

Global Scaling Up Handwashing Project

Practical Guidance for Measuring Handwashing Behavior

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The following individuals, in alphabetical order, have contributed to the thinking presented in this document: Adam Biran, Anna Bowen, Val Curtis, Jacqueline Devine, Stewart Granger, Orlando Hernandez, Steve Luby, Jack Molyneaux, Eddy Perez, and Wolf-Peter Schmidt. Sincere thanks go to them for their constant interest in this topic and their intellectual generosity.

Global Scaling Up Handwashing is a Water and Sanitation Program (WSP) project focused on learning how to apply innovative promotional approaches to behavior change to generate widespread and sustained improvements in handwashing with soap at scale among women of reproductive age (ages 15–49) and primary school-aged children (ages 5–9). The project is being implemented by local and national governments with technical support from WSP. For more information, please visit www.wsp.org/scalinguphandwashing.

This Working Paper is one in a series of knowledge products designed to showcase project findings, assessments, and lessons learned in the Global Scaling Up Handwashing Project. This paper is conceived as a work in progress to encourage the exchange of ideas about development issues. For more information please email Pavani Ram at wsp@worldbank.org or visit our website at www.wsp.org.

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Executive Summary

Accurate measures of handwashing behavior are critical to understanding households' health environment. But it can be challenging to measure handwashing reliably. This document discusses a set of handwashing indicators and recommendations that was prepared to support the Water and Sanitation Program's six-country scaling-up of handwashing promotion and community-led total sanitation. Descriptions of these measures, and the recommendations for their use (Table 1), should be of interest to a broad audience.

The following handwashing measures are assessed based on their validity, reliability, and efficiency:

Self-reports are the easiest way to measure handwashing. But they are invalid as measures of handwashing behavior because individuals often report better handwashing behavior than they display during observation. This exaggeration of true behavior may result from a perceived high social desirability of handwashing. However, self-reports remain an important source of information about handwashing knowledge and other determinants of handwashing behavior.

Rapid household observations include several easily collected valid and reliable indicators. These include observations on the availability of soap and water, and the presence of these tools at dedicated handwashing stations. While these indicators do not directly indicate handwashing behavior, they are currently used as surrogate markers because they are reliable and efficient. But evidence of how well they predict actual handwashing behavior and disease risk is still forthcoming.

Microbiological measures of hand contamination are objective measures of hand contamination, and consequently would seem desirable. However, this is currently a costly way to assess hand cleanliness. Moreover, hand contamination indicators have been found to be unrelated to observed handwashing behavior. Furthermore, reliability is a challenge. However, if the cost of such measurement can be decreased and reliability improved, hand microbiology may eventually be useful for measuring household environmental contamination.

Structured Observations have been used frequently in the handwashing literature. These observations require trained observers to watch and record household handwashing and related behaviors, and yield details about handwashing at critical times, such as after defecation. But they are costly and their validity has been recently questioned because of reactivity on the part of those observed. This preliminary evidence warrants caution but structured observations remain relevant to handwashing measurement because of the rich details yielded by them.

Bars of soap with motion sensors provide an objective record of the number and timing of soap-use events. The method is still relatively untested, but it is promising in select settings, despite facing several challenges. The method is relatively expensive, because of specialized hardware and personnel costs. The sensors may only be useful if households typically use soap bars for personal hygiene, as opposed to powder soap or bar soap used for multiple purposes. The data from soap with motion sensors do not generate respondent-specific information, nor do they inform about rates of handwashing with soap at critical times, such as after defecation. In spite of these caveats, the motion sensor yields objectivity and reliability to soap use measurement and, thus, further evaluation is clearly warranted.

Combined use of structured observations and motion sensors permits analysts to link the timing of observed soap-use events to the events recorded by the motion sensors, and to extend what is learned to periods outside of the structured observation. This permits analysts to study context-specific soap use, while also enabling them to distinguish soap use frequencies during the structured observation from frequencies observed during corresponding hours on unobserved days. But this approach incurs the combined costs of the two most costly measures considered.

Based on these assessments, the following recommendations are made according to the nature of the study, including well-funded projects, projects with minimal funding, and mixed-purpose, large population-based surveys.

For well-funded projects, the most rigorous methods should be considered. These include the combined use of

structured observations and soap with motion sensors, along with rapid observations. Questionnaires may also be used to learn about knowledge and other determinants of handwashing. Hand contamination measures should be considered, as much is still to be learned of them. These well-funded studies should also continue to measure health outcomes to better document the relationship between measured handwashing behaviors and health outcomes.

Studies with minimal funding, which need affordable yet reliable methods to monitor handwashing behavior, may warrant an investment in sample size estimates by a statistician or epidemiologist. These investments can frequently pay for themselves, as sample needs are frequently much lower than expected. As part of these evaluations, it is

advisable to consider conducting structured observations, and soap with motion sensors from small samples of households. Rapid observations and self-reported questionnaires remain the cheapest source of household information. Rapid observations are markers for actual behavior, and self-reports may be used to measure knowledge and other possible determinants of handwashing behavior.

For mixed-purpose, large population surveys, such as the Demographic and Health Survey (DHS) or the Multiple Indicator Cluster Survey (MICS), where handwashing is only one of many behaviors of interest, rapid observations are recommended as the most efficient method of measuring handwashing behavior.

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I. Introduction

Advocates of promoting handwashing with soap agree that this behavior has important health benefits across the globe.¹ Efforts, both large-scale and focused, are underway worldwide to promote handwashing with soap at the community level (www.globalhandwashing.org). Although there is broad agreement about the health benefits of promoting handwashing with soap, there is not similar agreement about the best ways to measure the behavior that these promotion programs set out to change. The reality is this: there is no universally applicable method for measuring handwashing behavior that is valid, relevant, affordable, and logistically feasible for the various settings in which such behavior might need to be measured. The aim of this document is to describe techniques and to propose strategies for measuring handwashing behavior for a variety of scenarios.

