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Global Scaling Up Handwashing

Validity of Rapid Measures of Handwashing Behavior: An Analysis of Data from Multiple Impact Evaluations in the Global Scaling Up Handwashing Project

Pavani K. Ram, Michelle W. Sahli, Benjamin Arnold, John M. Colford, Claire Chase, Bertha Briceño, Alexandra Orsola-Vidal, and Paul Gertler

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The Water and Sanitation Program is a multi-donor partnership administered by the World Bank to support poor people in obtaining affordable, safe, and sustainable access to water and sanitation services.

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Global Scaling Up Handwashing is a project by the Water and Sanitation Program (WSP) focused on applying innovative behavior change approaches to improve handwashing with soap behavior among women of reproductive age (ages 15–49) and primary school-age children (ages 5–9). It was implemented by local and national governments with technical support from WSP in four countries: Peru, Senegal, Tanzania, and Vietnam. For more information, please visit www.wsp.org/scalinguphandwashing.

WSP is a multidonor partnership created in 1978 and administered by the World Bank to support poor people in obtaining affordable, safe, and sustainable access to water and sanitation services. WSP's donors include Australia, Austria, Denmark, Finland, France, the Bill & Melinda Gates Foundation, Luxembourg, Netherlands, Norway, Sweden, Switzerland, United Kingdom, United States, and the World Bank.

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Executive Summary

There is increasing interest in improving handwashing in low- and middle-income countries. However, there is a paucity of information on the measurement of handwashing behavior from many low- and middle-income countries, because most prior studies have been carried out in South Asia. There is an unmet need to estimate handwashing behavior using practical measures that yield valid indicators of handwashing behavior across cultural and geographic contexts. The validity of rapid handwashing measures was evaluated by comparing them to handwashing behavior measured during five-hour structured observations.

Handwashing was measured in the Impact Evaluation of the Global Scaling Up Handwashing project, carried out by the Water and Sanitation Program (WSP) in Peru, Senegal, and Vietnam. Global Scaling Up Handwashing tested the effects of at-scale implementation of handwashing promotion on various outcomes, including behavior and health, in four countries—Peru, Senegal, Tanzania, and Vietnam—using cluster-randomized controlled trial designs.

For each country, data on self-reported and observed handwashing measures from primary caregivers of young children was analyzed during endline surveys among the control arms of the evaluations conducted in Peru, Senegal, and Vietnam. Structured observations were carried out among a subset of households participating in endline surveys in each country. The relationship between each of the rapid handwashing measures was evaluated, and handwashing behavior was observed, using regression models for all events observed, as well as events restricted to fecal contact. Logistic regression was used to model the relationship between the rapid handwashing measure and the probability that hands were washed during the observed event, accounting for the repeated nature of structured observation data.

During structured observations of primary caregivers, 1,467 critical events were observed in Peru, 444 in Senegal, and 1,421 in Vietnam. At these critical events, hands were washed with soap in 14 percent of events in Peru, 13 percent in Senegal, and 10 percent in Vietnam. Handwashing with soap was observed during 34 percent of fecal contact events in Peru, 25 percent in Senegal, and 24 percent in Vietnam. In all three countries, caregivers were 1.6 to 3.6 times more likely to be observed washing hands with soap if they lived in homes with observed soap at the handwashing place used after defecation, compared to caregivers living in homes without soap and water at that place. Similarly, caregivers were 2 to 2.4 times more likely to be observed washing hands with soap if soap and water were observed at the place where hands are washed before food preparation. Distance of the handwashing location from either the latrine or the food preparation place was not associated with observed handwashing with soap. Self-reported handwashing was not associated with observed handwashing behavior in multiple countries. In Peru and Vietnam, adjustment for wealth did not alter the associations between the rapid handwashing measures and observed handwashing with soap. In Senegal, none of the rapid handwashing measures were significantly associated with observed handwashing with soap in models including wealth.

This multicountry analysis of the validity of rapid handwashing measures confirms the utility of observing handwashing materials at the places where people wash hands, at the times most necessary for washing them (after fecal contact and before food preparation). The findings described here also reinforce the global imperative of improving handwashing behavior for prevention of the leading causes of death in young children.

Contents

I. Introduction

Because of the compelling evidence that handwashing reduces diarrhea and respiratory illness, two of the leading causes of child mortality globally (Aiello et al. 2008; Ejemot et al. 2008; Luby et al. 2005; Luby et al. 2004), this practice is increasingly being promoted in low- and middle-income countries. Public health practitioners promoting handwashing seek to evaluate program impacts on individual behavior. Researchers examine strategies to improve handwashing and investigate its role in improving health. Practitioners and researchers alike need to measure individuals' handwashing, a behavior often perceived to be challenging to measure because of the prevalent social desirability of washing hands (Ram 2013).

Structured observation is often considered the best way to measure handwashing behavior. During structured observation, an observer studies the target individual(s), such as the primary caregiver of a young child or all household members, from within the home/courtyard. The observer records opportunities for handwashing (e.g., potential fecal contact at times such as toileting or cleaning a child who has defecated), whether or not the target individual washes hands, how hands are washed and dried, and other details of interest. The duration of structured observations is several hours (Ibid.), often five, to allow the observer to witness a number of opportunities for handwashing.

Although structured observation is objective and yields detailed information on target individuals' handwashing behavior, it is resource intensive. A five-hour duration implies that a fieldworker can only complete one structured observation in a day, making personnel costs prohibitive. Training for structured observation is more intensive than for other approaches to measuring handwashing behavior. Practitioners and researchers who cannot carry out structured observations because of budgetary or logistical constraints seek valid measures of handwashing behavior that are more rapid.

An important characteristic of a rapid handwashing measure is the ease of data collection—for example, through an interview or rapid observation of a household environment. Such a measure would be logistically and financially feasible for use in large survey populations. In addition, data collection for the measure would not require multiple visits, or skill or training in the data collector beyond what is typical for most community-level studies of health or hygiene.

Rapid handwashing measures include:

- self-reported handwashing behavior,
- observation of handwashing materials in the home,
- handwashing behavior demonstrated upon request, and
- hand cleanliness on visual inspection.

Several rapid handwashing measures have been evaluated against health outcomes, given that improved health is the ultimate goal of any handwashing promotion program. In three studies from Bangladesh and one from Nepal, caregiver-reported handwashing behavior has been associated with neonatal mortality (Rhee et al. 2008), child diarrhea mortality (Unicomb et al. 2010), child diarrhea morbidity (Luby et al. 2011a), and child pneumonia (Silk et al. 2010). Observation of water at a handwashing place has twice been shown to be associated with fewer episodes of respiratory illness, with both studies set in Bangladesh (Manun'Ebo et al. 1997; Szklo and Nieto 2007). Another study, also carried out in Bangladesh, found that soap use by mothers during demonstration was significantly associated with lower prevalence of diarrhea among their children, compared to the children of mothers who did not use soap during demonstration (Luby et al. 2011a). In the same study population, observation of visibly clean fingerpads on a child's hands was associated with reduced diarrhea prevalence (Ibid.).

Rapid handwashing measures have also been evaluated against observed handwashing behavior, as measured by structured observations. For example, several studies have found that study populations tend to overreport their handwashing behavior severalfold, when compared to structured observation (Manun'Ebo et al. 1997; Stanton et al. 1987; Biran et al. 2008; ICDDR,B 2008; Danquah 2010). The presence of water at the handwashing place used after defecation has been associated with observed handwashing with soap during structured observation (Luby et al. 2009). In India, observed soap use during a

handwashing demonstration was associated with observed soap use after fecal contact during structured observation (Biran et al. 2008).

Most community-level assessments of the validity of handwashing behavior measures performed in low- and middle-income settings were conducted in a handful of countries, mostly in South Asia. This geographical focus limits the generalizability of the existing evidence on rapid handwashing measures. Validation studies using data from other sites would inform practitioners and researchers needing to use rapid handwashing measures elsewhere, for example in sub-Saharan Africa and Latin America. Analysis of data from multiple countries based on a common set of study methods and instruments would address concerns about the comparability of studies from different contexts. Therefore, this study sought to validate rapid handwashing measures against observed handwashing behavior through structured observation in three countries—Peru, Senegal, and Vietnam. The opportunity to analyze data on similarly measured handwashing measures from three countries was provided by the Impact Evaluation of Global Scaling Up Handwashing, which was initiated in 2006 by the Water and Sanitation Program (WSP).

