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Post-defecation Handwashing in Bangladesh: Practice and Efficiency Perspectives

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Inadequate handwashing after defecation and anal cleaning practices in the Indian subcontinent is an important source of faeco-oral transmission of enteric diseases. To better understand the process as traditionally practised, 90 women in semi-rural Bangladesh were observed washing hands after defecation. Several components of handwashing practices were identified: the cleaning agent, ng left or both hands; frequency of rubbing hands, type and amount of water used wash, and the drying of hands on the wearer's clothes. A subsequent e: erime w conducted to assess the effect of currently practised handwashing and ving cc ling to standardised procedure on faecal coliform count of hands.

As a rubbing agent, soil was commonly used (40%); soap was used by 19% and was reported unaffordable by about 81% of the non-users. Good handwashing behaviour was positively associated with better social and economic indicators including education of the women observed. Both hands were unacceptably contaminated after traditional handwashing (the geometric mean count of left was 1,995 and right hand was 1,318 faecal coliform units/hand). After standardising the observed components of handwashing procedures the use of any rubbing agent, i.e. soil, ash or soap, produced similar acceptable cleaning. Use of a rubbing agent (e.g. soil, ash or soap), more rubbing (i.e. six times), rinsing with safer water (e.g. 2 litres of tubewell water) and drying with a clean cloth or in the air produced acceptable bacteriological results. Components of traditional handwashing practices were defined through careful observation, and experiments on handwashing with standardised components showed that efficient and affordable options for handwashing can be developed; this knowledge should be helpful in disease control programmes.

Keywords: handwashing; defecation; cleaning agent; drying; safe water

Introduction

Studies in Bangladesh,[1-3] the United States of America[4] and Thailand[5] have shown reduction of diarrhoeal disease incidence by 14–40% to be associated with handwashing. Handwashing practices have been promoted by providing families with soap,[1,2] water storage containers[5,6] and by hygiene education on the use of soap or ash.[7] In India and Bangladesh[8,9] soil is used by the majority as a rubbing and scrubbing agent to wash their hands after defecation. Less than 10% of Bangladeshis used ash and less than 20% used soap, as soap was too expensive[7,9] and ash is not easily available in urban slums or areas where wood is not used as fuel for cooking.[9] No previous study describes the existing handwashing practices in detail, their efficiency, and whether the practices can or should be improved. We believe these issues have public health implications. Moreover, handwashing practices are promoted globally[10] and developing efficient handwashing will help in improving health intervention programmes in Bangladesh as well as in other developing countries.

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We observed handwashing after defecation by 90 rural women. In the Indian subcontinent people commonly clean their own or their children's anal region after defecation in the following way. They usually carry a container of water to the defecation site and after defecation they clean their anal region using the left hand while pouring water from the container held by the right hand (shoucho-kaj). Then they leave the defecation site to wash their hands, either both, or just the left, rubbing the hand on wetted ground (haat-mati). Finally they rinse. It is the custom to eat food using the right hand.

If hands are not properly washed at this time the faecal pathogens are likely to be transmitted to water, food, clothes, and other household objects and ultimately to mouths. Women play the key role in household activities and child care and whilst carrying out those activities would spread the remaining faecal bacteria from their hands. Following the observational phase, we conducted experimental trials based on the observed important and biologically plausible factors for developing efficient handwashing practices. Here we present our observations and experimental findings which showed that the existing post-defecation handwashing practices were associated with unacceptable contamination of hands and that efficient practices could be developed by standardising the observed components of handwashing.

Methods

The study was conducted in two phases in Uttarkhan, a village near Dhaka, Bangladesh. First, we observed the current handwashing practice and identified its different components. We also determined the efficacy of current handwashing practices by determining faecal coliform counts of hands. Then in the experimental phase we tested the identified components of the existing practices under standard conditions and developed biologically plausible and practical options for efficient handwashing practices.

