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Hard to handle: understanding mothers' handwashing behaviour in Ghana

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While handwashing with soap (HWWS) has been identified as a major pathway to reducing the risk of diarrhoeal diseases, and respiratory infections, rates of HWWS remain low across the globe. The current study, a national survey of Ghanaian mothers, found that as few as 4% of mothers engaged in HWWS after defecation, and only 2% after cleaning a child's bottom. In a multivariate analysis, we explored the determinants of handwashing at these key junctures, with and without soap. After defecation, mother's education, knowledge of important times to handwash with soap, the age of her children, and a measure of the quality of child care were all associated with handwashing (in any form). However, only the latter two variables also predicted soap use amongst handwashers. After cleaning a child's bottom, education, knowledge of important times to handwash with soap, and child care quality were associated with handwashing (in any form), yet only one variable, a measure of disgust sensitivity, showed any possible relationship with soap use. While this study has several important limitations, failure to explain much of the observed variance, despite a large range of potential determinants explored, suggests that we need to continue complementing quantitative surveys with in-depth qualitative studies if we are to better understand the motivations for, and constraints to, HWWS in community settings.

Keywords Hygiene behaviour, handwashing, diarrhoea, Ghana

KEY MESSAGES

- Handwashing with soap (HWWS) represents a highly effective way to limit the transmission of a range of diseases, including diarrhoea and respiratory infections which together result in some 5 million infant deaths globally each year.
- Rates of HWWS remain universally low and previous studies have generally failed to find strong relationships between handwash practice and variables such as the provision of handwash facilities, education, awareness of the importance of HWWS.
- This study echoes these findings, with a quantitative model being unable to account for much of the observed variance in handwash behaviour, suggesting that quantitative handwash studies need be complimented with in-depth qualitative probing to better understand motivations for, and constraints to, HWWS.

Introduction

Improving home handwashing practices remains one of the central challenges for the public health community in the 21st century. Each year over 5 million children in developing countries die from either diarrhoea or acute respiratory infections (Black *et al*. 2003). Handwashing with soap (HWWS) could significantly reduce the burden of each. HWWS after contact with faeces and before contact with food

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can reduce rates of diarrhoea among the under fives by 42–47% (Curtis and Cairncross 2003; Luby *et al*. 2004) and rates of respiratory infections by 16% (Rabie and Curtis 2006). However, rates of HWWS at key times are as low as 2 to 35% across the globe (Scott *et al*. 2003).

Meeting this challenge requires changes in behaviour in households around the world, and this, in turn, requires that that behaviour is understood (Curtis *et al*. 1999). However few studies have attempted to explain handwash practices outside of health care settings, or have addressed the issue in homes in the countries with the biggest disease burden, i.e. in developing countries. In this paper we present the results of a quantitative survey of mother's domestic handwashing practice in Ghana. This survey represents the baseline monitoring and evaluation study for a National Handwashing Promotion Campaign that took place across the country in 2004. Every year, Ghana suffers an estimated 9 million episodes of diarrhoea and 84 000 diarrhoea deaths among children under 5 years, at an estimated annual cost of US$33 million (CWSA 2002).

Our study concerns a nationally representative sample of mothers and their youngest child under the age of five (referred to throughout as the index child). Three key handwash junctures are investigated: (a) after mother's own defecation, (b) after cleaning the bottom of the index child after defecation, and (c) before feeding the index child. To quantify the relationships between the hygiene outcomes and a series of potential determinants (detailed below), we carried out univariate and multivariate analyses. We did not rely on oral reporting of handwashing but employed structured observations of behaviour, which, though laborious and difficult to implement, gives a better measure of actual handwashing practices than self report or other techniques (e.g. Manun'Ebo *et al*. 1997).

Traditionally hygiene promotion programmes have relied on an educational approach, operating on the assumption that simply increasing hygiene knowledge, understandings of biomedical models of disease transmission, and providing handwashing facilities with result in improved handwashing behaviour. Yet many hospital-based studies suggest such intuition represents over-simplification. For example, Preston *et al*. (1981) found no improvement in handwashing behaviour among health care staff when a hospital moved to new premises with a sink beside each and every bed, while Alvaran *et al*. (1994) found no association between handwash knowledge and practice. Gruber *et al*. (1989) even found a negative association between handwashing and biomedical knowledge.

