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Quantifying the relationships between measures of facial and hand cleanliness and household WASH conditions, psychosocial factors, and personal hygiene practices from the Andilaye Trial

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2019

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Abstract

Quantifying the relationships between measures of facial and hand cleanliness and household WASH conditions, psychosocial factors, and personal hygiene practices from the Andilaye Trial

By Rebecca Kann

Background: Many water, sanitation, and hygiene (WASH) interventions target improvements in personal hygiene behaviors to reduce the transmission of infectious diseases. Programs implementing WASH interventions confront challenges in addressing behavioral factors that serve as barriers to uptake of improved WASH behaviors. Accurate measurement of behavior change remains a challenge for monitoring and evaluation of WASH programs.

Methods: This analysis was a sub-study of the *Andilaye* Trial, an impact evaluation of a community-based WASH intervention implemented in Amhara, Ethiopia. The outcomes of interest were facial and hand cleanliness, as measured by the Quantitative Personal Hygiene Assessment Tool (qPHAT), an objective measure of cleanliness based on an 11-point color scale. Multivariable models evaluated the associations between qPHAT measures of facial and hand cleanliness and (1) household WASH conditions, (2) psychosocial factors, and (3) reported personal hygiene practices. Models employed a generalized linear regression framework with generalized estimating equations and robust standard errors to account for clustering at the community level.

Results: Higher perceived water insecurity, a measure of household WASH conditions, was associated with dirtier faces (β=-0.08 95%CI [-0.12,-0.04]). Several psychosocial factors were associated with cleanliness outcomes. Perceptions regarding the cleanliness of others in one's social group were associated with cleaner faces (β=0.41 95%CI [0.15,0.67]) and reported commitment to washing was associated with dirtier faces (β=-0.61 95%CI [-0.99,-0.13]). The belief that washing takes too much water was associated with both cleaner faces and cleaner hands (β=0.26 95%CI [0.10,0.57] and β=-0.26 95%CI [-0.19,0.43], respectively). Reported hygiene practices were not significantly associated with cleanliness outcomes. The *Andilaye* intervention did not result in meaningful differences in either facial or hand cleanliness (β=0.12, 95%CI [-0.23,-0.47] and β=0.05, 95%CI [-0.37,0.46], respectively).

Conclusions: This research highlights the role of intermediate behavioral factors, including water insecurity and psychosocial factors, in influencing hygiene practices. Many WASH interventions have identified biases in common proxy indicators of hygiene practices, including reported practices, as was seen in this study. This research highlighted the potential value of the qPHAT metric for future research and impact evaluations of hygiene interventions to provide a nuanced measure of hygiene outcomes that is less prone to bias.

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Introduction

Improved personal hygiene has the potential to reduce the global burden of infectious disease (Aiello & Larson, 2002; Ejere et al., 2015; Freeman et al., 2013; Prüss-Ustün et al., 2014). Community-based interventions in low- and middle-income settings often promote improved personal hygiene practices to control the spread of disease (V. Curtis, 2003; Delea et al., 2019; Peal et al., 2010; Tidwell et al., 2019). However, uptake of improved handwashing practices remains low in many parts of the world (Brauer et al., 2020; Freeman et al., 2014; Roche et al., 2017). Interventions to improve personal hygiene have shown mixed outcomes, with many resulting in modest changes or behavioral slippage back to unimproved practices after implementation (Luby et al., 2009; Najnin et al., 2019). Interventions that fail to acknowledge and address the factors that influence hygiene behavior change are not well suited to facilitate behavioral adoption and maintenance (V. A. Curtis et al., 2009; Dreibelbis et al., 2013; Watson et al., 2017). In most situations, there are several interconnected contextual, technological, and psychosocial factors that need to be addressed to create an enabling environment in which behavior change and maintenance can occur (V. A. Curtis et al., 2009; Delea et al., 2019; Dreibelbis et al., 2013; Mosler, 2012; White et al., 2020). Psychosocial factors, including attitudes and normative beliefs regarding improved practices, perceived and actual abilities to perform improved practices, self-regulation, and intentions to initiate and maintain the adoption of improved practices, can act as behavioral antecedents that may need to be addressed before behavior change can occur (Contzen & Mosler, 2015; Friedrich et al., 2017; George et al., 2017; Seimetz et al., 2016). Contextual and technological factors, including conditions of household washing stations, user interfaces with washing stations and materials, and experiences with water insecurity, may also act as intermediate factors that play a role in changing and maintaining hygiene behaviors (Ashraf et al., 2017; Dreibelbis et al., 2013; Stoler et al., 2020; Young et al., 2019).

One key challenge to assessing the impact of water, sanitation, and hygiene (WASH) programs is the scarcity of reliable, valid, and low-cost measures of handwashing and facewashing practices. While several hygiene metrics exist, they often rely on reported practices or observations of cleanliness, both of

which are prone to bias. Reported practices consistently overestimate observed behavior and direct observations or video surveillance of handwashing are expensive and are prone to reactivity bias (Contzen et al., 2015; V. Curtis et al., 1993; Luby & Halder, 2008; Manun'Ebo et al., 1997). Other methods including microbiological sampling, observations of environmental conditions, and sensor-recorded measurements are expensive and can only act as proxy indicators (Biran et al., 2008; Luby & Halder, 2008). Additionally, many of these methods are only able to provide dichotomous outcomes (e.g., presence/absence of: soap, washing station, nasal or ocular discharge [facial cleanliness], dirt under nails or on finger pads and palms [hand cleanliness]) (Halder et al., 2010; West et al., 2017), which may not be nuanced enough to detect incremental changes in personal hygiene practices. Without a practical and valid measure of personal hygiene practices, it is difficult to monitor and evaluate the effectiveness of hygiene promotion interventions on behavioral adaptation and maintenance.

The quantitative personal hygiene assessment tool (qPHAT) was developed to address prevailing gaps in conventional personal hygiene measurements and provide a tool for monitoring and evaluating incremental changes in personal hygiene practices facilitated by WASH behavior change interventions (Delea et al., 2020). Using color theory and a standardized 11-point color scale, the qPHAT metric generates more nuanced and quantifiable data on facial and hand cleanliness compared to conventional, dichotomous measures (Delea et al., 2020; Halder et al., 2010). The reliability of the qPHAT methodology was tested among households enrolled in the *Andilaye* Trial during baseline data collection (Delea et al., 2020). The findings of that sub-study indicated that qPHAT generated reliable measures of facial and hand cleanliness and could provide an enhanced method for monitoring of personal hygiene practices for interventions promoting hygiene behaviors. However, no prior studies have used qPHAT data to assess relationships between these measures and personal hygiene behavior or to examine the impact of an intervention.

The *Andilaye* intervention was a theoretically-informed WASH intervention, that targeted intermediate behavioral factors to facilitate uptake of improved WASH behaviors and improve mental well-being in Amhara, Ethiopia (Delea et al., 2019). It was developed to address gaps in existing community-based, demand-side WASH interventions. Psychosocial, contextual, and technological factors were

addressed as part of a multi-level intervention package implemented at the household, community, and district levels. An impact evaluation of the intervention, the *Andilaye* Trial, was conducted as a cluster-randomized trial, with half of the study clusters receiving the *Andilaye* intervention and half receiving the current standard of care sanitation and hygiene programming (Delea et al., 2019).

We sought to evaluate the impacts of the *Andilaye* intervention and its associated behavioral outcomes using the novel qPHAT metric to assess facial and hand cleanliness, proxy measures of personal hygiene practices. This research builds on previous assessments of the relationships between intermediate behavioral factors and handwashing by extending these examinations to behavioral factors associated with facewashing, a key prevention measure promoted in the WHO-endorsed SAFE strategy for trachoma elimination. The objective of this study was to assess the relationships between measures of facial and hand cleanliness outcomes and intermediate contextual, technological, and psychosocial factors and personal hygiene practices.

