provide useful working definitions in local Situations (WHO, 2005)

| [Specify other] |  
|----------------|---

### 5.17 (5.16) এর উত্তর হাঁ হলে, কি খরচের এবং কতগুলো? [If yes what type (how many)?]

| 1. ঘাসল [Goat] |  
|----------------|---
| 2. পুরু [Cow] |  
| 3. মুরগী [Chicken] |  
| 4. হুং [Duck] |  
| 5. বিজাল [Cat] |  
| 6. কবুতর [Pigeon] |  
| 7. তুমুল [Dog] |  
| 777. অন্যান্য [Other] |  

| [Specify other] |  
|----------------|---

### Section 6: Reported diarrhea

Note: প্রশ্ন ২.১১ অনুসারে খানার সকল ৫ বছরের কম বাসী শিশুর চিন্তিত করন এবং নিচের প্রশ্নগুলোকে প্রতূল শিশুর জন্য উত্তর লিপিবদ্ধ করন।

6.1 পাত ২ দিনে শিশুটির পাতলা পায়খানা ছিল কি? [Has the child had diarrhoea during the past two days?]

Diarrhoea is the passage of unusually loose or watery stools, usually at least three times in a 24 hour period. However, it is the consistency of the stools rather than the number that is most important. Frequent passing of formed stools is not diarrhoea. Babies fed only breast milk often pass loose, "pasty" stools; this also is not diarrhoea. Mothers usually know when their children have diarrhoea and may provide useful working definitions in local Situations (WHO, 2005)

| [Yes] |  
|-------|---
| [No] |  
| জানি না [Don’t know] |  

1. <5 Child ID no 1 (Target child)  
2. <5 Child ID no 2  
3. <5 Child ID no 3  
4. <5 Child ID no 4  
5. <5 Child ID no 5  

| [Specify other] |  
|----------------|---

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6.2 Has the child had diarrhoea during the past 1 week? [Has the child had diarrhoea during the past 1 week?]

- [Yes] ............................................................. 1
- [No] ............................................................. 0
- [Don’t know] ..................................................... 999

1. <5 Child ID no 1 (Target child) .................................................................
2. <5 Child ID no 2 .................................................................
3. <5 Child ID no 3 .................................................................
4. <5 Child ID no 4 .................................................................
5. <5 Child ID no 5 .................................................................

6.3 Has the child had diarrhoea during the past two weeks? [Has the child had diarrhoea during the past two weeks?]

- [Yes] ............................................................. 1
- [No] ............................................................. 0
- [Don’t know] ..................................................... 999

1. <5 Child ID no 1 (Target child) .................................................................
2. <5 Child ID no 2 .................................................................
3. <5 Child ID no 3 .................................................................
4. <5 Child ID no 4 .................................................................
5. <5 Child ID no 5 .................................................................

6.4 If 6.2 answer is 1, then how long did the diarrhoea last for?(N/A=888, DK= 999) [If 6.2 answer is 1, then how long did the diarrhoea last for?(N/A=888, DK= 999)]

1. <5 Child ID no 1 (Target child) .................................................. Hours b. Days
2. <5 Child ID no 2 .................................................. Hours b. Days
3. <5 Child ID no 3 .................................................. Hours b. Days
4. <5 Child ID no 4 .................................................. Hours b. Days
5. <5 Child ID no 5 .................................................. Hours b. Days
**PART B: SPOT CHECKS**

Section 7. Water-handling

7.1 **[May I take a look around your home to look at some of the items related to water, sanitation, and hygiene?]**

### Water Source

- **Shallow tube well (<250 feet)**: ........................... 01
- **Deep tube well (250+ feet)**: ............................. 02
- **Protected ring/dug well**: .................................. 03
- **Unprotected dug well**: ...................................... 04
- **Shallow Tara pump**: ........................................ 05
- **Deep Tara pump**: ........................................... 06
- **Arsenic free treatment plant**: ............................ 07
- **Water from protected spring**: ........................... 08
- **Water from unprotected spring**: ......................... 09
- **Surface water**: ............................................. 10
  - **Rainwater**: .................................................. 10
  - **Tanker truck**: ............................................. 11
  - **Cart with small tank**: ................................... 12
  - **Pathogen treatment plant (Pond Sand Filter): River/dam/lake/ponds/stream/canal/irrigation channel/tube well**: ... 13
  - **Directly from River/dam/lake/ponds/stream/canal/irrigation channel**: ............................................. 14

- **Piped water into dwelling**: ............................... 15
- **Piped water into yard/plot**: .............................. 16
- **Public tap/stand pipe**: ..................................... 17
- **Other**: specify ................................................ 777
7.1.1 Knowing the source coordinates of drinking water [GIS coordinates of the source for drinking water].

<table>
<thead>
<tr>
<th>Latitude</th>
<th>Longitude</th>
</tr>
</thead>
</table>

7.2 Knowing the source of drinking water? (ownership and registration) [(Ask and check): Ownership type of the water point?]

- Only for the household [On the household]: 1
- Shared [Shared]: 2
- Someone else [Someone else]: 3
- Public [Public]: 4

7.3 Knowing the user of the drinking water? [(Ask and check): User of the water point?]

- Only for the household [On the household]: 1
- Shared [Shared]: 2
- Public [Public]: 3

**Skip Note:** If the answer of 7.3 is 1, skip to 7.5

7.4 Knowing the number of households sharing the drinking water point? [(Ask and check): If the number of households using the water point is 2/3, how many households are sharing the drinking water point?]

7.5 How much time is needed to bring drinking water to the living room? (Ask the respondent) [How much time is needed to bring drinking water to the living room? (Ask the respondent)]

7.6 Knowing what is the source of drinking water usually used by the household for cooking (follow code list of 7.1)? (Ask the respondent to show you the source. Observe and ask question if necessary to identify the type of water source)

7.7 Knowing what is the source of drinking water usually used by the household for bathing? (follow code list of 7.1) (Ask the respondent to show you the source. Observe and ask question if necessary to identify the type of water source)

7.8 Knowing what is the source of drinking water usually used by the household for washing fruits and vegetables? (follow code list of 7.1) (Ask the respondent to show you the source. Observe and ask question if necessary to identify the type of water source)
source. Observe and ask question if necessary to identify the type of water source). .................................................................

7.9 আপনার খালা বাসদের যে পানি আপনি প্রধান উৎস কে? (7.1 এ দেয়া কোড লিস্ট থেকে কোড বসান) উত্তরদাতাকে পানির উৎস দেখাতে বলুন। প্রয়োজনে নথি ও প্রশ্ন করে পানির উৎস যাচাই করুন। [What is the source of the water that you usually use for washing utensils? (follow code list of 7.1)] (Ask the respondent to show you the source. Observe and ask question if necessary to identify the type of water source). .................................................................

7.10 খানাটি সকল ধরনের কাজের জন্য সারা বছর পর্যাপ্ত পরিমাণে পানি পায় কি? (প্রশ্ন করুন) (খাওয়ার জন্য, রান্নার জন্য, ফল-ফুল এবং তরী-তরকারি খেয়ের জন্য) [Does the household get enough water through the year for all purpose (Drinking, Cooking, Washing fruits & Vegetables)]. ............................................................................................

7.11 (7.1 এ উল্লেখিত) পানির উৎসের স্থানটি দেখে পরিষ্কার ছিল কী? [Did the source of water point observe looked clean?]. ............................................................................................

Note: (পরিষ্কার অর্থ স্থানটিতে পানি জমে থাকবে না, চারণাপাশে পায়েখানা বা অনেক মল পড়ে থাকবে না) [Clean means no water logging, no feces besides, no dirt besides, etc.]

    হ্যা [Yes] .................................................................1
    না [No]..........................................................0

7.12 পানির উৎসের স্থানটি দেখে কমন ছিল কী? (Note: পানির উৎসটি খাবার পানি) পর্যবেক্ষন করে নিমোক বিষয় গুলো সমন্বে তথ্য সংগ্রহ করুন [How was the source of water point looking?] (Note: Observe the water point and note the following points)

    হ্যা [Yes] .................................................................1
    না [No]..........................................................0
    গ্রামোজ্য [N/A]..............................888

1. প্ল্যাটফর্ম আছে [Plat form present].................................................................
2. প্ল্যাটফর্ম ভঙ্গ [Plat form broken].................................................................
3. স্থানটিতে পানি জমেছিল [water logging].................................................................
4. চারণাপাশে পায়েখানা ছিল [feceswere presented besides].................................
5. চারণাপাশে মল পড়েছিল [garbage were presentedaround.].........................

Section 8: Waste disposal

8.1. খানাটিতে মল/ আবর্জনা (তরল নয়) জেলার জন্য নির্দিষ্ট কোন স্থান রয়েছে কী? [Do the household has fixed place for solid waste disposal?]. ............................................................................................

    হ্যা [Yes] .................................................................1
    না [No]..........................................................0
    বলতে রাজি না [Refused].................................666
Skip Note: যদি উত্তর ০ বা ৬৬৬ হয়, তবে ৮.৪-এ যান [If answer of 8.1 is 0 or 666, skip to Section 9]

8.2 যদি ৮.১এর উত্তর ১ হয়, তাহলে সেটা কি ধরনের স্থান? [If 8.1 is 1 (yes), what kind of fixed place it is?]

8.3 সেখানে কিভাবে ময়লা/ আর্বজনা ফেলার জায়গাে বলুন। প্রয়োজনে দেখে ও প্রশ্ন করে যাচাই করুন | [Ask the respondent to show you the place of solid waste disposal. Observe and ask question if necessary]

8.4. খানাটিতে কি কোন পানি নিষ্কাশন ব্যবস্থা আছে? [Do the household has any water drainage system?]

Skip Note: যদি উত্তর ০/৬৬৬ হয়, তবে সেকসন ৯-এ যান [If answer of 8.4 is 0 or 666, skip to Section 9]

8.5. যদি ৮.৪এর উত্তর ১ হয়, তবে কি ধরনের পানি নিষ্কাশন ব্যবস্থা আছে? [If 8.4 is 1 (Yes), what kind of drainage system it is?]

[উত্তরদাতাকে পানি নিষ্কাশন ব্যবস্থা জায়গাদেখাতে বলুন। প্রয়োজনে দেখে ও প্রশ্ন করে যাচাই করুন | [Ask the respondent to show you the place of water drainage. Observe and ask question if necessary]
Section 9: Materials of the living household

9.1. ছাদ তৈরীতে কি কি উপাদান ব্যবহার করা হয়েছে? (পরিষ্কার করে যাচাই করুন) [Main material of the roof]....

(Interviewer: Record your observation)

[Natural roof]
কাঠা (বাঁশ/থাট্টা) [Kaccha (bamboo / thatch)] ............1

[Rudimentary roof]
টিন [Tin] .........................................................................................2

[Finished roof (pukka)]
সিমেন্ট/কঁটঁটি/টালি [Cement / concrete / tiled] ........3

[Other: Specify] ............................................................................... 777

9.2.  দেয়াল তৈরীতে কি কি উপাদান ব্যবহার করা হয়েছে? (পরিষ্কার করে যাচাই করুন) [Main material of the walls]........

(Interviewer: Record your observation)

[Natural walls]
পাতা/বাঁশ/মাটি (কাঠা) [Jute / bamboo / mud (kaccha)] .....1

[Rudimentary walls]
কঠা [Wood] .................................................................2

[Finished walls]
ইটি/সিমেন্ট [Brick / cement] .....................................................3

[Other: Specify] ............................................................................... 777

9.3. মেঝে তৈরীতে কি কি উপাদান ব্যবহার করা হয়েছে? (পরিষ্কার করে যাচাই করুন) [Main material of the floor]...........................

(Interviewer: Record your observation)

[Natural floor]
মাটি/বাঁশ (কাঠা) [Earth / bamboo (kaccha)]...............1

[Rudimentary floor]
কঠা [Wood] .................................................................2
Section 10: Sanitation

10.1.1 আপনার খানার সমস্ত সাধারণত কোন ধরনের পায়ানায়া ব্যবহার করেন? [What kind of toilet facility do members of your household usually use?] .................................................................

[Note: উত্তরদাতাকে প্যাকে টেকে অনুরোধ করুন এবং পায়ানায়া পর্যবেক্ষণ করার পর কোড করুন। যদি ফ্ল্যাশ অথবা পানি ডেলে ফ্ল্যাশ করা পায়ানায়া থাকে তাহলে ফ্ল্যাশকের বার্তা কোথায় যায় তা প্রে/চেক করুন।

(Note: Request the respondent to show the toilet facility and code after observing the facility. If “flush” or “pour flush” probe/check: Where does it flush to?)