II. Methods

WSP has led an intensive randomized controlled design to evaluate the impacts of at-scale handwashing promotion on health, growth, household productivity, and handwashing behavior. The handwashing promotion interventions deployed in the Global Scaling Up countries were based on the FOAM framework (Focus, Opportunity, Ability, and Motivation), which has been described in detail elsewhere (Coombes and Devine 2010). As part of the Impact Evaluation of Global Scaling Up Handwashing, handwashing behavior was measured. A common study methodology was developed to measure handwashing and largely similar data collection instruments were deployed across the Impact Evaluation countries. This analysis included data from the Impact Evaluation of Global Scaling Up Handwashing on handwashing behavior measured in control populations in endline surveys in Peru, Senegal, and Vietnam.

Participant selection, adherence to human subject research guidelines, and general data collection methods are described in detail in the individual country reports from the Impact Evaluation (Chase and Do 2012; Galiani et al. 2012). Only endline data from control populations were used for these analyses.

Table 1 describes the various measures of handwashing behavior, the data collection method, and the levels at which the data relevant to handwashing behavior were collected. In brief, handwashing was measured using self-reports of handwashing at critical times, rapid observations of handwashing materials in the home, respondent hand cleanliness, and, in a subset of households, structured observations of handwashing behaviors at critical times.

TABLE 1: MEASURES OF HANDWASHING BEHAVIOR ASSESSED IN GLOBAL SCALING UP HANDWASHING, BY METHOD AND LEVEL OF DATA COLLECTION

Indicator	Method of Data Collection	Level of Data Collection
Measures of observed handwashing behavior (basis of comparison for validation of rapid handwashing measures)		
Handwashing with soap at any type of event	Structured observation	Individual—caregivers
Handwashing with soap after fecal contact	Structured observation	Individual—caregivers
Handwashing with soap before food preparation	Structured observation	Individual—caregivers
Handwashing with soap before feeding a child	Structured observation	Individual—caregivers
Handwashing with soap before eating	Structured observation	Individual—caregivers
Rapid handwashing measures		
Presence of soap anywhere in the home	Rapid observation	Household
Presence of soap and water at the handwashing place used after defecation	Rapid observation	Household
Presence of soap and water at the handwashing place used before food preparation	Rapid observation	Household
Distance between toileting place and handwashing place	Rapid observation	Household
Distance between food preparation place and handwashing place	Rapid observation	Household

(continued)

TABLE 1: (Continued)

Indicator	Method of Data Collection	Level of Data Collection
Time taken to show soap upon request	Rapid observation	Household
Cleanliness index of caregiver hands (index based on observation of nails, palms, and fingerpads, dichotomized with score <7 considered "not clean" and score ≥ 7 considered "clean")	Rapid observation	Individual—caregiver
Handwashing with soap after fecal contact during previous day	Self-report	Individual—caregiver
Handwashing with soap before food preparation during previous day	Self-report	Individual—caregiver
Handwashing with soap before feeding a child during previous day	Self-report	Individual—caregiver
Handwashing with soap before eating during previous day	Self-report	Individual—caregiver

During a household visit for the endline survey, the survey team asked the household head or appropriate designee to describe household-level characteristics, including demographic details of household members, access to water supply and sanitation, and handwashing facilities. The interviewer asked whether the household members typically wash their hands after defecation or before food handling and observed the fixed location where hands were reportedly washed and materials at that location. An interviewer sat privately with the caregiver of a child under the age of 5 and asked about the caregiver's handwashing behavior, and inspected the caregiver's hands for cleanliness (palm, fingerpads, and fingernails).

Structured observations were carried out in a randomly selected subset of households in each country because it was infeasible to carry them out in the entire set of households included in the endline cross-sectional surveys. A survey team member carried out a five-hour observation to record details of handwashing practices. The observer recorded opportunities for handwashing, hereafter referred to as *events*, and whether and how hands were washed and dried at those times.

In Vietnam, only the caregiver of the youngest child under 5 years old was recruited per household, whereas in Senegal, multiple caregivers were recruited if present and consenting. In Peru, a small number of households were found to have multiple caregivers.

III. Data Analysis

Detailed definitions of the handwashing measures are provided in Annex 1: Supplemental Tables (Table S1).

All data analysis was conducted at the country level. Data from the three countries included in this analysis were not aggregated.

Agreement between the various rapid handwashing measures described in Table 1 was evaluated using kappa scores. For example, agreement between self-report of handwashing with soap after defecation with observation of soap at the handwashing place near the toilet was assessed. Kappa is considered a measure of "true agreement," in that it describes agreement taking into account the agreement that would be expected to occur by chance. Because kappa scores can be underestimated when the prevalence of one or more of the conditions under study is high or low, prevalence-adjusted kappa scores were also calculated using previously described methods (Byrt et al. 1993). A number of authors have recommended different cut-offs for interpretation of kappa scores, although many are overlapping (Szklo and Nieto 2007). This study used Altman's cutoffs: poor agreement ($k < 0.2$), fair ($k = 0.2$ to < 0.4), moderate ($k = 0.4$ to <0.6), good ($k = 0.6$ to 0.8), and very good ($k \geq 0.8$

For the principal study objective, to validate rapid handwashing measures against observed handwashing behavior, the analysis was restricted to those households with data from a structured observation. Data on handwashing behavior among primary caregivers was examined, and equivalence between households with structured observation data and those without was assessed. A dataset was then constructed in which each event observed during the structured observation was included as a record. For example, if 10 events were observed in household Y, the dataset contained 10 records associated with household Y. Multilevel log-binomial regression was used to model the relationship between the rapid handwashing measure (independent variable) and the probability that hands were washed during the observed event (dependent variable). Because of the repeated nature of structured observation data, standard errors were calculated using robust error variances in the log-binomial regression models. The events observed during structured observation were divided into four categories of critical events: fecal contact, food preparation, child feeding, and eating. Fecal contact included defecation or toilet use of the caregiver, as well as contact with child feces.

In Vietnam, only the primary caregiver was interviewed in each household. In Peru and Senegal, when multiple caregivers were present in a participating household, each caregiver was interviewed. For the purposes of this analysis, it was not possible to ascertain which of the caregivers was observed during any single event in the structured observation. Thus, the datasets of rapid handwashing measures and structured observations were restricted. In Peru, structured observation events occurring in households with multiple caregivers were excluded from the analyses. In Senegal, given the potential for a large loss in the sample if households with two or three caregivers were removed, those events occurring in households with more than three caregivers were excluded and a random number generator in SAS version 9.2 (a commonly used statistical program) was used to randomly choose one caregiver's responses in households with two or three caregivers listed.

The relationship between each of the rapid handwashing measures and observed handwashing behavior was evaluated using regression models for all events observed, as well as events restricted to fecal contact. Unadjusted risk ratios were estimated and adjusted risk ratios were calculated using log-binomial regression models, including wealth as a covariate, given the frequent description of associations between wealth and measures of handwashing behavior (Luby and Halder 2008; Ram et al. 2010); within each country dataset, a wealth index was created using principal component analysis of ownership of assets such as radio and television. Exploratory analyses evaluating water scarcity, distance to water source, and location of toilet in household or yard indicated that these variables did not act as potential confounders (data not shown).

IV. Results

Table 2 describes the timelines of endline data collection and sample sizes for control arms, by country. In all, endline data was collected from 1,368 Peru households, 757 Senegal households, and 1,105 Vietnam households.

Handwashing with soap after fecal contact was reported by about two thirds of caregivers in Peru and Vietnam, and by 45 percent of caregivers in Senegal (see Table 3). Soap was present in 83 percent of households in Peru, 90 percent in Senegal, and 98 percent in Vietnam. Soap and water together were observed at the place used to wash hands after defecation in 67 percent of households in Peru, 27 percent in Senegal, and 82 percent in Vietnam. Soap and water were observed at the place used to wash hands before food preparation in 67 percent of households in Peru, 19 percent in Senegal, and 79 percent in Vietnam. Hands were rated as clean for a majority of caregivers in all three countries.

