

**Provided for non-commercial research and educational use only.
Not for reproduction or distribution or commercial use.**



This article was originally published by IWA Publishing. IWA Publishing recognizes the retention of the right by the author(s) to photocopy or make single electronic copies of the paper for their own personal use, including for their own classroom use, or the personal use of colleagues, provided the copies are not offered for sale and are not distributed in a systematic way outside of their employing institution.

Please note that you are not permitted to post the IWA Publishing PDF version of your paper on your own website or your institution's website or repository.

Please direct any queries regarding use or permissions to washdev@iwap.co.uk

Sanitation coverage in Bangladesh since the millennium: consistency matters

Y. Zheng, S. A. I. Hakim, Q. Nahar, A. van Agthoven and S. V. Flanagan

ABSTRACT

Household surveys in Bangladesh between 1994 and 2009 assessed sanitation access using questions that differed significantly over time, resulting in apparently inconsistent findings. Applying the WHO and UNICEF Joint Monitoring Programme's 2008 definition for open defecation and improved sanitation facilities excluding shared facilities to the compiled data set, sensible sanitation coverage trends emerge. The percentage of households openly defecating declined at a rate of about 1.8% per year from 30% in 1994 to 6.8% in 2009, primarily due to changes in rural areas. Access to individual improved sanitation facilities nearly doubled from about 30% in 2006 to 57% in 2009, with both rural and urban areas showing impressive progress. Access to shared improved latrines also nearly doubled from about 13% in 2006 to 24% in 2009, with the urban slums recording the greatest gain from 17% in 2006 to 65% in 2009. Shared improved latrines are only slightly less clean than individual ones. Dependence on shared improved latrines increases with population density. In 2007, 20% of the poorest households still openly defecated, although more of them (38%) shared a latrine of any type. A poverty reduction program is recommended to address this equity issue, although applying consistent definitions is crucial to documenting progress.

Key words | Bangladesh, demographic and health survey, multiple indicator cluster survey, population density, sanitation, wealth

Y. Zheng (corresponding author)
S. A. I. Hakim
Q. Nahar
A. van Agthoven
S. V. Flanagan
Water and Environmental Sanitation Section,
UNICEF Bangladesh,
1 Minto Road,
Dhaka 1000,
Bangladesh
E-mail: yan.zheng@qc.cuny.edu;
yzheng@ldeo.columbia.edu

Y. Zheng
School of Earth and Environmental Sciences,
Queens College,
City University of New York,
Flushing, NY 11367 and
Lamont-Doherty Earth Observatory of Columbia
University,
Palisades,
NY 10964,
USA

INTRODUCTION

Globally, improving water, sanitation and hygiene (WASH) has the potential to prevent at least 9.1% of the disease burden in disability-adjusted life years (DALYs), or 6.3% of all deaths (Prüss-Üstün *et al.* 2008). Water and sanitation interventions are cost effective and have demonstrated economic benefits ranging from US\$ 5 to US\$ 46 per US\$ 1 invested (Hutton *et al.* 2007). The Joint Monitoring Programme (JMP) of the World Health Organization and the United Nations Children's Fund (WHO and UNICEF 2008) reckons that improving sanitation coverage offers the opportunity to save the lives of 1.5 million children a year who would otherwise succumb to diarrheal diseases. Access to sanitation facilities protects women's dignity and is fundamental to gender equity. However, the most recent JMP update (WHO and UNICEF 2012) shows that the world is off track to meet the Millennium Development

Goals (MDG) sanitation target, with 2.5 billion people lacking access to improved sanitation, including 1.1 billion who have no facilities at all as of 2010.

Slow progress in sanitation in sub-Saharan Africa and South Asia perpetuates a poverty cycle. In Bangladesh, inadequate sanitation was shown to cost US\$ 4.2 billion (10⁹), equivalent to 6.3 per cent of the gross domestic product (GDP) in 2007, with the largest contributor, diarrhea, accounting for two-thirds of the health-related economic impacts primarily due to premature deaths of young children (Water and Sanitation Program [WSP] 2011). Moreover, 71% of the impacts were borne by the poor. Since 2000, Bangladesh has emerged as a global leader in innovative approaches to rural sanitation. Community Led Total Sanitation (CLTS), which began in Bangladesh and was credited for improving rural sanitation coverage, has now

been adopted in many developing countries. However, with the percentage of the population using improved sanitation at 55% as of 2009 (Bangladesh Bureau of Statistics [BBS] and UNICEF 2010), Bangladesh is off track to meet the MDG target of 70% in 2015. Note that improved facilities shared by more than one household are not counted towards the MDG target in the 'improved' category in this 2009 figure. Here, we examine the progress in sanitation first by looking at open defecation because it is the easiest to measure and reduction in open defecation is a meaningful first step on the sanitation ladder. We then compare several data sets by applying a consistent definition for 'improved sanitation facilities' according to JMP 2008 (WHO and UNICEF 2008) in order to properly document progress of sanitation coverage in Bangladesh. The implications are discussed in terms of equitable access to sanitation.