ফ্ল্যাশ-টায়মেটে অথবা পানি ডেলে ফ্ল্যাশ করা টায়মেটে (প্রায় এবং পানি ধারনকারী ওয়াটারের সীল পর্যবেক্ষক করুন)] [Flush or pour flush toilet flushed to] (Observe the slab and water seal containing water):

টায়মেটেতে পায়ানায়াণ পাইপের সাথে সংযোগ করে দেয়া [Piped sewer system] .................................................................................................................. 01

টায়মেটেতে সেপ্টিক টাকে বসানো আছে(টায়মেটে কন্টেইন দিয়ে ডাকা আছে কিনা পর্যবেক্ষক করুন)] [Septic tank] (Observe the concrete cover of the tank) ........................................................................................................................................ 02

সেপ্টিক টাকে না কিংবা ফ্ল্যাশ করে বা পানি ডেলে পায়ানায়া নীচে/ছুরি পিটের মধ্যে সরিয়ে দেয়া যায় [Flush to pit latrine (onsite/Off set) with slab and water seal] ........................................................................................................................................ 03

অজানা জায়গায়/নিষিদ্ধ কোন জায়গায় নেই/ জানিনা [Unknown place/not sure/DK where]........................................................................................................ 04

পিট-টায়মেট, প্লাব আরে কিংবা পিটের সিল নেই তবে কমোডে ডাকনা দেয়ার বাবর্শা আছে) [Pit latrine with slab & no water seal but with a lid].................................................................................................................. 05

পিট-টায়মেট যেখানে প্লাব আছে, তবে ওয়াটারের সিল নেই কিংবা ফ্ল্যাশ আছে (উত্তরদাতাকে ফ্ল্যাশ সম্পর্কে জিজ্ঞাসা করেন, এ কেনে পাইপের এর শেষ মাথায় প্লুটিক লক্ষণা থাকে যা মশা মাছি বাই ও আশা প্রতিদর্শ করে) (Pit latrine with slab and flap, no water seal) (Ask the respondent about the flap, Flap: a plastic is attached at the end of the pipe to prevent files from coming out of the pipe)

................................................................................................................................................................. 06

বায়ু চলাচল উপযোগী উন্নত ল্যাট্রিন(প্রায় এবং ভূটিলেশন পাইপ পর্যবেক্ষক করুন)] [Ventilated Improved Pit (VIP) latrine] (Observe the slab and ventilation pipe))........................................................................................................................................ 07

কম্পোস্টিং টায়মেট (শাক সবজির মরলা, খড়, ঘাস, কাঠের গুড়া, ছাই পিটের মধ্যে মিশিয়ে হয়, সার হিসাবে এ মরলা বার্তা হয়, ওয়াটারের সিল নেই। একটি কম্পোস্টিং টায়মেটে প্রায় আলাদা করণ দিভাইস থ্রাকে পারে বা নাও থ্রাকেত পারে) [Composting toilet, (Composting toilet ensure separation of urine, water and excreta)vegetable wastes, straw, grass, sawdust, ash added in the pit, the waste used as manure, no water
A composting latrine may or may not have a urine separation device.]

[Pit latrine with slab & no water seal/broken water seal and no lid]..............

Flush-toilet advocates, plans, flush or pour flush toilet connected to somewhere else (canal, ditch, river, etc.) .........................

[Pit latrine without slab/open pit] ............................................................................

[Hanging toilet/latrine]...................................................................................

[Bucket]…………………………………………………………………... ............................................

[Open defecation]:

[GIS coordinates of the source of drinking water].

Latitude

Longitude

Skip Note: If answer of 10.1 is 12, skip to 10.18]

10.1.3 Apanar janma mato sarvesh, iti payamanaiti katho bhabhar karo harayedh?[When was the most recent time this toilet was used]?

10.2.2 Katwalu kana mila payamanaiti bhabhar karo? (Pravesh kashu) [(Ask): how many households sharing the toilet facility?]

10.2.1 Apana koi ehi payamanaiti anu kana sarhe mila bhabhar karo? [Do you share this toilet facility with other households?]

(Note: Any person or group of persons related or unrelated who do not live in the same dwelling space and do not share a common source of food as the respondent would be considered to belong to other household.)

1= ha[yes]

0= na [No] 10.2.4 na prave chal ye [skip to 10.2.4]

999= janna [DK] 10.2.4 na prave chal ye [skip to 10.2.4]

888= praveye jana [Not applicable] 10.2.4 na prave chal ye [skip to 10.2.4]
10.2.4 How many people including children use this toilet? (Ask)

10.3 Ownership type of the Toilet? (Ask)

- Only for the household [1]
- Shared [2]
- Someone else [3]
- Public [4]

10.4 Path to the toilet suggests regular use (is clear, well-worn, without grass or any barriers etc.)

10.5 Observe the general exterior of the toilet

a. Is there any superstructure on the toilet?
b. Is there a door/curtain?
c. Can an average sized adult use the toilet without being seen?
d. Is there roof over the toilet?
e. Is there any hole in the roof that may allow water to enter through the roof?
f. Is there a ventilation pipe?

   a. Skip Note: If answer of 10.5.6 is 0, skip to 10.5h

   g. Is there a cover on top of the ventilation pipe that protects the flies from going out?

   h) What are the walls of the toilet mostly made of?

1. Concrete
2. Tin
3. Bamboo/Mud
4. Plastic
5. Tree leaves
6. Jute bag
7. Straw

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8. काठ [Wood]

888= প্রয়োজন নয় [Not applicable])

i) পাতাকের ছাদ মূলত কি দিয়ে তৈরী? [What is the roof of the toilet mostly made of?]

1. কঠিন [Concrete]
2. টিন [Tin]
3. বাঁশ [Bamboo]
4. প্লাস্টিক [Plastic]
5. গাছের পাতা [Tree leaves]
6. পাতার ধাল [Jute bag]
7. খোঁড় [Straw]

888= প্রয়োজন নয় [Not applicable])

10.6 টুলাপ্রে থেকে ময়লা কোথায় যায়? (জিজ্ঞাসা কর্ম এবং সংবেদন্ত্বহলে পর্যাবেক্ষণ করন) [Where does the waste from toilet go? (Ask and observe if possible)]

1. ময়লা "পাথরিআরাদ ব্যবস্থার" পাইপের মাধ্যমে যায় (জিজ্ঞাসা কর্ম) [Waste drains to underground piped sewer system (Ask)] (১০.৮.১ নং প্রশ্নে চলে যান Skip to Q10.8.1)
2. ময়লা দুইটি পিটের মধ্যে পড়েছে এবং সেখানেই থাকছে (উত্তরদাতা পিট তৈরীতে কঠিনের রিং সম্পর্কে উল্লেখ করবে। পিটের উপরিভাগ এবং ছিদ্র আছে কি না পর্যবেক্ষণ করন) [Waste goes into onsite pit and stays there (Respondent will report using concrete rings to make the pit. Observe the top of the pit and any leakage)]
3. ময়লা দুইটি পিটের মধ্যে পড়েছে এবং সেখানেই থাকছে (উত্তরদাতা পিট তৈরীতে কঠিনের রিং সম্পর্কে উল্লেখ করবে। পিটের উপরিভাগ এবং ছিদ্র আছে কি না পর্যবেক্ষণ করন) [Waste goes into offset pit and stays there (Respondent will report using concrete rings to make the pit. Observe the top of the pit and any leakage)]
4. ময়লা দুইটি টাংকের মধ্যে পড়েছে এবং সেখানেই থাকছে (ট্যাংকের উপরের কঠিনের ঢাকনা এবং ছিদ্র আছে কি না পর্যবেক্ষণ করন) [Waste goes into onsite tank and stays there (Observe the concrete cover of the tank and any leakage. Respondent will report building the tank with concrete lining rather than buying the ring for pit lining)]
5. ময়লা দুইটি টাংকের মধ্যে পড়েছে এবং সেখানেই থাকছে (ট্যাংকের উপরের কঠিনের ঢাকনা এবং ছিদ্র আছে কি না পর্যবেক্ষণ করন) [Waste goes into offset tank and stays there (Observe the concrete cover of the tank and any leakage. Respondent will report building the tank with concrete lining rather than buying the ring for pit lining)]
6. কমপষ্টি পিট (শাক সবজির ময়লা, খোঁড়, ধাস, কাঠের চুলা, ছাঁই পিটের মধ্যে মিশ্রিত হয়, সার হিসাবে এই ময়লা ব্যবহৃত হয়, ওয়াটার সিল নেই, এটি এনজিও/সরকার সহায়তায় স্থাপিত) [Compost pit (vegetable wastes, straw, grass, sawdust, ash added in the pit, the waste used as manure, no water seal, Built in assistance with the NGOs/government)]
7. পাইপ বা তাত্বিকভাবে নানা দিয়ে ময়লা খোলা জায়গায় (লেক/নদী/পানিতে) পড়ছে (সংবেদন্ত্বহলে পর্যবেক্ষণ করন) [Waste drains to open (lake/river/water) via
pipe/covered drain (Observe if possible) \( (\text{10.8.1} \text{ N} \text{ Answer: Cholve Yane Skip to Q10.8.1}) \)

8. ঢাকা দের নলা দিয়ে মলা খোলা জায়গায় (লেজনাদি/পাশাপাশি) পড়ছে (পর্যবেক্ষণ করন)  
[Waste drains to lake/river/water via open drain (Observe)] \( (\text{10.8.1} \text{ N} \text{ Answer: Cholve Yane Skip to Q10.8.1}) \)

9. বালিতে পড়ছে [Bucket] \( (\text{10.8.1} \text{ N} \text{ Answer: Cholve Yane Skip to Q10.8.1}) \)

10. ময়লা সরাসরি জলাশয়ে বা নিচু জমিতে পড়ছে (হুলক্ত) [Waste directly fall into water body or low land (Hanging)] \( (\text{10.8.1} \text{ N} \text{ Answer: Cholve Yane Skip to Q10.8.1}) \)

777. অন্যান্য (নির্দিষ্ট করে লিখুন) [Other (specify)]

888. প্লাস্টিক নয় [Not applicable]

31. ময়লা দুরে পিটের মধ্যে পড়ছে (বিং নাই, ডাব আছে) [Waste goes into offset pit (Using no rings but slab)]

32. ময়লা দুরে পিটের মধ্যে পড়ছে (বিং নাই, ডাব নাই) [Waste goes into offset pit (Using no rings or slab)]

33. ময়লা দুরে পিটের মধ্যে পড়ছে (বিং আছে, ডাব নাই) [Waste goes into offset pit (Using rings but no slab)]

10.7 পিটের/টাংকের বাইরে বা ভিতরের চূড়িকে পর্যবেক্ষণ করন [Observe the onsite or off site pit/tank in all direction]

(1= হা [yes], 0= না [No], 999= জানিনা [DK], 888= প্লাস্টিক নয় [Not applicable])

1. পিটের/টাংকের উপরিভাগ মাটি থেকে উপরে দেখা যায়ে কি? [Is the top of the pit visible (above the ground)]?........................................................................................................................................

2. ময়লা দের চিল্যের/তাংকের পাইলের ভিতরের বা বাইরে ময়লা দেখা যাচ্ছে কি? [Waste/faeces visible in or around the pipe, because of Leakage in the connecting pipe].....

3. পিট/টাংকের ছিট্টের কারণে ভিতরে বা বাইরে ময়লা দেখা যায়ে [Waste/faeces visible because of leakage in the pit/tank].................................................................................................................................

**Skip Note:** ১০.৭.৩ নং প্রশ্নের উত্তর ১ হলো ১০.৮ নং প্রশ্নে চলে যান। [If the answer to question 10.7.3 is 1 go to question 10.8]

4. ময়লা দেখা যাচ্ছে না কিন্তু পিট/টাংকে ভাঙা দিয়ে মশা মাছি আশা যাওয়া করতে পারবে [No visible waste but broken pit/tank that may allow flies coming out of the toilet]......

**Skip Note:** ১০.৭.৪ নং প্রশ্নের উত্তর ১ হলো ১০.৮ নং প্রশ্নে চলে যান। [If the answer to question 10.7.4 is 1 go to question 10.8]

5. ময়লা দেখা যাচ্ছে না কিন্তু পিট/টাংকেতে ফাটল/ভাঙা দেখা যাঙ্গে দিয়ে মশা মাছি আশা যাওয়া করতে পারবে না [No visible waste but crack in the pit/tank].........................................................................................................................
**Observe the interior of the toilet**

10.8.1 **Odor of feces in the latrine/bathroom?**

\[ 1 = \text{Yes}, \ 0 = \text{No}, \ 888 = \text{not applicable} \]

10.8.2 **Flies present?**

\[ 1 = \text{Yes}, \ 0 = \text{No}, \ 888 = \text{not applicable} \]

10.8.3 **Is there a slab/platform in the toilet?**

(Note: Squatting slab or platform that is covering the pit on all sides, has a squatting hole and rose above the surrounding ground level to prevent any surface water entering the pit)

\[ 1 = \text{Yes}, \ 0 = \text{No}, \ 888 = \text{not applicable} \]

10.8.4 **Main material of the floor (select 1)**

1. Mud
2. Wood
3. Cement
4. Tile/brick
5. Plastic

\[ 888 = \text{not applicable} \]

10.8.5 **Is stool visible on the slab or floor?**

\[ 1 = \text{Yes}, \ 0 = \text{No}, \ 888 = \text{not applicable} \]

10.8.6 **Is stool visible on the walls?**

\[ 1 = \text{Yes}, \ 0 = \text{No}, \ 888 = \text{not applicable} \]

10.8.7 **Is stool visible on the door/curtain?**

\[ 1 = \text{Yes}, \ 0 = \text{No}, \ 888 = \text{not applicable} \]

**Skip note:** If 10.8.3 = 0/888 skip to 10.10

10.8.8 **Is there any commode in the toilet?**

\[ 1 = \text{Yes}, \ 0 = \text{No}, \ 888 = \text{not applicable} \]

**Skip to 10.9**
10.8.9  Is the commode broken?

..............................................................................................................................

1 = ยัง [Yes]
0 = ไม่ [No]
888 = ไม่สามารถระบุ [not applicable]

10.8.10  Is there faeces visible in the commode?

..............................................................................................................................

1 = ยัง [Yes], 0 = ไม่ [No], 888 = ไม่สามารถระบุ [not applicable]

10.9  Is there a lid covering the squatting hole/drop hole?

..............................................................................................................................

1 = ยัง [Yes] =1
0 = ไม่ [No]=0
888 = ไม่สามารถระบุ [not applicable]=888

10.10  Is the toilet full? (Note: Toilet is considered full if faeces have reached over the exit of the squatting hole. In case of toilets with water seal or offset pit/tank, if there is confusion flush water to see if the faeces flushes away.)