The measurement of handwashing behavior is relevant to research studies and public health programs for evaluation of the effectiveness of handwashing promotion with respect to behavior change and assessment of the role of hand hygiene in pathogen transmission and disease burden. As for other outcomes of interest to public health, measurements of handwashing behavior should be scrutinized with respect to the following criteria:²

- Validity: “an expression of the degree to which a measurement measures what it purports to measure”
- Reliability: “the degree to which the results obtained by a measurement . . . can be replicated”
- Efficiency: “the effects or end results achieved in relation to the effort expended in terms of money, resources, and time”

All measurement of handwashing is challenged by the complexities of this human behavior. An individual may wash hands with soap in the context of some critical times for pathogen acquisition or transmission, such as after

defecation, but not in other critical times, such as before feeding a child. Thus, summarizing an individual’s overall handwashing behavior requires taking into account variations in behavior at different critical times. Moreover, an individual may be inconsistent in her behavior, for example washing hands with soap after defecation sometimes but not always; such variation in reliability also makes assigning an individual to a category such as “handwasher” or “non-handwasher” under-informative. Furthermore, both reported and observed markers of handwashing behavior have been found to be significantly associated with socioeconomic status, making adjusting for this important explanatory factor extremely important.³

Described below are the positive and negative attributes of various commonly applied and novel methods of measuring handwashing behavior. Both self-reported and observed measures are described.

1 Curtis 2003; Curtis and Cairncross 2003; Rabie and Curtis 2006.

2 Last 2001.

3 Luby and Halder 2008.

II. Methods of Measuring Handwashing Behavior

Self-Report

The easiest way to measure handwashing behavior is to use a questionnaire to ask the respondent directly about her behavior (see Box 1). This format is efficient, since the information can be gathered quickly, among a large number of households, at relatively low cost. Unfortunately, awareness of the social desirability of handwashing may result in an individual's overestimation of self-reported handwashing behavior. This overestimation has been demonstrated repeatedly, when self-reported behavior has been compared to observed behavior.⁴ For example, in a study by Manun'Ebo et al. (1997), the frequency of washing hands with soap and water before eating was *reported* by 14 percent of respondents but *observed* for only 2 percent of respondents.⁵ In Bangladesh, whereas 77 percent of respondents *reported* washing hands with soap or ash after defecation, only 32 percent were *observed* to do so.⁶ Kappa score analysis, a statistical tool to describe agreement between two different measures of a construct, has been used in several studies; a kappa score less than 0.20 is considered to indicate "poor agreement" in the epidemiological literature. Stanton et al. (1987), and Biran et al. (2008), have each shown that there is poor agreement between reported behavior and observed behavior, with kappa scores of 0.11 and 0.10, respectively, for reported and observed measures of handwashing behavior after fecal contact. These studies, therefore, indicate that self-report is likely an invalid measure of true handwashing behavior. On the other hand, questionnaires may be used to elicit information relevant to behavioral factors that may facilitate or impede handwashing; such determinants may include attitudes and beliefs, as well as logistical factors such as access to adequate quantities of water. One set of determinants that is commonly measured is knowledge

related to handwashing behavior. Describing changes in knowledge of appropriate handwashing behavior may be useful as part of monitoring a handwashing promotion campaign that proposes to increase knowledge of handwashing in the target population.

Proxy Measures: Measurement of Microbiological Hand Contamination

Measurement of microbiological contamination of hands is another proxy measure of handwashing behavior. The underlying assumption is that hands that are washed with soap will be less contaminated with fecal organisms than hands that are not washed with soap. The details of measuring hand contamination, e.g., by fingertip rinses or hand imprints on semi-solid media, among others, are beyond the scope of this paper but are covered in numerous peer-reviewed publications.⁷ As a proxy measure, hand contamination offers a level of objectivity greater than self-report. In Bangladesh, hands tested immediately after thorough washing with soap have been found to have substantially lower contamination with fecal coliforms than unwashed hands,⁸ although even this finding is challenged by other research, in which there has been no reduction in bacterial contamination between pre- and post-handwashing measurements.⁹

In a recent study in Bangladesh, Ram and colleagues compared hand contamination as tested at random to hand contamination tested at critical times when pathogens may be passed from hands to a child or to a vehicle such as food.¹⁰ There was no significant correlation between results of hand contamination testing at random and at critical times. Even though there was a linear relationship between hands tested at

4 Manun'Ebo, et al. 1997; Stanton, et al. 1987; Biran, et al. 2008; *Health and Science Bulletin* 2008.

5 Manun'Ebo, et al. 1997.

6 *Health and Science Bulletin* 2008.

7 Pinfold 1990; Luby, et al. 2001; Hoque, et al. 1995; Luby, et al. 2007.

8 Hoque, et al. 1995.

9 Larson, et al. 2003.

10 Ram, et al. 2008.

BOX 1: INDICATORS THAT COULD BE CAPTURED BY SELF-REPORT**Knowledge**

- Knowledge of importance of washing hands with soap to prevent disease
- Knowledge of critical times to wash hands with soap
 - After defecation
 - After contact with the child's stool
 - After going to the toilet
 - Before preparing food
 - Before eating
 - Before feeding a child
 - Before handling water for storage

Other possible determinants of handwashing behavior that can be measured by questionnaires relate to the opportunity to access handwashing tools (e.g., access to soap and water near a latrine), ability (e.g., capacity to ensure access to steady supply of soap), and motivation (e.g., beliefs about the importance of soap). Appropriate measurement of these and other possible determinants can be maximized by reliance on a clearly considered framework for handwashing behavior change. Since this document focuses on measurement of handwashing behavior, a review of frameworks to promote handwashing behavior change is beyond its scope.