More recently, Pittet and colleagues have worked extensively to attempt to understand factors that can contribute to increased hand hygiene compliance in hospital, especially in intensive care settings. Pittet has emphasized that even after training, levels of knowledge of infection control measures remain low and that the degree of knowledge does not necessarily predict appropriate behaviour (Pittet *et al*. 2000).

In a community-based study in urban sites in the Gauteng, South Africa, educational attainment, levels of knowledge of and attitudes towards diarrhoea and good hygiene practice were not found to significantly influence reported hygiene behaviour. Instead the main predicting factors of hygiene behaviours were found to be the age of the (female) respondent and where she lived, those living in a township being less likely to report good hygiene behaviours than those living in service areas and squatter camps. The close availability of water was found to have a minimal positive effect on reports of safe hygiene behaviours (Westaway and Viljoen 2000).

In this study we revisited some of the factors investigated in previous studies of hygiene behaviours and included several more factors of our own. We hypothesized that mother's handwashing practice would be determined by factors both extrinsic and intrinsic to her. Extrinsic factors investigated that were expected to facilitate or constitute barriers to practicing handwashing included: the site of defecation, the method of stool disposal, and the age of the index child (which may represent the amount of free time available to the mother). Intrinsic factors included mother's formal education, her health consciousness and knowledge of the most important times to wash her hands, her attentiveness to the index child and her disgust score (a measure of her 'squeamishness' concerning hygiene) (see Curtis *et al*. 2004).

Methods

Sampling

The survey was conducted as a baseline for the evaluation study of the national handwash intervention programme by *Research International (RI) Ghana Bureau*, a professional Market Research Agency, in August-September 2003. Sample size was calculated to detect a doubling of rates of handwashing in handwashing behaviour pre and post intervention. Trained field workers gathered data from 531 households from across rural and urban areas in five regions (Greater Accra, Ashanti, Eastern, Western and Northern) purposefully selected to represent the three main ecological and socio-cultural zones of Ghana. Within each region, five rural and four urban enumeration areas were randomly selected from a national census list to reflect the urban-rural distribution of the Ghanaian population.

Following mapping of each enumeration area and introductions to members of the local authorities, every tenth household was selected using a random walk technique. Interviews were only conducted in those households where mothers with children under 5 years were present.

In each household, after permission had been sought from the household head, a fieldworker spent from 6am to 9am discreetly sitting and observing compound activities, recording defecation and hygiene behaviours of the mother and associated index child in a structured format provided by ourselves and the RI research directive. The observations were carried out at this time since this is the most likely period of the day for maternal defecation, child defecation and infant feeding to take place within the same time period. Observations were limited to 3 hours due to the general inability for fieldworkers to stay focused for much longer periods, and due to logistical and ethical constraints.

Following observations, short interviews were carried out with the mothers to obtain socio-economic and health-related information pertaining to the household and index child.

All fieldworkers had prior experience in carrying out both structured observations and interviews. Women were not told of the precise purpose of the visit, rather that the fieldworker was interested in daily activity patterns in Ghanaian households. This was due to concern that telling mothers the precise purpose of the study would have significant effects on their handwashing behaviours, leading to over-estimations of handwash practice.

Structured observation

Handwashing practice by the mother was recorded by observers at three junctures: after the mother herself had been to the toilet (or bush); after she cleaned up an index child who had defecated; and before she gave food to the child. The use of water and soap was recorded, and because some women combined a morning toilet visit with bathing (using soap), we also noted bathing immediately following defecation or child cleaning. This was counted as HWWS in the analysis of mothers' post-defecation practice, but not for the other two junctures, since bathing may have been coincidental rather than planned. Since defecation and feeding were not observed on every visit, the analysis concerned only those households with valid outcome data for each of the three potential handwash junctures. The site of defecation, of stool disposal, the water source, the type of food served, and the type of utensil used to eat the food were also recorded for the relevant junctures. It was not, of course, possible, to record whether mothers did indeed defecate on these early morning visits to toilet or bush, but this practice is commonly referred to as 'going for defecation', so we assumed it to be so (van der Geest 1998).