..............................................................................................................................

1 = ยัง [Yes] =1
0 = ไม่ [No]=0
999 = ไม่สามารถระบุ [not applicable]=999
888 = ไม่สามารถระบุ [not applicable]=888

Skip note: If 10.8.3 = 0/888 skip to 10.13

10.11  Observe through the hole in the toilet

..............................................................................................................................

1.  Water in pipe (Water seal, pour some water in the hole to check if there is water in the water seal)
2.  Only pipe visible (no water seal)
3.  Broken pipe (Water seal broken)
4. **Pail not, grass in the latrine (pit is not full yet)**

5. **Content of the pit is not full yet**

888. **Not applicable**

10.12 If answer to 12 is 2 or 3, is there any flap at the end of the pipe to prevent files from coming out? (Ask the respondent)

<table>
<thead>
<tr>
<th>Yes</th>
<th>No</th>
<th>DK</th>
<th>Not applicable</th>
</tr>
</thead>
</table>

10.13 **Observation:** What materials for anal cleansing and hand wash are present inside or immediately outside the latrine?

<table>
<thead>
<tr>
<th>Yes</th>
<th>No</th>
<th>DK</th>
<th>Not applicable</th>
</tr>
</thead>
</table>

1. Leaves/grass

2. Twigs/sticks

3. Rag/cloth

4. Stones

5. Hygienic toilet paper

6. Water container/vessel

7. Water tap

8. Soap

9. Ash or soil for cleansing

10. Newspaper

11. Nothing
10.14 How long have you had the present toilet in this place? (Don’t know = 999)

- [ ] Number of years
- [ ] Number of months

10.15 Where did the household member defecate before this latrine was built? (Note: Read the responses to the respondent)

- [ ] Open
- [ ] Owned a shared latrine
- [ ] Used someone’s latrine
- [ ] Had another latrine (individual)
- [ ] Don’t know
- [ ] Not applicable

10.16 When did the latrine that you use last fill up?

- [ ] Within the last 3 months
- [ ] > 3 – 6 months ago
- [ ] > 6 – 12 months ago
- [ ] > 12 months ago
- [ ] Not yet filled up
- [ ] Not applicable

Skip Note: If answer of 10.16 is 5/888/999, skip to 10.18

10.17 What did you do when the latrine filled?

- [ ] Discarded contents in a pit within 200 meters of the latrine
- [ ] Discarded contents in a pit > 200 meters from the latrine
- [ ] Discarded contents openly nearby bushes, river, pond or any other general water body
10.18 Is there any Human faeces present within the household?

- Yes [1]
- No [0]

10.20 Is there any Animal faeces present within the household?

- Yes [1]
- No [0]

10.22 Poultry (chicken, duck, and pigeon)

1. Poultry [1]
2. Cow / Buffalo [1]
4. Pig [1]
5. Dog or Cat [1]

- Other [777]
10.22 Is there any human faeces present within the compound?

Yes [ ] No [X] 0 10.24 Skip to 10.24

10.23 Number of piles of Human faeces within the compound that could be considered open defecation

[ ] Too numerous to count (more than 10 piles)

[ ] Cannot tell / could not observe

10.24 Is there any Animal faeces present within the compound?

Yes [ ] No [X] 0 11.1 Skip to 11.1

10.25 Number of piles of Animal faeces present within the compound (mark all that apply)

1. Poultry (chicken, duck, and pigeon) [ ]

2. Cow / Buffalo [ ]

3. Goat / Sheep [ ]

4. Pig [ ]

5. Dog or Cat [ ]

[ ] Other [ ]
Section 11: Hand washing

11.1 Can you show me where you mostly wash your hands after you back from the toilet? [(ASK TO SEE AND OBSERVE)]

- Inside/near toilet facility
- Inside/near kitchen/cooking place
- Elsewhere in yard (within 3 steps)
- Elsewhere in yard (>3 steps but < 10 feet)
- Outside yard (>10 feet from the latrine)
- No specific place

If answer is 7, skip to 11.5

Skip Note: If answer of 11.1 is 666, skip to 11.5

11.2 Observation only: Is water available there for hand washing? [Yes] [No]

11.3 Observation only: Is there soap or detergent or locally used cleansing agent? [Soap] [Detergent] [Ash] [Mud/sand] [Other: specify]

If answer is 7, skip to 11.5

Skip Note: If answer is 7, skip to 11.5
11.4 (Observation only: If cleaning agent is not present, can the respondent bring cleaning agent within 1 minute?)

<table>
<thead>
<tr>
<th>resposta</th>
<th>código</th>
</tr>
</thead>
<tbody>
<tr>
<td>[Yes]</td>
<td>1</td>
</tr>
<tr>
<td>[No]</td>
<td>0</td>
</tr>
<tr>
<td>[Not applicable]</td>
<td>888</td>
</tr>
</tbody>
</table>

1. सापांन [Soap]
2. डिट्रॉजर [Detergent]
3. अश [Ash]
4. मूट/ बालू [Mud/sand]
777. अन्य (निर्दिष्ट करे लिखने) [Other: specify]
6. उपरोक्त कोणतीही ना [None of the above]

11.5 खानाटीत पालींच्या टापु आहे किती? [Do you have water tap for your household?] ........................................................................

<table>
<thead>
<tr>
<th>resposta</th>
<th>código</th>
</tr>
</thead>
<tbody>
<tr>
<td>[Yes]</td>
<td>1</td>
</tr>
<tr>
<td>[No]</td>
<td>0</td>
</tr>
</tbody>
</table>

11.7 आमच्या अपनारे हातपंळू देखेल्यास पाहिल्या? [May I please look at your hands?]

<table>
<thead>
<tr>
<th>Descrição</th>
<th>código</th>
</tr>
</thead>
<tbody>
<tr>
<td>[Visible dirt]</td>
<td>1</td>
</tr>
<tr>
<td>[Unclean appearance]</td>
<td>2</td>
</tr>
<tr>
<td>[Clean]</td>
<td>3</td>
</tr>
<tr>
<td>[Observation was not possible/refused]</td>
<td>4</td>
</tr>
</tbody>
</table>

1. हाताचे नेक [Fingernails]
2. करतल [Palms]
3. आँगाने समस्यावर [Fingerpads]

11.8 हात धोया: ३० वर्षीच्या बाहुवर्षीच्या हातधोया: [(Hand washing demo): Hand washing demo for child 3 – 5 years old):

<table>
<thead>
<tr>
<th>Descrição</th>
<th>código</th>
</tr>
</thead>
<tbody>
<tr>
<td>Please show me how you usually wash your hands after you go to the toilet for defecation. (Please note in the blank space about how did she washed her hands and later on how did she dry and fill up the following questions with appropriate code)]</td>
<td>1</td>
</tr>
</tbody>
</table>

नीचे देखे उत्तरात्तून सांग तिथे हया या ना कोड करून [Please check this based on answers of the open question.]

<table>
<thead>
<tr>
<th>resposta</th>
<th>código</th>
</tr>
</thead>
<tbody>
<tr>
<td>[Yes]</td>
<td>1</td>
</tr>
</tbody>
</table>
11.8.1 Does the household have a baby aged 3-5 years? [Do the household has a baby aged 3-5 years...]

Skip Note: If answer is 0, skip to 11.9.

11.8.2 Did the person participate [Participated]?

Skip Note: If answer is 0, skip to 11.9.

11.8.3 Used only water [Used only water]

11.8.4 Used soap [Used soap]

11.8.5 Washed both hands [Washed both hands]

11.8.6 How long (count seconds) the person rubs hands with soap? [Washed both hands]?

11.8.7 Dried with [Dried with]

- Dried hands on clothing that she was wearing: Sharir Anchal, shalwer/ kamiz etc. 1
- Dirty cloth (such as lungi, gamsa, towel etc. those looked dirty) 2
- Clean cloth 3
- Air dry 4
- Not dry 5
- Not applicable 888

11.9 How did she wash her hands after going to toilet for defecation? [Hand washing demo: Hand washing demo by caregiver]

- Please show me how you usually wash your hands after you go to the toilet for defecation. (Please note in the blank space about how did she wash her hands and later on how did she dry and fill up the following questions with appropriate code)

---

Please check this based on answers of the open question.

- Yes 1
- No 0
11.9.1 অংশগ্রহণ করেছিলেন [Participated].................................................................................................

Skip Note: যদি ১১.৯.১ নং ঘাটনের উত্তর ০ হয় তাহলে ১২-এ যান। [If answer of 11.9.1 is 0, skip to 12]

11.9.2 ওষুধ পানি ব্যবহার করেছিলেন [Used only water].................................................................

11.9.3 সাবান ব্যবহার করেছিলেন [Used soap]..............................................................................

11.9.4 দুই হাত ধুয়েছিলেন [Washed both hands]..............................................................................

11.9.5 কতক্ষণ ধরে (সেকেন্ড গণনা করেন) হাত সাবান দিয়ে ধুয়েছিলেন [How long (count seconds) the personrub hands with soap?] .............................................................................

11.9.6 হাত বক্রিয়াছিলেন [Dried with........................................................................................................

- পরিধেয় কাপড় (শাড়ির আংটি, শালের/কামিজ ইত্যাদি) [Dried hands on clothing that she was wearing]: Sharir Anchal, shalwer/ kamiz et .............................. 1
- লুঁই/গামসা/অন্যান্য (যা পরিধান করেননি) নেওয়া দেখা ছিল [Lungi / gamsa / others (not wearing) and looked dirty]................................................................. 2
- পরিবার কাপড় [Clean cloth] 3
- বাতাসে [Air dry] 4
- ধুকানো হয়নি [Not dry] 5
- হয়েছে নয় [Not applicable] 888

12. এই খানায় হাত ধোয়া নমুনা সংগে করা হয়েছে কি? Has hand risne sampel been taken for this household?.................................................................................................................................

ঃঃ [Yes]........................................................................1

ঃ [ No]. ......................................................0

হয়েছে নয় [Not applicable]........888

13. এই খানায় বল সরবরাহ করা হয়েছে কি? Was a ball supplied to a child in this household?........

ঃঃ [Yes]........................................................................1

ঃ [ No]. ......................................................0

হয়েছে নয় [Not applicable]........888

14. এই খানায় মাছি ধরার টেপ স্থাপন করা হয়েছে কি? Has Fly tapes been placed in this household?........

ঃঃ [Yes]........................................................................1

ঃ [ No]. ......................................................0

হয়েছে নয় [Not applicable]........888
15. Have you checked if all the questionnaire is complete before leaving the household? .................................................................

[Yes] ................................................. 1
[No] .................................................... 0
[Not applicable] .................. 888

Thank you. Part-B is finished.

Name, signature of FRA:                                      Checked by FRO:
Follow up questionnaire survey

Project title: Role of sanitation in preventing contamination of the domestic environment and protecting health

Note: Ask these Questions to the mother or the main caregiver of the child.

[এই প্রশ্নগুলো বাচ্চার মাকে অথবা মূল পরিচালককে জিজ্ঞেস করুন ]

TOY COLLECTION SHEET (A4)

<table>
<thead>
<tr>
<th>Household ID</th>
<th>[ ] [ ] [ ]</th>
</tr>
</thead>
</table>

**Baseline visit related information**

1. Data collectors name

2. Date of Interview  
   [ ] / [ ] / [ ] (dd/mm/yy)

3. Time of Interview  
   [ ] : [ ] (hh:mm, 24 hr format)

**Follow up Visit**

<table>
<thead>
<tr>
<th>Household ID</th>
<th>[ ] [ ] [ ]</th>
</tr>
</thead>
</table>

4. Data collectors name

5. Date of Interview  
   [ ] / [ ] / [ ] (dd/mm/yy)

6. Time of Interview  
   [ ] : [ ] (hh:mm, 24 hr format)

7. Number of full hours since Baseline visit  
   [ ] : [ ] (hh:mm, 24 hr format)
<table>
<thead>
<tr>
<th>Location</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Outside home</td>
<td>on ground in yard</td>
</tr>
<tr>
<td>Outside home</td>
<td>in a container</td>
</tr>
<tr>
<td>Outside home</td>
<td>in another home</td>
</tr>
<tr>
<td>Inside home</td>
<td>in storage container/cabinet</td>
</tr>
<tr>
<td>Inside home</td>
<td>on surface other than ground, not in container (table, bed, etc)</td>
</tr>
<tr>
<td>Inside home</td>
<td>on ground/floor</td>
</tr>
<tr>
<td>in child’s hand</td>
<td></td>
</tr>
</tbody>
</table>

9. Appearance... |... Unused |
| Used and used and clean appearing |
| Used and unclean appearance |
| Used and visibly dirty |

10. Write any additional notes on toy appearance, location, damage, retrieval process, etc.)

11. Name of Respondent:

12. Relationship of respondent to index child:

1... Mother of youngest child |
2... Male caregiver |
3... Female caregiver other than mother |
### PART B: Use of Toy Ball

13. In your opinion, did your child (target) play with the toy ball?

<table>
<thead>
<tr>
<th></th>
<th>Yes</th>
<th>No</th>
<th>DK</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>999</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

14. In your opinion, how much did your child (target) play with the toy ball? (read each choice)

<table>
<thead>
<tr>
<th></th>
<th>Several times a day (4 or more times)</th>
<th>Few times a day (2/3 times)</th>
<th>Only once since he/she got the ball</th>
<th>Played but can’t tell how many times</th>
<th>Never</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
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<td>999</td>
<td></td>
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</tr>
</tbody>
</table>

15. In your opinion, did any of the children play with the toy ball?

<table>
<thead>
<tr>
<th></th>
<th>Yes</th>
<th>No</th>
<th>DK</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>999</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

16. In your opinion, how much did any of the other children in the household or Bari play with the toy ball? (read each choice)

<table>
<thead>
<tr>
<th></th>
<th>Several times a day (4 or more times)</th>
<th>Few times a day (2/3 times)</th>
<th>Only once since he/she got the ball</th>
<th>Played but can’t tell how many times</th>
<th>Never</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td></td>
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<tr>
<td>999</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

17. From what you saw, did the children play with...
the ball mostly inside the home, mostly outside the home or equal amount inside and outside the home?]