Agreement between various rapid handwashing measures behavior in each country sample was evaluated (Annex 1, Tables S2–S4). Table 4 describes the sets of handwashing measures for which there was moderate or greater agreement among the three countries. Only one set of measures was found to have moderate or greater agreement in all three countries:

- Soap and water observed at the handwashing place used postdefecation, and soap and water observed at the handwashing place used before preparing food
  - Peru (0.83)
  - Senegal (0.56)
  - Vietnam (0.84)

The following sets of measures were found to have moderate or greater agreement in both Peru and Vietnam, but not in Senegal:

- Self-reported handwashing after fecal contact, and soap observed anywhere in the home
  - Peru (0.46)
  - Vietnam (0.50)
- Soap observed anywhere in the home, and soap and water observed at the handwashing place used postdefecation
  - Peru (0.68)
  - Vietnam (0.81)

TABLE 2: TIMELINE AND SAMPLE SIZE OF CONTROL POPULATIONS IN ENDLINE SURVEYS OF THE IMPACT EVALUATION OF GLOBAL SCALING UP HANDWASHING, BY COUNTRY

Endline	Peru	Senegal	Vietnam
Dates	2/2011 to 6/2011	3/2011 to 7/2011	10/2010 to 1/2011
Number of households	1,368	757	1,105
Number of caregivers	1,379	1,411	1,064
Number of households with structured observation data	286	88	200

TABLE 3: DESCRIPTIVE ANALYSIS OF RAPID HANDWASHING MEASURES, ALL COUNTRIES

	Peru		Senegal		Vietnam	
Handwashing Measures	N	n (%)	N	n (%)	N	n (%)
Self-reported						
Handwashing with soap after fecal contact during the previous day	1,409	930 (66)	1,338	600 (45)	1,064	723 (68)
Handwashing with soap before food preparation during the previous day	1,409	950 (67)	1,338	258 (19)	1,064	333 (31)
Handwashing with soap before feeding a child during the previous day	1,409	284 (20)	1,338	43 (3)	1,064	388 (36)
Handwashing with soap before eating during the previous day	1,409	573 (41)	1,338	311 (23)	1,064	170 (16)
Rapid observation						
Presence of soap anywhere in the home	1,368 (Households)	1,119 (82)	757 (Households)	678 (90)	1,064 (Households)	1,045 (98)
Presence of soap and water at the handwashing place used postdefecation	1,362 (Households)	912 (67)	753 (Households)	213 (28)	1,063 (Households)	947 (89)
Presence of soap and water at the handwashing place used before food preparation	1,367 (Households)	915 (67)	753 (Households)	149 (20)	1,064 (Households)	946 (89)
High cleanliness index of caregivers hands*						
Hands rated clean based on observation of nails, palms, and fingerpads	1,395	919 (66)	1,280	1,026 (80)	1,064	687 (65)

* Index based on observation of nails, palms, and fingerpads, dichotomized with score <7 considered "not clean" and score ≥7 considered "clean"

TABLE 4: PREVALENCE-ADJUSTED KAPPA SCORES REFLECTING MODERATE OR GREATER AGREEMENT BETWEEN RAPID HANDWASHING MEASURES IN ENDLINE SURVEYS IN PERU, SENEGAL, AND VIETNAM, 2009–2011

All Countries	Reported Handwashing after Fecal Contact	Reported Handwashing before Food Preparation	Reported Handwashing before Feeding a Child	Reported Handwashing before Eating	Soap Observed Anywhere in Home	Soap and Water Observed at Handwashing Place Used Postdefecation	Soap and Water Observed at the Place Used to Prepare Food	Cleanliness Index of Caregiver Hands *
Reported handwashing after fecal contact	—				Peru (0.46) Vietnam (0.50)			
Reported handwashing before food preparation	—	—	Senegal (0.61)				Senegal (0.41)	
Reported handwashing before feeding a child	—	—	—	Senegal (0.55)			Senegal (0.61)	
Reported handwashing before eating	—	—	—	—				
Soap observed anywhere in home	—	—	—	—	—	Peru (0.68) Vietnam (0.81)	Peru (0.68) Vietnam (0.79)	Senegal (0.52)
Soap and water observed at handwashing place used postdefecation	—	—	—	—	—	—	Peru (0.83) Senegal (0.56) Vietnam (0.84)	
Soap and water observed at the place used before preparing food	—	—	—	—	—	—	—	
Cleanliness index of caregiver hands*	—	—	—	—	—	—	—	—

*Index based on observation of nails, palms and fingerpads, dichotomized with score <7 considered "not clean" and score ≥7 considered "clean"

- Soap observed anywhere in the home, and soap and water observed at the handwashing place used before preparing food
  - Peru (0.68)
  - Vietnam (0.79)

For the analyses of validity of rapid handwashing measures, data from four households, each with two caregivers, was removed in Peru. In Senegal, where households had two or more caregivers, 11 households were removed, each with more than three caregivers listed.

Structured observations were completed in 286 (21 percent), 88 (12 percent), and 200 (18 percent) households in Peru, Senegal, and Vietnam, respectively. Differences in household- and caregiver-level characteristics among households with and without structured observation data were evaluated (Table S5). In Peru, households with structured observations had a toilet located in the household or yard and reported frequent scarcity of water at the source more often than households without structured observation; however, the differences were relatively minor. There were no statistically significant differences between caregivers with and without structured observations in Peru. In Senegal, there were statistically significant differences between households with and without structured observation data. Households with structured observation data had lower wealth scores and were less likely to have improved sanitation than their counterparts. In addition, differences in caregiver hand cleanliness score, self-reported handwashing with soap after fecal contact, and self-reported handwashing before eating suggested poorer handwashing behavior in the structured observation group than in the group without structured observations in Senegal. In Vietnam, there were statistically significant differences between the two groups in possession of a refrigerator, type of fuel used for cooking, and highest education level attained, indicating a somewhat higher socioeconomic status among households with structured observation than those without structured observation.

Data on handwashing behavior among primary caregivers was available for 278 households in Peru, 77 households in Senegal, and 199 households in Vietnam. Among primary caregivers, there were 1,467 events observed in Peru, 444 observed in Senegal, and 1,421 observed in Vietnam (Table 5). Overall, primary caregivers washed hands with soap at a minority of all events observed in Peru (14 percent), Senegal (13 percent), and Vietnam (10 percent). Events of the following types were designated as *critical events*, because of their potential relevance to pathogen transmission to or from hands: fecal contact, food preparation, eating, or feeding a child. For the critical events of interest, handwashing with soap was observed in the minority (Table 6). For example, handwashing of any kind (with or without soap) ranged from 61 percent to 74 percent after fecal contact events, but handwashing with soap was observed at only 24 to 34 percent of such events. Soap use was less frequently observed before food preparation (7 to 8 percent), eating (6 to 14 percent), and feeding events (4 to 9 percent).

Table 6 details the associations between rapid handwashing measures and observed handwashing behavior in Peru, Senegal, and Vietnam. In all three countries, caregivers who lived in homes with observed soap and water at the handwashing place used after defecation were more likely to be observed washing hands with soap than caregivers living in homes without soap and water at that place: Peru (RR = 1.59, 95% CI = 1.11–2.28), Senegal (RR = 2.63, 95% CI = 1.36–5.10), and Vietnam (RR = 3.61, 95% CI = 1.53–8.50). Similarly, caregivers were more likely to be observed washing hands with soap if soap and water were observed at the place where hands are washed before food preparation: Peru (RR = 2.02, 95% CI = 1.40–2.92), Senegal (RR = 2.44, 95% CI = 1.11–5.34), and Vietnam (RR = 2.20, 95% CI = 1.14–4.24). Also, observation of soap at the place used after defecation, irrespective of the presence of water, was associated with observed handwashing with soap in Senegal and Vietnam. Observation of soap at the place used to wash hands before food preparation was associated with observed handwashing with soap in Peru and Vietnam, but not in Senegal. In Senegal, soap retrieval within 60 seconds was found to be strongly associated with observed handwashing behavior (RR = 8.21, 95% CI = 1.68–40.08). However, in Vietnam, the inverse association was found, such that primary caregivers living in households in which soap retrieval occurred within 60 seconds were *less* likely to be observed washing hands with soap. In Vietnam alone, self-reported handwashing after fecal contact or

TABLE 5: FREQUENCY OF OBSERVATION OF CRITICAL EVENTS FOR HANDWASHING, AND HANDWASHING BEHAVIOR, DURING ENDLINE STRUCTURED OBSERVATIONS, BY COUNTRY, 2011

Observation	Peru*	Senegal#	Vietnam
Number of structured observations completed	278	77	199
Number of events observed among all household members	2,911	1,742	2,416
Number of critical events among all household members	1,627	966	1,507
Number of events observed among primary caregivers	1,467	444	1,421
Number of events among primary caregivers when hands were washed with or without soap (% of events)	725 (50)	189 (43)	961 (68)
Number of events among primary caregivers when hands were washed **with soap** (% of events)	207 (14)	52 (13)	136 (10)
Number of critical events observed among primary caregivers	725	266	858
Number of critical events among primary caregivers when hands were washed with or without soap (% of events)	431(59)	112 (42)	318 (37)
Number of critical events among primary caregivers when hands were washed **with soap** (% of events)	106 (15)	29 (11)	103 (12)
Number of fecal contact events among primary caregivers	168	47	289
Number of fecal contact events among primary caregivers after which hands were washed with or without soap (% of fecal contact events)	103 (61)	35 (74)	182 (63)
Number of fecal contact events among primary caregivers after which hands were washed **with soap** (% of fecal contact events)	57 (34)	12 (25)	69 (24)
Number of food preparation events among primary caregivers	361	70	181
Number of food preparation events among primary caregivers before which hands were washed with or without soap (% of food preparation events)	258 (71)	25 (36)	60 (33)
Number of food preparation events among primary caregivers before which hands were washed **with soap** (% of food preparation events)	27 (7)	5 (7)	14 (8)
Number of eating events among primary caregivers	92	97	125
Number of eating events among primary caregivers before which hands were washed with or without soap (% of eating events)	40 (43)	37 (38)	31 (25)
Number of eating events among primary caregivers before which hands were washed **with soap** (% of eating events)	13 (14)	10 (10)	8 (6)
Number of feeding events among primary caregivers	104	52	263
Number of feeding events among primary caregivers before which hands were washed with or without soap (% of feeding events)	30 (29)	15 (29)	45 (17)
Number of feeding events among primary caregivers before which hands were washed **with soap** (% of feeding events)	9 (9)	2 (4)	12 (5)

*Excludes structured observations in households with more than one primary caregiver
#Excludes structured observations in households with more than three primary caregivers

before feeding a child, and observed hand cleanliness, were each associated with observed handwashing with soap at any observed event. Distance of the handwashing location from either the latrine or the food preparation place was not associated with observed handwashing with soap.