Fieldworkers recorded the attentiveness of the mother towards the index child (on a scale of 1–3), and how groomed and neat the child appeared (on a scale of 1–4). These were combined to produce a proxy index of child caring (low, medium or high). In addition, the overall presence of the mother in the vicinity of the child was recorded as a percentage of the total observation time.

Interviews

Following the structured observations, fieldworkers conducted interviews with the index mothers to collect demographic variables on mother and child, along with mother's health knowledge and disgust sensitivity. Demographic information included the age, religion, ethnicity and education of the mother, the wages of the highest household earner, the age and sex of the index child, and the number of older siblings (living within the household). Health knowledge was assessed by two distinct measures that Ghanaian health professionals felt best indicated mother's health awareness: the mother's ability to identify the health functions of vitamin A (mothers that could name no functions were categorized as having low knowledge, mothers who could name one or more as having high knowledge); and mother's ability to identify the key times at which HWWS should be practiced in order to prevent disease transmission (mothers that could name none or only one function were categorized as having low knowledge, mothers that could name two or three as having high knowledge). Because we have previously hypothesized that an individual's squeamishness, or 'disgustability', may correlate with hygienic behaviour (Curtis and Biran 2001), we assessed disgust sensitivity by showing mothers four images—a photo of a feverish, dirty man with a runny nose; an open wound; a plate of yellow liquid with a splash of red resembling bloody puss; and a clump of intestinal worms—which she was asked to rate in terms of how disgusting each one was on a 10-point scale (adapted from Curtis *et al*. 2004). Mothers were then categorized into low/medium (scoring 1–6) and high disgust sensitivity (scoring 7–10).

Data analysis

Chi-squared tests were used to identify crude associations between each potential explanatory variable and handwashing practices at each juncture. We first tested for associations between potential explanatory variables and any handwashing, and then did the same for HWWS (amongst handwashers). We then built stepwise logistic regression models to examine and quantify multivariate relationships. For each model, all explanatory variables crudely associated with each outcome ($p < 0.1$) were included in first step, then the least statistically significant variable in the model was dropped and the new model tested (using the LR criterion in SPSS). This process was repeated until all variables left in the model had a statistically significant association with the outcome variable. In the case of handwashing before feeding a child, the above analyses were, however, not possible, due to the extremely rare occurrence of handwashing at this juncture.

Results

Descriptive information on the potential determinants of handwashing behaviour for our sample ($n = 531$) is provided in Table 1. Three-quarters of the sample were Christian (74%); over half were Akan (53%) and lacking in secondary education (55%). Over two-thirds of the population had household incomes under 500 000 cedis (US$55)/month, with over a third existing on under 250 000 cedis (US$28)/month. Over half of households had 2–3 children, with the index child (with an average age of 2 years) representing the only infant in 16% of homes.

During the observation periods, less than half of mothers (47%, $n = 251$) were observed to go for defecation. Of those that did, over half of mothers used a public toilet (58%), 27% a household or compound toilet, and 15% practiced open defecation. Table 2 shows that handwashing was a rare event post-defecation, with under half of the mothers washing their hands and only 4% using soap. Ten per cent of women bathed immediately after visiting the toilet. The majority of those who washed their hands (93%) took water from a stored container in the compound.