Behavior (*The validity of these indicators is in doubt*)*Unprompted Measures*

- Self-reported handwashing with soap during previous 24 hours (e.g., 'Since this time yesterday, did you wash your hands with soap?')
- Self-reported handwashing with soap at critical times (e.g., 'Under which circumstances did you wash hands with soap?')

Prompted Measures

- Frequency of handwashing with soap (e.g., always, often, rarely, never)
 - Frequency of handwashing at critical times
 - After fecal contact events
 - After defecation
 - After cleaning a baby's bottom after the baby has defecated
 - Before food-related events
 - Before eating
 - Before feeding a child
 - Before cooking, cutting, or preparing food
 - Before water-related events
 - Before retrieving water from a wide-mouthed water storage container

two different random times, the mean absolute differences in the actual counts of fecal coliforms and *E. coli* between the two random times confirmed substantial variability in measurements of hand contamination. That is, the level of hand

contamination on an individual's hands varies greatly within the course of several hours and, thus, reliability is not achieved. Therefore, the validity of single-point hand contamination as a measure of overall handwashing behavior may be poor.

It is likely that duration since last handwashing with soap, duration since last fecal contact, and overall fecal contamination of the environment all impact upon the level of contamination detected on a subject's hands. Also, in some cultures, an individual's two hands may have different levels of contamination, since left hands may have more fecal contact than right hands.¹¹ Currently, measuring hand contamination is relatively expensive; in Bangladesh, laboratory-based microbiological testing for fecal coliforms and *E. coli* costs ~US\$10 per individual, well beyond the means of most program monitoring and evaluation budgets. Less expensive and field-friendly methods of measuring fecal coliforms and *E. coli* on hands are being sought and may prove to be more feasible methods of testing for hand contamination (M. Sobsey, University of North Carolina, personal communication).

Currently, substantial variability in the results of serial microbiologic testing of hands from the same individual in our recent study in Bangladesh suggests that single-point hand contamination is a poor measure of handwashing behavior. Given the relative expense of this approach at present and challenges to its validity as a measurement of overall handwashing behavior, it is not recommended that hand contamination tests be built into routine monitoring and evaluation of handwashing promotion programs at this time. Further study to refine microbiology as a measure of overall handwashing behavior may enhance the utility of this approach in the future.

Proxy Measures: Rapid Observations

Observations of the household environment can be efficient means to gather clues about the household's handwashing behavior since they can be rapidly collected in a large number of households, and at relatively low cost. These rapid observations provide useful information on whether or not soap is present in the home, whether the household has a designated place for handwashing, and whether the tools required (i.e., soap and water, or mud/ash and water) are simultaneously in place to practice the behavior for the individual that chooses to do so. Another way

to ascertain whether soap is readily available for handwashing is to record the amount of time needed for the respondent to bring soap to the interviewer when asked; if less than one minute is required, that could indicate the ready availability of soap. Since rapid observation measures are objectively recorded and relatively straightforward, validity and reliability are preserved.

In a recent study completed in India, the proportion of households observed to have soap in the household (beside the latrine or in the yard) was similar to the proportion of mothers in those households observed to wash hands properly.¹² However, there was only slight agreement, based on kappa scores, between observation of soap in the home and observation of the mother washing hands with soap.¹³ In this study, proper handwashing during structured observation was defined as washing both hands with soap after all fecal contact events. While the validity of structured observation as the basis of comparison may be called into question, given the potential for reactivity to the observer and the definition of soap use may be overly restrictive, these findings do underscore the point that rapid observations are surrogate markers of behavior and, thus, cannot indicate with certainty the handwashing behavior of the individual or the household. The presence of soap and water at a designated handwashing place cannot confirm the frequency or consistency of handwashing with soap for the individual or the household, or whether hands are washed during critical times such as after defecation. Additionally, rapid observations of the household do not provide information on the handwashing behavior of an individual of interest, such as the mother of a young child. Instead, they may only provide information about the household as a whole, since, in most households, soap is a communal resource and not an individual one. Still, since handwashing behavior tends to be socially mediated, household-level measurement may be very useful for describing handwashing behavior of a population.

One approach to using rapid observations to obtain clues to individual behavior is to ask the individual of interest

11 Hoque, et al. 1995.

12 Biran, et al. 2008.

13 Ibid.

to demonstrate usual handwashing practice. Here, too, awareness of social desirability may prompt improved handwashing practice during the demonstration compared to usual behavior. Of note, in the study from India described above, there was a fair degree of agreement between observation of soap use when the mother was asked to demonstrate her usual handwashing routine and observation of both hands being washed with soap after all fecal contact events witnessed during structured observation.¹⁴

Rapid observations are now being widely used to capture handwashing behavior (Box 2). For example, the Rapid CATCH indicators used by the U.S. Agency for International Development (USAID) child survival grantees include the measurement of the presence of soap at the location where hands are usually washed.¹⁵

Direct Measures: Structured Observations

As noted above, self-reported handwashing behavior has been proven invalid when compared with observed behavior. In the literature, this observed behavior has mainly been recorded during continuous structured observation. Such an observation consists of the placement of an observer for several hours, typically between three and seven hours, in a household.¹⁶ The observer records opportunities for handwashing, such as feeding a child or visiting the toilet, and the target respondent's handwashing practices. The benefits of structured observation are the ability to record objective data on handwashing practices and the richness of information gathered.¹⁷ During structured observation, the observer has the opportunity to record information about numerous individuals of interest, including mothers, young children, non-caregiver males, etc. Additionally, the observer can record detailed information on particular critical times, whether hands are washed, whether both hands are washed, the type of cleansing agent used, and the way in which hands are dried. This richness of details allows for assessment of consistency in handwashing practices. Respondents may be assigned to categories representing degrees of appropriate