METHODS: SANITATION SURVEYS

Sanitation coverage in Bangladesh (Table 1) has been measured through household surveys (Table 2) such as the Demographic and Health Survey (DHS) in 1994, 1997, 2000, 2004 and 2007 by Mitra Associates and Macro International funded by USAid, the Multiple Indicator Cluster Survey (MICS) in 1994, 1995, 1996, 1997, 1998, 1999, 2000, 2003, 2006 and 2009 by the Bangladesh Bureau of Statistics and UNICEF, and additionally the Maternal Health Services and Maternal Mortality Survey in 2001 (MHS01) by Mitra Associates, Associates for Community and Population Research (ACPR), Johns Hopkins, International Centre for Diarrhoeal Disease Research Bangladesh (ICDDRDB) and Macro International funded by USAid, and the National Sanitation Survey in 2003 (NSS03) by the Government of Bangladesh.

The sampling designs of DHS and MICS surveys are mostly similar with a two-stage stratification, although there are also differences. Both DHS and MICS use primary sampling units (PSUs) that were the enumeration areas of the Bangladesh Census, comprising around 100 households for census 2000 for example. The number of households in a PSU (cluster) is kept the same within each MICS but can be different from survey to survey (Table 1). However, this value can vary in a DHS that uses a standard segment

design (UNICEF 2006). In addition, a MICS tends to have more PSUs in more strata than a DHS does. For example, DHS07 had two strata with 227 and 134 PSUs in rural and urban areas, respectively (National Institute of Population Research and Training [NIPORT] 2009). On average, 30 households were selected to represent each PSU. In comparison, MICS06 had five strata with 1,280, 384, 156, 52 and 78 PSUs for rural, municipal, city corporation, slum and tribal areas, respectively (BBS and UNICEF 2006). A sample of 35 households was drawn for each of these PSUs (clusters). The sampling errors for DHS and MICS are comparable but are smaller for surveys with a higher number of total households and smaller clusters such as MICS2009 (Table 1).

The JMP00, or the Global Water Supply and Sanitation Assessment 2000 used a water supply and sanitation sector questionnaire submitted to WHO that presumably used some of the aforementioned surveys (Table 1), and was the first systematic global effort to report on improved sanitation. JMP00 defines the improved facilities as connection to a public sewer, connection to septic system, pour-flush latrine, simple pit latrine and ventilated improved pit (VIP) latrine (WHO and UNICEF 2000). However, it stated that the excreta disposal system was considered adequate if it was private or shared (but not public) and if it hygienically separated human excreta from human contact. This left a possibility that some shared facilities would count as improved, leading to inaccurate documentation. The not improved category includes service or bucket latrines where excreta are manually removed, public latrines and open latrines. JMP06 made clarifications on the technical definition of improved facilities as flush or pour-flush toilet/latrine to piped sewer system, septic tank and pit latrine, VIP latrine, pit latrine with slab, and composting toilet (WHO and UNICEF 2006). It also puts pit latrines without a slab or platform, hanging latrines and bucket latrines into the 'unimproved' category. JMP08 further clarified and added shared facilities as one step of the four-step sanitation ladders (open defecation, unimproved, shared, improved), defined as otherwise improved sanitation facilities but are either public or shared between two or more households, and are consequently not considered as improved (WHO and UNICEF 2008). JMP08 definitions have not been revised and are still in use today.

Table 1 | Sanitation coverage and surveys in Bangladesh

Survey	Year	%HH OD	%HH improved	%HH shared	No. HHS	No. Rural HHS	HHS/Cluster	Survey Period	Remarks
DHS94	1994	30.0	41.6 ^a	N.D.	9174	7798		1993/11–1994/03	
DHS97	1997	25.4	45.2 ^a	N.D.	8683	7327		1996/11–1997/03	
DHS00	2000	19.9	54.1 ^a	N.R.	10268	7271		1999/11/10–2000/03/15	First DHS with ‘shared’ question
DHS04	2004	13.7	58.6 ^a	N.D.	10811	7165		2004/1/1–2004/05/24	
DHS07	2007	8.4 ^b	25.3	14.9 ^c	10400	8133	30	2007/03/24–2007/08/11	First DHS using similar to JMP definition
MHS01	2001	23.6	59.4 ^a	N.R.	104323	87029		2000/11–2001/04	Similar to DHS04
MICS94	1994	N.D.	11.4 to 34.8 ^d	N.D.	N.R.	N.R.	40	N.R.	
MICS95	1995	N.D.	13.0 to 40.7 ^d	N.D.	39000	33280	40	N.R.	
MICS96	1996	N.D.	13.3 to 48.0 ^d	N.D.	39000	33280	40	N.R.	
MICS97	1997	N.D.	16.2 to 43.8 ^d	N.D.	52000	42880	50	1996/12/20–1997/01/10	
MICS98	1998	27.0	11.4 to 40.4 ^d	N.D.	55000	45440	50	1997/11/15–1998/01/15	First MICS with Open Defecation
MICS99	1999	24.5	12.1 to 40.3 ^d	N.D.	60000	50884	50	1999/05/26–1999/07/15	
MICS00	2000	23.7	13.5 to 43.4 ^d	N.D.	63200	51000	50	2000/06/01–2000/08/07	Water seal and all pit as improved, an over-estimate
MICS03	2003	19.3	17.6 to 53.2 ^d	N.D.	63383	43686	50	2003/06/10–2003/08/14	Water seal and all pit as improved, an over-estimate
MICS06	2006	8.0	39.2 ^a	N.R.	68247	44797	35	2006/06/20–206/10/8	First MICS using similar to JMP definition and ‘shared’
MICS09	2009	6.8	56.8	28.9	300000	237120	20	2009/04/28–2009/05/31	Similar to JMP with GoB definition considered
NSS03	2003	42.0 ^f	33.2 ^e	N.D.	21394093	18326332			

In all tables, HH, N.R., N.D., OD, and GoB stand for Household, Not Reported, No data, Open Defecation, and Government of Bangladesh, respectively.