Methods

This research assessed the potential associations between measures of hand and facial cleanliness and intermediate behavioral factors (e.g., psychosocial, contextual, and technological factors) and reported personal hygiene practices observed during the *Andilaye* Trial. The objective of this study was to quantify the relationships between intermediate behavioral factors, personal hygiene outcomes, and differences therein associated with the *Andilaye* intervention, using the qPHAT metric as a proxy indicator of hygiene outcomes. The primary research question (RQ1) for this sub-study was: What associations exist between quantitative assessments of (a) facial and (b) hand cleanliness and intermediate contextual, technological, and psychosocial behavioral factors and reported personal hygiene practices in the context of the *Andilaye* Trial? Our secondary research question (RQ2) was: Is there a causal association between quantitative measures of (a) facial and (b) hand cleanliness and the *Andilaye* intervention?

Study Population

The *Andilaye* Trial was carried out in Amhara, Ethiopia, a region with poor WASH conditions (*Ethiopia Demographic and Health Survey, 2016*). In 2016, only 5% of households in Amhara had access to soap and water for handwashing, which was the lowest rate compared to other regions of Ethiopia (*Ethiopia Demographic and Health Survey, 2016*). The *Andilaye* Trial was a parallel cluster-randomized trial conducted in 50 rural or peri-urban sub-districts, or *kebeles* (i.e., clusters), with half of the study clusters receiving the *Andilaye* intervention, and half receiving the standard of care intervention, community-led total sanitation and hygiene (CLTSH). The three districts, or *woredas*, chosen for the *Andilaye* Trial - Bahir Dar Zuria, Fogera, and Farta - were targeted for this study given they represented a range of the topographical conditions in Amhara.

Details of the *Andilaye* Trial are published elsewhere (Delea et al., 2019). Briefly, we employed a structured sampling strategy to randomly select *kebeles* from a list of eligible *kebeles* in the three targeted *woredas*. The primary sampling unit for the trial was the *kebele*. The secondary sampling unit for the trial was the household; specifically, any household residing in a targeted, sentinel village (*gott*) within a randomly selected study *kebele*. Households were randomly selected for inclusion in the *Andilaye* Trial from *gott* census books (i.e., the household-level sampling frame), and were enrolled in the study just prior to baseline data collection during May - June 2017. Randomly selected households were enrolled in the trial if they met the study's inclusion criteria, which reflected any household that: (1) had at least one child aged 1–9 years at baseline (i.e., the household's index child) that consented to allowing study staff to observe the child, specifically the child's faces and hands, and (2) provided consent to participate in the study, with at least one adult household member consenting to serve as the primary survey respondent.

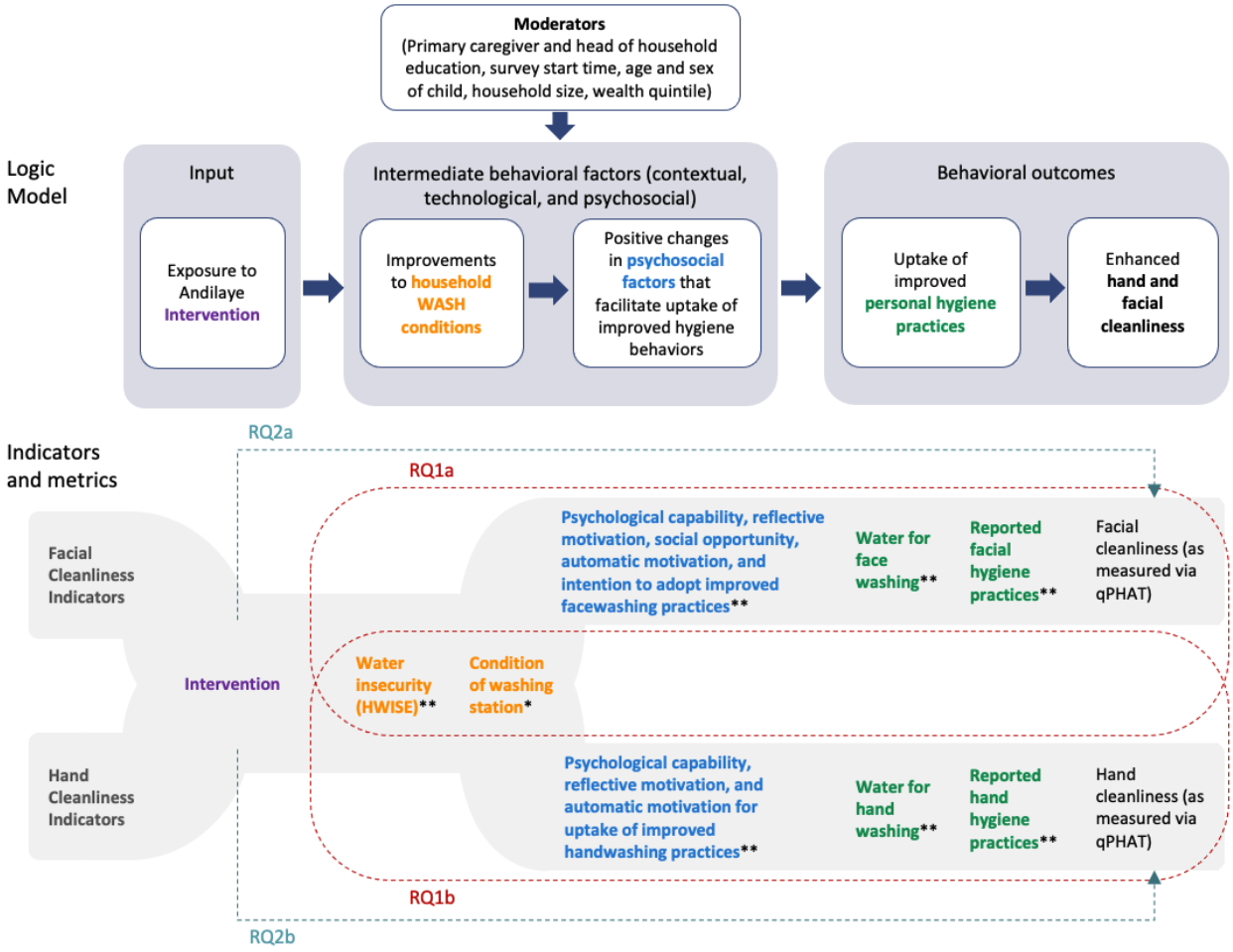
Data Source

Data for this study were collected as part of the *Andilaye* Trial's endline data collection, which took place during March - May 2019. Enumerators targeted primary survey respondents, based on the following order of priority: (1) the primary female caregiver of the index child, (2) any female household member

who was a caregiver, (3) any male household member who was a caregiver, and (4) any household member over 18 years of age. Survey questions collected information on household demographics, water and hygiene practices, the quality and accessibility of washing stations, and facial and hand cleanliness via the qPHAT metric, amongst other data points required for the evaluation. Households were excluded from this analysis if hand and facial cleanliness data were not collected from the index child due to the absence of the child during the endline survey or refusal of the index child or respondent to allow these data to be collected.

Variables

The conceptual diagram presented in Figure 1 reflects a summarized version of the *Andilaye* Trial's logic model as well as the indicators and metrics used to analyze the relationships examined in this study. For RQ1, the variables considered as intermediate behavioral factors fall under one of three main categories; (1) household WASH conditions (i.e., contextual and technological factors), (2) psychosocial behavioral factors (e.g., internalized risk and capability, perceptions, attitudes, and norms), and (3) reported personal hygiene practices.