In Peru and Vietnam, adjustment for wealth did not alter the associations between the rapid handwashing measures and observed handwashing with soap. In Senegal, none of the rapid handwashing measures were significantly associated with observed handwashing with soap in models including wealth.

Caregivers whose hands were not observed to be clean were less likely than caregivers whose hands were noted to be clean to be observed washing hands with soap after fecal contact in Peru (RR = 2.20, 95% CI = 1.67–4.16) and Vietnam (RR = 2.63, 95% CI = 1.40–4.95). The only other measure significantly associated with observed handwashing with soap after fecal contact was self-reported handwashing with soap after defecation, a finding only detected in Vietnam (RR = 3.33, 95% CI = 1.45–7.67).

The extremely low levels of soap use for handwashing at food preparation, eating, and feeding events during structured observation made it impossible to estimate the association between rapid handwashing measures and observed handwashing with soap at these critical times.

TABLE 6: ASSOCIATIONS BETWEEN RAPID HANDWASHING MEASURES AND OBSERVED HANDWASHING BEHAVIOR, ENDLINE SURVEYS AND STRUCTURED OBSERVATIONS IN PERU, SENEGAL, AND VIETNAM, 2009–2011

Associations between rapid handwashing measures behavior and observed handwashing						
	Peru N = 1,446§ events		Senegal N = 435§ events		Vietnam N = 1,410§ events	
Measure of Handwashing Behavior	Unadjusted Relative Risk (95% CI**)	Adjusted* Relative Risk (95% CI)	Unadjusted Relative Risk (95% CI)	Adjusted* Relative Risk (95% CI)	Unadjusted Relative Risk (95% CI)	Adjusted* Relative Risk (95% CI)
Structured observation of handwashing behavior at <u>any event</u> compared to:						
Self-report of handwashing with soap in the last 24 hours:						
after fecal contact	0.93 (0.67–1.29)	0.92 (0.66–1.29)	1.83 (0.84–4.00)	1.24 (0.65–2.40)	**2.94 (1.53–5.64)*** **	**2.93 (1.53–5.64)**
before preparing food	1.31 (0.92–1.87)	1.34 (0.94–1.92)	1.35 (0.59–3.10)	1.22 (0.63–2.34)	0.97 (0.60–1.58)	0.97 (0.59–1.58)
before feeding a child	0.78 (0.50–1.20)	0.74 (0.47–1.16)	undefined#	undefined#	**2.22 (1.45–3.41)**	**2.22 (1.45–3.41)**
before eating	1.37 (0.98–1.90)	1.39 (0.99–1.93)	1.06 (0.35–3.28)	1.76 (0.64–4.83)	1.24 (0.72–2.13)	1.24 (0.72–2.14)
Rapid observation of:						
soap in the home	1.15 (0.80–1.65)	1.14 (0.79–1.63)	4.23 (0.58–31.16)	2.05 (0.31–13.74)	undefined#	undefined#

(continued)

TABLE 6: (Continued)

Measure of Handwashing Behavior	Peru N = 1,446§ events		Senegal N = 435§ events		Vietnam N = 1,410§ events	
	Unadjusted Relative Risk (95% CI**)	Adjusted* Relative Risk (95% CI)	Unadjusted Relative Risk (95% CI)	Adjusted* Relative Risk (95% CI)	Unadjusted Relative Risk (95% CI)	Adjusted* Relative Risk (95% CI)
Handwashing place used after defecation						
soap observed	1.27 (0.87–1.87)	1.23 (0.86–1.86)	**3.02 (1.54–5.93)**	1.54 (0.69–3.41)	**3.29 (1.42–7.61)**	**3.32 (1.44–7.69)**
water observed	**1.81 (1.06–3.07)**	**1.79 (1.05–3.05)**	**2.37 (1.08–5.20)**	1.13 (0.59–2.19)	undefined#	undefined#
soap and water observed	**1.59 (1.11–2.28)**	**1.58 (1.10–2.26)**	**2.63 (1.36–5.10)**	1.19 (0.63–2.26)	**3.61 (1.53–8.50)**	**3.64 (1.55–8.58)**
handwashing station ≤3 meters from latrine	1.00 (0.72–1.38)	1.01 (0.72–1.40)	**2.31 (1.01–5.30)**	1.19 (0.52–2.72)	1.23 (0.79–1.93)	1.26 (0.78–2.04)
Handwashing place used before food-related event						
soap observed	**1.68 (1.12–2.53)**	**1.67 (1.11–2.22)**	**2.47 (1.17 – 5.20)**	1.40 (0.78 – 2.52)	**2.03 (1.07 – 3.84)**	**2.03 (1.07 – 3.86)**
water observed	**2.16 (1.01–4.61)**	**2.14 (0.99–4.36)**	1.20 (0.56–2.56)	1.20 (0.68–2.12)	2.47 (0.73–8.33)	2.52 (0.73–8.68)
soap and water observed	**2.02 (1.40–2.92)**	**2.01 (1.38–2.91)**	**2.44 (1.11–5.34)**	1.49 (0.84–2.64)	**2.20 (1.14–4.24)**	**2.20 (1.14–4.26)**
handwashing station ≤3 meters from food preparation place	0.81 (0.57–1.16)	0.82 (0.57–1.18)	2.29 (0.93–5.61)	2.02 (0.86–4.74)	0.95 (0.62–1.47)	0.95 (0.62–1.48)
Soap retrieved in ≤60 seconds	0.60 (0.29–1.24)	0.50 (0.23–1.08)	**8.21 (1.68–40.08)**	**6.84 (1.16–40.26)**	**0.20 (0.06–0.63)**	**0.16 (0.03–0.83)**
Hand cleanliness index ≥7	1.09 (0.77–1.54)	1.08 (0.77–1.53)	4.11 (0.93–18.15)	1.76 (0.37–8.37)	**2.75 (1.66 – 4.55)**	**2.75 (1.66–4.55)**
Structured observation of handwashing behavior after fecal contact event compared to:						
Self-report of hand washing with soap in the last 24 hours						
after defecation	1.03 (0.65–1.63)	1.02 (0.64–1.61)	3.11 (0.99–9.63)		**3.33 (1.45–7.67)**	**3.32 (1.44–7.65)**
Rapid observation of:						
soap in the home	0.92 (0.52–1.63)	0.93 (0.52–1.66)	1.02 (0.17–6.16)		undefined#	undefined#

TABLE 6: (Continued)

Measure of Handwashing Behavior	Peru N = 1,446§ events		Senegal N = 435§ events		Vietnam N = 1,410§ events	
	Unadjusted Relative Risk (95% CI**)	Adjusted* Relative Risk (95% CI)	Unadjusted Relative Risk (95% CI)	Adjusted* Relative Risk (95% CI)	Unadjusted Relative Risk (95% CI)	Adjusted* Relative Risk (95% CI)
Handwashing place used after defecation						
soap observed	0.89 (0.52–1.78)	0.91 (0.53–1.55)	2.45 (0.83–7.24)		5.60 (0.85–37.04)	5.53 (0.84–36.49)
water observed	1.05 (0.53–2.07)	1.07 (0.54–2.12)	1.60 (0.48–.29)		undefined#	undefined#
soap and water observed	1.03 (0.63–1.70)	1.05 (0.64–1.73)	2.08 (0.74–5.90)		6.44 (0.96–43.21)	6.37 (0.95–42.67)
handwashing station ≤3 meters from latrine	1.26 (0.76–2.04)	1.25 (0.76–2.05)	2.50 (0.65–9.63)		1.45 (0.90–2.34)	1.43 (0.88–2.34)
Hand cleanliness index ≥7	**2.20 (1.67–4.16)**	**2.21 (1.17–4.17)**			**2.63 (1.40–4.95)**	**2.68 (1.43–5.00)**