^aMost likely have included shared improved.

^bThe percent of population openly defecate is 7.5%. Here, percent of household values are listed throughout.

^cThis value is for any shared facility, the shared improved is less than 14.9%.

^dThe first value is for water sealed, the second for water seal and all types of pit latrines, included shared for both types.

^eThe 33.2% is for hygienic latrine, defined differently from improved (Table 2).

^fThis value is determined by subtracting the percent of household having hygienic and un-hygienic latrines from 100%.

Table 2 | Sanitation questions in household surveys of Bangladesh

Survey	Sanitation Questions
DHS94	Q24. Where do adult women in your household usually defecate? Q25. Where do children in your household usually defecate? Septic tank/modern toilet, Pit toilet/latrine: water sealed/slab latrine, pit latrine, open latrine, hanging latrine, No facility/bush/field, Other (above for Q25, plus No children)
DHS97	Q20. What kind of toilet facility does your household have? Septic tank/modern toilet, Pit toilet latrine: water sealed/slab, pit, open, hanging, No facility/bush/field, Other
DHS00	Q20. What kind of toilet facility does your household have? Septic tank/modern toilet, Pit toilet latrine: water sealed/slab, pit, open, hanging, No facility/bush/field, Other Q21. Do you share this facility with other households? Yes No
DHS04	Q29. What kind of toilet facility does your household have? Septic tank/modern toilet, Pit toilet latrine: water sealed/slab, pit, open, hanging, No facility/bush/field, Other
DHS07	Q106. What kind of toilet facility do members of your household usually use? Flush or pour flush toilet: flush to piped sewer system, flush to pit latrine, flush to somewhere else, flush, don't know where, Pit latrines: pit latrine with slab, pit latrine without slab, open pit, Bucket toilet, Hanging toilet/hanging latrine, No facility/Bush/Field Q107. Do you share this facility with other households? Yes No
MHS01	Q16. What kind of toilet facility does your household have? Septic tank/modern toilet, water sealed/slab latrine, pit latrine, open latrine, hanging latrine, no facility, other Q16A Do you share this facility with other households? Yes No
MICS94	Questions were not included in final report. Types of facilities with multiple response possible are: Water seal, Pit, Hanging and Other
MICS95	Questions were not included in final report. Types of facilities with multiple response possible are: Water seal, Pit, Hanging and Other
MICS96	Questions were not included in final report. Types of facilities with multiple response possible are: Water seal, Pit, Hanging and Other
MICS97	Questions were not included in final report. Types of facilities with multiple response possible are: Water seal, Pit, Hanging and Other
MICS98	Questions were not included in final report. Types of facilities with multiple response possible are: Water seal, Pit, Hanging and Open Defecation
MICS99	Questions were not included in final report. Types of facilities with multiple response possible are: Water seal, Pit, Hanging and Open Defecation
MICS00	Q14 Type of latrines the household members use? Water seal, Pit latrine, hanging/open, Open defecation (Multiple Response Possible)
MICS03	Q10M What is the type of latrines the household members use? Water seal, Pit latrine, hanging/open, Open defecation (Multiple Response Possible)
MICS06	WS7. What kind of toilet facility do members of your household usually use? Flush/pour: Flush to piped sewer system, flush to septic tank, flush to pit (latrine), flush to somewhere else, flush to unknown place/not sure/don't care where, Pit latrine with slab, Pit latrine without slab/open pit, Bucket, Hanging toilet/hanging latrine, No facilities or bush or field, Other. WS8. Do you share this facility with other households Yes No WS9. How many households in total use this toilet facility? No. of HHs (if less than ten, record value), Ten or more HHs, Don't care
MICS09	WS4. What kind of toilet facility do members of your household usually use? Flush to piped sewer system, flush to septic tank, flush to other/unknown place/Don't care, Pit latrine with slab and water seal, Pit latrines with no water seal: VIP, with slab and lid no water seal, with slab but no lid nor water seal, slab and flap, no water seal, without lab/open pit, Composting toilet, Bucket latrine, Hanging toilet/hanging latrine, No facilities or bush or field, Other WS5. How many households use this toilet facility? One Two Three or more Don't care
NSS03	Type of latrine. Hygienic latrine: Pit, Ring slab, Sanitary latrine; Un-hygienic latrine: latrine connected with pond/canal, ditch or Broken ring, Open/Hanging latrine

Bold font indicates survey with shared question.

Compilation of the questions on sanitation used in household surveys (Table 2) shows that they have evolved over the past two decades, converging to JMP-like in 2006. Even though the question whether a facility is shared or not is asked in five surveys, not all surveys report on this factor. In addition, there are also variations of what is considered 'improved' in these surveys compared to the JMP08 definition for improved sanitation facilities (Table 3). These differences can result in apparently confusing results (Table 1). Here, data are re-analyzed by applying only the JMP08 definition. Coverage is reported as percentage of households, not as percentage of population. Data are further disaggregated for analysis in rural, urban, tribal and/or urban slum areas. In each stratum, the sample size ranged from a minimum of 1,355 to a maximum of 237,120 households. Had the surveys used a simple randomization of all households, this would have corresponded to a margin of error of 2.7 and 0.2%, respectively, at a confidence

level of 95% (Bartlett II *et al.* 2001). However, because these surveys relied on two-stage sampling, the errors are magnified by the design effect (deff) with a maximum possible value roughly equal to the number of households in each PSU or cluster (Ahmed 2009). The deff value for access to improved sanitation was estimated to be 3.8 for a typical MICS (UNICEF 2007), and is most likely comparable for DHS (Ahmed 2009). Assuming a deff value of 5 for the Bangladesh DHS and MICS, the errors for each stratum would range from 1 to 13.5%. In other words, the results for each stratum are less accurate than those of the entire Bangladesh so should not be over-interpreted. The exceptionally large sample size of MICS 2009 (Table 1), stratified to four strata consisting of 12,506 rural, 440 city corporation, 1,920 municipality and 134 slum clusters, allows for geographical disaggregation of data to upazila level, although there were concerns of non-sampling errors that may reduce accuracy.