1. [Mostly inside the home]
2. [Mostly outside the home]
3. [equal amounts inside and outside the home]

18. [When the ball was inside, how often did the ball touch the ground? (read each choice)]

1. [All of the time]
2. [Most of the time]
3. [Sometimes]
4. [Rarely]
5. [Never]
6. [Was never played with inside]

19. [When the ball was outside, how often did the ball touch the ground? (read each choice)]

1. [All of the time]
2. [Most of the time]
3. [Sometimes]
4. [Rarely]
5. [Never]
6. [Was never played with outside]

7. [Was never played with inside]

999... [DK]
Appendix 4: Details of Microbiological sample collection and laboratory procedures used in pilot study presented in chapter 2 and 3.

Hand contamination sample collection

Hand rinse sampling technique of collecting hand contamination data was used since this technique has been used in many studies [1, 2] to assess hand contamination and has been found to be associated with diarrhoea [2]. A microbiologist trained in aseptic method of microbiological sample collection, collected data on unannounced hand contamination from both hands of the mother and the <5 children on the same day as the initial household questionnaire survey.

The mother of the <5 child was asked to give consent for giving hand rinse sample for the under <5 child and herself. Hand rinsed samples were collected at the beginning of the household questionnaire survey after the consent process was complete. Both hands were rinsed in a Whirl-Pak bag (Nasco, Fort Atkinson, WI) containing 200 ml sterile Ringer’s solution one after another. Ringer’s solution contains sodium chloride, potassium chloride, calcium chloride di-hydrate, and sodium lactate. The microbiologist held the bag from outside. When the selected hand of the mother/child completely came into contact with the Ringer’s solution, the microbiologist asked the mother/child to rub the fingers and palm against each other for 15 seconds. Then the microbiologist massaged the inserted hand from the outside of the Whirl-pak bag for additional 15 seconds to ensure that all parts of the hand are fully immersed in Ringer’s solution. The microbiologist then instructed the respondent to remove the hand, shaking it so that all the drops of solution remain in the bag. The closed Whirl-Pak bags were placed immediately into a cold box, maintained at ≤ 10°C with ice packs, to prevent bacterial multiplication. Then the samples were transported to the Environmental Microbiology Laboratory of icddr,b for processing.

Sentinel toy sample collection

We measured contamination of a sentinel non-porous plastic toy ball (20 cm diameter) (Picture 1) as a measure of environmental contamination, as this has been found to be associated with quality of latrine in Bangladesh [3, 4]. The sentinel toy sample collection was conducted following similar methodology as used in these studies.

The toy balls were initially sterilized, wrapped in foil paper and stored in a sterile bag until it was given to the selected households. The sentinel toys were given to the households for the child to play with on the same day as the initial household questionnaire survey. The mother was instructed that the child can play with the toy ball with his usual play
mates and sites. The field team visited the household 24 hours later on the following day to collect the toy rinse sample. During the follow up visit the microbiologist asked the mother to locate the ball. The mother was then requested to place the ball in a Whirl-Pak bag filled with 200 ml ringer’s solution. The ball was rinsed in the solution for 30 seconds fully immersed. The bag was first shaken for 15 seconds and then rubbed from outside for an additional 15 seconds to make sure all sides of the ball is rinsed in the solution. Once the ball has been rinsed it was dried and given back to the child. The closed Whirl-Pak bags were placed immediately into a cold box, maintained at $\leq 10^\circ$C with ice packs, to prevent bacterial multiplication. Then the samples were transported to the lab for processing within 24 hours.

**Floor/Yard sample collection**

Based on the formative research, the field team identified potential mud surfaces that can be consistently identified in different household. Surface rather than soil sample was chosen as most of the contamination was found in the upper surface of the soil [5] in a previous study. The surfaces were chosen based on the experience of the formative research and the data on soil contamination in rural Tanzania [5]. Two type of surface sample was collected. We collected environmental contamination sample from the surfaces using a sterile Whirl-Pak Speci-Sponge bags (Whirl-Pak Speci-Sponge bag, Nasco, Fort Atkinson, WI) (3.6 cm wide, 7.6 cm Long and 1.5 cm thick) . The sponge was pre-hydrated with 20 ml of ringer’s solution in the Environmental Microbiology Laboratory of icddr,b.

The first surface sample was collected from the **floor of entrance of the main house**. A 100 cm$^2$ sampling area was marked on the centre of the floor/surface with a sterile aluminium stencil frame. Between the samples collection in different household the stencil frame was sterilized using 70% methanol. The sponge was rubbed over the fixed sampling area twice, and then placed into the Whirl-Pak bag.

The second surface sample was a **composite floor sample**. The idea was to collect surface sample from 3 different part of the same household to measure an average of the faecal contamination. The 3 surface areas included the middle of the yard, middle of the living room and middle of the kitchen. For the composite sample one pre-hydrated sponge was used. The data collector first identified 100 cm$^2$ area in each of the areas and sponged the area twice. One half of one side of a sponge was swiped over 100 cm$^2$ sampling area twice so that sample from each of the 3 sites can be collected using the same sponge.

The closed Whirl-pak bags were placed immediately into a cold box, maintained at $\leq 10^\circ$C with ice packs, to prevent bacterial multiplication. Then the samples were transported to the lab for processing within 24 hours.

**Quality Control**

A sample Whirl-Pak bag was opened at the household during sample collection and then closed without collecting any sample using the bag. This way a field blank was analyzed every day to ensure sample rinse bags are free of indicator organisms and are not getting contaminated during the field sampling process.
Laboratory procedures
All the laboratory procedures took place in Environmental Microbiology Laboratory of icddr,b.

Preparing toy balls
The toy balls were prepared following similar standard operating procedure as a previous study conducted in Bangladesh [6]. The microbiologist washed the balls with soap and water. Then the balls were dried with paper towel. Then the toys were bathed in bleach [200mL of industrial bleach (5.25%) and 1.8 litres of distilled water] for 10 minutes, making sure that the balls were coated with bleach, and after 5 minutes the balls were re-submerged into the bleach. The microbiologist then removed the toys from bleach bath and placed in tub that was sterilized in with bleach. Then the toys were rinsed with distilled water 3 times transferring to sterile tubs between each rinse. Then the balls were left a sterile tub to dry for 30 minutes to 1 hour. Once the balls were dry, they were wrapped in aluminium foil (Cleaned with 70% ethanol), placed inside zipper bags and stored in bucket for the field team to pick up.

Preparing sample for membrane filtration
The environmental contamination samples were processed by a microbiologist in the Environmental Microbiology Laboratory of icddr,b. All the environmental samples were stored in 2-8 °C refrigerators in the lab after transported to the lab until analysed within 24 hours. The samples collected from mother’s hands, child’s hands and sentinel toy was directly processed. In case of sponge samples collected from the surfaces, 180ml of Ringer’s solution was poured into each of the bags containing the sponge. Then the bags were manually shaken vigorously for 1 minute and rubbed with hands for an additional minute. The sponges were then removed from the bags leaving the solutions ready for further processing.

Enumeration of faecal coliform and E. coli using membrane filtration
The samples were processed by a microbiologist via membrane filtration technique to detect faecal coliform using mFC media and E. coli using MI media following EPA method [7, 8] (Box 1) used for drinking water.

The microbiologist filtered 50 ml to 1 ml (Table 2) of liquid recovery media depending on turbidity and type of the sample through a 0.22 µm Millipore (Billerica, MA) membrane filter using a vacuum pump. In majority of the cases only one volume was processed for each sample considering the resource constraints. To develop preliminary understanding of the amount of sample to we first processed samples collected from 3 households (Table 1). The samples from the first 3 households were not included in the final analysis. For each sample droplets of the original recovery media, 10⁻¹ and 10⁻² dilutions of the recovery media, was also plated at a total volume of 100 µl in case the results from the membrane filtration appears Too Numerous to Count (TNTC) [9, 10]. If the samples processed via membrane filtration on the first day produced no detectable colonies, a higher concentration was filtered on the second day using samples stored at 4 °C.
temperature. If there were no target colonies found in the plates on both the days, then the microbiologists reported 0 CFU/200 ml of recovery media.

If there is no target colonies found in the plates then reported 0.5 CFU/200 ml of recovery media. If there is characteristic colony present and less than 500, report as number of CFU per 200 ml of recovery media. If there is characteristic colony present but exceed 500 CFU per membrane, then count the colonies found in the in the droplet of the original recovery media. If the droplet of the original recovery media is also found too numerous to count, then count droplet for $10^{-1}$ dilution were interpreted. In case the droplet of the $10^{-1}$ is also too numerous to count then consider the droplet of $10^{-2}$ dilution to count the number of CFU per 200 ml of recovery media. To control the quality of the test negative controls were tested for contamination for each set of agar media. Every day one lab blank was tested for contamination. The samples were processed by a microbiologist who followed general standard operating procedures that are followed in the lab as described in box 1.

**Box 1:** Standard operating procedure of enumeration of faecal coliform and *E. coli* followed in the environmental microbiology laboratory of ICDDR,B

**Filtration of sample through membrane filtration procedure**

1. Label laboratory ID and processing date on mFC agar plate with a label pen.

2. Sterilize the surface of the Microfil Membrane Filtration Unit *(Billerica, MA)* by flaming for 3-5 sec, paying particular attention to the outer edges.

3. Open a membrane (0.22μm) envelope by peeling back one of the two “easy-to-open” corners and place it on the Microfil support after sufficient cooling.

4. Take a sterile funnel, grasping from the middle and place it carefully on to the support.

5. Shake the sample for a while and then pour 50-1 ml or recovery media based on visual inspection of turbidity and experience with the sample into the funnel. Filter the sample under vacuum until the sample has passed entirely through the membrane. Close valve of vacuum, remove the funnel, and press the lever on the vacuum support stem to lift the membrane filter from the vacuum support surface.

**Plating and Incubation**

6. Use sterile forcep to remove the membrane filter and place the membrane filter on to the mFC agar Petri dish for faecal coliform and MI agar (BD Difco, Franklin Lakes, NJ) Petri dish for *E. coli*. The orientation of the filter should remain the same as in the filtration unit.

7. Drop plate 100 μl of original sample as well as 10 and 100 times diluted sample on to mFC agar (faecal coliform) and MI agar (*E. coli*).

8. Incubate the plate at 44.5 ± 0.2°C for 24 ± 2 hours for faecal coliform. Incubate the plates at 35 ± 2°C for 24 hours for *E. coli*. Store the remaining sample at 2-8°C in a refrigerator for further repetition, if required.

**Enumeration**

9. a) Carefully count the blue and greenish blue coloured colonies on the mFC agar and keep record as FC in the Laboratory work log sheet.
b) Carefully count the deep blue colour colonies on the MI agar plate and record as *E. coli*.

### Quality Control

10. Quality control is performed with each new lot of media prepared

a) For mFC agar *Escherichia coli* ATCC-13706 is used as positive control and *Staphylococcus aureus* ATCC-25923 is used as negative control.

b) For MI agar *Escherichia coli* ATCC-13706 is used as positive control and *Staphylococcus aureus* ATCC-25923 is used as negative control.

### Interpretation

a) If there are no target colonies of faecal coliforms/*E. coli* on first day then filter a higher amount of recovery media from the stored sample on the second day. If there are no target colonies of faecal coliforms/*E. coli* both days, report: 0 CFU/200 mL.

b) If there is characteristic colony present and less than 500 CFU per membrane, report: number of CFU/ 200 mL.

c) If there is characteristic colony present but exceed 500 CFU per membrane, than interpret the colonies in the 100 µl droplets of the original sample.

d) If the 100 µl droplets of the original sample also exceed 500 CFU than interpret the colonies in droplets of 10 times diluted sample.

e) If the 100 µl droplets of the 10 times diluted sample also exceed 500 CFU than interpret the colonies in droplets of 100 times diluted sample.

f) If all the in all of the plates of the first day presents with characteristic colony more than 500 than repeat the test using appropriate dilution to achieve countable colony the next day from the sample preserved in the refrigerator.
Table 7.4: Volume of sample filtered or plated as droplets to successfully enumerate *E. Coli* and faecal coliform in 3 household (pilot data not included in the main analysis)

<table>
<thead>
<tr>
<th>Type of sample</th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td><em>E. Coli</em></td>
<td>Faecal Coliform</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Amount filtered to detect successfully detect colonies</td>
<td>Freq.</td>
<td>Amount filtered to detect colonies</td>
<td>Freq.</td>
</tr>
</tbody>
</table>
| 1 | Mothers hands | Day 1: 5 ml filtration  
Day 2: 20 ml filtration | 2  
1 | Day 1: 10 ml filtration | 3 |
| 2 | Childs Hands | Day 1: 5 ml filtration  
Day 2: 20 ml filtration | 2  
1 | Day 1: 10 ml filtration | 3 |
| 3 | Sentinel toy |  | Day 1: 5 ml filtration  
100 µl of 10⁻¹ dilution Drop | 2  
1 |
| 4 | Entrance of living room | Day 1: 0.5 ml filtration  
100 µl Drop | 2  
1 | Day 1: 100 µl of 10⁻¹ dilution Drop | 3 |
| 5 | Composite-floor | Day 1: 0.5 ml filtration | 3 | Day 1: 100 µl of 10⁻¹ dilution Drop | 3 |
Table 7.5: Showing the percentage of samples with various detection limits for each type of sample (N=20)