Observational phase: (Phase I)

In rural Bangladesh people usually defecate in some rudimentary latrines or behind the bushes. Although we knew that people commonly wash their hands outside the defecation facilities because it is inconvenient to wash them at the sites, we reconfirmed it by discussion with a few local women. Ninety rural women (housewives) from 90 randomly selected households were observed washing their hands after defecation (between 5:30 and 9:00 am) by trained local women workers. The faecal coliform counts of the subjects' hands, after washing, were estimated using a special hand sampling technique which is described later. We did not mention that we were observing handwashing; these women were informed that their routine activities were being observed to help us identify diarrhoea risk behaviour. They were told that if they had any objection they would not be observed. We attempted to observe 100 women and 10 of them objected to this. We present results for the 90 observed women. The information was recorded in pre-tested semi-structured forms.

Experimental phase: (Phase II)

We studied the effectiveness of the more common components of handwashing recorded in the observation phase, i.e. cleaning agents, rubbing frequencies, quality and quantity of rinsing water and drying technique, by comparing the faecal coliform counts of hands after washing, in various ways. The impact of varying each

component on the faecal coliforms of hands was estimated while keeping the other components constant.

During this phase, visits were made by the same (Phase I) trained women workers to every household between 5:30 and 9:00 a.m. Any women of the same area (including the 90 in phase I) who were seen coming out of the defecation sites and who had not yet washed their hands were requested to take part in the experiment by washing hands according to one of our instructions (Table I). The instructions were

Table I Progression of handwashing in the Experimental Phase: testing handwashing components under different conditions

Components	Conditions of tests
(A) Washing agent	Testing of different agents: **Soil* (kitchen) + 6 rubbings + 2 litres of water + tubewell water + drying in air *Soap* + 6 rubbings + 2 litres of water + tubewell water + drying in air *Ash* + 6 rubbings + 2 litres of water + tubewell water + drying in air Testing of soil: **Soil* (kitchen) + 6 rubbings + 2 litres of water + tubewell water + drying in air *Soil* (near latrine) + 6 rubbings + 2 litres of water + tubewell water + drying in air *Soil* (wet soil near latrines) + 6 rubbings + 2 litres of water + tubewell water + drying in air *Rubbing hands on ground* + 2 litres of water + tubewell water + drying in air
(B) Rubbing	Testing of rubbing frequency: Soil (near kitchen) + *3 rubbings* + 2 litres of water + tubewell water + drying in air *Soil (near kitchen) + *6 rubbings* + 2 litres of water + tubewell water + drying in air
(C) Rinsing	Testing of volume of water: Soil (near kitchen) + 6 rubbings + *1 litre of water* + tubewell water + drying in air Soil (near kitchen) + 6 rubbings + *0.5 litres of water* + tubewell water + drying in air *Soil (near kitchen) + 6 rubbings + *2 litres of water* + tubewell water + drying in air Testing of type of water: Soil (near kitchen) + 6 rubbings + 2 litres of water + *pond water* + drying in air *Soil (near kitchen) + 6 rubbings + 2 litres of water + *tubewell water* + drying in air
(D) Drying	Testing drying of hands: After washing with soil (near kitchen) + *6 rubbings* + 2 litres of water + tubewell water + drying in air Dried in air Dried on worn cloth Dried on a clean piece of cloth

Note: *This was conducted in one group only and used as the reference group for comparison.

designed to progress through a logical model of starting with the comparison of effects of locally available cleaning agents. A handwashing activity is often referred to by the type of cleaning agent used since it appears to play the main role in producing the scrubbing action necessary to loosen bacteria from hands.[11] Washing hands using water only has been found to produce unacceptable results under controlled field trials.[9] The effects of other observed common components were then tested by incorporating them into washing of hands by using the tested biologically acceptable, yet cheapest and most available, agent, which in this case is soil. The soil-using groups washed with a teaspoonful of soil collected from specified locations.

One control sample, i.e. a handwashing sample of a woman who had not washed hands (in the usual or experimental way) after defecation, was collected twice a week throughout the sampling period.

Sampling and microbiological technique for determining the faecal coliform count of hands, soil and water

Each hand was sampled separately for faecal coliform using a slightly modified finger-tip count technique.[12] Briefly, every woman washed two hands separately into two plastic bottles containing 100 ml of Ringers solution with 10% v/v of Tween 20. They made washing movenents inside the container by rubbing the fingers up onto their palms at least 10 times, with their hands immersed up to the palm in the solution. The containers were then tightly closed and stored chilled in insulated boxes. During the drying test (Table II) they were sampled after instructed standardised handwashing and again after drying of hands.