Table 3 | Definition of improved sanitation facilities since 2000

Type of Sanitation Facility	JMP 2008 Impr	JMP 2000 Impr	DHS 2000 Impr	MICS 2000 Impr	MHS 2001 Hygienic	NSS 2003	MICS 2003 Impr	DHS 2004 Impr	MICS 2006 Impr	DHS 2007 Impr	MICS 2009 Impr	Bangladesh Hygienic
Number of Households Sharing a Facility	1	unclear	any	any		any	any	any	any	1	1	1 and 2
1. Flush to piped sewer system	X	X		N.A.	N.A.	N.A.	N.A.	N.A.	X	X	X	X
2. Flush to septic tank	X	X	X	N.A.	X	N.A.	N.A.	X	X	X	X	X
3. Flush to pit (latrine)		X		N.A.	N.A.	N.A.	N.A.	N.A.	X	X	N.A.	
4. Flush to unknown place/don't know		N.A.		N.A.	N.A.	N.A.	N.A.	N.A.				
5. Pit latrine with slab and water seal	X	X	X	X	X	X	X	X	X	X	X	X
6. Pit latrine with slab and lid, no water seal	X	X	X	X	X	X	X	X	X	X	X	X
7. Pit latrine with slab but no lid, nor water seal	X	X	X	X	X	X	X	X	X	X	X	
8. Pit latrine with slab and flap, no water seal	X	X	X	X	X	X	X	X	X	X	X	X
9. Pit latrine without slab/open pit		X	X	X	X	X	X	X				
10. Ventilated improved pit latrine (VIP)	X	X	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	X	X
11. Composting toilet	X	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	X	X
12. Bucket or tub or bucket latrine	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.			
13. Open or hanging latrine												
14. No facilities or bush or field												
15. 'Other' – water seal				X		X	X					

N.A. = facility was not included in survey questionnaire.

X = Included under definition.

RESULTS AND DISCUSSION

Open defecation

People who have no access to any sanitation facilities often practice open defecation in fields, forests, bushes, bodies of water or other open spaces and thus the two are considered equivalent by JMP, although there could be confusion depending on how the questionnaire is structured. This could be the case for NSS03. The survey form tallied the number of households with either hygienic or un-hygienic latrines – possibly excluding a fraction of the population who share latrines instead of owning their own and may not openly defecate. The results of the DHS and MICS

surveys between 1994 and 2009 are comparable and suggest a significant decline of open defecation (Table 4). In rural areas, excluding tribal areas or the Chittagong Hill Tracts, open defecation decreased at a rate of 1.8% a year. The tribal areas, located mostly in the Chittagong Hill Tracts, also witnessed a rapid decrease at a rate of about 4% a year. It is interesting to note that open defecation is practiced at a very low rate (mostly <1%) for urban slums, lower than the urban municipalities or small towns (Table 5). The results show that it is likely that by 2015 Bangladesh will be open defecation free, except for pockets of poverty as studies indicate the poorest quintile of the population continues to openly defecate even in government declared open defecation free unions (the smallest

Table 4 | Open defecation in rural, urban and tribal areas in Bangladesh since 2000

Year	Survey	National Open defecation (%)	Rural		Urban		Tribal/CHTs	
			No. samples	Open defecation (%)	No. samples	Open defecation (%)	No. samples	Open defecation (%)
1994	DHS94	30.0	7,798	33.8	1,376	8.3		
1997	DHS97	25.4	7,327	22.9	1,355	6.4		
1998	MICS98	27.0	45,440	29.7	8,520	4.2		
1999	MICS99	24.5	50,848	27.0	12,712	3.9		
2000	DHS00	19.9	7,271	23.8	2,991	3.0		
2000	MICS00	23.7	48,800	26.1	12,000	2.9	2,400	29.2
2001	MHS01	23.6	87,029	26.6	17,294	10.4		
2003	MICS03	19.3	43,686	19.9	17,337	4.0	2,360	41.5
2004	DHS04	13.7	7,165	16.4	3,646	4.1		
2006	MICS06	8.0	44,797	9.3	20,719	2.4	2,731	29.0
2007	DHS07	8.5	8,133	10.2	2,267	1.8		
2009	MICS09	6.8	237,120	7.0	49,880	2.0	14,800	18.3

Table 5 | Open defecation in urban metropolitan, municipality and slum areas since 2000