<table>
<thead>
<tr>
<th>Method</th>
<th>Amount filtered or drop plated</th>
<th>Detection limit†</th>
<th>Mother’s hands (%)</th>
<th>Children’s hands (%)</th>
<th>Sentinel toy</th>
<th>Entrance of living room</th>
<th>Composite floor sample</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Lower</td>
<td>Upper</td>
<td>EC*</td>
<td>FC*</td>
<td>EC</td>
<td>FC</td>
</tr>
<tr>
<td>100 µl of 10⁻² dilution Drop</td>
<td>1000000</td>
<td>1000000000</td>
<td>10%</td>
<td>5%</td>
<td></td>
<td>45%</td>
<td>35%</td>
</tr>
<tr>
<td>100 µl of 10⁻¹ dilution Drop</td>
<td>10000</td>
<td>1000000</td>
<td>20%</td>
<td>35%</td>
<td>5%</td>
<td>20%</td>
<td>35%</td>
</tr>
<tr>
<td>Drop plate technique</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1 ml filtration</td>
<td>100</td>
<td>100000</td>
<td>25%</td>
<td>20%</td>
<td>30%</td>
<td>10%</td>
<td>30%</td>
</tr>
<tr>
<td>2 ml filtration</td>
<td>50</td>
<td>50000</td>
<td>30%</td>
<td>10%</td>
<td>35%</td>
<td>5%</td>
<td></td>
</tr>
<tr>
<td>Membrane filtration</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5 ml filtration</td>
<td>20</td>
<td>20000</td>
<td>50%</td>
<td>15%</td>
<td>45%</td>
<td>20%</td>
<td>10%</td>
</tr>
<tr>
<td>10 ml filtration</td>
<td>10</td>
<td>10000</td>
<td>5%</td>
<td>25%</td>
<td>5%</td>
<td>25%</td>
<td>10%</td>
</tr>
<tr>
<td>20 ml filtration</td>
<td>5</td>
<td>5000</td>
<td>15%</td>
<td>10%</td>
<td>10%</td>
<td>15%</td>
<td>40%</td>
</tr>
<tr>
<td>50 ml</td>
<td>2</td>
<td>2000</td>
<td>0%</td>
<td>5%</td>
<td>5%</td>
<td>10%</td>
<td>10%</td>
</tr>
</tbody>
</table>

* E. coli (EC), Faecal coliform (FC)
† For lower detection limit we counted 0.5 for no characteristic colony per plate and for upper detection limit we considered 500 colonies per plate to countable.
References


7. CDC, *Microbiological Indicator Testing in Developing Countries: A Fact Sheet for the Field Practitioner*. 2010, Centre for Disease Control and Prevention.


Appendix 5: Consent form and questionnaire for Neighbourhood questionnaire survey

Informed consent form for neighbourhood questionnaire survey (Chapter 4)

Project title: Role of sanitation in preventing contamination of the domestic environment and protecting health.

Part I: Information Sheet

Introduction

Hello (Assalamualaikum/Nomoshkar). My name is __________ and I work with the ICDDR,B (Cholera Hospital) in Dhaka. I am here to invite you to take part in a research study. You are free to decide whether or not to be in the study.

Purpose of the research:

The purpose of this study is to understand whether neighbourhood sanitation coverage is linked with household environmental contamination. This will help us understand how to improve health of children.

Procedure:

We are enrolling households with at least one child aged between 6 and 24 months in the neighbourhood. If you agree to participate in the study I will visit different parts of your household. At the end of observation I will ask some questions about your household routine and practices. It will take around 30 minutes. I will take some notes on a tablet computer.

I also wish to ask you for the permission to take pictures. I might take some pictures of different facilities and activities of your household. I will show you the pictures that I will take. If you agree, these pictures might be shown as illustration in future presentations. If you do not want your face to be visible on the pictures I will blur your face, so that nobody can recognize you.

Benefits:

There is no immediate benefit to you from this study. The study will help us better understand conditions in Bangladesh. This information may help to improve child health in future.

Costs and Compensation:

There is no cost to you for being in this study. You will not receive anything for being in the study.

Risks:

There is no risk from being in the study. We will only collect information. My presence in your home for several hours may be uncomfortable for you. But we do not expect any harm to come to you or your family because of the study.

Privacy:

We assure that the privacy of information identifying you will be strictly maintained. The information identifying you will only be accessible to me, my research team, the ethical Review Committee. Any information that is gathered
about you and your family will be kept anonymous. All paper documents will be kept in a locked cabinet at ICDDR,B. The research team will have sole access to the locked cabinet. All digital data with personal identifiers will be maintained on secure systems protected by passwords. Your name and identity will not be used in reporting and presenting study findings, or in their publication in journals. We will use the information only for the purpose of research. In case of future use of the information collected from the study anonymous information may be supplied to other researchers. But this will not compromise with your privacy and anonymity.

**Voluntary participation:**

You are free to decide whether or not to be in the study. You are free to leave the study at any time. You do not have to give any reason for leaving the study. You will not lose any benefits for leaving the study. If you do take part in the study, you are free to refuse to answer any question. You do not have to give any reason for refusing to answer any questions.

**Persons to Contact**

If you have any question about this research study you may contact Mr. Tarique Md. Nurul Huda (Study Coordinator). His mobile number is 01772362311. His office number is 988-1761.

If you have questions about your right in the study, you may call Mr. M A Salam Khan, Committee coordination secretariat at 9886498. His office is located at 68, Shaheed Tajuddin Ahmed Sarani Mohakhali, Dhaka 1212.

**Part II: Consent Form**

The nature of the study has been explained to me. I have had the opportunity to ask questions about it. I understand what will be required of me and what will happen to me, if I take part. I understand that my participation in this study is voluntary. I understand that I do not have to answer any questions if I do not want. I understand that I can leave the study freely at any time. I understand that these conditions also apply to any children for whom I give consent to participate in the study. I do agree to quotations from my participation in the study to be included anonymously in reports about the study.

- [ ] I agree to participate in the study (tick)
- [ ] I do agree to quotations from my participation in the study to be included anonymously in reports about the study.
- [ ] I give my consent for pictures of me and my household facilities to be taken and used.
- [ ] I give my consent for all household members below the age of 18 years and for whom I am the parent of guardian to participate in the study. (Tick)

Name of the main caregiver ________________________________
Age __________ Years

_________________________________________  _________________
Signature of the Investigator or his representative  Date
Neighbourhood questionnaire survey

Project title: Role of sanitation in preventing contamination of the domestic environment and protecting health

Note: Ask these Questions to the mother or the main caregiver of the child.

PART A: QUESTIONNAIRE

Section 1: Questionnaire identification

1.1 Neighbourhood ID: .................................................................

1.2 Target Household ID: ............................................................... (Please follow the specific code sheet)

1.3 Instrument Type (Code: Cross Sectional Survey=A2): ...............

1.4 Cluster number (starting point number): ........................................

1.5 District name & district geocode: ...........................................

1.6 Address: ..............................................................................

1.7 Name of household head: ..........................................................

1.8 Father’s/ husband’s name: ........................................................

1.9 Location (specify): ...................................................................

1.10 GIS coordinates of the entrance of the living room.

1.11 Is data collection possible? ......................................................

1.12 If 6.10 answer is 0, then why? ................................................

Section 2: Respondent and household/compound demographics

2.1 Name of respondent: ..............................................................

2.2 How many people in total live in your HH at present? ...............
2.3 আপনার খানাতে ৫ বছরের নীচে কত জন শিশু আছেন? [How many children less than five years old live in your household?]

2.3.x ছেলে [Male]....................................................................................................................
2.3.y মেয়ে [Female]...................................................................................................................

Skip Note: শিশু সংখ্যা ০০ হলে ৩.১ নং প্রশ্ন চলে যান (If the number of the children=00 skip to q3.12)

2.4 আপনার এই খানায় ৫ বছরের ছোট কতজন শিশু আছেন? (ছোট থেকে বড়) [How many children less than five years old live in your household? List the child youngest to old]

<table>
<thead>
<tr>
<th>A. Child ID/Name</th>
<th>B. Date of birth (DD/MM/YY)</th>
<th>C. Age in months</th>
<th>D. Gender Male=1, Female=0</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5.</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Section 3: Household Faeces disposal

3.1 আপনার খানার সদস্যদের পায়েরা করার জন্য সাধারণত কোথায় যায়? (Note: উভয়দাতাকে উভয়গুলো পড়ে শোনান [Where do the members of your household usually go for defecation? (Note: Read out the responses to the respondent)]............................................................................................

5. খোঁলা জঙ্গল [Open bush]
6. খোঁলা মাঠ [Open field]
7. খোঁলা জায়গায়, নদী/পুকুর/লেকের পাশে [Open, by the side of river/pond/lake]
8. পায়নায় [In a toilet]

3.2 আপনি সাধারণত কোথায় পায়নায় করেন? Note: উভয়দাতাকে উভয়গুলো পড়ে শোনান [Where do you usually defecate?]

1. খোঁলা জঙ্গল [Open bush]
2. খোঁলা মাঠ [Open field]
3. খোঁলা জায়গায়, নদী/পুকুর/লেকের পাশে [Open, by the side of river/pond/lake]
4. পায়নায় [In a toilet]

3.3 আপনার খানার অন্যান্য প্রাঙ্গন বয়স্ক (১৮+) সদস্য সাধারণত কোথায় পায়নায় করেন? Note: উভয়দাতাকে উভয়গুলো পড়ে শোনান [Where do other adults (18+) in the household usually defecate?]

.............................................................................................

5. খোঁলা জঙ্গল [Open bush]
6. খোঁলা মাঠ [Open field]
7. খোঁলা জায়গায়, নদী/পুকুর/লেকের পাশে [Open, by the side of river/pond/lake]
8. **In a toilet**

3.4 Where do the <3 child in the household usually defecate? (Use name of the child from question 2.4) ..........................................................................................................................................................

8. [Potty]
9. [Nappy / diaper]
10. In the courtyard (without potty)
11. Inside the house (without potty)
12. [In Toilet / Latrine]
13. [Bush / forest / field]
14. No specific place
777. Other (specify) __________________________________
888. Not Applicable
999. Don’t know / Not sure

3.5 Where do the children aged 3-5 years usually defecate? [Probe to see if someone in the HH knows]

8. [Potty]
9. [Nappy / diaper]
10. In the courtyard (without potty)
11. Inside the house (without potty)
12. [In Toilet / Latrine]
13. [Bush / forest / field]
14. No specific place
777. Other (specify) __________________________________
888. Not Applicable
999. Don’t know / Not sure

3.6 Where do the children above 5 (Upto 18 usually defecate)? [Probe to see if someone in the HH knows]

8. [Potty]
9. [Nappy / diaper]
10. In the courtyard (without potty)
11. Inside the house (without potty)
12. [In Toilet / Latrine]
13. [Bush / forest / field]
14. कोन निरिपित जानाय नय [No specific place]

777. अन्याना (बन्धन लिपु) [Other (specify)] ________________

888. प्रयोजन नय [Not Applicable]

999. जानि न / निशिचि नय [Don’t know / Not sure] खानाय अन्य केउ जने कि ना देखि [Probe to see if someone in the HH knows]

3.7 अपनि सर्पेश चोखाय पायःनाय करेरे? उर्दुकाते उरुड़ोला पढ़े शोनान [Where did you defecate the last time? (Note: Read out the responses to the respondent)] .................................................................

1. चोळा जंपले [Open bush]
2. चोळा माथे [Open field]
3. चोळा जाय़याय, नदी/पूँकुड़/लोके पाशे [Open, by the side of river/pond/lake]
4. पायःनाय [In a toilet]

3.8 अपनार्य (३ वर्ष) शिव सर्पेश कथन पायःनाय करेरे? [When was the last time your youngest child / infant (<3 years) defecated?] ............................................................................................

1. आज [Today]
2. परशुराम [Yesterday]
3. २ दिन वा त्यार आङ्गे [2 or more days ago]
4. मने करते पाराच्य ना [Cannot remember] ३.१२ नं ओङ्गे चले यान (Skip to q3.12)
5. बलके राजी नया [Refused] ३.१२ नं ओङ्गे चले यान (Skip to q3.12)

888. प्रयोजन नय [Not Applicable] ३.१२ नं ओङ्गे चले यान (Skip to q3.12)

3.9 अपनार्य (३ वर्ष) शिव सर्पेश कोेख चोखाय पायःनाय करेरे? [Where did the child (<3 years) defecate the last time?] वॉर पढ़े शोनाने नया [Do Not Read Responses]............................................

8. पटी [Potty]
9. नाप्पी/डायपर/कौशा [Nappy / diaper]
10. उठाने (पटी हाड़ा) [In the courtyard (without potty)]
11. घराचे भिंतरे (पटी हाड़ा) [Inside the house (without potty)]
12. पायःनायाय/टॉयलेट [In Toilet / Latrine] ३.१२ नं ओङ्गे चले यान (Skip to q3.12)
13. कोप-काड़े/संगले [Bush / forest / field]
14. कोन निरिपित जाय़याय नय [No specific place]

777. अन्याना (बन्धन लिपु) [Other (specify)] ________________

888. प्रयोजन नय [Not Applicable]

999. जानि न / निशिचि नय [Don’t know / Not sure] खानाय अन्य केउ जने कि ना देखि [Probe to see if someone in the HH knows]

3.10 देऊ पायःनाय कं की हरेरे? [What was done with the faeces?] वॉर पढ़े शोनाने नया [Do Not Read Responses].................................................................................................