RQ 1 – What associations exist between quantitative assessments of (a) facial and (a) hand cleanliness and intermediate behavioral factors (e.g., contextual, technological, and psychosocial) and personal hygiene practices in the context of the *Andilaye* Trial?
RQ 2 - Is there a causal association between quantitative assessments of (a) facial and (b) hand cleanliness and the *Andilaye* intervention?
Notes: *Observed; **Reported

Figure 1 – Conceptual flow diagram depicting a summarized version of the *Andilaye* Trial's logic model (top section); indicators and metrics used for this study (middle section); the dotted ovals and arrows encompass the indicators and metrics assessed via the primary and secondary research questions (two overlapping dotted ovals and two dotted arrows, respectively) that are written out below the image (bottom).

Outcomes of interest: Hand and facial cleanliness

The outcomes of interest for both RQ1 and RQ2 were hand and facial cleanliness, as measured via the qPHAT metric, for the index child, or the youngest child aged 1-11 years (at endline; aged 1-9 years at baseline) residing in the study household. To obtain quantitative cleanliness data via the qPHAT

methodology, enumerators used gauze pads pre-moistened with sterile saline (Hygea), with excess solution removed, to collect one wipe from the skin around the eyes and one wipe from the skin of the inside of the index child's right hand. Enumerators employed standardized procedures to trace the skin along the index child's eyes and hand. The wipes were then scored against the 11-point qPHAT color scale by trained raters (i.e., the enumerator), with higher scores representing cleaner wipes and lower scores representing dirtier wipes (Delea et al., 2020).

Household WASH conditions

We assessed household WASH conditions using two primary measures; (1) level of water insecurity, and (2) presence and quality of household washing station. Water insecurity was quantified using the cross-culturally validated Household Water Insecurity Experiences (HWISE) scale (Young et al., 2019). Respondents reflected on 12 prompts designed to assessed their perceived level of water insecurity. As recommended by the HWISE scale developers, responses were added together to create a score between 0 and 36, with higher scores representing higher levels of water insecurity. The quality of the washing station was evaluated based on the presence/absence of water and soap or soap substitute, as observed by the survey enumerators. These indicators of the household WASH conditions were used based on the definitions used in the WHO/UNICEF Joint Monitoring Programme (JMP) for Water Supply, Sanitation, and Hygiene (UNICEF & WHO, 2018).

Psychosocial factors

The psychosocial factors considered in these analyses represent behavioral factors that typically reflect antecedents, or precursors of behavior that often need to be addressed before behavior change can occur. The development of the *Andilaye* intervention and the design of the survey questions employed during the *Andilaye* Trial were grounded in several behavioral theories and frameworks, including the *Theory of Triadic Influence* (Flay & Petraitis, 1994), the *Risks, Attitudes, Norms, Abilities, and Self-Regulation* (RANAS) approach (Mosler, 2012), and the *Capability, Opportunity, Motivation, and Behavior* (COM-B) model (Michie et al., 2011). Respondents were asked to respond to a range of statements reflecting various psychosocial factors including their internalized risks and capabilities, attitudes, and

norms related to their own personal hygiene and the hygiene practices of the index child. Respondents were asked to indicated their level of agreement with each statement on a 5-point Likert-type scale (i.e., completely disagree, partially disagree, neither agree nor disagree, partially agree, completely agree). Psychosocial factors were included in the models on a continuous scale (Champion, 1985; Fishbain et al., 2008; Odom et al., 2010). The full list of survey prompts related to psychosocial factors that were considered in this analysis can be found in Appendix B.

Personal hygiene practices

Two variables were considered for assessing personal hygiene practices: (1) the reported personal hygiene practices of the index child, and (2) the perceived availability of water for hygiene practices. Personal hygiene practices were reported by the survey respondent. Respondents were asked to indicate if their children's hands and faces were cleaned during the day prior to the survey, and if so, if soap (or soap substitute) and water were used. Respondents were also asked if they had sufficient water for their hand and facial hygiene practices during the day prior to the survey. Responses were dichotomous (yes/no).

Moderators

Moderators of the relationships between intermediate behavioral factors and facial/hand cleanliness were considered in these analyses. The educational attainment of the primary caregiver and head of household were included on a dichotomous scale, comparing those that had below a secondary education level to those that had at least a secondary education level. The age and sex of the index child were also included. The time of day of the survey was included as a moderator based on previous studies assessing its potential effect on hygiene outcomes (Harding-Esch et al., 2020). The time of day of the survey was included in the model on a continuous scale. Times that fell outside of reasonable survey times (i.e., before 5:00 AM and after 5:00 PM East Africa Time [EAT]) were considered outliers and were excluded from the analysis. The socioeconomic status of the household was considered by including household size and a wealth index variable. The wealth index was created by conducting a principal component analysis of variables that were collected at baseline to reflect a wide range of household assets (Appendix C). The development of the wealth index aligns with the variables used in the most recent Ethiopia DHS survey

(*Ethiopia Demographic and Health Survey 2016*, 2016). After wealth index values were calculated, households were split into quintiles, with the lowest quintile being the poorest households and the highest quintile representing the wealthiest households.

Statistical Analyses

Four multivariable generalized linear models were used for our analysis, outlined in more detail in Appendix D. For RQ1, all variables reflecting intermediate behavioral factors (contextual, technological, and psychosocial), personal hygiene practices, and moderators were included as covariates. Two multivariable models including the intervention group and adjusting for moderators were assessed for RQ2 to determine if a causal association exists between facial and hand cleanliness outcomes and the *Andilaye* intervention. The same set of moderators, as defined above, were used to adjust all models. For RQ1a and RQ2a, the outcome measure was qPHAT scores for facial cleanliness, and for RQ1b and RQ2b, the outcome measure was qPHAT scores for hand cleanliness.

We assessed multicollinearity between all covariates to determine if any needed to be removed from the models. For the facial cleanliness prediction model, the "Takes too much time" and "Takes too much water" psychosocial factors were found to be correlated (correlation coefficient = 0.72), and the "Beliefs of social group" and "Cleanliness of social group" factors were strongly correlated (correlation coefficient = 0.62). To address this, the "Takes too much time" and "Beliefs of social group" variables were excluded from the multivariable analyses as it was believed that the other variables more strongly represented the psychosocial factors we wanted to assess. For the hand cleanliness prediction model, the "Ability to wash after defecating" and "Ability to wash before eating" variables were strongly correlated (correlation coefficient = 0.79). The latter was removed from the multivariable analyses to avoid collinearity.

Analyses were conducted using R version 4.0.0 (R Core Team, 2020). Generalized linear regression frameworks were used for the qPHAT metric outcomes because the distribution of the outcome data was found to be non-normal. qPHAT outcomes were modeled on a linear scale under the assumption that,

because it is based on an 11-point scale with equal distribution between cut-points, it could be modeled as a continuous outcome (Donneau et al., 2014; McCullagh, 1980). All models developed for these analyses used generalized estimating equations with robust standard errors to account for the clustering at the *kebele* level.

Results

Descriptive Statistics and Unadjusted Univariable Analyses

Endline data collection reflect complete data from 1,472 (93%) of 1,589 households enrolled in the trial at baseline. Overall, 1,010 (69%) households with endline data had hand or facial cleanliness data collected from the index child and were included in the analysis, of which 490 received the *Andilaye* intervention and 520 received the standard of care (i.e., CLTSH) (see data flow diagram in Appendix A for more details). Primary female caregivers were the targeted respondents for the survey, so the majority of respondents were the mother of the index child (87.1%) or another female caregiver (5.5%). Approximately half the index children were girls (52.0%, n=525) and the average age of the children was 5.9 years (Interquartile range [IQR] = 4-7).