In a majority of observations (87%, $n = 397$), mothers were recorded to clean up a child's stools. The most common child defecation site was on the floor or in a plastic bag (61%), only 26% using nappies and 14% a toilet. Seventy-three per cent of mothers did not wash their hands after cleaning up a child, leaving 22% washing hands just with water and only

Table 1 Potential determinants of handwashing behaviour (n = 531)*

Determinant		
Mother's age	Mean = 30	S.D. = 6.5
Age of index child	Mean = 2	S.D. = 1.4
Sex of child		
Male	52%	(274)
Female	48%	(257)
Mother's religion		
Christian	74%	(394)
Moslem	22%	(115)
Spiritualist/no religion	4.1%	(22)
Mother's ethnicity		
Akan	53%	(281)
Ga/Adangbe	17%	(89)
Ewe	6%	(33)
Mole-Dagbani	16%	(83)
Other	8%	(45)
Monthly wages of highest household earner (cedis)		
⩽250 000	36%	(184)
251 000–500 000	36%	(186)
501 000–900 000	21%	(107)
⩾901 000	8%	(42)
Missing	–	(12)
Mother's education		
None	27%	(143)
Primary	28%	(150)
Junior Secondary	32%	(171)
Senior Secondary	12%	(62)
University +	0.9%	(5)
No. of older siblings living with child		
0	16%	(83)
1–2	57%	(300)
3–4	28%	(48)
Presence of mother around index child		
0–50%	13%	(67)
60–80%	40%	(210)
90–100%	48%	(254)
Index child care (based on attentiveness and appearance)		
Low (1–3)	25%	(135)
Medium (4)	41%	(216)
High (5–7)	34%	(180)
Mother's knowledge of the key times to HWWS		
Low (0–1/3)	45%	(237)
High (2–3/3)	55%	(294)
Mother's health consciousness (roles of vitamin A identified)		
Low (0)	71%	(378)
High (1+)	29%	(294)
Disgust sensitivity (ratings of disgusting images)		
Low (1–6)	28%	(149)
High (7–10)	72%	(377)
Missing	–	(5)
After own defecation: defecation site (n = 251)		
Bush	15%	(38)
Public toilet	58%	(146)
Toilet in house/compound	27%	(67)
After cleaning child: defecation site (n = 462)		
Open defecation or plastic bag	61%	(283)
Nappy/pants/wrapper	25%	(113)
Potty/toilet	14%	(66)
After cleaning child: how was stool disposed of (n = 406)		
Not disposed of by mother	20%	(82)
Immediately by mother	56%	(225)
Later by mother	24%	(97)
Missing	–	(2)
After cleaning child: stool disposal site (n = 321)		
In yard	30%	(94)
Outside yard	46%	(144)
Safely	24%	(77)
Missing	–	(6)

*In cases where data are missing, the number of missing cases is given in brackets and not included in calculation of percentage.

2% HWWS. A small number of mothers (2%) also bathed immediately after cleaning up a child.

It was also common for a child to be fed during the observation period (71% of mothers, n = 378). Food (solid, liquid, snack or breast milk) was observed to be served with hands on 57% of occasions. Handwashing was least common at this juncture, with 5% of mothers washing their hands prior to feeding and only 1% using soap. No difference in handwashing practice was observed when food was served with utensils versus hands.

Univariate analyses: crude associations with handwashing practices

Table 3 shows the results of the univariate analysis for handwashing after defecation or wiping a child's bottom. As few mothers washed their hands before feeding a child, there was limited value to carrying out univariate analysis for handwashing at this juncture.

Factors found to be crudely associated ($p < 0.05$ significance) with the occurrence of any handwashing activity after mother or child defecation were:

- mother's ethnicity
- mother's education
- income of the household's highest earner
- knowledge of the key times for HWWS
- awareness of the benefits of vitamin A
- disgust sensitivity
- the child care index
- where defecation occurred
- percentage of time the mother spent with the infant.

Age of index child was significant at the $p < 0.1$ level.