BOX 2: INDICATORS THAT COULD BE TRACKED USING RAPID OBSERVATIONS OF THE HOUSEHOLD
Hand cleansing agents include soap, ash, or mud, depending on the cultural context and the focus of the handwashing promotion program (e.g., soap specifically or any cleansing agent):

- Presence of soap anywhere in the home
- Procurement of soap in the home within one minute of interviewer's request
- Presence of a designated place to wash hands
- Presence of a designated place to wash hands with water available at the time of inspection
- Presence of a designated place to wash hands with a hand cleansing agent, such as soap, available at the time of inspection
- Presence of a designated place to wash hands with a hand cleansing agent and water available at the time of inspection
- Presence of a designated place to wash hands, in or near the sanitation facility, with a hand cleansing agent and water available at the time of inspection
- Presence of a designated place to wash hands, in or near the food preparation area, with a hand cleansing agent and water
- Use of soap to wash hands following a request to demonstrate usual handwashing behavior

handwashing practice, based on observation of behavior during multiple opportunities for handwashing.¹⁸

The utility of structured observation in detecting overestimation of self-reported handwashing behavior has been demonstrated. However, the same awareness of social desirability that likely results in overestimation of self-reported handwashing

¹⁴ Ibid.

¹⁵ See <http://www.childsurvival.com/kpc2000/kpc2008.cfm>.

¹⁶ Biran, et al. 2008; Bentley, et al. 1994; Curtis, et al. 2001.

¹⁷ Bentley, et al. 1994.

¹⁸ Biran, et al. 2008.

behavior may also result in reactivity to the presence of the observer during a structured observation.^{19,20} That is, an individual may practice better handwashing behaviors while an observer is present than when she is unobserved. A key factor in minimizing reactivity to structured observation is the information given to the target respondent in advance of the observation. During the informed consent process, and in other verbal and non-verbal communications by the study worker and observer, it is critical not to emphasize that the observation is principally about measuring handwashing behavior. Without violating the respondent's right to understand the nature of the study, the evaluator may indicate that the observation is aimed at understanding "general household practices."

In a study in Bangladesh, the goal of observation was described as the measurement of water, sanitation, and hygiene practices in the home.²¹ The observer's training and skills with respect to objective data collection may also impact reactivity on the part of the individuals being observed. With the use of soaps with motion sensors described in more detail below, there was substantial reactivity to structured observation, particularly in about one-third of the study population.²² The reactive subset was characterized markers of high socioeconomic status. Reactive households were also much more likely to have soap available at a designated handwashing location near the toilet, suggesting that they may, indeed, prioritize hand hygiene more than non-reactive households. The risk with reactivity, either to structured observation alone, or to the combination of structured observation and the soap with motion sensor is that the evaluator would overestimate the change in handwashing behavior in response to an intervention. If there is no increase in handwashing behavior following exposure to

handwashing promotion, as evidenced by structured observation, with or without reactivity, it would be clear that the handwashing promotion intervention did not result in substantial behavior change among the target population.

The use of structured observation for measurement of handwashing behavior can incur substantial costs in terms of personnel time. It is preferable to use highly trained staff who are experienced in behavioral observation methods to perform observations, or at least train other observers.²³ Intensive standardized training for observers should emphasize details such as the time frame within which handwashing would be considered associated with a particular critical time (e.g., the number of minutes after defecation that handwashing occurs) as well as observational techniques, such as the need to utilize neutral body language and avoid judgment or prompting of socially desirable behaviors). Ideally, the time frame for observation would be based on local knowledge of the timing of behaviors of interest. If handwashing after defecation is the behavior of interest, then timing the observation to ensure that the observer is present in the home when most people defecate (early in the morning in many cultures) would be very important. This is not always feasible due to safety or logistical concerns, thus necessitating structured observation at other times of day. Over the span of several hours, an observer can only complete observation in one household. In the Bangladesh study, where five-hour structured observations were compared to 90-minute structured observations, shorter observation periods resulted in a greater-than-proportional loss in observed numbers of defecation-related events, suggesting that it is counter-productive to shorten the observation periods in an attempt to reduce data collection costs.²⁴ Such extended durations of observation come at a

19 Cousens, et al. 1996.

20 It is certainly possible that the reactivity was not solely as a result of the structured observation but, rather as a result of the combination of introducing both the soap with motion sensor and the structured observation into the household. That is, when the structured observation began, respondents may have remembered that the soap with motion sensor had been given to them several days prior. Since the observer was connected with the study that introduced the soap with motion sensor into the home, the respondents may have utilized the soap more while the observer was present than before the observer had been present.

21 Ram, Halder, et al. 2008.

22 Ibid. We detected this reactivity based on increases in the number of soap use events detected during the structured observation, using soap with a motion sensor, compared to the same time period on days preceding the structured observation.

23 Bentley, et al. 1994.

24 We compared observations of 5 hours duration to those of 90 minutes duration in order to examine data loss resulting from reducing the observation duration. Essentially, we sought to understand whether similar information could be gained by reducing the observation duration, which might have allowed for multiple households to be observed by an observer in a single day. Compared to those in 5-hour observation households, observers in 90-minute observation households were significantly less likely to observe one or more defecation-related events. The ability to witness at least one observation of other types of events, such as feeding a child, was not significantly different between the 90-minute and 5-hour observation households. Perhaps, it took several hours for the observed individual to become comfortable enough with the presence of the observer that she engaged in her usual toileting behavior. To our knowledge, this question has only been tested in Bangladesh and our findings may not be representative of other cultural settings. Still, our results do inform about the greater depth of information provided by prolonged structured observations.

cost since each observer can only conduct one observation per household per day. From a practical standpoint, it would be difficult to carry out two 5-hour (or even 4-hour) observations in a single day without risking substantial interviewer fatigue and compromise in the quality of observed data. Moreover, handwashing, bathing, and toileting behavior may differ according to the time of day, possibly rendering morning observations incomparable to afternoon observations. Thus, depending on the required sample size to demonstrate project outcomes of interest, structured observations would require substantial numbers of trained individuals, or a prolonged data collection period, either of which might be expensive for the program being monitored.