The average qPHAT score for facial cleanliness was 5.22 for the intervention group and 5.24 for the control group (Mean Difference=0.02, 95% CI = [-0.24, 0.27]; IQR = 4-7 for both groups). The qPHAT scores for hand cleanliness were lower (dirtier), on average, than those for facial cleanliness. The mean qPHAT score for hand cleanliness was 2.64 for the intervention group and 2.70 for the control group (Mean Difference=0.06, 95% CI = [-0.18, 0.31]; IQR = 1-4 for both groups). Figure 2 below shows the distribution for both measures of facial cleanliness and measures of hand cleanliness by intervention group.

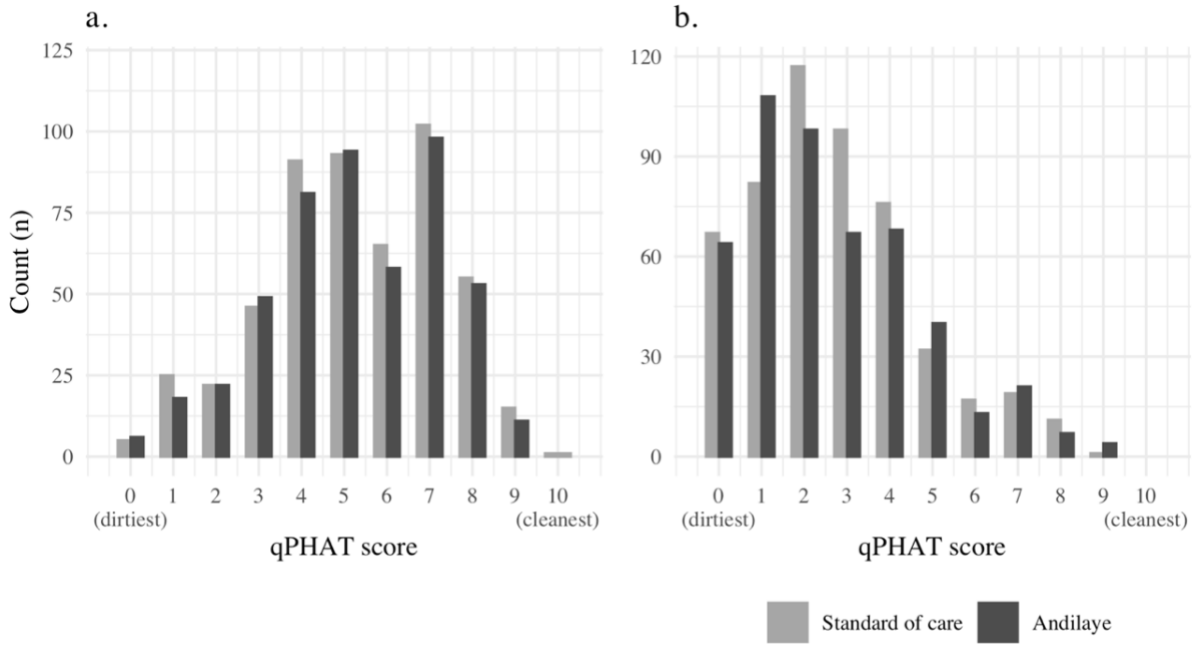


Figure 2 - qPHAT outcomes by intervention group: a. qPHAT scores for facial cleanliness measures; b. qPHAT scores for hand cleanliness measures

The quality of washing stations was relatively low for households enrolled in the study, as shown in Table 1, with only 2% of intervention households and 1.7% of control households having a washing station with water and soap. Few households (Intervention: n=21, 4.3%; Control: n=24, 4.6%) perceived that they were water insecure based on the HWISE score (having a score of 12 or higher). From the responses to questions assessing psychosocial factors (Table 3), in general, study households held values that supported motivators for improved hygiene practices. Most respondents reported improved personal hygiene practices, including washing with water and washing with water and soap, for both facial and hand hygiene, and most households reported that they had sufficient water for hand and face washing (Table 1).

RQ1 - Associations between quantitative measures of cleanliness and intermediate behavioral factors and outcomes

For RQ1a, we assessed the associations between intermediate behavioral factors (i.e., contextual, technological, and psychosocial), behavioral hygiene outcomes, and facial cleanliness, measured via the

qPHAT metric (Figures 3a and 3b). Level of water insecurity was negatively associated with facial cleanliness (β=-0.08, 95% CI [-0.12, -0.04]), indicating that households with a higher level of water insecurity were more likely to have dirtier faces. For psychosocial factors, the perception of the cleanliness of one's social group (social opportunity) was associated with cleaner faces (β=0.41, 95% CI [0.15,0.67]). Cleaner faces were also associated with the respondent's belief that facewashing takes too much water (reflective motivation) (β=0.26, 95% CI [0.10,0.57]). The level of commitment to washing (automatic motivation) was associated with dirtier faces (β=-0.61 95% CI [-0.99, -0.23]). The education level of the head of household and the size of the household were found to be significant moderators of these relationships. No significant associations were found between the condition of the household washing station, facial hygiene practices, or amount of water for face washing and facial cleanliness outcomes.

For RQ1b, we assessed what associations may exist between intermediate behavioral factors, behavioral outcomes, and hand cleanliness (Figures 4a and 4b). One psychosocial factor, the belief that hand washing takes too much water (reflective motivation), was found to be associated with cleaner hands (β=-0.26, 95% CI [-0.19, 0.43]). The education level of the primary caregiver, the time of survey collection, and the sex of the index child were found to be significant moderators of the relationships with hand cleanliness outcomes. No significant associations were found between hand cleanliness and the condition of the household washing station, water insecurity, hand hygiene practices or water for hand washing.

RQ2 - Association between quantitative measures of cleanliness and the *Andilaye* intervention

Results from the multivariable analyses conducted for RQ2 are shown in Figures 3c and 4c. The intervention was not statistically associated with facial (RQ2a) or hand (RQ2b) cleanliness outcomes (β=0.12, 95% CI [-0.23, -0.47] and β=0.05, 95% CI [-0.37, 0.46], respectively). The age and sex of the index child were significant moderators in the assessments of both hand and facial cleanliness outcomes.

Table 1 – Descriptive statistics and unadjusted univariable analyses for household characteristics and cleanliness practices for households enrolled in the study.

Variable	Levels	Intervention Group (n=490)	Control Group (n=520)	Univariable analysis w/ facial cleanliness outcome		Univariable analysis w/ hand cleanliness outcome	
				Unadjusted Est. (95% CI)	p-value	Unadjusted Est. (95% CI)	p-value
Measures of hand and facial cleanliness							
qPHAT scores for facial cleanliness – mean (IQR)		5.22 (4-7)	5.24 (4-7)				
qPHAT scores for hand cleanliness – mean (IQR)		2.64 (1-4)	2.70 (1-4)				
Intervention Group							
Intervention Group	Received *Andilaye* Intervention			-0.02 (-0.35, 0.32)	0.925	-0.06 (-0.42, 0.30)	0.731
Household WASH conditions							
Condition of washing station – n (%)	Absent of any washing materials or washing station	8 (1.6)	13 (2.5)	Reference Level		Reference Level	
	At least one washing station present but without water or soap/soap substitute	374 (76.3)	397 (76.3)	0.60 (-0.31, 1.52)	0.197	0.50 (-0.13, 1.12)	0.120
	At least one washing station present with water only	98 (20.0)	101 (19.4)	1.14 (0.25, 2.03)	0.012	0.62 (-0.03, 1.27)	0.060
	At least one water station present with both water and soap/soap substitute	10 (2.0)	9 (1.7)	1.32 (0.09, 2.55)	0.035	1.54 (0.11, 2.98)	0.035
Water Insecurity (HWISE) – n (%)**	Not perceived to be water insecure (HWISE <12)	346 (70.6)	244 (46.9)	-0.05 (-0.08, -0.02)	0.004	-0.04 (-0.07, -0.01)	0.019
	Perceived to be water insecure (HWISE ≥12)	21 (4.3)	24 (4.6)				
	Missing	123 (25.1)	252 (48.5)				
Personal Hygiene Practices							
Facial hygiene practices – n (%)	Child's face was not cleaned	11 (2.2)	9 (1.7)	Reference Level			
	Child's face was cleaned/wiped without water or soap	11 (2.2)	9 (1.7)	0.70 (-0.35, 1.75)	0.192		