Table 2 Mother's handwashing practice (n = 531)

Behaviour	After own defecation	After cleaning a child	Before feeding a child
Did not wash hands	52% (130)	73% (291)	94% (357)
Washed hands with water only (HWWO)	35% (88)	22% (89)	4.8% (18)
Washed hands with soap and water (HWWS)	3.6% (9)	2.0% (8)	0.8% (3)
Took a bath	9.6% (24)	2.3% (9)	0% (0)
Total	251	397	378

Table 3 Summary of univariate analyses

	After own defecation		After cleaning up child	
	(i) Wash hands?	(ii) Use soap?	(i) Wash hands?	(ii) Use soap?
Demographic info: index mother				
Mother's age				
Mother's ethnicity	*		*	
Mother's religion	*		*	
Mother's education	*	*	*	
Highest wages (income)	*	*	*	
Demographic info: index child				
Sex of child				
Age of child (0–4+)	+	*	*	
No. of older siblings				
Additional potential determinants				
Knowledge of the key times to HWWS	*		*	
Health conscious index Vitamin A	*	+	+	
Disgust sensitivity				+
Combined child care index	*	+	*	
Mother's presence		*	*	
Context-specific factors				
Where defecated	*	+	*	
Stool disposal – how	n.a.	n.a.		
Stool disposal – site	n.a.	n.a.		

Note: Crude associations between potential determinants and handwash outcomes at a $p < 0.05$ (*) and $p < 0.1$ (+) alpha level for (i) did not wash hands vs. washed hands (with or without soap), and (ii) washed hands with water vs. washed hands with soap and water.
HWWS = handwashing with soap.
n.a. = not applicable.

Those factors crudely associated with handwashing *with soap* after maternal defecation ($p < 0.05$) were:

- mother's education
- household wages
- the age of the index child
- the amount of time mother spent with child.

There was also an association between HWWS after defecation and health consciousness, child care and place of defecation ($p < 0.1$).

After cleaning a child's bottom, no factors were found to have a significant association with soap use amongst handwashers at the $p < 0.05$ level, though disgust sensitivity shows association at the $p < 0.1$ level. Comparing low versus high disgust sensitive mothers provides a very high odds ratio (2197.48, CI: 0.00–1.68 E + 25). However, as the wide confidence limits indicate, this effect size is questionable—a product of the rarity of soap use at this juncture. Due to the retention of only one potential association, no multivariate analysis was carried out for HWWS after cleaning a child.

Multivariate analyses: determinants of handwashing practice

After mother's own defecation

As shown in Table 4a the logistical regression model retained five variables as predictors of handwashing behaviour:

- education
- knowledge of the key handwash junctures
- levels of child care
- age of the index child.

The most attentive mothers, as indicated by child care level, were over six times more likely to wash their hands (in any

Table 4a Stepwise log regression models for handwashing behaviour after own defecation (did not wash hands = 0, washed hands = 1)

	% washed hands (x/n)	Exp (β) Odds Ratio (95% CI)
Education		
None (reference category)	26% (20/75)	1.00
Primary	51% (39/76)	3.23 (1.52–6.86)
Middle	59% (42/71)	3.15 (1.46–6.80)
Secondary +	69% (20/29)	3.20 (1.12–9.11)
Knowledge of the key HWWS times		
Low (0–1/3) (reference category)	40% (44/111)	1.00
High (2–3/3)	55% (77/140)	1.86 (1.04–3.33)
Child care level		
Poor (reference category)	30% (19/64)	1.00
Medium	43% (46/103)	1.72 (0.84–3.53)
High	60% (56/81)	6.25 (2.68–14.49)
Age of child		
<1 (reference category)	40% (17/42)	1.00
1	49% (34/69)	2.53 (1.03–6.24)
2	43% (27/63)	2.05 (0.79–5.31)
3	44% (16/36)	2.04 (0.73–5.74)
4+	56% (5/9)	5.75 (1.92–17.18)
Hosmer and Lemeshows' measure: 52.80/333.99 = 0.16		

HWWS = handwashing with soap.

form) than those displaying the least attention to the index child (OR = 6.25; 95% CI: 2.68–14.59). The older the index child, the more likely the mother became to wash her hands, with a significant increase in the odds of this behaviour when the child was 4 years old. Those mothers educated to at least primary level were over three times as likely as uneducated mothers to wash their hands, while those who could correctly cite 2–3 of the key handwash junctures were almost twice as likely as those able to cite 0–1 of the junctures.