Despite these caveats, several groups have successfully completed structured observations on the scale of hundreds of households without substantial difficulty. They provide a wealth of detail regarding handwashing behavior at critical times of interest, including defecation, feeding, eating, and cooking (Box 3).

Direct Measures: Soap with Motion Sensors

A technology-based method of objective recording of handwashing behavior is the SmartSoap, a Unilever-developed technology. The SmartSoap consists of a motion sensor embedded in ordinary-appearing Lifebuoy® soap. The motion sensor tracks movement of the soap in three

dimensions. Based on the movement patterns of the soap, the number of times soap is used in a given time period can be counted. The soap can be left in a household for several days, allowing for observation of soap use behavior over a much longer period of time than would be feasible by structured observation. The SmartSoap's ability to detect consistency in soap use behavior has been demonstrated in Bangladesh, where the number of times soap was used in a household was remarkably consistent across each of eight days. It is possible that, overall, households increase the number of times they use soap when SmartSoap is in the home, compared to when SmartSoap is not in the home. There was no evidence that the households used SmartSoap more frequently on the first day of having the SmartSoap in the home and then reduced use as they became accustomed to its presence. A study is underway now in Bangladesh to understand whether households reduce overall soap use once the novelty of SmartSoap wanes, after it has been in the home for several weeks.

It is likely best to replace bar soap existing in the household with SmartSoap, rather than introducing bar soap in the form of SmartSoap to a household that is not in the practice of using bar soap daily. Also, it is likely best to suggest that all household members that use the existing bar soap use the SmartSoap provided in its place. This would minimize bias that might result from asking only the mother of young children, or other such targeted respondents, to use the SmartSoap. However, such a strategy allows only for soap use measurement at the household level and not at the level of a single respondent of interest, such as the mother of the youngest child. Using the household size, the analyst may convert the number of soap use events into per capita soap use events but this would remain an estimate of individual soap use behavior. Additionally, since the soap use is detected by the motion sensor, it would not be possible in many circumstances to detect the circumstances in which hands are being washed with soap. For example, it would not be possible to detect whether a mother is washing hands before feeding the child. Unilever has devised one solution to this by attaching motion sensors to items that are closely associated with defecation. In South Asia, it is common to reserve one water vessel for washing oneself after defecating. Unilever has worked in India and Bangladesh to attach motion sensors to these water vessels, thereby allowing for detection

BOX 3: INDICATORS THAT COULD BE TRACKED USING STRUCTURED OBSERVATIONS

- All household members, or specifically primary caregivers of young children
 - Any use of soap for handwashing
 - Any use of another cleansing agent, such as ash or mud, for handwashing
 - Proportion of all critical times observed during which one and/or both hands are washed with soap and water
 - Proportion of specific critical times observed during which hands are washed with soap and water, e.g., proportion of defecation-related events after which hands are observed to be washed with soap and water

BOX 4: INDICATORS THAT COULD BE TRACKED USING SMARTSOAP

- Total number of soap use events in a specified time period, e.g., 24 hours or during the duration of the structured observation
- Number of per capita soap use events in a specified time period
- Proportion of defecation-related events that are followed by soap use, within a designated period of time
 - This is applicable if a motion sensor can be attached to an item closely associated with defecation, e.g., water vessel used to cleanse oneself after defecation or a roll of toilet paper

of defecation events (Granger, Unilever R&D, personal communication).²⁵ Pairing that information with data from the SmartSoap allows for detection of soap use during the several minutes following defecation, which would be robust information indeed (Box 4). If the water vessel is used for purposes other than cleansing oneself after defecation, it would be difficult to pair water vessel use information with soap use information. Ultimately, if a program proposes to increase soap use in general, the SmartSoap would serve as a useful tool to detect that outcome of interest.

There are a few caveats to the use of SmartSoap at present. The experience reported above is based on one study of SmartSoap conducted in Bangladesh, although additional studies are underway. The consistency of soap use from day to day in households is a comforting marker of accuracy, but such accuracy should be confirmed in multiple studies in a spectrum of cultures and handwashing practices. SmartSoap provides household-level soap-use data and, thus, if individual soap use behavior is of interest, SmartSoap would not be the measurement technique of choice. In many countries, households often use multipurpose bar soaps for washing hands. Replacing multipurpose bar soaps, which may also be used for washing laundry or dishes, is

potentially problematic, since the bar soap in which the motion sensor has usually been embedded has been a beauty-soap (Lifebuoy®). To date, there is no publicly available or published information on whether data from motion sensors embedded in multipurpose bar soaps is complicated by the fact that such multipurpose bar soaps are used for a variety of purposes, and not handwashing or bathing alone. The movement signatures for handwashing may be difficult to distinguish from those of washing clothes, washing dishes, or playing with the soap. In many countries, powder detergent or liquid soap are the most commonly used forms of soap. Replacing powder or liquid with a bar may allow for substantial bias, in that the observed household is given a novel and ‘special’ way of washing hands that it has not previously used.

Further experience with SmartSoaps in the hands of various researchers, and publication in peer-reviewed journals on positive and negative experiences, are needed to understand fully the utility of this novel technique. Currently, the largest drawback to the use of the SmartSoap for monitoring handwashing promotion programs are capacity limitations of staff associated with Unilever to deploy, extract, and analyze data from the soaps with motion sensors. Transfer of technical capacity is imperative if SmartSoaps are to become more widely adopted for monitoring handwashing behavior. However, such transfer clearly comes at the risk of lack of assurance of the various steps contributing to data quality. Additionally, the cost of individual motion sensors is projected at approximately US\$120, which may be prohibitive if a program actually had to purchase large numbers of the sensors.