	Child's face was cleaned with water only	310 (63.3)	357 (68.6)	-1.02 (-1.87, -0.16)	0.19		
	Child's face was cleaned with water and soap	155 (31.6)	141 (27.1)	-0.86 (-1.73, 0.02)	0.055		
	Missing	3 (0.6)	4 (0.8)				
Hand hygiene practices – n (%)	Child's hands were not cleaned	6 (1.2)	10 (1.9)			Reference Level	
	Child's hands cleaned with water only	262 (53.5)	286 (55.0)			-0.49 (-1.34, 0.36)	0.261
	Child's hands cleaned with water and soap	216 (44.1)	209 (40.2)			-0.10 (-0.97, 0.76)	0.815
	Missing	6 (1.2)	15 (2.9)				
Water for face washing – n (%)	Did not have sufficient water	10 (2.0)	16 (3.1)	Reference Level			
	Had sufficient water	479 (97.8)	504 (96.9)	0.44 (-0.37, 1.24)	0.288		
	Missing	1 (0.2)	0				
Water for hand washing – n (%)	Did not have sufficient water	13 (2.7)	13 (2.5)			Reference Level	
	Had sufficient water	476 (97.1)	507 (97.5)			0.14 (-0.48, 0.76)	0.660
	Missing	1 (0.2)	0				
Moderators							
Education level of primary caregiver - n (%)	Primary caregiver/mother has below secondary education level	430 (87.8)	446 (85.8)	Reference Level		Reference Level	
	Primary caregiver/mother has at least secondary education level	60 (12.2)	73 (14.0)	0.43 (0.02, 0.85)	0.038	0.36 (-0.06, 0.77)	0.091
	Missing	0	1 (0.2)				
Education level of head of household n (%)	Head of household has below secondary education level	367 (74.9)	351 (67.5)	Reference Level		Reference Level	
	Head of household has at least secondary education level	69 (14.1)	81 (15.6)	0.51 (0.20, 0.82)	0.001	0.40 (-0.07, 0.87)	0.093
	Missing	54 (11.0)	88 (16.9)				
Survey start time n (%)**	Early Morning (5:00 AM – 7:59 AM)	299 (61.0)	296 (56.9)	-0.02 (-0.11, 0.07)	0.711	-0.01 (-0.10, 0.07)	0.803
	Mid-morning (8:00 AM – 10:59 AM)	172 (35.1)	189 (36.3)				
	Afternoon (11:00 AM – 1:00 PM)	9 (1.8)	14 (2.7)				

	Missing	10 (2.0)	21 (4.0)				
Age of index child –	Mean (IQR)	5.88 (4-7)	5.92 (4-7)	0.08 (0.02, 0.13)	0.005	0.08 (0.01, 0.04)	0.017
Sex of index child n (%)	Male	236 (48.2)	248 (47.7)	Reference Level		Reference Level	
	Female	254 (51.8)	271 (52.1)	-0.33 (-0.55, -0.12)	0.002	-0.25 (-0.45, -0.05)	0.014
		0	1 (0.2)				
Size of household –	Mean (IQR)	5.34 (4-6)	5.31 (4-6)	-0.07 (-0.16, 0.01)	0.103	-6.45e-03 (-0.09, 0.08)	0.880
Wealth quintile index - n (%)**	First quintile (poorest)	22 (4.5)	25 (4.8)	-0.10 (-0.27, 0.07)	0.223	-0.13 (-0.35, 0.09)	0.225
	Second quintile	18 (3.7)	35 (6.7)				
	Third quintile	62 (12.7)	82 (15.8)				
	Fourth quintile	96 (19.6)	113 (21.7)				
	Fifth quintile (wealthiest)	90 (18.4)	63 (12.1)				
	Missing	202 (41.2)	202 (38.8)				

** Descriptive statistics presented as categorical variable. Unadjusted univariable estimates calculated with variable on continuous scale.

Table 2 – Descriptive statistics and unadjusted univariable analyses for psychosocial factors related to hand and facial cleanliness for households enrolled in the study and responded to psychosocial factors questions.

	COM-B framework category	**Behavior Factors** (0=”completely disagree”; 4=”completely agree”)	**Intervention Group** (n=474)	**Control Group** (n=483)	**Univariable analysis** Unadjusted Est (95% CI)	p-value
Facial cleanliness factors						
	Psychological capability	Risk to others	3.60 (4)	3.41 (4)	0.07 (-0.08, 0.21)	0.356
		Risk to index child	3.85 (4)	3.88 (4)	0.06 (-0.27, 0.39)	0.724
		Benefit to index child	3.94 (4)	3.93 (4)	-0.07 (-0.54, 0.40)	0.770
		Ability to wash	3.75 (4)	3.62 (4)	9.23e-03 (-0.24, 0.26)	0.942
	Reflective motivation	Takes too much time	0.57 (0)	0.52 (0)	0.14 (0.01, 0.26)	0.040
		Takes too much water	0.63 (0)	0.64 (0)	0.14 (0.02, 0.26)	0.022
		Use of water	3.74 (4)	3.81 (4)	-0.08 (-0.29, 0.13)	0.452
	Social opportunity	Beliefs of social group	3.40 (4)	3.30 (4)	0.26 (0.08, 0.44)	0.004
		Cleanliness of social group	3.19 (3)	2.98 (3)	0.33 (0.17, 0.50)	<0.001
		Belief in value of cleanliness	3.80 (4)	3.78 (4)	0.24 (0.00, 0.49)	0.049
	Automatic motivation	Commitment to washing	3.75 (4)	3.65 (4)	-0.09 (-0.34, 0.16)	0.470
		Plan for washing	3.78 (4)	3.70 (4)	5.32e-03 (-0.26, 0.27)	0.969
	Intention analysis	Intention for washing	3.69 (4)	3.72 (4)	0.04 (-0.16, 0.23)	0.722
Hand cleanliness factors						
	Psychological capability	Risk to index child	3.83 (4)	3.84 (4)	-0.09 (-0.44, 0.26)	0.610
		Ability to wash after defecating	3.30 (4)	3.03 (3)	0.29 (0.20, 0.39)	<0.001
		Ability to wash before eating	3.27 (4)	3.05 (3)	0.28 (0.19, 0.38)	<0.001
	Reflective motivation	Takes too much water	1.34 (0)	1.41 (0)	0.12 (0.04, 0.20)	0.003
	Automatic motivation	Commitment to washing	3.58 (4)	3.42 (4)	0.19 (0.04, 0.34)	0.014