Soil samples were collected every day from the same location as that used during the handwashing experiments. Water samples were also collected from the same source as the one used during standard rinsing according to instruction. The faecal coliform count of these samples was determined at the ICDDR,B laboratory within 2–3 hours of collection.

Tenfold dilutions of water, soil and handwash samples were prepared in phosphate buffer saline (PBS) and then plated onto membrane filter coliform (MFC) agar. The plates were then incubated at 44 °C for 18–24 hours. The characteristic blue colonies were counted as faecal coliforms. The dilution chosen for counting was that which contained 30–300 colonies per plate. When the coliform count in a sample was very low, 10 or 100 ml of the sample was passed through a millipore membrane filter (pore size 0.45 μm) and then the filter paper was placed on MFC agar media and incubated at 44 °C for 18–24 hours. After incubation, the characteristic colonies were counted as faecal coliforms and further identification was carried out following standard procedures.[13]

Data analysis

The analysis of observational data was descriptive. A composite score for handwashing behaviour was computed based on the observed handwashing components: used both hands (= 1, else = 0), used a washing agent (= 1, else = 0), rubbed hands more than three times (= 1, else = 0), and used more than 0.7 litres or more of water (= 1, else = 0). The scores were then weighted by the proportion positive for the element. The score for washing agent use was computed to give different weights for soap and soil; 17 of the total of 90 women used soap and the score for soap use was $1 - (17/90) = 0.81$; 36 mothers used soil and therefore the score for soil use is weighted by a ratio of 36/73 (i.e. the remaining mothers who did not use soap) to give a score of $1 - (36/73) = 0.5$, i.e. a lower score than for soap use. This approach

Table II Faecal coliform count of left and right hands after standardised handwashing and before and after drying of hands[†]

Drying of hands	No.	*t*-values on log-transformed data		Geometric means	
		LH	RH	LH	RH
After standardised handwashing[‡] and before drying	40	—	—	112	55
Dried on worn clothes after standardised* handwashing[‡]	20	3.10*	2.52*	812	437
Dried on a clean piece of cloth after standardised handwashing[‡]*	*20*	*1.90*	*1.76*	*191*	*89*

Notes: [†]After standardised handwashing 20 were dried on clothes worn and 20 on a clean piece of cloth.
[‡]Standardised handwashing: soil (kitchen), rubbing both hands six times and rinsing with 2 litres of tubewell water.
*Differed significantly over 95% level. The comparison was between reference handwashing before drying and either after drying on clothes worn or on a clean cloth.

of weighing gives a higher score for those behaviours which were less commonly observed. The women were divided into those having median scores or less and those having scores above median, to indicate poor or good handwashing behaviour respectively. The association between socio-economic indicators and handwashing behaviour was evaluated. We also ran an analysis without weighing the scores and giving score 2 for soap use and 1 for soil use and the results were not different.

Because the distribution of faecal coliform counts was skewed, $\log_{10}$ transformation was used to compare the data. The *t*-test was used to compare the differences between mean $\log_{10}$ faecal coliform counts of hands of a reference category and test category. Data of the left hands were compared with those of right hands. The counts of hands are reported as geometric means of a specific test group; geometric means are the antilog of the mean of the transformed values.

Results

Observational phase

Of the 90 women observed to wash their hands outside defecation sites, 40% used mud (i.e. 38% used mud and 2% used ash), 19% used soap, and 41% used water only and no rubbing agent. Those who used mud either rubbed fingers and palms on the ground or scooped out a small amount of soil and rubbed it between fingers and palms. Mud from different locations was used: near their kitchen, defecation site or the dwelling house. Altogether, 81% of the non-soap users reported that they might use soap but could not afford it.

A total of 44% washed both hands and 56% washed only their left hands; 74% rinsed their hands with 0.7 litres of water or less: 48% used tubewell water and the rest used surface water. During 62% of all washing events, fingers were rubbed three times or more. The majority of women who used soap rubbed their fingers more than three times. About 78% of the women dried/wiped their hands on their clothes and the rest let them dry in the air.

A positive association was demonstrated between better socio-economic indicators or water-sanitation practices, and good handwashing behaviour (Table III). The women's age, education of family head, and family size were not associated with the quality of handwashing.