Use of Composite Measures

Several studies have attempted to combine information from different methods of measuring handwashing behavior.²⁶ These composite measures have included information obtained purely from demonstration of handwashing, as well as information from self-report. In our review of the literature, it appears that the same composite measure has not been repeatedly tested in different geographic areas, which might provide information on its utility across cultural settings. There has been no comparison of these

²⁵ Biran et al. 2009.

²⁶ Hoque, et al. 1995; Yalcin, et al. 2004; Sandora, et al. 2005.

composite indicators to other objective measures, such as structured observation or soaps with motion sensors.

Based on our review of existing literature and our own experience, combining information from structured observation with data from the soap with motion sensor may provide the strongest information on a household's soap use behavior. The soap with motion sensor can provide information on household-level soap use on days preceding structured observation and can facilitate the identification of households that are reactive to the presence of the observer during the structured observation. Structured

observation data, from those households shown *not* to be reactive to the presence of the observer, can then be useful for examining context-specific handwashing practices, such as washing hands after defecation or before feeding a child. There is no guarantee that the observed individual (from a household that is shown not to be reactive) would behave in the same way during the structured observation as she would during her usual practice. But, the removal of structured observation data from obviously reactive households would certainly enhance the validity of data obtained via structured observation.

III. Conclusion

This document attempts to give a balanced view of each of the methods of measuring handwashing behavior, including both routinely used and novel methods. Positive and negative attributes of each method have been described (Table 1). The attempt to be balanced may lead to skepticism about the utility of measuring handwashing behavior at all. However, there are few perfect measurements available for outcomes of human behavior or health, apart from cadaver autopsy for some health conditions. Thus, health researchers and public health practitioners must frequently accept the limitations of the measures that are available to them but not be paralyzed by those limitations. Examples of imperfect measures that still provide useful and necessary information are self-reported breastfeeding or self-reported use of oral rehydration therapy for diarrhea treatment, as well as caregiver reported symptoms of childhood diarrhea and other illnesses. These measures are undertaken in every

Demographic and Health Survey (DHS) and every multi-indicator cluster survey (MICS) undertaken in resource-poor countries. While these self-reported measures likely misrepresent true practices and health conditions, they do provide insights into trends in these behaviors over time and important predictors of child morbidity and mortality. Given these caveats, described below are potential approaches to measuring handwashing behavior for a variety of program types and settings. Reference to health outcomes as proxy measures of handwashing behavior has been intentionally minimized, since, almost universally, measurement of health outcomes such as diarrhea incidence or prevalence is very costly. As indicated below, additional data on the relationship between other measures of handwashing behavior and health outcomes is clearly needed and should be sought where possible.

TABLE 1: SUMMARY OF STRATEGIES TO MEASURE HANDWASHING BEHAVIOR

Measurement strategy	Requirements for use	Advantages	Disadvantages	Appropriate setting for use
Self-report: using closed or open-ended questions to ask respondents about their own handwashing behavior	<ul style="list-style-type: none"> • Questionnaire • Training 	<ul style="list-style-type: none"> • Is efficient • Can be incorporated into multipurpose surveys 	<ul style="list-style-type: none"> • Shown to overestimate handwashing behavior 	<ul style="list-style-type: none"> • Self-report is not recommended for measurement of handwashing behavior • Questionnaires may be useful for tracking knowledge, monitoring the reach of a handwashing promotion program, or identifying barriers to handwashing
Microbiological hand contamination: (a proxy measure)	<ul style="list-style-type: none"> • Supplies for hand rinse / hand imprint collection • Microbiology laboratory or equipment for field-level quantitation of hand contamination • Training and quality control • At least one staff member with microbiology experience 	<ul style="list-style-type: none"> • Is objective • Reflects individual hand contamination 	<ul style="list-style-type: none"> • Is not reliable • Is expensive • Serves as a proxy measure of handwashing behavior • Requires some structured observation for measurement at critical times (e.g., after defecation) 	<ul style="list-style-type: none"> • Well-funded handwashing promotion program evaluations or research studies may be able to improve the utility of microbiological hand contamination as a marker of handwashing behavior • Not recommended for small or minimally funded handwashing promotion programs • Not recommended for nationally or regionally representative multipurpose surveys (e.g., DHS, MICS)
Rapid observations: recording presence of soap and water at a designated handwashing station (a proxy measure)	<ul style="list-style-type: none"> • Checklist • Training 	<ul style="list-style-type: none"> • Is efficient • Is objective • Can be incorporated into multipurpose surveys • Shown to have internal validity with structured observation 	<ul style="list-style-type: none"> • Serves as a proxy measure • Cannot confirm the frequency or consistency of handwashing • Does not reflect individual-level behavior 	<ul style="list-style-type: none"> • Well-funded handwashing promotion program evaluations or research studies • Evaluations of small or minimally funded handwashing promotion programs • Nationally or regionally representative multipurpose surveys (e.g., DHS, MICS)

(Continued)

TABLE 1: SUMMARY OF STRATEGIES TO MEASURE HANDWASHING BEHAVIOR (Continued)