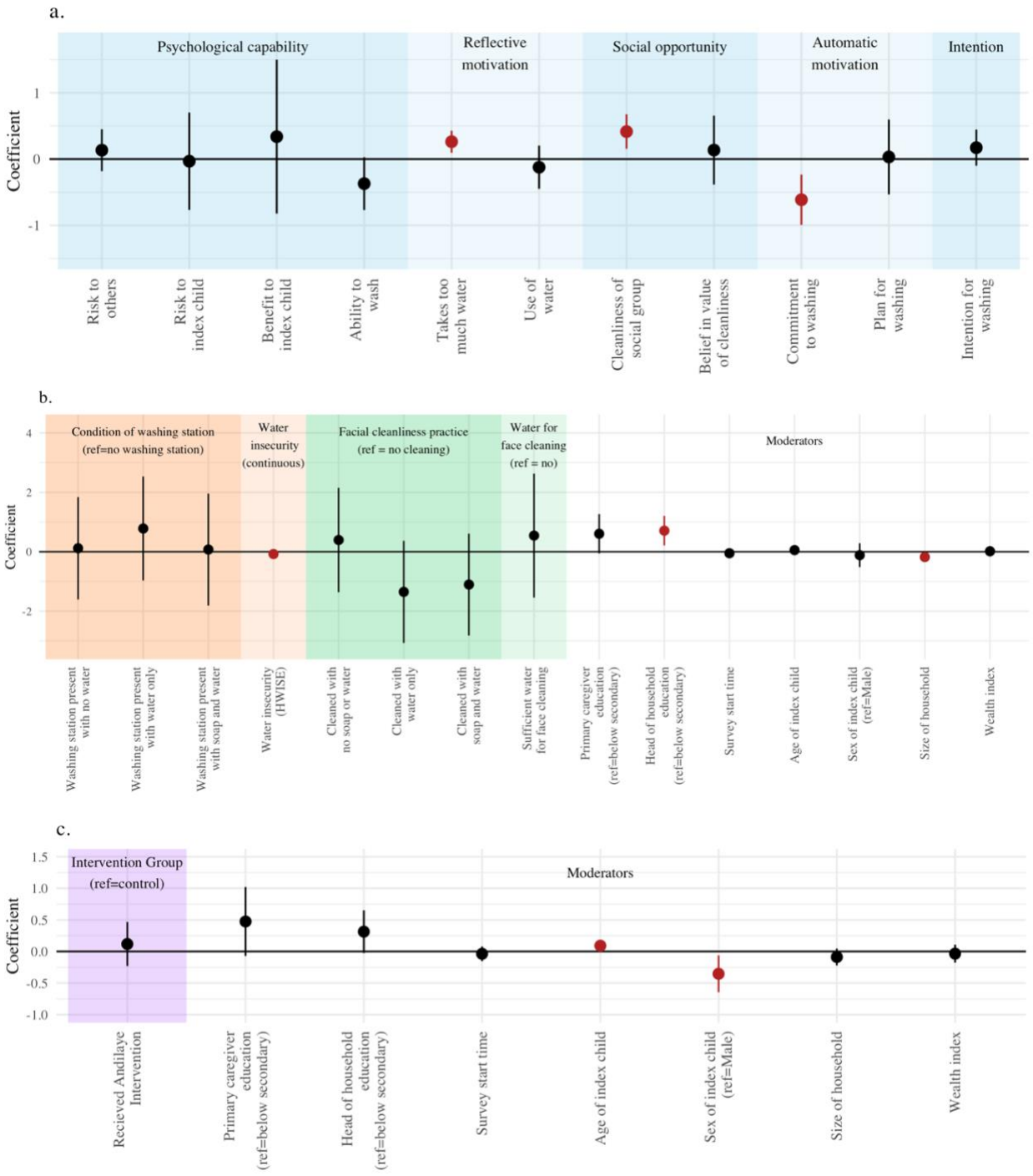


Figure 3 – Facial cleanliness outcomes; a. Adjusted estimates and 95% confidence intervals for all psychosocial factors for RQ1a, adjusting for all other variables in the model. b. Adjusted estimates and 95% confidence intervals for variables assessing household WASH conditions, facial hygiene practices, and potential moderators for RQ1a, adjusting for all other variables in the model. c. Adjusted estimates and 95% confidence intervals for intervention group and moderators for RQ2a, adjusting for all other variables in the model. Significant findings (α=0.05) for all are highlighted in red.

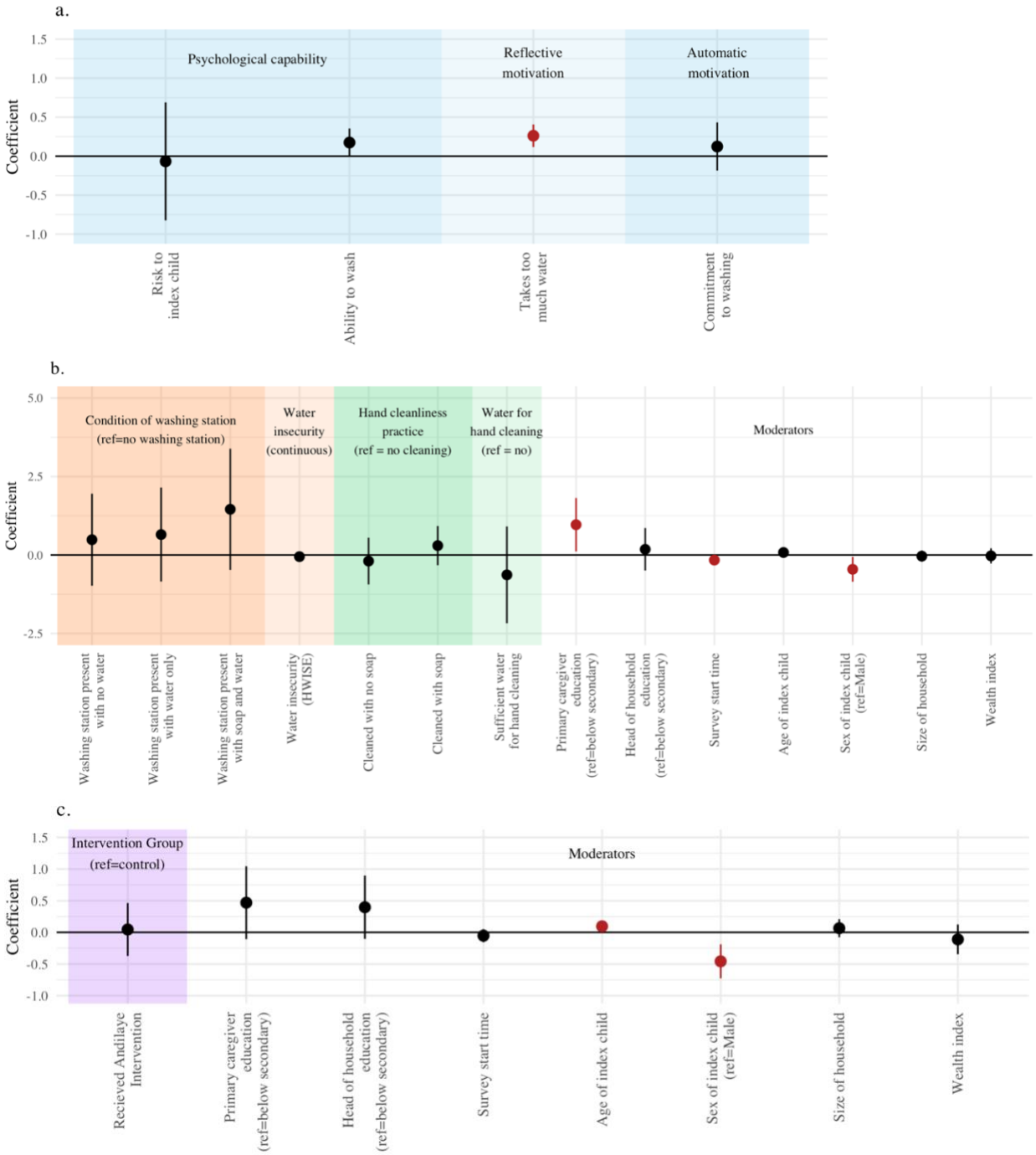


Figure 4 – Hand cleanliness outcomes; a. Adjusted estimates and 95% confidence intervals for all psychosocial factors for RQ1b, adjusting for all other variables in the model. b. Adjusted estimates and 95% confidence intervals for variables assessing household WASH conditions, hand hygiene practices, and potential moderators for RQ1b, adjusting for all other variables in the model. c. Adjusted estimates and 95% confidence intervals for intervention group and moderators for RQ2b, adjusting for all other variables in the model. Significant findings (α=0.05) for all are highlighted in red.