Year	Survey	Urban Metro		Urban Municipality		Urban Slum	
		No. Samples	Open Defecation (%)	No. Samples	Open Defecation (%)	No. Samples	Open Defecation (%)
1998	MICS98	2,840	0.6	5,680	8.0	N.R	0.4
1999	MICS99	3,178	1.0	9,534	6.9	N.R	3.5
2000	MICS00	N.R	0.3	N.R	5.6	N.R	1.0
2001	MHS00	9,169	4.8	8,125	17.2		N.D.
2003	MICS03	4,874	0.31	10,932	6.0	1,531	1.3
2006	MICS06	5,459	0.20	13,440	3.5	1,820	0.4
2009	MICS09	8,800	0.05	38,400	2.6	2,680	0.9

administrative unit in Bangladesh) (Hanchett *et al.* 2011). The decline of open defecation between 1994 and 2009 can be fitted by a linear fit with an R^2 value of 0.93 with a slope of $-1.74 \pm 0.16\%$ ($n = 12$, Figure 1). A linear fit for eight data points between 2000 and 2009 has a slope of $-1.99 \pm 0.28\%$ ($R^2 = 0.8965$). The rate of decline (-1.99%) between 2000 and 2009 is not significantly different from that between 1994 and 2009 (-1.74%) considering only the regression errors not to mention other errors in household surveys. For instance, in 2000, DHS reports open defecation as 19.9% but MICS reports open defecation as 23.7%. Unfortunately, any acceleration in the decline of open defecation by CLTS or other initiatives since 2000 is not large enough to be evident in these data.

Improved sanitation facilities

Impressive progress has been made on access to improved sanitation in Bangladesh since 2006 (Table 6) at a rate of about 9% per year (Figure 1(b)). Due to inconsistent

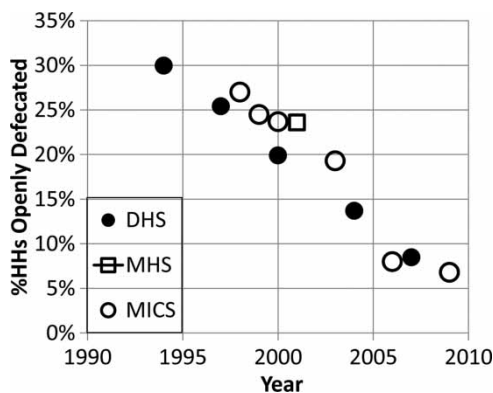


Figure 1 | Percentage of households which openly defecated in Bangladesh shows a linear decline at a rate of 1.74% per year between 1994 and 2009 based on DHS (solid circle), MHS (open square) and MICS (open circle) data.

definitions (Table 1 footnote a), data prior to 2006 are compromised and hence not included. Five surveys, DHS00, MHS01, MICS06, DHS07, and MICS09 included a question on shared facilities (Table 2). However, this result was not reported by DHS00 and MHS01. Data of MICS06, DHS07, and MICS09 were re-analyzed following the JMP08 definition for improved facilities that excluded shared ones. The progress is slower for urban slum areas (Table 7) although this has more to do with dependence on shared facilities (see next). A linear regression of three data points would imply that the extrapolated 1990 baseline value would be less than zero. While this cannot be the case, it is reasonable to expect that the 1990 baseline is likely to be lower than 25% based on the MICS06 and DHS07 findings (Table 6). The JMP reported the access to improved sanitation facilities in Bangladesh in 1990 as 20, 26, 39 and 34% in its 2004 (WHO and UNICEF 2004), 2008 (WHO and UNICEF 2008), 2010 (WHO and UNICEF 2010) and 2012 (WHO and UNICEF 2012) publications, respectively. It is understood that this is due to the linear regression method that the JMP uses, resulting in a ‘moving’ baseline for 1990 as new data points are added. Ability to reduce the uncertainty in this ‘moving’ baseline is crucial because the baseline value is used to determine whether Bangladesh’s sanitation progress towards MDG is on track or not. If a closer to reality 1990 baseline value of 25% were to be used, then the MDG target would only be 63%. In this case, Bangladesh is on track to meet its MDG towards sanitation if current trend continues.

The Government of Bangladesh has been implementing a Sanitation, Hygiene Education and Water Supply (SHEWA B) Program with a budget of US\$ 100 million supported by UNICEF and UKAid in 19 districts between 2007 and 2011. Approximately 20 million people reside in the

Table 6 | Improved latrine in rural, urban and tribal areas in Bangladesh since 2006

Year	Survey	National Improved Latrine	Rural		Urban		Tribal/CHTs	
			No. Samples	Improved Latrine	No. Samples	Improved Latrine	No. Samples	Improved Latrine
2006	MICS06	31.5%	44,797	29.0%	20,719	38.6%	2,731	18.3%
2007	DHS07	25.3% ^a	8,133	22.0% ^a	2,267	37.41% ^a	N.R.	N.R.
2009	MICS09	56.8%	237,120	55.1%	48,080	56.0%	14,800	43.9%

^a May be too low because pit latrine without water seal was wrongly categorized as pit latrine without slab hence unimproved in DHS07

Table 7 | Improved latrine in urban metropolitan, municipality and slum areas since 2006

Year	Survey	Urban Metro		Urban Municipality		Urban Slum	
		No. Samples	Improved Latrine	No. Samples	Improved Latrine	No. Samples	Improved Latrine
2006	MICS06	5,459	44.6%	13,440	37.2%	1,820	3.5%
2009	MICS09	8,800	54.6%	36,600	59.0%	2,680	10.8%

rural program areas of these districts. MICS06 found access to improved sanitation was only 17% in those districts and hence the reasons for intervention. MICS09 found access to improved sanitation has since increased to 49% in the SHEWA B program area, equivalent to 6.4 million people gaining access to improved sanitation. This is equivalent to an annual rate of increase of 10.8%, higher than that of all rural areas of Bangladesh combined, which is 8.7% based on MICS06 and MICS09 data. In the SHEWA B program areas, non-governmental organizations (NGOs) were engaged to promote access to WASH, although without paying for construction of latrines that typically cost about US\$ 50. The cost of the promotional activities, roughly 2/3 of the program, is approximately US\$ 10 per person.