9. एखानेपै चोखाया करेरे एखानेपै फेले राखा हरेरे [Left there]
10. Put / rinsed into toilet or latrine
11. Put / rinsed into drain or ditch
12. Rinsed near tubewell/pond
13. Thrown into the bush / forest / field
14. Thrown into garbage
15. Thrown into a specific pit for child’s faeces
16. Buried

777. Other (specify) __________________________________
999. Don’t know / Not sure

3.11 How did you handle the faeces?
6. Hands only/bare hands
7. Hands and cloth / paper / leaves / straw
8. Local agricultural hoe/instrument
9. Sani-scoop
10. Did nothing

777. Other (specify) __________________________________
999. Don’t know / Not sure

3.12 When was the last time your youngest child / infant (3-5) defecated?
1. Today
2. Yesterday
3. 2 or more days ago
4. Cannot remember
5. Refused

888. Not Applicable

3.13 Where did the child 3 –5 years defecate the last time?
8. Potty
9. Nappy / diaper
10. In the courtyard (without potty)
11. Inside the house (without potty)
12. In Toilet / Latrine
13. Bush / forest / field
14. No specific place
3.14 What was done with the faeces?

1. Left there

2. Put / rinsed into toilet or latrine

3. Put / rinsed into drain or ditch

4. Thrown into the bush / forest / field

5. Thrown into garbage

6. Thrown into a specific pit for child’s faeces

7. Buried

8. Hands only/bare hands

9. Hands and cloth / paper / leaves / straw

10. Local agricultural hoe/instrument

11. Sani-scoop

12. Did nothing

Where did the child above 5 years (up to 18 years) defecate the last time?

8. Potty

9. Nappy / diaper

10. In the courtyard (without potty)

11. Inside the house (without potty)

12. In Toilet / Latrine

13. Bush / forest / field

14. No specific place
PART B: SPOT CHECKS

Section 4: Sanitation

4.1 What kind of toilet facility do members of your household usually use?

(Note: Request the respondent to show the toilet facility and code after observing the facility. If “flush” or “pour flush” probe/check: Where does it flush to?)

Flush-to-pit latrine (onsite/Off set) with slab and water seal containing water:

- Piped sewer system [Code: 01]
- Septic tank [Code: 02]
- Flush to pit latrine (onsite/Off set) with slab and water seal [Code: 03]
- Pit latrine with slab & no water seal but with a lid [Code: 04]
- Pit latrine with slab and flap, no water seal [Code: 05]
- Ventilated Improved Pit (VIP) latrine [Code: 06]
- Composting toilet [Code: 07]
- Vegetable wastes, straw, grass, sawdust, ash added in the pit, the waste used as manure, no water seal. A composting latrine may or may not have a urine separation device. [Code: 08]

Pit latrine with slab & no water seal/broken water seal and no lid [Code: 09]
পাতার আর্থিক পানি দেখার জন্য টারাইল যা কোন খাল, ত্রেন, নদী ইত্যাদির সাথে সংযোগজন
করার দীর্ঘ অংশের অবস্থার সৃষ্টি করে থাকে......................................................... 10

[Flush or pour flush toilet connected to somewhere else (canal, ditch, river, etc.)]

পিট/পর্দার পাতাখানা, স্ফটিক নেই এবং ডিচের থেকে মশা/মাছি যাওয়া আসা করতে পারে এবং দুর্গন্ধ ছড়ায়……. 11

[Pit latrine without slab/open pit]

বৃত্ত পাতাখানা [Pit latrine] .................................................................................. 12
বালতি [Bucket] ............................................................................................................. 13

[Flush or pour flush toilet connected to somewhere else (canal, ditch, river, etc.)]

বৃত্ত পাতাখানা [Pit latrine] .................................................................................. 12
বালতি [Bucket] ............................................................................................................. 13

[Flush or pour flush toilet connected to somewhere else (canal, ditch, river, etc.)]

বৃত্ত পাতাখানা [Pit latrine] .................................................................................. 12
বালতি [Bucket] ............................................................................................................. 13

[Flush or pour flush toilet connected to somewhere else (canal, ditch, river, etc.)]

বৃত্ত পাতাখানা [Pit latrine] .................................................................................. 12
বালতি [Bucket] ............................................................................................................. 13

বৃত্ত পাতাখানা [Pit latrine] .................................................................................. 12
বালতি [Bucket] ............................................................................................................. 13

বৃত্ত পাতাখানা [Pit latrine] .................................................................................. 12
বালতি [Bucket] ............................................................................................................. 13

বৃত্ত পাতাখানা [Pit latrine] .................................................................................. 12
বালতি [Bucket] ............................................................................................................. 13

বৃত্ত পাতাখানা [Pit latrine] .................................................................................. 12
বালতি [Bucket] ............................................................................................................. 13

বৃত্ত পাতাখানা [Pit latrine] .................................................................................. 12
বালতি [Bucket] ............................................................................................................. 13

বৃত্ত পাতাখানা [Pit latrine] .................................................................................. 12
বালতি [Bucket] ............................................................................................................. 13

বৃত্ত পাতাখানা [Pit latrine] .................................................................................. 12
বালতি [Bucket] ............................................................................................................. 13

বৃত্ত পাতাখানা [Pit latrine] .................................................................................. 12
বালতি [Bucket] ............................................................................................................. 13

বৃত্ত পাতাখানা [Pit latrine] .................................................................................. 12
বালতি [Bucket] ............................................................................................................. 13

বৃত্ত পাতাখানা [Pit latrine] .................................................................................. 12
বালতি [Bucket] ............................................................................................................. 13

পাতার জিআইইসি কোডারিটে লিপিবদ্ধ করন [GIS coordinates of the source of drinking water].

Latitude

Longitude

Skip Note:- যদি 4.1 এর প্রশ্নের উত্তর 14 হয়, তবে 4.14 এ প্রান্তে যান। [If answer of 4.1 is 14, skip to 4.18]

4.2.1 আপনার জানা মতে সর্বশেষ এই পায়ারা খাদ্য তথ্য কখন ব্যবহার করা হয়েছিল? [When was the most recent time this toilet was used?] ............................................................................................................. দিন আগে [days ago]
4.2.2 আপনি কি এই পায়ারা খাদ্য তথ্য কখন এর সাথে মিলে ব্যবহার করেন? [Do you share this toilet facility with other households?] ....................................................................................
(Note: কোন বাড়ি বা গোষ্ঠী, যারা একই আবাস স্থানে বসবাস করেন বা একই উৎস থেকে খাবারে শরীর হয় না, তারা অন্য খানার অংশগত হিসাবে বিবেচিত হয় । (Note: Any person or group of persons related or unrelated who do not live in the same dwelling space and do not share a common source of food as the respondent would be considered to belong to other household.)

1= হ্যা [yes]
0= না [No]
4.3.2 এর প্রান্তে যান [skip to 4.3.2]
999= জানিনা [DK]
4.3.2 এর প্রান্তে যান [skip to 4.3.2]
888= প্রযোজ্য নয় [Not applicable] 4.3.2 এর প্রান্তে যান [skip to 4.3.2]

4.3 কতগুলো খানা মিলে পায়ারাটি ব্যবহার করে? .................................................................
(প্রশ্ন কর্ম এবং পরিবর্তন করণ) {[Ask and check]: how many households sharing the toilet facility?]}

4.3.1 কতজন আপনার কতজন এই পায়ারাটি ব্যবহার করেন? [How many people including children use this toilet]?..............................

4.3.2 পায়ারাটির মালিকানা ? (প্রশ্ন করণ) {[Ask]: Ownership type of the Toilet?]..........................

49= এই খানার অধিকারী [Only for the household]........................................ 1
999= করেকটি খানা যেমন/ অংশীদার [Shared]........................................... 2
888= অন্য কেউ [Someone else]................................................................. 3
4.4 Path to the toilet suggests regular use (is clear, well-worn, without grass or any barriers etc.)..........
(1= হাঁ [Yes], 0= না [No], 999= জানিনা [DK], 888= গ্রেস্যা না [Not applicable])

4.5 Observe the general exterior of the toilet
(1= হাঁ [Yes], 0= না [No], 999= জানিনা [DK], 888= গ্রেস্যা না [Not applicable])
1. Is there any superstructure on the toilet?...........
2. Is there a door/curtain?...........................
3. Can an average sized adult use the toilet without being seen?
4. Is there roof over the toilet?
5. Is there any hole in the roof that may allow water to enter through the roof?
6. Is there a ventilation pipe?

Skip Note: যদি 10.5f সম্প্রসারণের উত্তর 0 হয়, তবে 10.5h সম্প্রসারণের যান। [If answer of 10.5f is 0, skip to 10.5h]

7. Is there a cover on top of the ventilation pipe that protects the flies from coming out?

h) What are the walls of the toilet mostly made of?

8. Concrete
9. Tin
10. Bamboo/Mud
11. Plastic
12. Tree leaves
13. Jute bag
14. Straw

888= গ্রেস্যা না [Not applicable]

i) What is the roof of the toilet mostly made of?

8. Concrete
9. Tin
10. Bamboo
11. Plastic
12. Tree leaves
13. Jute bag
14. Straw

888= গ্রেস্যা না [Not applicable]
11. Waste drains to underground piped sewer (Ask) [4.8.1 Skip to Q4.8.1]
12. Waste goes into onsite pit and stays there (Respondent will report using concrete rings to make the pit. Observe the top of the pit and any leakage)
13. Waste goes into offset pit and stays there (Respondent will report using concrete rings to make the pit. Observe the top of the pit and any leakage)
14. Waste goes into onsite tank and stays there (Observe the concrete cover of the tank and any leakage. Respondent will report building the tank with concrete lining rather than buying the ring for pit lining)
15. Waste goes into offset tank and stays there (Observe the concrete cover of the tank and any leakage. Respondent will report building the tank with concrete lining rather than buying the ring for pit lining)
16. Compost pit (vegetable wastes, straw, grass, sawdust, ash added in the pit, the waste used as manure, no water seal, Built in assistance with the NGOs/government)
17. Waste drains to open (lake/river/water) via pipe/covered drain (Observe if possible) [4.8.1 Skip to Q4.8.1]
18. Waste drains to lake/river/water via open drain (Observe) [4.8.1 Skip to Q4.8.1]
19. Waste directly fall into water body or low land (Hanging) [4.8.1 Skip to Q4.8.1]
20. Other (specify) [Not applicable]

4.7 Observe the onsite or off site pit/tank in all direction

(1= yes, 0= no, 999= don’t know [DK], 888= not applicable [Not applicable])
1. Is the top of the pit visible (above the ground)?

2. Waste/faeces visible in or around the pipe, because of Leakage in the connecting pipe?

3. Waste/faeces visible because of leakage in the pit/tank?

Skip Note: 4.7c If the answer to question 4.7c is 1 go to question 4.8

4. No visible waste but broken pit/tank that may allow flies coming out of the toilet?

Skip Note: 4.7d If the answer to question 4.7d is 1 go to question 4.8

5. No visible waste but crack in the pit/tank?

4.8.1 Odor of feces in the latrine/bathroom? (1=Yes, 0=No, not applicable=888)

4.8.2 Flies present? (1=Yes, 0=No, not applicable=888)

4.8.3 Is there a slab/platform in the toilet? (Note: Squatting slab or platform that is covering the pit on all sides, has a squatting hole and rose above the surrounding ground level to prevent any surface water entering the pit)

4.8.4 Main material of the floor (select 1)

4.8.5 Is Stool visible on the slab or floor? (1=Yes, 0=No, not applicable=888)

4.8.6 Is Stool visible on the walls? (1=Yes, 0=No, not applicable=888)

4.8.7 Is Stool visible on the door/curtain? (1=Yes, 0=No, not applicable=888)

Skip note: If 4.8.3=0/888 skip to 4.10

4.8.8 Is there any commode in the toilet?...
1= হা [Yes],  
0= না [No],  
4.9 নং প্রশ্ন চলে যান (Skip to 4.9)  
প্রয়াপ্ন নয় [not applicable] =888)  
4.9 নং প্রশ্ন চলে যান (Skip to 4.9)

4.8.9 কমোড চিকিৎসা করার জন্য আছে কি? Is the commode broken? .................................................................
(1= হা [Yes], 0= না [No], প্রয়াপ্ন নয় [not applicable] =888)

4.8.10 কমোডের উপর পাথরনা দেখিয়ে আছে কি [Is there faeces visible in the commode]?.................................
(1= হা [Yes], 0= না [No], প্রয়াপ্ন নয় [not applicable] =888)

4.9 নিপিনিন জিডিয়টে কমোড চাকনা আছে কি? [Is there a lid covering the squatting hole/drop hole?]

4.8.9 কমোড চিকিৎসা করার জন্য আছে কি? Is the commode broken? .................................................................

c= হা [Yes] =1
0= না =0

4.8.10 কমোডের উপর পাথরনা দেখিয়ে আছে কি [Is there faeces visible in the commode]?.................................

c= হা [Yes] =1
0= না =0

4.9 নিপিনিন জিডিয়টে কমোড চাকনা আছে কি? [Is there a lid covering the squatting hole/drop hole?]

4.10 পাথরনাটি কি মল দ্বারা ভরা গেছে? (Note: পাথরনাটি মল দ্বারা পূর্ণ হিসাবে ভরা হবে যদি কমোড মল দ্বারা পূর্ণ থাকে। এভাবে, ওয়াটার সীল থেকে পাথরনায় বা বাইরের পিটটাঁকি সহ পাথরনার জন্য, যদি স্কুশ থাকে মল নিপিনিন সম্পুর্নভাবে ভরা জন্য পানি ফ্লয়ন্ড করান। (Is the toilet full? (Note: Toilet is considered full if faeces have reached over the exit of the squatting hole. In case of toilets with water seal or offset pit/tank, if there is confusion flush water to see if the faeces flushes away. )..................................................)

c= হা [Yes] =1
0= না =0

4.11 পাথরনার কমান্ড এর জিডিয়টি পরিবর্তন করেন [Observe through the hole in the toilet].................