Discussion

We assessed relationships between intermediate contextual, technological, and psychosocial behavioral factors, reported personal hygiene practices, and indicators of facial and hand cleanliness in the context of the *Andilaye* Trial. The scores from the qPHAT metric showed that most study participants had at least some dirt on both their faces and hands, without significant differences between intervention groups. The average scores for hand cleanliness were low, indicating that most participants' hands were dirty. We found that water insecurity was associated with facial cleanliness and that several psychosocial factors were associated with facial and hand cleanliness, as measured using qPHAT. The condition of household washing stations and reported hygiene practices were not associated with facial or hand cleanliness. The *Andilaye* intervention did not lead to significant differences in facial or hand cleanliness outcomes.

Households with a higher level of perceived water insecurity were more likely to have index children with dirtier faces. The conditions of washing stations were not associated with facial cleanliness. Observations of household washing stations may not be accurate indicators of personal hygiene (i.e., washing) practices. In other words, presence of washing hardware does not equate to personal hygiene practices (Biswas et al., 2017; Hulland et al., 2013). Many components beyond just the availability of water and soap at the washing station, including capacity, durability and location of the washing station within the household as well as socio-contextual factors, play a role in driving the use of washing stations (Biswas et al., 2017; Hulland et al., 2013). Therefore, household water insecurity may act as a stronger indicator of contextual factors driving a household's ability to carry out hygiene practices than the observation of a household washing station. As supported by our findings, water insecurity should be considered a key contextual factor that influences the uptake of behavior change in future hygiene promotion interventions and evaluations thereof.

While the manner in which water insecurity experiences influence hygiene behaviors has been established previously (Nounkeu et al., 2019; Polack et al., 2006; Seimetz et al., 2016), the COVID-19 pandemic has further highlighted the relationship, particularly in low- and middle-income settings (Brauer

et al., 2020; Stoler et al., 2020). The findings of this research add to previous evidence by suggesting there is a relationship between water insecurity and behavioral outcomes (i.e., qPHAT scores). These findings also demonstrate the relationships that can be identified with higher-resolution and quantifiable measures of behavioral factors (HWISE) and outcomes (qPHAT). Both HWISE and qPHAT were developed out of the need for reliable measures of hygiene behavioral factors (Delea et. al., 2020; Young et. al., 2019). The findings from this research highlight the value of using quantitative and nuanced measures of hygiene factors and outcomes, such as HWISE and qPHAT, to identify important relationships that can be addressed during hygiene interventions.

Several significant associations were found between psychosocial factors and qPHAT measures of hand and facial cleanliness. Evidence suggests that psychosocial factors influence personal hygiene decisions, as indicated by our study results, however these factors may also be prone to reporting bias (V. A. Curtis et al., 2009; B. E. Scott et al., 2007; Seimetz et al., 2016). The findings from this research reflect motivators for hygiene practices, although they do not necessarily equate to behavioral adoption. For example, reported commitment to washing was associated with dirtier faces, signaling that people with poor cleanliness outcomes at least intended to adopt improved hygiene practices even if those intentions did not result in behavioral adoption. As reflected in several behavioral models, commitment is an important, but not sufficient antecedent of behavioral adoption (Gollwitzer & Sheeran, 2006). Perceptions regarding the cleanliness of others in one's social group was associated with cleaner faces, suggesting that empirical expectations or social pressures may influence hygiene decisions. On the other hand, the belief that washing takes too much water was associated with both cleaner hands and faces, which contradicts the aforementioned association between water insecurity and dirtier faces. Given the findings reflecting the importance of empirical expectations, this may suggest that people are willing to overcome their perceptions about the amount of water needed for washing in order to conform to social pressures. These results provide insight into behavioral antecedents that may influence hygiene outcomes but also reflect the fact that reported beliefs, attitudes, and intentions do not necessarily equate to behavioral adoption (Contzen et al., 2015; De Wandel et al., 2010; Hutton & Chase, 2016; O'Boyle et al., 2001).

Reported personal hygiene practices were not associated with qPHAT cleanliness scores, indicating that reported practices may not be reliable in predicting cleanliness outcomes. Improved personal hygiene practices, per respondent report, were prevalent for both hand and facial washing, and most households felt they had sufficient water for hand and facial washing practices. However, qPHAT scores indicated that hand and facial cleanliness was poor among the study population. Over-reporting of hygiene practices is common in studies examining hygiene (Biran et al., 2008; Contzen et al., 2015; V. Curtis et al., 1993; Hutton & Chase, 2016; Manun'Ebo et al., 1997), which poses challenges for monitoring and evaluating hygiene behavior change interventions. This finding further highlights the need for valid and objective measures of hygiene and the potential value of the qPHAT metric in providing a measure of hygiene outcomes that is less prone to bias.

The *Andilaye* intervention did not result in meaningful changes in hand or facial cleanliness within the study period. As presented in this study, there are many contextual, technological, and psychosocial factors that act to influence a person's personal hygiene practices (Assefa & Kumie, 2014; V. A. Curtis et al., 2009; B. Scott et al., 2007; B. E. Scott et al., 2007). In order to fully understand the scope of the changes caused by an intervention, it is often important to evaluate the intermediate behavioral determinants that drive hygiene behavior change (Dreibelbis et al., 2013; Parker Fiebelkorn et al., 2012). Understanding the factors influencing behavior change helps to provide information about the reasons that different people and communities make decisions, which is valuable for designing new interventions that can address those factors and facilitate behavioral adoption and maintenance. Hygiene interventions grounded in behavioral theory and evaluations that assess intermediate behavioral factors may be able to more fully examine and enhance intervention impact (Dreibelbis et al., 2013).

This research had some limitations. Some data for this research, including data used to develop the wealth index, was collected during the baseline survey. It is possible that some household-level factors may have changed between the baseline and endline surveys, impacting the accuracy of the wealth index. Additionally, several variables were subject to reporting bias, including the reported personal hygiene practices, which may not reflect actual hygiene behaviors.

Conclusion

This study assessed the relationships between measures of hand and facial cleanliness and intermediate contextual, technological, and psychosocial behavioral factors as well as reported hygiene practices. Water insecurity was found to be an important contextual factor associated with facial cleanliness outcomes. The other contextual factor considered in this analysis, condition of household washing stations, was not associated with cleanliness outcomes. Significant findings of psychosocial factors provided insight into behavioral antecedents that influence hygiene behaviors, including the role of empirical expectations in influencing facial hygiene practices. Reported personal hygiene practices were not associated with cleanliness outcomes, which suggests potential biases in reporting hygiene practices. We found no association between the intervention group and cleanliness outcomes, highlighting the importance of understanding intermediate behavioral factors in driving hygiene practices. This research adds to existing studies assessing intermediate behavioral determinants of hygiene practices, which primarily focus on handwashing, by evaluating the outcome of facial cleanliness. This is also the first paper using the qPHAT metric to assess the impact of an intervention. Continued research looking at the role of intermediate behavioral factors on hygiene outcomes over time and under different cultural contexts would be valuable in further exploring these relationships.