Shared facilities

The percentage of households using shared (but otherwise improved) facilities is increasing in rural and urban areas (Table 8), and especially in urban slums (Table 9). JMP

does not consider latrines that are shared by more than one household as 'improved' based on the assumption that they are not being maintained and cleaned properly. A study that evaluated 53 government declared 'open defecation free' unions in 35 districts of Bangladesh (Hanchett *et al.* 2011) found that 50.9% of improved (and also individual) latrines and 34.9% of shared (but otherwise improved) latrines were clean (Table 10). Similarly, 54.1% of improved (and also individual) latrines and 38.9% of shared (but otherwise improved) latrines in rural areas of the SHEWA B program (Table 10) are considered as clean by observing the absence of feces around the latrines (ICDDR 2009). Although further studies from other countries are needed, the results from Bangladesh suggest that it is too simplistic to use individual status alone to categorize technologically the same sanitation facilities as 'improved'. Better criteria are needed to determine whether a technologically improved facility, either individual or shared, reaches its potential to protect public health.

Table 8 | Shared improved latrine in rural, urban and tribal areas in Bangladesh since 2000

Year	Survey	National Shared	Rural		Urban		Tribal/CHTs	
			No. Samples	Shared	No. Samples	Shared	No. Samples	Shared
2006	MICS06	12.8%	44,797	9.2%	20,719	21.4%	2,731	7.4%
2007	DHS07	14.9%	8,133	13.0%	2,267	14.9%	N.R.	N.R.
2009	MICS09	24.0%	237,120	23.5%	48,080	30.9%	14,800	9.8%

Table 9 | Shared improved latrine in urban metropolitan, municipality and slum areas

Year	Survey	Urban Metro		Urban Municipality		Urban Slum	
		No. Samples	Shared	No. Samples	Shared	No. Samples	Shared
2006	MICS06	5,459	37.5%	13,440	15.4%	1,820	16.9%
2009	MICS09	8,800	35.0%	36,600	27.4%	2,680	64.7%

Table 10 | Individual and shared improved latrine cleanliness in representative areas of Bangladesh

Year	Source	Overall			Plain Land			CHTs		
		# Sample	Clean	%	# Sample	Clean	%	# Sample	Clean	%
Individual improved latrines										
2007	SHEWAB ^a	739	327	44.2%	657	286	43.5%	82	41	50.0%
2009	SHEWAB ^a	704	381	54.1%	646	338	52.3%	58	43	74.1%
2009	Hanchett	1,588	808	50.9%						
Shared improved latrines										
2007	SHEWAB ^a	315	131	41.6%	293	120	41.0%	22	11	50.0%
2009	SHEWAB ^a	375	146	38.9%	365	140	38.4%	10	7	70.0%
2009	Hanchett	1,098	383	34.9%						

^a Obtained at baseline and midline as part of the health impact study conducted by ICDDRDB (2009).

The cleanliness increases among individual latrines from 2007 to 2009 in SHEWAB areas are significant ($p < 0.01$) for overall, plain land and CHTs.

Higher percentage of clean individual improved facilities compared to the shared in 2009 for SHEWAB area are significant ($p < 0.01$) only for overall and plain land only.

This criterion is especially relevant to Bangladesh because it is the world's most densely populated non-city state, with an estimated 156 million people as of 2009 residing in 143,998 km² of land. Space constraints are prominent in areas that flood regularly and in urban slums where 65% of households relied on shared improved latrines in 2009 (Table 9). In rural areas, traditionally several related households live together in one 'bari', a compound in which facilities such as water and sanitation are shared. MICS 2009 collected sanitation data with spatial resolution sufficient to examine results at upazila (sub-district) level. The census 2000 population density data (2010 census data are not yet available but are expected to have similar spatial pattern) were grouped to low, medium, high and highest density quartiles for 25 upazilas in the Chittagong Hill Tracts region with an average population density of 135 persons/km², and for 437 upazilas of the plain land area with an average population density of 992 persons/km² (38 upazilas with >5,000 persons/km² were excluded because they have urbanized). There is a clear shift towards increasing dependence on shared (but otherwise improved) latrines as the population density increases (Figure 2). The mean value of the percentage of households using shared (but otherwise improved) latrines increases from 17.2% for the low population density quartile to 27.7% for the highest population density quartile for the plain land area (Figure 3). However, the mean values of the percentage of households using improved individual latrines reach a maximum of 59.6%