6. পাইপের পানি আছে (ওয়াটার সীলে পানি আছে কি না তা দেখার জন্য অন্য পানি চালু) [Water in pipe (Water seal, pour some water in the hole to check if there is water in the water seal)]

7. পাইপের পানি দেখা যায়, কমোড ওয়াটার সীল নেই [Only pipe visible (no water seal)]

8. পাইপের ভাঙা (ওয়াটার সীল ভাঙা) [Broken pipe (Water seal broken)]

9. পাইপের পানি দেখা যায়, কমোড ওয়াটার সীল নেই (পিটেটের খোলা), তবে পিটেট এখনও সম্পূর্ণ ভাবে ধারালু [No pipe, open hole to the pit, can see faeces in the pit, but the pit is not full yet]

10. কমোড এর জিডিয়টি মল দিয়ে ভরে গেছে (faeces have reached the exit of the squatting hole) 

4.12 যদি 4.11 নং প্রশ্নের উত্তর 2 বা 3 হয়, তবে ময়দা নিপিনিন প্রতিরোধে পাইপের শেষে কমোড ক্লুপ আছে কি? (উত্তরদাতাকে জিজ্ঞাসা করুন) [If answer to 12 is 2 or 3, is there any flap at the end of the pipe to prevent files from coming out?] (Ask the respondent)..................................................
4.13 Observation: What materials for anal cleansing and hand wash are present inside or immediately outside the latrine?

- [Yes] ..............................................................................................................1
- [No] ...............................................................................................................0

If applicable or not observed, please mark [Not Applicable/Could not observe]...

11.  [Leaves/grass]...............................................................................................
12.  [Twigs/sticks]..............................................................................................
13.  [Rag or cloth] ..............................................................................................
14.  [Stones] ......................................................................................................
15.  [Hygienic (toilet) paper] ..............................................................................
16.  [Water container/vessel] ............................................................................
17.  [Water tap] ...................................................................................................
18.  [Soap] ...........................................................................................................
19.  [Ash or soil for cleansing] ...........................................................................
20.  [Newspaper] ................................................................................................

Note: Request the respondent to show the toilet facility and code after observing the facility. If "flush" or "pour flush" probe/check: Where does it flush to?

Flush or pour flush toilet flushed to: (Observe the slab and water seal containing water):

- [Piped sewer system] ............. 01
- [Septic tank] (Observe the concrete cover of the tank) .............................. 02
- [Flush to pit latrine (onsite/Off set) with slab and water seal] ............... 03
- [Unknown place/not sure/DK where] ......................................................... 04
- [Pit latrine with slab & no water seal but with a lid] ................................. 05
Pit latrine with slab and flap, no water seal] (Ask the respondent about the flap, Flap: a plastic is attached at the end of the pipe to prevent files from coming out of the pit).

Ventilated Improved Pit (VIP) latrine] (Observe the slab and ventilation pipe)]

Composting toilet, (Composting toilet ensure separation of urine, water and excreta)

Vegetable wastes, straw, grass, sawdust, ash added in the pit, the waste used as manure, no water seal. A composting latrine may or may not have a urine separation device.)

Flush or pour flush toilet connected to somewhere else (canal, ditch, river, etc.)

Pit latrine without slab/open pit

Hanging toilet/latrine

Bucket

Open defecation):

No facility/bush/field] ........................ 14

Others: Specify] ....................................................................  777

Skip Note:-  

If answer of 4.1 is 14, skip to 4.3.2
888= প্রয়োজন নয় [Not applicable] 4.3.2 নং প্রশ্ন চলে যান [skip to 4.3.2]

4.3a কতগুলো খানা রয়েছে পায়োখানাটি ব্যবহার করে? .......................................................................................................................... 

(প্রশ্ন করা এবং পরিমাপ করা) [(Ask and check): how many households sharing the toilet facility?] 

4.3.1a বিভিন্ন আপাতান্ত্রিক কবরস্থা এই পায়োখানাটি ব্যবহার করেন? [How many people including children use this toilet].......................................................................................................................... 

4.3.2a পায়োখানাটির মালিকানা ? (প্রশ্ন করা) [(Ask): Ownership type of the Toilet?]..........................................................................................................................

প্রাথমিক বিশ্লেষণ [Detail observation of the toilet facility]

4.4a পায়োখানার যাবার রাস্তা দেখে যাচ্ছ কি যে এটা নির্মিত ব্যবহার করা হয় (পরিকল্পনা, জীবন ইত্যাদি) Path to the toilet suggests regular use (is clear, well-worn, without grass or any barriers etc.).......... 

(1= হা [Yes], 0= না [No], 999= জানিনা [DK], 888= প্রয়োজন নয় [Not applicable])

4.5a টয়লেটের বাইরের অবস্থা পর্যবেক্ষণ [Observe the general exterior of the toilet] 

(1= হা [Yes], 0= না [No], 999= জানিনা [DK], 888= প্রয়োজন নয় [Not applicable])

1 পায়োখানাটির উপর কোন ছাপনা আছে কি? [Is there any superstructure on the toilet? ]........ 

2 কোন দরজা / পার্দা আছে কি? [Is there a door/curtain?]......................................................... 

3 বাইরে থেকে দেখা যাওয়া ছাড়া গড় প্রাঙ্ক বয়স্ক কোন বাচ্চা এই টয়লেটে ব্যবহার করতে পারে কি? [Can an average sized adult use the toilet without being seen? ].................................

4 টয়লেটের উপর ছাদ আছে কি? [Is there roof over the toilet?].............................................

5 ছাদ এমন কোন ত্রিভাষা আছে কি যার মাধ্যমে ছাদ দিয়ে পানি পড়তে পারে? [Is there any hole in the roof that may allow water to enter through the roof?].........................................................

6 বায়ু চাপাচাপ উপরোক্তো কোন পাপে আছে কি? [Is there a ventilation pipe?].................................................

Skip Note: যদি 10.5f নং প্রশ্নের উত্তর 0 হয়, তবে 10.5h নং প্রশ্ন চলে যান [If answer of 10.5f is 0, skip to 10.5h]

7 পাপে এর মাধ্যমে কোন ক্ষুর আছে কি যা মায়া মাথি বের হওয়া প্রতিরোধ করতে পারে? [Is there a cover on top of the ventilation pipe that protects the flies from going out?]..........................................................................................................................

h) পায়োখানার দেয়ালগুলো মূলত কি দিয়ে তৈরী।? [What are the walls of the toilet mostly made of?] ..........................................................................................................................

1. কন্ক্রেট [Concrete]
2. টিন [Tin]
3. বোম/মাটি [Bamboo/Mud]
4. প্লাস্টিক [Plastic]
5. গাছের পাতা [Tree leaves]
6. পাতার গল্প [Jute bag]
7. কঠোর [Straw ]
8. কাঠ [Wood]
i) What is the roof of the toilet mostly made of?

1. Concrete
2. Tin
3. Bamboo
4. Plastic
5. Tree leaves
6. Jute bag
7. Straw
8. Not applicable

Where does the waste from toilet go? (Ask and observe if possible)

1. Waste drains to underground piped sewer (Ask) (Skip to Q4.8.1)
2. Waste goes into onsite pit and stays there 
3. Waste goes into offset pit and stays there
4. Waste goes into onsite tank and stays there
5. Waste goes into offset tank and stays there
6. Compost pit 
7. Waste drains to open drain (via pipe/covered drain) 
8. Waste drains to lake/river/water via open drain (Observe if possible) (Skip to Q4.8.1)
9. Bucket (Skip to Q4.8.1)
10. Waste directly fall into water body or low land (Hanging) (Skip to Q4.8.1)
307

888. প্রশ্নানা নয় [Not applicable]
31. মল দূর পিটের মধ্যে পড়ছে (রিং নাই, প্লাব আছে) [Waste goes into offset pit (Using no rings but slab)]
32. মল দূর পিটের মধ্যে পড়ছে (রিং নাই, প্লাব নাই) [Waste goes into offset pit (Using no rings or slab)]
33. মল দূর পিটের মধ্যে পড়ছে (রিং আছে, প্লাব নাই) [Waste goes into offset pit (Using rings but no slab)]

4.7a পিটের/টাংকের বাইরে বা ভিতরের চাঁদেকে পর্যবেক্ষণ করন [Observe the onsite or off site pit/tank in all direction]

(1= হাঁ [yes], 0= না [No], 999= জানিনা [DK], 888= প্রশ্নানা নয় [Not applicable])
1. পিটের উপরিভাগ মাটি থেকে উপরে দেখা যায় কি? [Is the top of the pit visible (above the ground)]?.................................................................
2. সংযোগনলের ছিদ্রের/ংংগার কারণে পাইপের ভিতরে বা বাইরে মলা দেখা যায় কি? [Waste/faeces visible in or around the pipe, because of Leakage in the connecting pipe]? ......................................................................................
3. পিট/টাংকের ছিদ্রের কারণে ভিতরে বা বাইরে মলা দেখা যায় [Waste/faeces visible because of leakage in the pit/tank]?..............................................................................................

Skip Note: 4.7c নং প্রশ্নের উত্তর 1 হলে ৪.৮ নং প্রশ্নে চলে যান [If the answer to question 4.7c is 1 go to question 4.8]
4. মলা দেখা যায় না কিন্তু পিট/টাংকের মাটি বা ভাঙা যা দিয়ে মলা মাছি আশা যাওয়া করতে পারবে [No visible waste but broken pit/tank that may allow flies coming out of the toilet]?
.............................................................................................................................

Skip Note: 4.7d নং প্রশ্নের উত্তর 1 হলে ৪.৮ নং প্রশ্নে চলে যান [If the answer to question 4.7d is 1 go to question 4.8]
5. মলা দেখা যায় না কিন্তু পিট/টাংকের মাটি বা ভাঙা যা দিয়ে মলা মাছি আশা যাওয়া করতে পারবে না [No visible waste but crack in the pit/tank]..........................................................................................

পায়োনার অভায়ীন অবস্থা পর্যবেক্ষণ [Observe the interior of the toilet]

4.8.1a পায়োনার/উঁচুঁটাপায়োনার পথ রয়েছে কি? [Odor of feces in the latrine/bathroom]?..........................□
(1= হাঁ [Yes], 0= না [No], 999= জানিনা [DK], 888= প্রশ্নানা নয় [Not applicable] =888])

4.8.2a মাটির উপরিভাগ রয়েছে কি? [Flies present?] .................................................................
(1= হাঁ [Yes], 0= না [No], 999= জানিনা [DK], 888= প্রশ্নানা নয় [Not applicable] =888])

4.8.3a ভিতরের পিটের/প্লাটফর্ম রয়েছে কি? [Is there a slab/platform in the toilet]?........................................................
(Note: প্লাটফর্মের সম্পর্কে বিস্তারিত তথ্য দেওয়া রয়েছে এবং পিটের ভিতরের দিকে ফুটানো পিটের উপরে করে রেখা দিয়ে থাকে, যার একটি নির্দেশ ছিদ্র আছে এবং যা পিটের চাঁদের সাথে পিটের উপরে অবতীর্থ থাকে) (Note: Squatting slab or platform that is covering the pit on all sides, has a squatting hole and rose above the surrounding ground level to prevent any surface water entering the pit)

হাঁ [Yes] =1
না [No]=0 4.8.6 নং প্রশ্নে চলে যান [Skip to 4.8.6]

4.8.4a প্লেনার প্লেসার উপযোগী [Main material of the floor (select 1)].............................................................

[ 1 ] মাটি Mud
[ 2 ] কাঠ Wood
4.8.5a Is Stool visible on the slab or floor? [1= Yes, 0= No, [not applicable] = 888]
(2) Is Stool visible on the walls? [1= Yes, 0= No, [not applicable] = 888]
4.8.7a Is Stool visible on the door/curtain? [1= Yes, 0= No, [not applicable] = 888]

4.9a Is the toilet full? (Note: Toilet is considered full if faeces have reached over the exit of the squatting hole. In case of toilets with water seal or offset pit/tank, if there is confusion flush water to see if the faeces flushes away.) [1= Yes, 0= No, [not applicable] = 888]

4.10a Observe through the hole in the toilet [1= Yes, 0= No, [not applicable] = 888]
4. No pipe, open hole to the pit, can see faeces in the pit, but the pit is not full yet

5. Faeces have reached the exit of the squatting hole [Not applicable] = 888

4.12a Ask the respondent: If answer to 12 is 2 or 3, is there any flap at the end of the pipe to prevent files from coming out? [Ask the respondent]....................................................

  हाँ [Yes] = 1
  ना [No] = 0
  जानिना [DK] = 999
  अनुप्त [Not applicable] = 888

4.13a Observation: What materials for anal cleansing and hand wash are present inside or immediately outside the latrine?

  हाँ [Yes] ................................................................. 1
  ना [No] ........................................................................ 0
  अनप्त [Not applicable/ Could not observe] ........ 888

1. Leaves/grass
2. Twigs / sticks
3. Rag or cloth
4. Stones
5. Hygienic (toilet) paper
6. Water container / vessel
7. Water tap
8. Soap
9. Ash or soil for cleansing
10. Newspaper
11. Nothing

4.a Do you want to add more toilet? ........................................