* Adjusted for wealth index score
** CI: confidence intervals
*** Associations shown in bold significant at $p < 0.05$
# Undefined due to zero observations in some cells
§ Total events observed less those in which information on handwashing was missing (21 events in Peru, 9 events in Senegal, and 11 events in Vietnam)

V. Discussion

There is interest globally in improving handwashing behavior (http://www.globalhandwashingday.org). However, there is a paucity of information on handwashing behavior from many low- and middle-income countries, with most prior studies carried out in the South Asian subcontinent. Hence, there is a substantial unmet need to estimate handwashing behavior globally using a methodology that is valid for measuring handwashing behavior across cultural and geographic contexts. This multicountry analysis sought to describe handwashing behavior in the absence of handwashing promotion, and to validate rapid handwashing measures against observed handwashing behavior through structured observation in three countries—Peru, Senegal, and Vietnam. Improving handwashing behavior remains a priority for each of these three countries, where handwashing with soap is practiced during only a minority of critical times when pathogens can be transmitted to or from hands. The agreement between the various measures was evaluated, and the extent to which each rapid handwashing measure was associated with observed handwashing with soap, as measured by structured observation of behavior, was assessed. The findings reported here reinforce the importance of using objective measures of handwashing, rather than simply asking respondents to describe their own behavior. Observation of materials at designated handwashing locations yielded valid and internally consistent measures of handwashing with soap overall. Observed hand cleanliness is promising as a proxy measure for handwashing at the specific critical time of fecal contact. Multicountry evidence of association with observed behavior provides a strong basis for the use of rapidly observed measures as proxies of handwashing behavior when structured observation is infeasible. Therefore, the findings of associations between the presence of soap and water at designated handwashing locations, and observed handwashing behavior, in multiple countries affirm the recent inclusion of observations of handwashing locations and materials into the standard modules of both the Demographic and Health Surveys (DHS) and Multiple Indicator Cluster Surveys (MICS).

No measures that were associated with observed handwashing at specific critical times, other than fecal contact, were identified. Handwashing overall, and handwashing with soap, were much less common at critical times other than fecal contact (Table 5), making it difficult to estimate associations between rapid handwashing measures and observed handwashing with soap at these critical times.

Handwashing with Soap Is Infrequent in All Three Countries

Low rates of handwashing with soap were observed. Only one third of fecal contact events in Peru and one quarter in both Senegal and Vietnam were followed by handwashing with soap. Soap use was substantially lower at other critical times, when pathogens can be transmitted from hands to food, or one's own mouth, or the mouth, mucosa, or hands of a child. These low frequencies of handwashing prevented identification of which rapid handwashing measures serve as reasonable proxies of handwashing at critical times other than fecal contact. More importantly, these data reinforce the substantial opportunity and imperative to improve handwashing with soap to decrease child diarrhea and respiratory infections (Curtis et al. 2009).

Water and Soap Together at Locations Designated for Handwashing Associated with Observed Handwashing

The findings reported here confirm the work of Luby and colleagues, who found in Bangladesh that having soap at the place to wash hands after toileting, and having water at that place, were independently associated with observed handwashing with soap after fecal contact (Luby et al. 2009). The analysis of baseline data from the Impact Evaluation of Global Scaling Up Handwashing in Peru similarly found that having soap and water together at one or more designated handwashing places was associated with observed soap use following at least one fecal contact event (Ram et al. 2014).

The majority of households in each country had soap present somewhere in the home. Soap is a highly valued commodity in many low-income settings and its use may be limited in order to keep household expenditures low. Also, soap present in a home may be used for a number of purposes, including bathing, dishwashing, and laundry. In contrast to soap presence anywhere in the home, soap kept at a designated

handwashing place suggests a prioritization of the product for handwashing. Certainly, the same location may be used for washing hands as for washing dishes or clothes. But the convenience of washing hands may be substantially increased by having all the materials needed to carry out the behavior at the location where hands need to be washed (Kamm et al. 2011). Individuals leaving a latrine may be more likely to wash hands if the soap and water are consistently available at a location in or near the latrine; if they have to fetch soap from the home either before going into the latrine or after coming out of it, they may not remember, or may not feel they have sufficient time to carry out the behavior.

Curtis describes habit as a learned, automated behavior that is reinforced by cues (Curtis et al. 2011). The presence of soap and water at a location commonly used for handwashing may provide a visual cue, an immediate prompt to the behavior at critical times (e.g., a handwashing station visible near the latrine for use after defecation). Consistently maintaining the materials needed for handwashing at the same location, and thus providing visual cues tied to the site of hand contamination, may foster a handwashing habit.

The finding of the lack of an association between proximity of the handwashing location and observed handwashing behavior is notable. It warrants further inquiry into the extent to which a proximal location is required for handwashing to occur habitually at critical times. Perhaps habit can be formed as long as the location is fixed, and the cues and convenience are preserved, even if the location is not immediately inside or next to the place where hands must be washed. Not only does this finding imply that investigators need not invest time in measuring distance between the site where the critical event occurs (e.g., latrine, cooking area) and the site where handwashing takes place, but it also suggests that individuals may wash their hands consistently as long as they maintain the necessary materials in a fixed location that is somewhat more distant, if they cannot set up a handwashing station immediately next to a latrine or food preparation area.

Observed Hand Cleanliness

In Bangladesh, cleanliness of children's hands has been shown to be associated with reduced diarrhea risk (Luby et al. 2011a), whereas mothers' hand cleanliness has not. This study evaluated mother's hand cleanliness but did not look at children's hands. Only hand cleanliness was associated with handwashing with soap after fecal contact in both Peru and Vietnam, suggesting that it is worthwhile to continue to explore the use of this measure in some contexts. It is important to better understand why hand cleanliness observation is incongruous with observed handwashing behavior in Senegal. It is possible that differentiating gradations of cleanliness by visual inspection may be more difficult with the darker skin complexions often found in sub-Saharan Africa, compared to relatively lighter skin complexions more commonly found elsewhere.

Self-Reported Measures Not Consistently Associated with Observed Handwashing

Self-reported measures have been shown to overestimate observed handwashing behavior in numerous countries (Manun'Ebo et al. 1997; Stanton et al. 1987; Biran et al. 2008; ICDDR,B 2008; Danquah 2010; Byrt et al. 1993; Sim and Wright 2005; Curtis et al. 2009) so the finding of a lack of consistent association between self-reported and observed handwashing across countries is not novel. The analysis presented here underscores previously expressed concerns about using self-report as the sole approach to measuring handwashing behavior. Alternatives to measuring event-specific handwashing behavior by self-report include structured observation, video observation, or sensor-based technologies; all of these can be intrusive, time-consuming, personnel-intensive, and costly (Ram 2013). For settings in which such intensive resources are not available, it is important to validate similarly the use of other questionnaire-based approaches to measuring event-specific handwashing behavior, including Likert-scale questions (e.g., do you always, sometimes, or never wash your hands after defecation), as well as indices indicating a handwashing habit (Aunger et al. 2010; Stevenson et al. 2009; Verplanken and Orbell 2003).

Wealth and Handwashing Behavior

Prior studies have demonstrated the important relationship between wealth and soap availability in the home, as well as observed handwashing behavior (Luby and Halder 2008; Ram et al. 2010). Compared to poor households, wealthier households may be able to purchase soap more regularly, may be able to prioritize the use of soap for handwashing as opposed to other purposes, or may be more aware of the health benefits or the social desirability of handwashing.

Whereas in Senegal, wealth was an important confounder for the relationship between observed handwashing materials and observed handwashing behavior, the associations in models including wealth were stable in Peru and Vietnam. This lack of consistency in the effects of wealth suggests the need to better understand the potentially variable role of wealth in influencing access to soap in different cultural or geographical contexts.

Challenge to Validating Rapid Handwashing Measures Using Observed Handwashing

Given emerging data on the association between observed handwashing behavior and improved health outcomes, observed handwashing behavior serves as a reasonable basis of evaluating rapid handwashing measures (Luby et al. 2011b). However, there are important concerns about reactivity, the extent to which individuals behave in their usual way during a structured observation, when an outsider is present in their home or compound (Ram et al. 2010; Cousens et al. 1996). The overarching goal of most handwashing programs is neither cosmetic nor social, but rather to reduce the burden of preventable infections, particularly in children. It is important, therefore, that rapid handwashing measures be further validated using health outcomes when feasible (Luby et al. 2011a).