Faecal coliform counts of hands before handwashing were 8,511 and 977 units per hand for left and right hands respectively. Although the counts of left hands were reduced significantly ($P < 0.01$) after the observed (usual) handwashing practices, they were still high (geometric mean: left hand = 1,995 and right hand = 1,318 faecal coliforms/hand).

Experimental phase

When each of the components of hand cleaning was adequately executed they favourably influenced the reduction of faecal coliform counts. All the controlled handwashings showed statistically (at 95% level) as well as substantially (more than 80% reduction except for rubbing on ground) reduced faecal coliform counts of hands over traditional post-defecation handwashing.

Under experimental washing conditions all local washing agents—soil, soap and ash—showed similar results (Table IV). Although faecal coliform counts in soil varied according to the location of the soil (geometric mean counts in soil near kitchen, soil

Table III Association of socio-economic indicators with good handwashing behaviour in 90 women in rural Bangladesh

Socio-economic indicators	Hand washing behaviour after defecation†		Relative rate* (95% CI)
	Good	Poor	
1. Three or more years of schooling (women)			
Yes	24	14	1.64 (1.08–2.50)
No	20	32	
2. Tubewell water used for all needs			
Yes	18	10	1.53 (1.03–2.29)
No	26	36	
3. Own sanitary latrine used			
Yes	22	11	1.73 (1.15–2.59)
No	22	35	
4. Radio owned			
Yes	16	16	1.04 (0.67–1.60)
No	28	30	
5. Owns agricultural land			
Yes	36	24	2.25 (1.20–4.22)
No	8	22	
6. Belief that washing hands prevents diseases			
Yes	26	27	1.01 (0.66–1.55)
No	21	18	

Notes: †See text for definition; composite weighted score was divided into < median = poor, > median = good.

*Indicates the association of good handwashing behaviour with the presence of the socio-economic indicator.

near latrine and wet soil near latrine were 3,877, 4,000 and 7,010 of faecal coliforms/gm of soil, respectively), their quality did not significantly affect the efficiency of the handwashing. It is, however, likely that dry soil from a clean place produces better results. The counts of faecal coliform of hands after handwashing by rubbing hands on ground (geometric mean of left hands = 971 and of right hands = 562) were significantly higher than every other handwashing practice. Lower faecal coliform counts of hands were observed with increased rubbing frequency. Increased volume of water showed lower faecal coliform count and the difference was statistically significant between rinsing with 2 litres and 0.5 litres of water. Compared with tubewell water the use of pond water showed significantly higher counts of right hands. The quality of water, however, varied significantly also; the geometric mean of the count of tubewell water was 32 faecal coliforms/100 ml and that of pond water was 17,330 faecal coliforms/100 ml. Drying the hands on clothing being worn tended to contaminate the hands (Table IV).

Table IV Comparison of faecal coliform of count of hands under various experimental conditions

Experimental conditions	Left hand: geometric mean (P values, 95% CI)	Right hand: geometric mean (P values, 95% CI)
[†] *Reference washing*		
Soil (near kitchen), 6 rubbings and rinsed with 2 litres of tubewell water (N = 83)	129	89
(A) Washing agent		
Testing of agents:		
Ash	98	54
(N = 84)	(P = 0.5; 0.33, 1.74)	(P = 0.23; 0.26, 1.38)
Soap	195	112
(N = 60)	(P = 0.25; 0.74, 3.02)	(P = 0.52; 0.63, 2.45)
Testing of soil:		
Soil (near latrine)	132	110
(N = 75)	(P = 0.97; 0.48, 2.19)	(P = 0.57; 0.6, 2.45)
Soil (wet)	240	159
(N = 65)	(P = 0.07; 0.95, 3.72)	(P = 0.09; 0.91, 3.47)
Rubbing hands on ground	977	562
(N = 65)	(P = 0.001; 3.63, 13.18)	(P = 0.001; 2.88, 13.49)
(B) Testing rubbing frequencies		
3 times	200	132
(N = 73)	(P = 0.20; 0.79, 3.02)	(P = 0.30; 0.71, 3.09)
(C) Testing volume of water used		
0.5 litres	269	234
(N = 75)	(P = 0.05; 1.01, 4.37)	(P = 0.02; 1.23, 5.25)
1 litre	128	79
(N = 64)	(P = 0.99; 0.48, 2.04)	(P = 0.71; 0.44, 1.74)
(D) Testing type of water		
Pond	288	263
(N = 75)	(P = 0.01; 1.23, 4.17)	(P = 0.000; 1.62, 5.25)

Note: Reference handwashing for statistical comparison with every group. P value is for t-test of $\log_{10}$ transformed data comparing the reference washing group[†] and the test group. The confidence interval is expressed as ratio of the geometric means of the two compared groups.