  1= हाँ [yes]  4.1 अनप्त चले गया [skip to 4.1b]
  0= ना [No]

4.1b Note: Request the respondent to show the toilet facility and code after observing the facility. If “flush” or “pour flush” probe/check: Where does it flush to?
flush-toilet অথবা পানি চেলে ফ্লাস করা টয়লেট (প্লাব এবং পানি ধরনকারী ওয়াটার সীল পর্যবেক্ষণ করন)।
[Flush or pour flush toilet flushed to] (Observe the slab and water seal containing water):

টয়লেটের পাদান্তের পাইপের সাথে সংযোগ করে দেন [Piped sewer system].............. 01
টয়লেটের সেপ্টিক ট্যাঙ্ক বসানো আছে (টয়লেটের কণ্ঠলী ড্রাকা আছে কিনা পর্যবেক্ষণ করন) [Septic tank] (Observe the concrete cover of the tank)......................... 02
সেপ্টিক ট্যাঙ্কে নাই কিন্তু ফ্লয় করে বা পানি চেলে পাণ্যান্তর নীচে/সুন্দর পিটের মধ্যে সরিয়ে দেয়া যায় [Flush to pit latrine (onsite/Off set) with slab and water seal]................................. 03
অজানা জায়গায় /নির্দিষ্ট কোন জায়গায় নেই/ জানিনা [Unknown place/not sure/DK where] ................................. 04

পিট-টয়লেট, প্লাব আছে কিন্তু ওয়াটার সিল নেই তবে কমোডে ডাকানো দেয়ার বয়স্থা আছে)................................. 05

[Flush latrine with slab & no water seal but with a lid]
পিট-টয়লেট যাতে প্লাব আছে, তবে ওয়াটার সিল নেই কিন্তু ফ্লয় আছে (উরবনামাতে ফ্লয় সর্বপ্রথম জিকানা
করন), এ ক্ষেত্রে পাইপ এর জেল মাধ্যমে প্রতিস্থাপন লাগানো থাকে যা মস্তা মাছি বাইতে অথা প্রত্যক্ষ করে)...... 06

[Flush latrine with slab and flap, no water seal] [Ask the respondent about the flap, Flap: a plastic is attached at the end of the pipe to prevent files from coming out of the pit].

বায়ু লালালে উপায়ী উচ্চ লাইটন (প্লাব এবং বেকটিলেশন পাইপ পর্যবেক্ষন করন) [Ventilated Improved Pit (VIP) latrine] (Observe the slab and ventilation pipe)................................. 07

কমপ্লেট টয়লেট [Composting toilet, (Composting toilet ensure separation of urine, water and excreta)]................................. 08
(শাক সবজির ময়লা, ডামা, ঘাস, কাঠের হোড়া, ছানা পিটের মধ্যে মিশ্রিত হয়, সার হিসাবে এই ময়লা ব্যবহৃত হয়,
ওয়াটার সিল নেই। একটি কমপ্লেট টয়লেটের প্লাব আলাদাকরণ ডিভাইস থাকতে পারে বা নাও থাকতে পারে) (Vegetable wastes, straw, grass, sawdust, ash added in the pit, the waste used as
manure, no water seal. A composting latrine may or may not have a urine separation
device.)

পিট/পাথর পাণ্যান্তর স্থান আছে তবে ওয়াটার সিল নেই এবং ওয়াটার সিল ভাল এবং কোন ডাকানও নেই।.... 09

[Flush latrine with slab & no water seal/broken water seal and no lid]

flush-উটালেট অথবা পানি চেলে ফ্লাস করা টয়লেট যা কোন ক্লাস, প্লাব, নদী ইত্যাদির সাথে সংযোগ
করার ফলে অস্থায়ির অবস্থার সৃষ্টি করে থাকে ................................................................. 10

[Flush or pour flush toilet connected to somewhere else (canal, ditch, river,

পিট/পাথর পাণ্যান্তর, স্থান নেই এবং সেখান থেকে মস্তা/মাছি যাওয়া আসা করতে পারে এবং ঝুরিচ ঝুঁজুয়া......... 11

[Flush latrine without slab/open pit]

বুলার পাণ্যান্তর [Hanging toilet/latrine] ................................................................. 12
ব্যালতি [Bucket]............................................................................................................. 13

ঝোলা পাণ্যান্তর/ টয়লেট (Open defecation):
কোন পাণ্যান্তর নেই/ক্লেন/কোপে বাঁধে/ ঝোলা জায়গায় [No facility/bush/field] ................................. 14

অন্যান্য (নির্দিষ্ট করে লিখুন) [Others: Specify] ................................................................. 777
4.2.1. When was the most recent time this toilet was used? [If answer of 4.1 is 14, skip to 4.18]

4.2.2. Do you share this toilet facility with other households?

(Note: Any person or group of persons related or unrelated who do not live in the same dwelling space and do not share a common source of food as the respondent would be considered to belong to other household.)

4.3. Ask and check: how many households sharing the toilet facility?

4.3.1. How many people including children use this toilet?

4.3.2. Ownership type of the Toilet?

1= হাঁ [Yes]  0= না [No]  999= জানিনা [DK], 888= না মানে [Not applicable]

4.4. Path to the toilet suggests regular use (is clear, well-worn, without grass or any barriers etc.)

4.5. Observe the general exterior of the toilet

1= হাঁ [Yes], 0= না [No], 999= জানিনা [DK], 888= না মানে [Not applicable]
Skip Note:- যদি 10.5f নং প্রশ্নের উত্তর 0 হয়, তবে 10.5h নং প্রশ্নে যান। [If answer of 10.5f is 0, skip to 10.5h]

7 পাইপ এর মাধ্যমে কোন ক্ষেত্রে আছে কি যা মায়া মার্জ বের করতে পারে? [Is there a cover on top of the ventilation pipe that protects the flies from going out?]…………………………

j) পাগাঙ্গার দেয়ালগুলো মূলত কি দিয়ে তৈরী? [What are the walls of the toilet mostly made of?] ..................................................................................................................

8. কঠিন [Concrete]
9. টিন [Tin]
10. বাংলাদেশ [Bamboo/Mud]
11. পলিনিক [Plastic]
12. পাদন পাতা [Tree leaves]
13. পাটের খাল [Jute bag]
14. ঝাড় [Straw ]

8. কঠিন [Wood]

888= গ্রেঞ্জ না [Not applicable]

k) পাগাঙ্গার মাঝ মূলত কি দিয়ে তৈরী? [What is the roof of the toilet mostly made of?]..................................................................................................................

8. কঠিন [Concrete]
9. টিন [Tin]
10. বাংলাদেশ [Bamboo]
11. পলিনিক [Plastic]
12. পাদন পাতা [Tree leaves]
13. পাটের খাল [Jute bag]
14. ঝাড় [Straw ]

888= গ্রেঞ্জ না [Not applicable]

4.6b টায়লেট থেকে ময়লা খাওয়া যায়? (জিজ্ঞাসা কর্ম এবং সম্ভব হলে পর্যবেক্ষণ করন) [[Where does the waste from toilet go? (Ask and observe if possible)]] ..................................................................................

1. ময়লা দূরত্ব নালায় পড়েছে (জিজ্ঞাসা করন) [Waste drains to underground piped sewer (Ask)] (4.8.1 নং পশে চলে যান Skip to Q4.8.1)
2. ময়লা মুখোশের মাঝে পড়েছে এবং সেখানেই থাকছে (উজরাতা পিট তৈরীতে কঠিনটিতে রিং সম্পর্কে উল্লেখ করেন। পিটের উচ্চতা এবং ঝিড় আছে কি না পর্যবেক্ষণ করন) [Waste goes into onsite pit and stays there (Respondent will report using concrete rings to make the pit. Observe the top of the pit and any leakage)]
3. ময়লা দূরে পিটের মাঝে পড়েছে এবং সেখানেই থাকছে (উজরাতা পিট তৈরীতে কঠিনটিতে রিং সম্পর্কে উল্লেখ করেন। পিটের উচ্চতা এবং ঝিড় আছে কি না পর্যবেক্ষণ করন) [Waste goes into offset pit and stays there (Respondent will report using concrete rings to make the pit. Observe the top of the pit and any leakage)]
4. ময়লা মুখোশের মাঝে পড়েছে এবং সেখানেই থাকছে (টায়লেট উপরের কঠিনটিতে চাঁকনা এবং ঝিড় আছে কি না পর্যবেক্ষণ করন) [Waste goes into onsite tank and stays there (Observe the concrete cover of the tank and any leakage. Respondent will report building the tank with concrete lining rather than buying the ring for pit lining)]
5. ময়লা দূরে টায়লেটের মাঝে পড়েছে এবং সেখানেই থাকছে (টায়লেট উপরের কঠিনটিতে চাঁকনা এবং ঝিড় আছে কি না পর্যবেক্ষণ করন) [Waste goes into offset tank and stays there (Observe the concrete cover of the tank and any leakage. Respondent will report building the tank with concrete lining rather than buying the ring for pit lining)]
6. Compost pit (vegetable wastes, straw, grass, sawdust, ash added in the pit, the waste used as manure, no water seal, Built in assistance with the NGOs/government)

7. Pit containing vegetable wastes, straw, grass, sawdust, ash added in the pit, waste used as manure, no water seal, Built in assistance with the NGOs/government

8. Waste drains to open lake/river/water via pipe/covered drain (Observe if possible)

9. Waste drains to lake/river/water via open drain (Observe)

10. Waste directly fall into water body or low land (Hanging)

777. Other (specify)

888. Not applicable

31. Waste goes into offset pit (Using no rings but slab)

32. Waste goes into offset pit (Using no rings or slab)

33. Waste goes into offset pit (Using rings but no slab)

4.7b Observe the onsite or off site pit/tank in all direction

4.7c If the answer to question 4.7c is 1 go to question 4.8

4.7d If the answer to question 4.7d is 1 go to question 4.8

4.8.1b Odor of feces in the latrine/bathroom?
4.8.2b [Files present?] .................................................................

(1= [Yes], 0= [No], [not applicable] =888)

4.8.3b [Is there a slab/platform in the toilet?]…………………….

(Note: Squatting slab or platform that is covering the pit on all sides, has a squatting hole and rose above the surrounding ground level to prevent any surface water entering the pit)

[Yes] =1  [No]=0  4.8.6  (Skip to 4.8.6)

4.8.4b [Main material of the floor (select 1)]............................

1] মাটি Mud
2] কাঠ Wood
3] সিঁড়ির পাথর Cement
4] টাইল / ব্রিক Tile / brick
5] প্রাকৃতিক Plastic

[ 888 ] [not applicable] / could not observe / cannot tell

4.8.5b [Is Stool visible on the slab or floor?].............................

1= [Yes], 0= [No], [not applicable] =888)

4.8.6b [Is Stool visible on the walls?].................................

1= [Yes], 0= [No], [not applicable] =888]

4.8.7b [Is Stool visible on the door/curtain?]..................

1= [Yes], 0= [No], [not applicable] =888]

Skip note: If 4.8.3= 0/888 skip to 4.10

4.8.8b [Is there any commode in the toilet?]............................

1= [Yes], 0= [No], [not applicable] =888)

4.8.9b [Is the commode broken?] ...........................................

1= [Yes], 0= [No], [not applicable] =888)

4.8.10b [Is there faeces visible in the commode?]..............

1= [Yes], 0= [No], [not applicable] =888)

4.9b [Is there a lid covering the squatting hole/drop hole?]........

1= [Yes], 0= [No], [not applicable] =888)

4.10b [Is there a lid fully covering the squatting hole at the time of observation?]...

1= [Yes], 0= [No], [not applicable] =888)
Is the toilet full? (Note: Toilet is considered full if faeces have reached over the exit of the squatting hole. In case of toilets with water seal or offset pit/tank, if there is confusion flush water to see if the faeces flushes away.) ........................................

Yes [1]  No [0]  DK [999], Not applicable [888]

Skip note: If 4.8.3 = 0/888 skip to 4.13

4.11b Observe through the hole in the toilet

1. Water in pipe (Water seal, pour some water in the hole to check if there is water in the water seal)
2. Only pipe visible (no water seal)
3. Broken pipe (Water seal broken)
4. No pipe, open hole to the pit, can see faeces in the pit, but the pit is not full yet
5. If answer to 12 is 2 or 3, is there any flap at the end of the pipe to prevent files from coming out? (Ask the respondent) ................................................

Yes [1]  No [0]  DK [999], Not applicable [888]

4.12b Observation: What materials for anal cleansing and hand wash are present inside or immediately outside the latrine?

Yes [1]  No [0]  DK [999], Not applicable [888]

11. [Nothing]

Observation [For the following]:

4.14 Is there any Human faeces present within the household? [Nothing]

<table>
<thead>
<tr>
<th>Yes</th>
<th>No</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0</td>
</tr>
</tbody>
</table>

4.15 Number of piles of Human faeces within the household that could be considered open defecation:

<table>
<thead>
<tr>
<th>555</th>
<th>AwaK msL¨K</th>
</tr>
</thead>
<tbody>
<tr>
<td>999</td>
<td>ejv hv‡“Q bv/</td>
</tr>
</tbody>
</table>

4.16 Is there any Animal faeces present within the household? [Nothing]

<table>
<thead>
<tr>
<th>Yes</th>
<th>No</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0</td>
</tr>
</tbody>
</table>

4.17 Number of piles of Animal faeces present within the household (mark all that apply):

<table>
<thead>
<tr>
<th>555</th>
<th>AwaK msL¨K</th>
</tr>
</thead>
<tbody>
<tr>
<td>999</td>
<td>ejv hv‡“Q bv/</td>
</tr>
</tbody>
</table>

1. Poultry (chicken, duck, and pigeon) [Poultry (chicken, duck, and pigeon)]
2. Cow / Buffalo [Cow / Buffalo]
4. Pig [Pig]
5. Dog or Cat [Dog or Cat]

Other [Other]

Thank you.

Name, signature of FRA: _________________________

Checked by FRO: _________________________