Limitations

Apart from reactivity to structured observation, which is described above, there are several limitations to the data and analyses presented in this article. First, although data collection instruments and training guidance documents were designed centrally, with only minor adaptations, training of survey teams was carried out by different investigators within each country, potentially leading to differences in survey administration and data collection that could have affected the estimates of agreement and validity. Still, the common survey tools used in each country allowed for greater comparison across countries than is typically possible when comparing disparate studies, often carried out by entirely different research teams. Moreover, to be widely applicable, handwashing measures must withstand application by investigators of various skill levels. To that end, the validity of observations of soap and water at a handwashing place as appropriate proxies for observed handwashing behavior is strengthened.

Second, structured observations were carried out in only a relatively small subset of households in each country. The subsets may not have been representative of the larger populations of the Impact Evaluation countries, as noted by differences between households taking part in structured observation and those not taking part (Table 6).

Third, small numbers of certain critical events, such as eating and feeding a child, were observed, making it impossible to determine which rapid handwashing measures might be associated with handwashing at the specific times when pathogens may be transmitted to or from hands. To address the small numbers of specific critical events observed, events consisting of potential contact with one's own feces (defecation) were combined with events of potential contact with a child's feces (cleaning a child who has defecated). This approach of group critical times related from a microbial transmission perspective may have ignored behavioral realities. For example, latrine use events were combined with cleaning the anus of a child who had defecated into a single "fecal contact." Handwashing behaviors may differ based on the individual's perception of disgust associated with the feces; in many cultures, there is substantial disgust associated with touching one's own feces but somewhat less with touching children's feces. Ideally, a larger number of specific critical events would have allowed the investigation of the extent to which rapid handwashing measures were associated with observed handwashing at each type of event, acknowledging the unique drivers of behavior at each type of event when pathogens may be transmitted to and from hands.

Conclusions

This multicountry analysis has shown that observation of handwashing materials at the places where people wash hands, at the times most necessary for washing (after fecal contact and before food preparation), is a valid measure of handwashing with soap in multiple cultural and geographic contexts. There continues to be an overarching need for developing valid measures of handwashing behavior that can be collected in an efficient and inexpensive fashion. The structured observation data indicating low rates of soap use for handwashing at times of pathogen transmission reinforce the global imperative to improve handwashing behavior for prevention of the leading causes of death in young children.

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Annex 1: Supplemental Tables

TABLE S1: DEFINITIONS OF HANDWASHING MEASURES

Presence of Soap Anywhere in the Home
• The indicator is defined as presence of at least one type of soap observed by the enumerator anywhere in the home.
• Following observations of handwashing places, enumerators asked the household respondent to show soap typically used for washing hands, irrespective of where it was located in the home. All households that allowed observation of soap anywhere in the home are included in this analysis.
Presence of Soap and Water at a Fixed Handwashing Place Used Post-Defecation
• The indicator is defined as the presence of at least one type of soap observed by the enumerator at the handwashing place reportedly used after defecation.
• Questions to describe the location of the handwashing place and materials observed at that place followed an introductory question regarding whether hands are usually washed after defecation. Households in which the respondents indicated washing hands after defecation, and where respondents allowed observation of the location of the handwashing place and the presence of soap and water at that place, were eligible for analysis.
• Enumerators recorded whether the handwashing place was inside the toilet or cooking place, or elsewhere in the yard. In Peru and Senegal, if the handwashing place was located elsewhere in the yard, the distance from the toilet was recorded (< 3 feet from the toilet, 3 to 10 feet from the toilet, more than 10 feet from the toilet). In Vietnam, if the handwashing place was located elsewhere in the yard, enumerators recorded distance in meters, but the precoded categories approximated the ones used in Peru and Senegal. Enumerators recorded the type of soap present at the handwashing place. In Peru and Senegal, the types of soap observed were beauty bar soap, multipurpose bar soap, and powder/detergent soap. In Vietnam, the types of soap observed were liquid soap, multipurpose bar soap, and powder/detergent soap. For the indicator, a household was considered as having soap at the handwashing place if at least one type of soap, irrespective of type, was present at the handwashing place. The presence of water was recorded at the handwashing place, irrespective of the type of device located therein.
Presence of Soap and Water at a Fixed Handwashing Place Used before Food Preparation
• The indicator is defined as the presence of at least one type of soap observed by the enumerator at the handwashing place reportedly used before food preparation.
• Questions to describe the location of the handwashing place and materials observed at that place followed an introductory question regarding whether hands are usually washed before food preparation. Observations of soap and water were carried out if the handwashing place used before food preparation differed from the handwashing place used after defecation.
• Households identified as eligible for this analysis were, first, those that showed a handwashing place used before food preparation that was distinct from the handwashing place used after defecation, and for which observation of the location, soap, and water were all completed. Also included in the analysis were those households in which the handwashing place used after defecation was located in the kitchen and was the same place used to wash hands before food preparation. Households in which the respondent indicated not usually washing hands before food preparation, or that had no specific place for washing hands before food preparation, were also added.

(continued)

TABLE S1: (Continued)

Presence of Soap and Water at a Fixed Handwashing Place Used before Food Preparation
• Questions to describe the location of the handwashing place and materials observed at that place followed an introductory question regarding whether hands are usually washed before food preparation. All households in which the respondents indicated washing hands before food preparation were eligible for analysis, and where respondents allowed observation of the location of the handwashing place and the presence of soap and water at that place.
• Enumerators recorded whether the handwashing place was inside the toilet or cooking place, or elsewhere in the yard. The distance of the handwashing place from the cooking place was recorded similarly to the distance from the toilet, as described above for the postdefecation handwashing place. Soap and water observations were also recorded similarly.
Cleanliness Index of Caregiver Hands (Index Based on Observation of Nails, Palms, and Fingerpads)
• This is a nine-point index based on the enumerator's observation of the cleanliness of the nails, palms, and fingerpads of individual caregivers. Each aspect of the hand was rated on a three-point scale, ranging from one point for visible dirt to three points for clean appearance. These points were totaled to compute the hand cleanliness index.
• Caregivers who did not allow observation of one or more aspects of the hand were not included in the analysis of the cleanliness index. The distribution of the index scores among caregivers in the control arm is reported below. Caregivers were also dichotomized according to cleanliness, with an index of 7 or higher denoting "clean hands," and an index score less than 7 denoting "unclean hands."
Self-Reported Handwashing with Soap at Critical Times during Previous Day
• The indicator is defined as self-reported handwashing with soap at one of the four critical times during the previous day.
• Individual caregivers were asked whether they had washed hands with soap at least once during the previous day (since the same time the day before the enumerator's visit). If they reported washing hands, they were asked in an unprompted fashion about the context of when hands were washed with soap and all other times that hands were washed with soap during the previous day. Although information about a number of critical times was captured, those of principal interest are as follows: after fecal contact, before food preparation or cooking food, before eating, or before feeding a child.
• Caregivers described as being alone at the time of the interview were included in the analysis, because the presence of others may have influenced caregivers' responses to handwashing questions.
Observed Handwashing with Soap at Critical Times
• Structured observation data can be analyzed and reported in numerous ways. Here, handwashing behavior was analyzed at the caregiver level, rather than at the household level. Observed handwashing behavior is reported below for each event, overall and by type of critical event observed. The events of interest were the same as those for self-reported handwashing behavior: after fecal contact, before food preparation, before eating, and before feeding a child. In particular, behavior as measured among primary caregivers is reported.

TABLE S2: AGREEMENT BETWEEN RAPID HANDWASHING MEASURES BEHAVIOR IN ENDLINE SURVEYS, PERU, 2011

Peru		Reported Handwashing after Fecal Contact	Reported Handwashing before Food Preparation	Reported Handwashing before Feeding a Child	Reported Handwashing before Eating	Soap Observed Anywhere in Home	Soap and Water Observed at Handwashing Place Used Post Defecation	Soap and Water Observed at the Place Used to Prepare Food	Cleanliness Index of Caregiver Hands *
Reported handwashing after fecal contact	Kappa	—	0.04	0.04	0.03	**0.03**	–0.01	—	0.03
	(95%CI)		(–0.01 – 0.10)	(0.01 – 0.07)	(–0.01 – 0.08)	**(–0.02 – 0.08)**	(–0.06 – 0.05)		(–0.03 – 0.08)
	Prev-adj		0.15	0.06	0.04	**0.46**	0.10		0.12
	Kappa		n = 1,373	n = 1,373	n = 1,373	**n = 1,364**	n = 1,358		n = 1,349
Reported handwashing before food preparation	Kappa		—	0.03	–0.03	0–.05	—	–0.04	0.11
	(95%CI)			(0.00 – 0.06)	(–0.08 – 0.02)	(–0.09 – 0.0)		(–0.09 – 0.02)	(0.06 – 0.16)
	Prev-adj			0.04	–0.02	0.20		0.14	0.21
	Kappa n			n = 1,373	n = 1,373	n = 1,364		n = 1,363	n = 1,349
Reported handwashing before feeding a child	Kappa			—	–0.11	0.00	—	–0.01	0.00
	(95%CI)				(–0.15 – –0.06)	(–0.02 – 0.02)		(–0.04 – 0.03)	(–0.03 – 0.04)
	Prev-adj				0.05	0.00		0.01	0.12
	Kappa n				n = 1,373	n = 1,364		n = 1,363	n = 1,349
Reported handwashing before eating	Kappa				—	0.01	—	–0.05	–0.09
	(95%CI)					(–0.02 – 0.05)		(–0.10 – –0.01)	(–0.14
	Prev-adj					0.06		–0.04	– –0.05)
	Kappa n					n = 1,364		n = 1,363	–0.09
									n = 1,349
Soap observed anywhere in home	Kappa					—	**0.58**	**0.58**	0.05
	(95%CI)						**(0.53 – 0.63)**	**(0.53 – 0.63)**	(0.00 – 0.10)
	Prev-adj						**0.68**	**0.68**	0.26
	Kappa n						**n = 1,373**	**n = 1,378**	n = 1,351