Measurement strategy	Requirements for use	Advantages	Disadvantages	Appropriate setting for use
Structured observations: recording observed frequency of handwashing with soap at critical times, e.g., after defecation	<ul style="list-style-type: none"> Structured format to capture details regarding critical times of interest and handwashing behaviors Several hours of observation, preferably at the same time of day in all households, and at times that capture critical times of interest and that are locally acceptable Training and quality control Preferable to have staff with experience in behavioral observation 	<ul style="list-style-type: none"> Is objective Reflects individual behavior Captures rich detail on handwashing behavior 	<ul style="list-style-type: none"> Shown to result in reactivity, because of the presence of the human observer Is costly in terms of person-time Requires highly trained staff 	<ul style="list-style-type: none"> Well-funded handwashing promotion program evaluations or research studies Sample size calculations, and consultation with persons with epidemiological or statistical expertise, may indicate feasibility of this approach for evaluation of even small handwashing promotion programs
Soap with motion sensors: recording the number of times soap is used during an observation period	<ul style="list-style-type: none"> Equipment, including soaps with motion sensors and microwave Training in the preparation, initialization, deployment, data download, and data analysis 	<ul style="list-style-type: none"> Is objective Does not require the presence of a human observer 	<ul style="list-style-type: none"> Does not reflect individual-level behavior Cannot provide information on handwashing at critical times Requires highly trained staff Is costly in terms of equipment needs May not be useful in settings in which bar soap is used for multiple purposes, or in which liquid or powder soap is commonly used 	<ul style="list-style-type: none"> Well-funded handwashing promotion program evaluations or research studies Sample size calculations, and consultation with persons with epidemiological and statistical expertise, may indicate feasibility of this approach for evaluation of even small handwashing promotion programs

IV. Recommendations for Various Scenarios

The recommendations below are made on the basis of ease of data collection and potential cost to the program or study. The focus here is on the measurement of handwashing behavior, although I comment on the utility of collecting data regarding knowledge, attitudes, and health outcomes in some of these contexts.

Well-Funded Handwashing Promotion Programs or Research Studies

Ideally, such studies should strive to use the most rigorous methods to measure handwashing behavior. Specifically, the use of soaps with motion sensors *and* structured observations is recommended. Soaps with motion sensors can be used to track overall soap use in target households. The soap use measurement is not context specific, not tied to specific critical times. However, overall soap use may be expected to increase if there is an increase in handwashing with soap in response to handwashing promotion. This recommendation is made for those sites in which bar soap is the predominant form of soap utilized.

The soaps with motion sensors are also useful for detecting a household's reactivity to structured observation. This is critical in order to elucidate which data is useful (i.e., from households that are not reactive to the presence of the observer) and which data may be compromised as a result of substantial reactivity to the presence of the observer.

Structured observation data can elucidate handwashing behavior for specific household members, e.g., primary caregivers of young children, and/or during particular critical times, for example, after defecation. The use of soap with motion sensors may elucidate the degree to which a particular household is reactive. The program will need to decide upon acceptable levels of reactivity and the extent to which obtaining context-specific information is important enough to warrant collection of structured observation data.

Rapid observations, which are proxies, should also be included among measures of handwashing behavior used in well-funded programs. These observations provide useful information on the facilitating environment found in the home for good handwashing behavior.

For measurement of changes in knowledge or attitudes, or exposure to handwashing promotion programs or specific messages, questionnaires may prove useful. As noted above, the use of questionnaires for measurement of handwashing behavior is not recommended, since self-reported handwashing behavior overestimates observed behavior.

At present, random or critical-time measurement of hand contamination is also not recommended as a measure of handwashing behavior, given the substantial variability detected in several studies described above. But, as detailed below, well-funded programs or research studies may serve as opportunities for improving upon this measure. Future studies should address the utility of indicator organisms other than *E. coli*, whether variability in hand contamination is evident in other laboratories, and the relationship between hand contamination and health outcomes.

Several questions of import may be answered in the context of well-funded public health program evaluations and research studies.

- There is a fundamental gap in the literature on the relationship between the various measures of handwashing behavior and health outcomes. At present, it is not clear whether changes in handwashing behavior, as measured by the techniques described above, are correlated with changes in risk of health outcomes of interest, particularly diarrhea and respiratory infections. It is strongly recommended that well-funded research studies and programs include measurement of both behavioral outcomes and health outcomes in the same study populations, preferably in a longitudinal fashion, in order to examine these relationships in detail.
- At present, there is still a paucity of published effectiveness data regarding the impact of public health programs on behavioral and health outcomes. It is strongly recommended that effectiveness data (positive, negative, and neutral) be published in peer-reviewed literature in order to inform the public health community, policy makers, and funding agencies.

- Well-funded programs and research studies may be opportunities to improve upon the utility of microbiological testing of hand contamination, as well as other innovative and/or composite measures. It would be useful to examine, for example, whether rates and levels of contamination several hours following a supervised, thorough handwashing, change over the course of a handwashing promotion program. Also, it would be useful to examine whether mean levels of hand contamination, as obtained from serial measurements from the same individual, are associated with other objective measures of handwashing behavior, such as soaps with motion sensors, or with health outcome data.
- The utility of principal components analysis, or other such means of assigning participating households or participants to categories of handwashing behavior should be further examined, particularly in relationship to health outcomes, and as a means of identifying important explanatory factors associated with strata of handwashing behavior.

Handwashing Promotion Programs with Minimal Funding

Ideally, these programs, as better-funded programs, would obtain objective measurement of handwashing behavior with soaps with motion sensors and structured observations. Cost is the primary limiting factor. Program evaluation staff are strongly encouraged to consult statistical and/or epidemiologic expertise in order to determine required sample sizes for measurement of handwashing behavior with soaps with motion sensors and structured observations. Universal recommendations regarding sample sizes cannot be made here, given the diversity in program types, evaluation

designs, and program goals and targets. However, because of the “longitudinal” nature of data collected from each of these data sources, required sample sizes to measure impact of the program may indeed be smaller than one might expect.

Rapid observations, which are proxies, are certainly recommended as efficient measures of handwashing behavior in not-so-well-funded public health programs.

Questionnaires may be useful for measurement of knowledge, attitudes, and program exposure. Again, questionnaires are not recommended for measurement of self-reported handwashing *behavior*.