However, only two of these factors were associated with HWWS: child care levels and the age of index child (Table 4b). Mothers with index children of 4 years were over 20 times more likely to HWWS than those women with children under 1 year (OR = 20.26; 95% CI: 2.34–175.8). Women in houses with the greatest incomes were more likely than those with the least income to HWWS (OR = 1.76; 95% CI: 0.70–4.42), while those in the middle income category were less likely than the poorest households to HWWS (OR = 0.43; 95% CI: 0.14–1.29).

After cleaning a child's bottom

In common with the regression model for handwashing after maternal defecation, the following variables were associated with handwashing after cleaning a child's bottom (see Table 5):

- mother's education
- knowledge of the key handwash junctures
- levels of child care.

Ethnicity is also retained, while the number of siblings is not.

Table 4b Stepwise log regression models for handwashing behaviour after own defecation (washed hands with water only = 0, handwashing with soap and water = 1)

	% used soap (x/n)	Exp (β) Odds Ratio (95% CI)
Highest household wages (cedis)		
⩽250 000/month (reference category)	15% (13/87)	1.00
251 000–500 000/month	6% (5/85)	0.43 (0.14–1.29)
⩾501 000/month	25% (15/61)	1.76 (0.70–4.42)
Child care level		
Poor (reference category)	8% (5/59)	1.00
Medium	11% (12/106)	2.01 (0.64–6.29)
High	20% (16/81)	3.43 (1.07–10.96)
Age of child		
<1 (reference category)	2% (1/42)	1.00
1	13% (9/69)	8.45 (1.00–71.26)
2	14% (9/63)	8.63 (1.01–73.72)
3	8% (3/36)	4.92 (0.46–52.17)
4+	27% (10/37)	20.26 (2.34–175.8)
Hosmer and Lemeshow's measure: 25.80/189.05 = 0.14		

Table 5 Stepwise log regression models for handwashing behaviour after cleaning up a child (did not wash hands = 0, washed hands = 1)

	% washed hands (x/n)	Exp (β) Odds Ratio (95% CI)
Ethnicity		
Akan (reference category)	31% (69/220)	1.00
Mole-Dagbani	12% (7/60)	0.29 (0.10–0.86)
Ewe	38% (8/21)	1.17 (0.41–3.38)
Ga/Adangbe	17% (11/59)	0.36 (0.15–0.84)
Other	7% (2/28)	0.15 (0.03–0.72)
Education		
None (reference category)	13% (15/114)	1.00
Primary	30% (33/110)	1.69 (0.74–3.88)
Middle	25% (32/127)	1.15 (0.50–2.63)
Secondary +	50% (17/37)	3.47 (1.21–9.96)
Knowledge of the key HWWS times		
Low (0–1/3) (reference category)	17% (30/181)	1.00
High (2–3/3)	32% (67/207)	2.03 (1.16–3.55)
Child care level		
Poor (reference category)	8% (9/103)	1.00
Medium	18% (30/165)	2.04 (0.90–4.64)
High	48% (58/120)	8.66 (3.85–19.46)
Hosmer and Lemeshow's measure: 91.68/425.06 = 0.22		

HWWS = handwashing with soap.

Again we find that those mothers displaying the highest levels of child care are significantly more likely than the least attentive mothers to practice any handwashing behaviour, the relationship being more pronounced for handwashing

after cleaning a child's bottom (OR = 8.66; 95% CI: 3.85–19.46). Those with knowledge of more of the key handwash junctures were, again, twice as likely to handwash (OR = 2.03; 95% CI: 1.16–3.55). While in the case of handwashing after mother's own defecation, primary education was sufficient to increase the likelihood of its practice, in the case of handwashing after cleaning a child's bottom, the greatest influence of education is at the secondary level, with those with this level of education being over three times as likely as uneducated women to handwash (OR = 3.47; 95% CI: 1.21–9.96). Those mothers of Ewe ethnicity were marginally more likely than the majority Akan to handwash (OR = 1.17; 95% CI: 0.41–3.38), while Mole-Dagbani and Ga/Adangbe were much less likely to do so.