(continued)

TABLE S2: (Continued)

Soap and water observed at handwashing place used postdefecation	Kappa (95%CI) Prev-adj Kappa n		—	—	—	—	**0.81** **(0.78 – 0.85)** **0.83** **n=1,372**	0.14 (0.09 – 0.20) 0.24 n = 1,345
Soap and water observed at the place used to prepare food	Kappa (95%CI) Prev-adj Kappa n	—					—	0.15 (0.09 – 0.20) 0.24 n = 1,349
Cleanliness index of caregiver hands*	Kappa (95%CI) Prev-adj Kappa n							—

*Index based on observation of nails, palms, and fingerpads, dichotomized with score <7 considered "not clean" and score ≥7 considered "clean"

TABLE S3: AGREEMENT BETWEEN RAPID HANDWASHING MEASURES BEHAVIOR IN ENDLINE SURVEYS, SENEGAL, 2011

Senegal		Reported Handwashing after Fecal Contact	Reported Handwashing before Food Preparation	Reported Handwashing before Feeding a Child	Reported Handwashing before Eating	Soap Observed Anywhere in Home	Soap and Water Observed at Handwashing Place Used Postdefecation	Soap and Water Observed at the Place Used to Prepare Food	Cleanliness Index of Caregiver Hands *
Reported handwashing after fecal contact	Kappa (95%CI) Prev-adj Kappa	—	0.10 (0.05 – 0.14) 0.21 n = 1,338	0.05 (0.03 – 0.08) 0.27 n = 1,338	0.08 (0.03 – 0.13) 0.17 n = 1,338	0.01 (–0.02 – 0.04) 0.11 n = 1,338	0.08 (0.03 – 0.13) 0.15 n = 1,329	—	0.09 (0.05 – 0.13) 0.15 n = 1,280
Reported handwashing before food preparation	Kappa (95%CI) Prev-adj Kappa n		—	**0.05** **(0.01 – 0.10)** **0.61** **n = 1,338**	0.00 (–0.05 – 0.06) 0.33 n = 1,338	0.02 (0.00 – 0.03) 0.02 n = 1,338	—	**0.05** **(–0.01 – 0.10)** **0.41** **n = 1,331**	0.03 (0.01 – 0.05) 0.03 n = 1,280
Reported handwashing before feeding a child	Kappa (95%CI) Prev-adj Kappa n			—	0.05 (0.01 – 0.9) 0.55 n = 1,338	0.00 (–0.01 – 0.01) 0.00 n = 1,338	—	**0.04** **(0.00 – 0.09)** **0.61** **n = 1,331**	0.01 (0.00 – 0.02) 0.02 n = 1,280
Reported handwashing before eating	Kappa (95%CI) Prev-adj Kappa n				—	0.01 (–0.01 – 0.03) 0.02 n = 1,338	—	–0.04 (–0.09 – 0.01) 0.31 n = 1,331	0.01 (–0.02 – 0.04) 0.01 n = 1,280
Soap observed anywhere in home	Kappa (95%CI) Prev-adj Kappa n					—	0.09 (0.07 – 0.10) 0.10 n = 1,402	0.05 (0.04 – 0.06) 0.05 n = 1,404	**0.08** **(0.02 – 0.14)** **0.52** **n = 1,280**
Soap and water observed at handwashing place used postdefecation	Kappa (95%CI) Prev-adj Kappa n		—	—	—		—	**0.39** **(0.33 – 0.44)** **0.56** **n = 1,395**	0.06 (0.03 – 0.09) 0.06 n = 1,271

(continued)

TABLE S3: (Continued)

Soap and water observed at the place used to prepare food	Kappa (95%CI) Prev-adj Kappa n	—	0.04 (0.02 – 0.06) 0.04 n = 1,273
Cleanliness index of caregiver hands*	Kappa (95%CI) Prev-adj Kappan		—

*Index based on observation of nails, palms, and fingerpads, dichotomized with score <7 considered "not clean" and score ≥7 considered "clean"

TABLE S4: AGREEMENT BETWEEN RAPID HANDWASHING MEASURES BEHAVIOR IN ENDLINE SURVEYS, VIETNAM, 2011

Vietnam		Reported Handwashing after Fecal Contact	Reported Handwashing before Food Preparation	Reported Handwashing before Feeding a Child	Reported Handwashing before Eating	Soap Observed Anywhere in Home	Soap and Water Observed at Handwashing Place Used Postdefecation	Soap and Water Observed at the Place Used to Prepare Food	Cleanliness Index of Caregiver Hands *
Reported handwashing after fecal contact	Kappa	—	0.03	0.11	0.05	**0.03**	0.06	—	0.11
	(95%CI)		(0.00 – 0.07)	(0.06 – 0.16)	(0.02 – 0.08)	**(0.00 – 0.06)**	(0.01 – 0.11)		(0.04 – 0.17)
	Prev-adj		0.03	0.12	0.07	**0.50**	0.36		0.20
	Kappa		n = 1,064	n = 1,064	n = 1,064	**n = 1,064**	n = 1,063		n = 1,064
Reported handwashing before food preparation	Kappa		—	0.09	–0.02	0.00	—	0.03	0.05
	(95%CI)			(0.03 – 0.15)	(–0.07 – 0.04)	(–0.01 – 0.01)		(0.00 – 0.05)	(0.01 – 0.10)
	Prev-adj			0.19	0.07	0.06		0.06	0.06
	Kappa n			n = 1,064	n = 1,064	n = 1,064		n = 1,064	n = 1,064
Reported handwashing before feeding a child	Kappa			—	0.00	0.00	—	0.04	0.10
	(95%CI)				(–0.06 – 0.05)	(–0.01 – 0.01)		(0.02 – 0.07)	(0.05 – 0.15)
	Prev-adj				0.06	0.09		0.09	0.27
	Kappa n				n = 1,064	n = 1,064		n = 1,064	n = 1,064
Reported handwashing before eating	Kappa				—	0.00	—	–0.01	0.00
	(95%CI)					(0.00 – 0.01)		(–0.02 – 0.01)	(–0.03 – 0.04)
	Prev-adj					0.01		-0.01	0.03
	Kappa n					n = 1,064		n = 1,064	n=1,064
Soap observed anywhere in home	Kappa					—	**0.23**	**0.15**	0.02
	(95%CI)						**(0.14 – 0.32)**	**(0.07 – 0.23)**	(–0.01 – 0.04)
	Prev-adj						**0.81**	**0.79**	0.37
	Kappa n						**n = 1,063**	**n = 1,064**	n = 1,064
Soap and water observed at handwashing place used postdefecation	Kappa		—	—	—		—	**0.58**	0.08
	(95%CI)							**(0.50 – 0.66)**	(0.03 – 0.13)
	Prev-adj							**0.84**	0.33
	Kappa n							**n = 1,063**	n = 1,063

(continued)

TABLE S4: (Continued)

Soap and water observed at the place used to prepare food	Kappa (95%CI) Prev-adj Kappa n	–		–	0.07 (0.02 – 0.12) 0.32 n = 1,064
Cleanliness index of caregiver hands*	Kappa (95%CI) Prev-adj Kappa n				–

*Index based on observation of nails, palms, and fingerpads, dichotomized with score <7 considered "not clean" and score ≥7 considered "clean"

TABLE S5: CHARACTERISTICS OF HOUSEHOLDS AND CAREGIVERS WITH AND WITHOUT ENDLINE STRUCTURED OBSERVATION (SO) DATA, AMONG CONTROLS, PERU, SENEGAL, AND VIETNAM, 2011