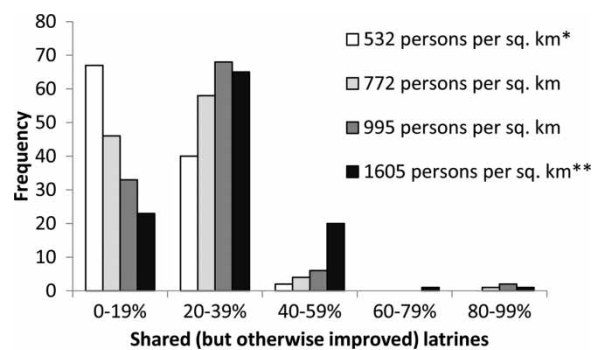


Figure 2 | Frequency distribution of the percentage of households with access to shared (but otherwise improved) latrines grouped by low, medium, high and highest population density quartiles with mean population density values shown in legend. Symbol * indicates that the distribution of the sanitation coverage is significantly different ($p < 0.001$) from all other quartiles. Symbols ** indicate that the distribution of the sanitation coverage is significantly different ($p < 0.01$) from the low and medium quartiles only. The statistics test used was the Kolmogorov-Smirnov test.

for the medium population quartile, beyond which, it starts to decrease (Figure 3). The mean values of sanitation coverage for the plain land area that are significantly different ($p < 0.05$) from three other quartiles are indicated in Figure 3. There is a large decrease of open defecation as the population density increases, especially in the Chittagong Hill Tracts (Figure 3).

Equity focus

Similar to other basic social services, the poorest quintile of the population is usually the least served by sanitation

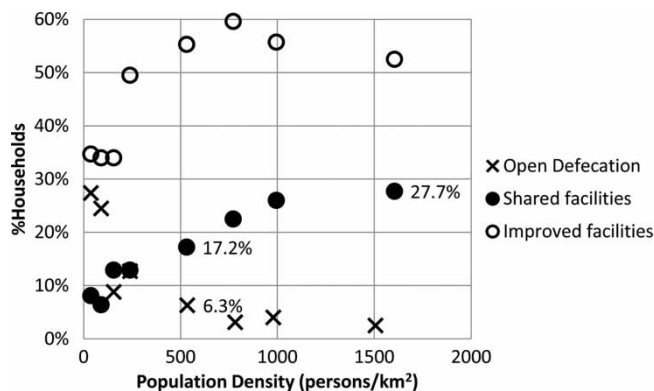


Figure 3 | Sanitation coverage plotted vs. population density. The mean values of the percentage of households who practiced open defecation (cross), used shared (but otherwise improved) latrines (solid circle), and improved (and also individual) latrines (open circle) are plotted vs. the mean values of population density of the low, medium, high and highest population density quartiles for the Chittagong Hill Tracts (<500 persons per square km) and the plain land upazilas (>500 persons per square km). The three sanitation coverage values written next to the symbols indicate that they are significantly different ($p < 0.05$) from all other quartiles for the plain land upazilas using student t -test.

facilities. In 1997, the percentage of the poorest households openly defecating was 60% (Table 11). This decreased to 20% in 2007. For the poorest households, shared (but otherwise improved) latrine access was 7% (Table 11) and shared unimproved latrine access was 31% based on DHS07. The predominance of sharing any latrines (38%) among the poorest may be due to economic and space constraints. Therefore, social assistance targeting the poorest

groups can do abundant good by including a sanitation component, through eliminating open defecation and by assisting the poor to move up the sanitation ladder, including emphasizing maintaining cleanliness of any latrine facilities to minimize disease transmission. Sustained public health gains are built on the foundation of water and sanitation access (Cutler & Miller 2004; WHO 2006). Focusing on the poorest offers an opportunity not to be missed.

CONCLUSION

Re-analysis of household survey data of Bangladesh after applying a consistent definition for sanitation facilities as described in the WHO and UNICEF JMP 2008 report has found that Bangladesh is on track to meet its MDG target for sanitation of about 63% for 2015, assuming a more reasonable 1990 baseline value of 25%. However, due to its high population density, progress will likely slow down if improved sanitation facilities that are shared continue to be counted separately by JMP. In densely populated developing countries, the pros and cons of only counting individual household improved sanitation facilities towards the MDG target should be carefully weighed. A health

Table 11 | Wealth quintile and access to sanitation

	Wealth Quintile	Q1	Q2	Q3	Q4	Q5
Source	Access to Sanitation (%Households)	Poorest	Poorer	Middle	Richer	Richest
DHS97	Open Defecation	60%	33%	22%	6%	2%
DHS00	Open Defecation	41%	23%	10%	4%	0%
DHS04	Open Defecation	31%	16%	8%	2%	0%
MICS06	Open Defecation	27%	9%	4%	1%	0%
DHS07	Open Defecation	20%	8%	4%	1%	0%
DHS97	Improved + Shared	12%	20%	48%	64%	89%
DHS00	Improved + Shared	22%	43%	60%	79%	88%
DHS04	Improved + Shared ^a	25%	46%	64%	79%	90%
MICS06	Improved + Shared	10%	22%	31%	50%	82%
DHS07	Improved + Shared	14%	26%	38%	56%	80%
DHS07	Improved ^b	7%	14%	21%	33%	62%

^a %population with access to individual and shared improved facilities are 29%, 46%, 60%, 77% and 89% for Q1 to Q5 (Halder & Kabir 2008).

^b Wealth quintile analysis following JMP08 definition for improved and also individual facilities is possible.

based criterion may be necessary to help re-define what improved sanitation facility means.

ACKNOWLEDGEMENTS

This paper reflects the view of the authors only and not that of UNICEF. The authors would like to thank the team at ICDDRB led by S. Luby for sharing data of latrine cleanliness in the SHEWA B area, and L. Unicomb for comment. The paper benefited from constructive reviews of four anonymous reviewers. UKAid, UNICEF and the Government of Bangladesh funding for the Sanitation, Hygiene Education and Water Supply in Bangladesh (SHEWAB) program that enabled this work is acknowledged.