Discussion

Contrary to our expectations, the defecation site, stool disposal site and stool disposal methods did not figure in any of our models, suggesting that such extrinsic factors did not greatly influence handwashing practice in this population. Unfortunately, errors in data collection led to the unavailability of data regarding the availability of soap and water across all households, two key resources that might be expected to have significant impact on handwashing practice. However, there are other indicators that point towards their only having a marginal impact on behaviour. In particular, a negative relationship between the utilization of public toilets (where water and soap are rare) or open defecation and the occurrence of handwashing with or without soap might have been expected if there was a strong relationship between soap and water availability and handwash practice. We also know from previous research that 95% of Ghanaian households own soap (Scott *et al*. 2002) even if it was not being used, as shown here, for handwashing.

The non-linear relationship between household wealth and handwashing behaviour is difficult to interpret. We might have expected a clear relationship whereby rates of handwashing (with and without soap) increased as household income rose, at least in part due to increased access to water and ability to afford (beauty) soaps. However, household income only appears in the regression model for HWWS after defecation, and here we find that while the wealthiest segment are most likely to HWWS, the poorest are more likely than those in the middle income bracket to do so.

Limited time and ability may have represented a real barrier to handwashing. We found that those mothers whose index child (youngest child) was older were more likely than those with babies to wash their hands after their own defecation. This might reflect the increasing independence of the child as it grows older and the mother's ability to leave it unsupervised while she carries out minor tasks. The failure of this relationship to hold true in the case of handwashing after cleaning a child's bottom can potentially be related to past findings from Ghana and beyond, that mothers tend to believe that children's faeces are harmless and display a lack of disgust at the sight of their own child's excrement (De Zoysa *et al*. 1984; Scott *et al*. 2002).

Amongst the intrinsic factors considered as determinants in our analysis, the level of child care appears to have the strongest relationship to handwashing practice, and appears in three of our four models, including that for HWWS after mother's own defecation. It may be that mothers able to provide a higher level of nurturance are more likely to take the time and effort to engage in protective hygienic behaviour. There is a possibility that this relationship stands across all the models because fieldworkers biased their judgements of a mother's attentiveness according to her handwashing practice, but the finding is strongly supported by a previous formative research study with Ghanaian mothers that found nurturing, caring for and protecting children to be a primary motivation for women to carry out hygiene behaviours. In particular, mother's felt that their hands should be clean when touching their babies (Scott *et al*. 2002).

We also find strong evidence of a consistent positive relationship between level of formal education in general, and knowledge of the most important times to handwash in particular, with the incidence of handwashing with water, but not with the use of soap amongst handwashers. However, it must be noted that while there was a relationship between handwashing behaviour and knowledge of when hands should be washed, we cannot ascertain the causal direction of this relationship. Thus, while increased hygiene awareness may lead to improved hygiene practice, it is also possible that those washing their hands at key junctures were more likely to cite the correct handwashing times, simply because they do so. It is likely that we see here a combination of the two effects, some mothers washing their hands due to education to do so (see Rothschild 1999 for a model outlining the potential power of education, marketing and finally legislation to change behaviour), and others citing the correct times to handwash because this is when they do so.

The relationship between level of education and handwashing was also unclear, it being possible that this relationship reflects not the direct effect of hygiene education on behaviour but the installation of the handwashing habit at school due to other factors such as social pressure and copying of role models. Such social influences have been posited to exert great influence on human behaviour, some studies even demonstrating increased handwashing when individuals (health workers) believe others are watching them (Pittet *et al*. 2000). The study also failed to find a relationship between health awareness (as indicated by Vitamin A benefit awareness) and hygiene behaviours, mirroring findings from past studies and supporting the supposition that the relationship between handwashing and education *may* not be a direct one. In future studies, the collection of more indicators of health awareness, allowing for the development of a composite indicator, would allow better exploration of this relationship.

Disgust is best understood as an emotion which has evolved in humans, as in other animals, in order to prevent contact with disease-causing agents (Curtis *et al*. 2004). As such, we had expected a strong consistent relationship between disgust sensitivity and handwashing practice. However, disgust score had no predictive power in the case of handwashing with water, and the sample size of those HWWS was too small for reliable interpretation of the extreme odds ratio observed in the model exploring HWWS before feeding a child.