Thus, the handwashing was found efficient if a standard procedure was followed, i.e. (i) using an agent, e.g. soap, soil or ash; (ii) thoroughly rubbing both hands more than three times; (iii) rinsing of hands with 2 litres of tubewell water; and (iv) drying of hands using a clean cloth or in the air.

Discussion

Handwashing has been observed to be a complex behaviour made up of several components. Handwashing consisted of the use of a cleaning agent, rubbing hands and varying frequency, rinsing with water and drying; under controlled conditions, soap, soil and ash gave similar microbiological results on hand cleaning. Literacy, indicators of higher economic status (e.g. possession of a radio), use of tubewell water and defecation in sanitary latrines were significantly associated with the use of soap.

Under field conditions all women washed their hands. Soil was used by the majority of the women who used a washing agent. Use of soil and rubbing hands three or more times have cultural/religious implications. Although a substantial proportion of women washed one hand (left hand) and used water only, the Islamic religion suppports washing of both hands, rubbing closely three times. All of the studied women were Muslims. Socio-economic status and better sanitation practices were associated with use of soap and relatively good handwashing practices. People in Bangladesh use soap more for mental or physical satisfaction or for feeling 'clean' than for health reasons.[14]

The conventional handwashing practices observed in 90 women did reduce faecal coliform counts of left hands, but they remained unacceptably high. Although the left hand is used to clean the anal region after defecation, and the right hand is carefully kept isolated and believed to be clean,[8] both hands were found to be highly contaminated after defecation. We cannot explain why the mean values of the counts of the right hands were higher than those of the left hands after washing.

To help us understand the role of observed handwashing components and logically build efficient options based on these components we conducted the experimental phase. This experimental phase showed that under similar conditions any usual household washing agent—soil, ash or soap—produces similarly efficient results. It reconfirms the clinic-based studies[11,15] which showed that it is the effectiveness of the scrubbing action rather than a specific agent which removes the bacteria from the hands. The trend toward better cleaning results from handwashing as measured by reduced faecal coliform count with both hands rubbing together, increased frequency of the rubbing, and an increase volume of rinsing water all support the prime importance of scrubbing/frictional motion and consequent washing out of loosened bacteria with water.

The bacteriological quality of the soil did not show a significant negative effect on bacterial counts. The soil appears to have produced scrubbing effects comparable to the other agents including soap under similar standard conditions. This finding is useful for public health programmes; in many developing countries, as in Bangladesh, people cannot afford soap, but soil is universally available. However, rubbing hands on the ground had significantly less cleaning effect than the other techniques. The practice itself may be inherently inefficient; it permits only parts of the fingers and palms to be rubbed against the ground. Our data suggest that cleaner rinsing water was associated with reduced faecal coliform counts of hands. Pond water is used for most domestic purposes[16] but it showed a significantly higher faecal coliform count than tubewell water. When tubewell/improved quality water is available its use should

be emphasised for the obvious biological reasons but when improved quality water supplies are limited it may be appropriate to recommend rinsing with a higher volume of any available safe water.

Clinical studies have found that drying of hands on paper towels helps to reduce bacterial contamination[11,15] but drying with paper towels or a clean cloth is not feasible for the majority of people from Bangladesh or the rest of this subcontinent. On the other hand, wiping of hands on the person's clothes leads to increased contamination. We recommend instead that hands be dried in the air, if clean cloth/paper towels are not available.

In conclusion, we have described the major components of traditional handwashing practice after defecation and anal cleaning with water using the left hand and evaluated its efficiency in reducing bacterial contamination of hands. We have also shown that by standardising the components of this behaviour one can develop a standard handwashing practice which is reasonably efficient and is affordable by the majority of poor people in the subcontinent.

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