	Peru			Senegal			Vietnam		
Characteristic	Households with SO n = 286 Number (%)	Households without SO n = 1,086 Number (%)	p-value#	Households with SO n = 88 Number (%)	Households without SO n = 669 Number (%)	p-value#	Households with SO n = 200 Number (%)	Households without SO n = 864 Number (%)	p-value#
Wealth									
Mean wealth index (sd)	0.013 (1.01)	0.11 (0.31)	0.13	–0.50 (2.5)	0.49 (2.5)	**<0.001**	4.24 (1)	4.17 (1)	0.24
Water- and sanitation-related characteristics									
JMP defined improved sanitation	146 (52)	572 (53)	0.75	51 (58)	483 (72)	**<0.01**	127 (64)	605 (70)	0.07
Toilet is located in the household or yard	218 (79)	771 (71)	**<0.01**	57 (67)	496 (75)	0.11	170 (85)	763 (88)	0.28
JMP defined improved water source	252 (95)	1,045 (92)	0.10	64 (74)	533 (81)	0.09	197 (99)	837 (97)	0.21
Reports treating drinking water every day in the past seven days (any method)	227 (87)	877 (88)	0.78	15 (20)	104 (18)	0.64	171 (86)	764 (88)	0.25
Handwashing behavior measures									
Presence of soap anywhere in the home	228 (81)	891 (82)	0.64	75 (85)	603 (90)	0.16	199 (99)	846 (98)	0.23##
Presence of soap and water at the handwashing place used postdefecation	192 (68)	720 (67)	0.58	18 (20)	195 (29)	0.08	181 (91)	766 (89)	0.35

(continued)

TABLE S5: (Continued)

Characteristic	Households with SO n = 286 Number (%)	Households without SO n = 1,086 Number (%)	p-value#	Households with SO n = 88 Number (%)	Households without SO n = 669 Number (%)	p-value#	Households with SO n = 200 Number (%)	Households without SO n = 864 Number (%)	p-value#
Handwashing behavior measures									
Presence of soap and water at the handwashing place used before food preparation	187 (67)	728 (67)	0.87	13 (15)	136 (20)	0.21	179 (90)	767 (89)	0.77
Ability to bring soap in ≤ one minute§	31 (89)	112 (65)	0.34	42 (86)	262 (79)	0.25	13 (93)	56 (90)	0.77
	Caregivers with SO n = 300 Number (%)	**Caregivers without SO n = 1,115 Number (%)**	**p-value#**	**Caregivers with SO n = 171 Number (%)**	**Caregivers without n = 1,240 Number (%)**	**p-value#**	**Caregivers with SO n = 200 Number (%)**	**Caregivers without SO n = 864 Number (%)**	**p-value#**
Female	299 (99.5)	1,115 (99.5)	1.00+	169 (99)	1,232 (99.7)	0.48+	186 (93)	808 (94)	0.79
Mean age in years (sd)	30.16 (7.5)	29.31 (8.0)	0.01	31.00 (9.0)	30.9 (8.7)	0.86	35.30 (13.1)	35.63 (12.5)	0.75
Ever attended school	281 (94)	1,045 (94)	0.93	36 (21)	362 (29)	**0.03**	192 (98)	837 (98)	0.87
Education level attained*			0.60						**<0.01**
Kindergarten or primary school	128 (47)	447 (43)		Data not available			42 (23)	189 (23)	
Lower secondary$	125$ (46)	497$ (48)		Data not available			88 (46)	456 (54)	
Upper secondary	—	—		Data not available			31 (16)	132 (16)	
Trade school (college), university, or higher	21 (8)	87 (8)		Data not available			29 (15)	60 (7)	

TABLE S5: (Continued)

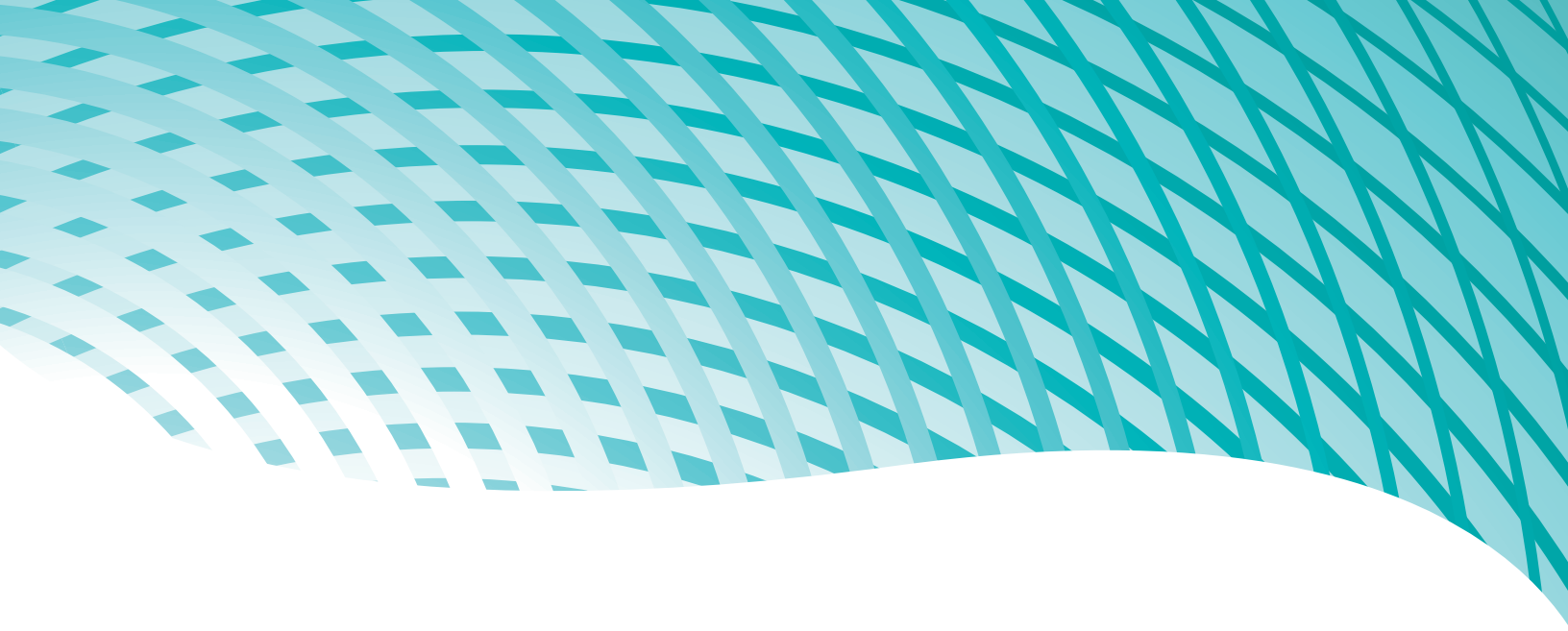
Handwashing behavior measures									
Presence of soap and water at the handwashing place used postdefecation	192 (68)	720 (67)	0.58	18 (20)	195 (29)	0.08	182 (91)	765 (89)	0.34
Presence of handwashing station ≤3 meters from latrine	150 (55)	530 (51)	0.18	48 (56)	397 (62)	0.37	88 (44)	354 (41)	0.43
Presence of soap and water at the handwashing place used before food preparation	187 (67)	728 (67)	0.87	13 (15)	136 (20)	0.21	179 (90)	767 (89)	0.77
Presence of handwashing station ≤3 meters from food preparation place	217 (78)	726 (71)	**0.02**	51 (58)	372 (56)	0.74	134 (67)	491 (57)	**<0.01**
All three aspects of hands rated clean	137 (46)	509 (46)	0.31	94 (60)	758 (68)	**0.01**	93 (47)	389 (45)	0.72
Self-reported handwashing with soap after fecal contact during previous day	190 (64)	740 (67)	0.41	55 (34)	545 (46)	**<0.01**	142 (71)	581 (68)	0.31
Self-reported handwashing with soap before food preparation during previous day	203 (68)	747 (67)	0.70	35 (22)	223 (19)	0.40	54 (27)	279 (32)	0.15

(continued)

TABLE S5: (Continued)

Handwashing behavior measures									
Self-reported handwashing with soap before feeding a child during previous day	53 (18)	231 (21)	0.26	2 (1)	41 (3)	0.13	70 (35)	319 (37)	0.61
Self-reported handwashing with soap before eating during previous day	112 (38)	461 (41)	0.25	23 (14)	288 (24)	**<0.01**	29 (15)	141 (16)	0.53

* Chi square comparing distribution of education level among those with structured observation to those without
# p-values were calculated using a chi-square test for categorical data comparisons and t-tests for continuous data comparisons
Fisher's exact test to test for differences between groups used due to small cell size
§ For those households in which soap was not readily observable
$ In Peru, this category refers to any secondary school



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