Despite the associations we found between available time, education, child nurturance and disgust and handwashing, the majority of the variance in handwashing behaviour remains unaccounted for in our analyses (a Hosmer and Lemeshow's measure of 14–22% across our models clearly shows this). Assuming that our measures were reliable and that handwashing behaviour was not random, this suggests that many determinants remain unidentified in this investigation. More detailed measures of the facilities available to each mother may potentially prove productive. However, given the results of this study regarding defecation site, stool disposal and wealth, it is our suggestion that such factors will only account for a small amount of additional variance. It is our suggestion rather, that deeper, subconscious, even unconscious, motivations and instinct driving hygiene behaviours may provide the answers.

Our parallel, in-depth qualitative work which attempted to uncover socio-cultural and unconscious motivation using qualitative interviews suggested that key factors such as a mother's nurture (revealed here also), her fear of contamination (that can be sensed via smell, sight, touch or imagination)/disgust, her concern for social acceptance and status enhancement are key in understanding and motivating hygiene behaviours (Scott *et al*. 2002). In the case of Ghana, lack of habit associated with the belief that if hands appear and smell clean then they are clean have, qualitatively, proven central to explaining low rates of HWWS.

Further attempts at quantifying the determinants of handwash behaviour need to make more effort to measure these factors that we have thus far accessed only qualitatively. However, these tend to be deep-rooted in the brain and thus difficult to elicit via direct 'surface' questioning, and are mostly only revealed through in-depth, in-direct questioning and probing (Zaltman 2003). This suggests that until new quantitative tools can be developed, the role of qualitative research in understanding hygiene behaviour, the deep-rooted motivations for it and socio-cultural influences upon it, will remain vital, and that in-depth interviews and behavioural trials should be used as the central research tools in the development of hygiene promotion programmes.

Conclusions: understanding mothers' handwashing behaviour and designing studies for the future

Rates of handwashing with or without soap are universally low across Ghana. This is particularly true in the case of handwashing after cleaning a child's bottom, especially handwashing with soap. Echoing the results of hospital-based studies in the developed world (Preston *et al*. 1981; Gruber *et al*. 1989; Alvaran *et al*. 1994; Pittet *et al*. 2000) and a community-based study in South Africa (Westaway and Viljoen 2000), we found only weak relationships between hygiene behaviours and explanatory variables such as education, health knowledge and wealth. Furthermore, despite the inclusion of a range of other potential variables, we were only able to explain a minority of the observed variance in handwashing behaviour, suggesting that other, less easily measured factors come into play.

The most important predictors of handwashing behaviour revealed in our study were the age of the index child and levels of child care afforded by the mother, suggesting that future hygiene behaviour studies should attempt to measure nurturance and time budgets also. Disgust sensitivity may also be important, however our findings are inconclusive and fieldworker experiences using the tool suggest that it needs refining in the field and adaptation to the local contexts within which it is being used.

The failure of this and other quantitative studies to explain much of the variance in handwashing behaviour observed leads us to suggest that theory development is required, alongside the development of new measures and tools that delve deeper into understanding the influence of psychological and psycho-social factors in determining and motivating hygiene behaviours. Until these are available, qualitative research remains critical to our understanding of hygiene behaviours and the development of successful field hygiene promotion programmes.

This tool has now been adapted and upgraded in light of learnings from its initial use in Ghana. It is currently being utilized in a survey of handwashing behaviour in Vietnam, where the results, along with in-depth qualitative research, will, as they were in Ghana, be used to inform the development and monitor the impact of a national handwashing campaign. In particular, data will be collected regarding handwashing before preparing food and the availability of water and soap in every household regardless of handwash practice. Similar data collection is also expected in Tanzania, Uganda, Kenya and other countries taking part in the Global Public-Private Partnership for Handwashing (http://www.globalhandwashing.org). These studies provide the opportunity for significantly enhancing our understanding of handwashing determinants in developing country community settings and exploring further the relative roles of extrinsic and intrinsic factors in a range of socio-cultural contexts.

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