REFERENCES

- Ahmed, S. 2009 *Methods in Sample Survey: Cluster Sampling*. The Johns Hopkins University Bloomberg School of Public Health. Online. Available from <http://ocw.jhsph.edu/courses/statmethodsfor samplesurveys/PDFs/Lecture5.pdf> (accessed 14 February 2013).
- Bartlett II, J. E., Kortlik, J. W. & Higgins, C. C. 2001 Organizational research: determining appropriate sample size in survey research. *Information Technology, Learning, and Performance Journal* **19** (1), 43–50.
- BBS and UNICEF 2006 Multiple Cluster Indicator Survey 2006 Volume I: Technical Report. Bangladesh Bureau of Statistics and UNICEF.
- BBS and UNICEF 2010 Multiple Cluster Indicator Survey 2009, Progotir Pathay, Volume I: Technical Report. Bangladesh Bureau of Statistics and UNICEF.
- Cutler, D. & Miller, G. 2004 The role of public health improvements in health advances: The 20th century United States. National Bureau of Economic Research Working Paper 10511, Cambridge, MA, USA.
- Halder, A. K. & Kabir, M. 2008 Child mortality inequalities and linkage with sanitation facilities in Bangladesh. *J. Health Popul. Nutr.* **26** (1), 64–73.
- Hanchett, S., Krieger, L., Kahn, M. H., Kullmann, C. & Ahmed, R. 2011 Long-Term Sustainability of Improved Sanitation in Rural Bangladesh. Water and Sanitation Program of the World Bank, Technical Report.
- Hutton, G., Haller, L. & Bartram, J. 2007 *Global cost-benefit analysis of water supply and sanitation interventions*. *J. Water Health* **5**, 481–502.
- ICDDRBR 2009 *SHEWA-B Health Impact Study Midline Report*. (S. P. Luby, ed.). International Centre for Diarrhoeal Disease Research, Dhaka, Bangladesh.
- National Institute of Population Research and Training (NIPORT), Mitra and Associates, and Macro International. 2009 Bangladesh Demographic and Health Survey 2007, Dhaka, Bangladesh and Calverton, Maryland, USA, National Institute of Population Research and Training, Mitra and Associates, and Macro International. Available at <http://www.measuredhs.com/pubs/pdf/FR207/FR207%5BApril-10-2009%5D.pdf>
- Prüss-Üstün, A., Bos, R., Gore, F. & Bartram, J. 2008 *Safer Water, Better Health: Costs, Benefits and Sustainability of Interventions to Protect and Promote Health*. World Health Organization, Geneva.
- UNICEF 2006 *MICS3 Technical Manual Chapter 4 Designing and Selecting the Sample*. UNICEF. Online. Available from http://www.childinfo.org/mics3_manual.html (accessed 14 February 2013).
- UNICEF 2007 *Calculation of Sampling Errors*. UNICEF. Online. Available from http://powershow.com/view/146ac3-Mzc2N/Calculation_of_Sampling_Errors_powerpoint_ppt_presentation (accessed 14 February 2013).
- WHO 2006 *Neglected Tropical Diseases, Hidden Successes, Emerging Opportunities*. WHO. Online. Available from http://whqlibdoc.who.int/hq/2006/WHO_CDS_NTD_2006_2_eng.pdf (accessed 14 February 2013).
- WHO and UNICEF 2000 *The Global Water Supply and Sanitation Assessment 2000*. WHO and UNICEF. Online. Available from http://www.who.int/water_sanitation_health/monitoring/globalassess/en/ (accessed 14 February 2013).
- WHO and UNICEF 2004 *Meeting the MDG Drinking Water and Sanitation Target: A Mid-term Assessment of Progress*. WHO and UNICEF. Online. Available from http://www.who.int/water_sanitation_health/monitoring/jmp2004/en/index.html (accessed 14 February 2013).
- WHO and UNICEF 2006 *Meeting the MDG Drinking Water and Sanitation Target: The Urban and Rural Challenge of the Decade*. WHO and UNICEF. Online. Available from http://www.who.int/water_sanitation_health/monitoring/jmp2006/en/index.html (accessed 14 February 2013).
- WHO and UNICEF 2008 *Progress on Drinking-Water and Sanitation - Special Focus on Sanitation*. WHO and UNICEF. Online. Available from http://www.who.int/water_sanitation_health/monitoring/jmp2008/en/index.html (accessed 14 February 2013).
- WHO and UNICEF 2010 *Progress on Sanitation and Drinking-Water - 2010 Update*. WHO and UNICEF. Online. Available from http://www.who.int/water_sanitation_health/publications/9789241563956/en/index.html (accessed 14 February 2013).
- WHO and UNICEF 2012 *Progress on Drinking Water and Sanitation: 2012 Update*. WHO and UNICEF. Online. Available from http://www.who.int/water_sanitation_

[health/publications/2012/jmp_report/en/index.html](http://www.wsp.org/sites/wsp.org/files/publications/health/publications/2012/jmp_report/en/index.html)
(accessed 14 February 2013).

WSP 2011 *The Economic Impacts of Inadequate Sanitation in Bangladesh*. Water and Sanitation Programme

of the World Bank, Washington DC. Online. Available from <http://www.wsp.org/sites/wsp.org/files/publications/WSP-ESI-Bangladesh-Report.pdf> (accessed 14 February 2013).

First received 17 April 2012; accepted in revised form 9 October 2012