Nationally Representative Surveys

The Demographic and Health Surveys are described as “nationally-representative household surveys that provide data for a wide range of monitoring and impact evaluation indicators in the areas of population, health, and nutrition”. The multi-indicator cluster surveys (MICS) are conducted by UNICEF and may be described similarly. DHS and MICS surveys are conducted every 3-5 years in most low- and middle-income countries. Handwashing is only one of a myriad number of topics covered in these surveys and, thus, measurement of handwashing behavior is necessarily restricted to the most efficiently administered questions. Therefore, the use of rapid observations, which are proxies, for measuring handwashing behavior is recommended.

It is not feasible to do more intensive measurements, such as structured observations or soaps with motion sensors, in the context of these large nationally representative surveys.

References

- Bentley, M., Boot, M., Gittelsohn, J., Stallings R. 1994. *The Use of Structured Observations in the Study of Health Behaviour*. IRC International Water and Sanitation Centre. The Hague, The Netherlands.
- Biran, A., Rabie, T., Schmidt, W., Juvekar, S., Hirve, S., Curtis, V. 2008. Comparing the performance of indicators of hand-washing practices in rural Indian households. *Trop Med Int Health* 13(2): 278–85.
- Biran, A., Schmidt, W-P, Wright, R., Jones, T., Seshadri, M., Isaac, P., Nathan, NA, Hall, P., McKenna, J., Granger, S., Bidingier, P., and Curtis, V. The effect of a soap promotion and hygiene education campaign on handwashing behavior in rural India: a cluster randomized trial. *Trop Med Int Health* 14 (10): 1303-1314.
- Cousens, S., Kanki, B., Toure, S., Diallo, I., Curtis, V. 1996. Reactivity and repeatability of hygiene behaviour: structured observations from Burkina Faso. *Soc Sci Med* 43(9):1299–308.
- Curtis, V. 2003. Talking dirty: how to save a million lives. *Int J Environ Health Res* 13 Suppl 1:S73-9.
- Curtis, V., Cairncross, S. 2003. Effect of washing hands with soap on diarrhea risk in the community: a systematic review. *Lancet Infectious Disease* 3:275–281.
- Curtis, V., Kanki, B., Cousens, S., Diallo, I., Kpozehouen, A., Sangare, M., et al. 2001. *Evidence of behavior change following a hygiene promotion programme in Burkina Faso*. Bull WHO 79(6):518–527.
- Halder, A.K, Luby, S.P., Bhuiya, A., Tronchet, C., Akhter, S., Johnston, R. 2008. Handwashing behavior in rural Bangladesh. *Health and Science Bulletin* 6(3).
- Hoque, B.A., Mahalanabis, D., Alam, M.J., Islam, M.S. 1995. Post-defecation handwashing in Bangladesh: practice and efficiency perspectives. *Public Health* 109(1):15–24.
- Larson, E., Aiello, A., Lee, L.V., Della-Latta, P., Gomez-Duarte, C., Lin, S. 2003. Short- and long-term effects of handwashing with antimicrobial or plain soap in the community. *J Community Health* 28(2):139–50.
- Last, J.M., ed. 2001. *A Dictionary of Epidemiology*. Fourth ed. New York: Oxford University Press.
- Luby, S.P., Halder, A.K. 2008. Associations among handwashing indicators, wealth, and symptoms of childhood respiratory illness in urban Bangladesh. *Trop Med Int Health* 3(6):835–44.
- Luby, S.P., Agboatwalla, M., Billhimer, W., Hoekstra, R.M. 2007. Field trial of a low cost method to evaluate hand cleanliness. *Trop Med Int Health* 12(6):765–71.
- Luby, S.P., Agboatwalla, M., Raza, A., Sobe, I. J., Mint, E.D., Baier, K., et al. 2001. Microbiologic effectiveness of hand washing with soap in an urban squatter settlement, Karachi, Pakistan. *Epidemiol Infect* 127(2):237–44.
- Manun’Ebo, M., Cousens, S., Haggerty, P., Kalengaie, M., Ashworth, A., Kirkwood, B. 1997. Measuring hygiene practices: a comparison of questionnaires with direct observations in rural Zaire. *Trop Med Int Health* 2(11):1015–21.
- Pinfold, J.V. 1990. Faecal contamination of water and fingertip-rinses as a method for evaluating the effect of low-cost water supply and sanitation activities on faeco-oral disease transmission. A case study in rural north-east Thailand. *Epidemiol Infect* 105(2):363–75.
- Rabie, T., Curtis, V. 2006. Handwashing and risk of respiratory infections: a quantitative systematic review. *Trop Med Int Health* 11(3):258–67.
- Ram, P., Halder, A., Granger, S., Hall, P., Jones, T., Hitchcock, D., Nygren, B., Islam, M., Molyneaux, J., Luby, S., 2008. Use of a novel method to detect reactivity to structured observation for measurement of handwashing behavior. *American Society of Tropical Medicine and Hygiene*. New Orleans, LA.
- Ram, P., Jahid, I., Halder, A., Nygren, B., Islam, M., Granger, S., et al. 2008. Variability in measurement of hand contamination: implications for evaluating hand hygiene promotion programs. *American Society of Tropical Medicine and Hygiene*. New Orleans, LA.

- Sandora, T.J., Taveras, E.M., Shih, M.C., Resnick, E.A., Lee, G.M., Ross-Degnan, D., et al. 2005. A randomized, controlled trial of a multifaceted intervention including alcohol-based hand sanitizer and hand-hygiene education to reduce illness transmission in the home. *Pediatrics* 116(3):587–94.
- Stanton, B.F., Clemens, J.D., Aziz, K.M., Rahman, M. 1987. Twenty-four-hour recall, knowledge-attitude-practice questionnaires, and direct observations of sanitary practices: a comparative study. *Bull World Health Organ* 65(2):217–22.
- Yalcin, S.S., Yalcin, S., Altin, S. 2004. Hand washing and adolescents. A study from seven schools in Konya, Turkey. *Int J Adolesc Med Health* 16(4):371–6.