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Appendices

Appendix A – Data Flow Diagram

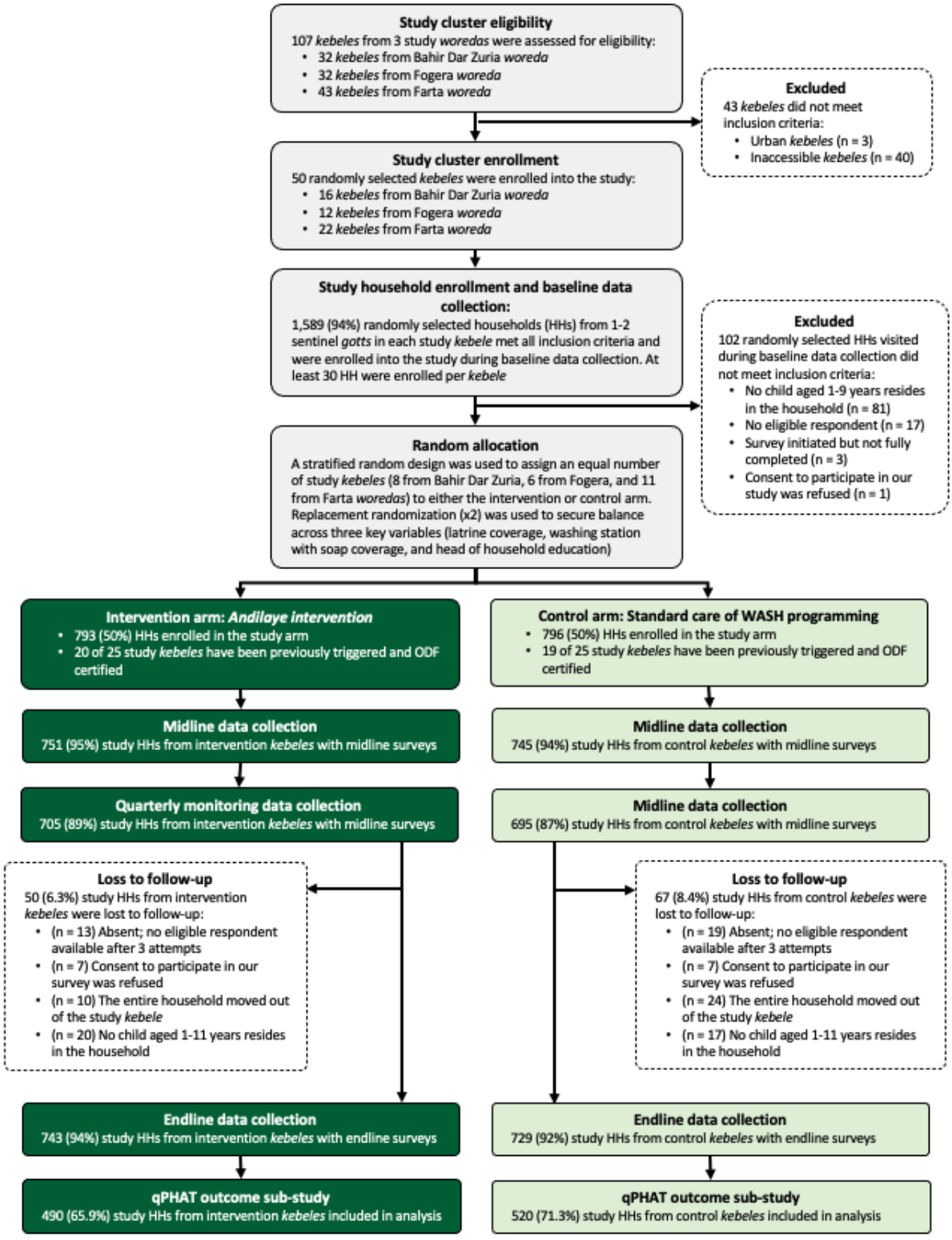

Figure A.1 – *Andilaye* trial data flow diagram, developed based on *Andilaye* intervention design paper (Delea et al., 2019)

Appendix B – Psychosocial Factor Variables

Table B.1 – Psychosocial factors considered in facial and hand cleanliness prediction models

COM-B framework category	Variable Name	Survey Prompt (0=”completely disagree”; 4=”completely agree”)
Facial cleanliness factors		
Psychological capability	Risk to others	If my children's faces are not washed when they are dirty, others in the community may have an increased risk of becoming infected with a disease.
	Risk to index child	My children may become sick or lose their eyesight if they have dirty faces.
	Benefit to index child	Washing my children's faces when they are dirty can keep them healthy.
	Ability to wash	I have the ability to wash my children's faces whenever they are dirty.
Reflective motivation	Takes too much time	Facewashing takes too much time.
	Takes too much water	Facewashing takes too much water.
	Use of water	To clean my children's faces, I prefer using water over wiping debris from their faces when it's dry.
Social opportunity	Beliefs of social group	Most of my relatives, neighbours, and friends believe that children ought to have a clean face.
	Cleanliness of social group	Most of my relatives, neighbours, and friends ensure their children's faces are clean throughout the day.
	Belief in value of cleanliness	I am personally committed to washing my children's faces whenever they are dirty.
Automatic motivation	Commitment to washing	I have a plan to wash my face and my children's faces daily, even when there are challenges.
	Plan for washing	I intend to ensure my children's faces are washed with water on a daily basis.
Intention analysis	Intention for washing	I am personally committed to washing my children's faces whenever they are dirty.
Hand cleanliness factors		
Psychological capability	Risk to index child	Having dirty hands can cause my children to become sick.
	Ability to wash after defecating	I have the ability to ensure my children's hands are washed with soap or ash after they defecate.
	Ability to wash before eating	I have the ability to ensure my children's hands are washed with soap or ash before they eat.
Reflective motivation	Takes too much water	Handwashing with soap or ash takes too much water.
Automatic motivation	Commitment to washing	I am personally committed to ensuring my children's hands are washed with soap or ash before they eat.

Appendix C – Variables for Wealth Index

Table C.1 – Full list of variables used in principal component analysis to develop the wealth index variable, based on variables used in Ethiopia 2016 DHS survey (Ethiopia Demographic and Health Survey, 2016).

Variable Name	*Description*
I_1a	Working electricity
I_1b	Functioning radio set
I_1c	Functioning television
I_1d	Functioning bicycle
I_1e	Functioning motorcycle/scooter
I_1f	Functioning car/truck
I_1g	Functioning mobile phone
I_1h	Functioning mitad
I_1i	Functioning kerosene or pressure lamp
I_1j	One or more beds and one or more tables
I_1k	An enclosed bathing area
cattle0	No Cows/bulls/oxen/cattle
cattle1_4	Cows/bulls/oxen/cattle 1-4
cattle5_9	Cows/bulls/oxen/cattle 5-9
cattle10	Cows/bulls/oxen/cattle 10+
horses0	No horses, mules, or donkeys
horses1_4	horses, mules, or donkeys 1-4
horses5_9	horses, mules, or donkeys 5-9
horses10	horses, mules, or donkeys 10+
sheep0	No sheep or goats
sheep1_4	Sheep or goats 1-4
sheep5_9	Sheep or goats 5-9
sheep10	Sheep or goats 10+
chicken0	No chickens
chicken1_4	Chickens 1-4
chicken5_9	Chickens 5-9
chicken10	Chickens 10+
I_2a	A homestead/house
I_2b	Crop land
I_2c	Cash crops
I_3	Do any of the members of your household work their own or their family's agricultural land?
fuel_electricity	Electricity
fuel_gas	Gas
fuel_kerosene	Kerosene
fuel_charcoal	Charcoal
fuel_wood	Wood
fuel_dung	Dung, manure
fuel_biofuel	Corn cobbs or other biofuel
fuel_other	Other
income_crops	Selling crops
income_animals	Selling animal products
income_fishing	Fishing
income_dailylabor	Daily labour
income_farmlabor	Farm labour
income_business	Business/trade
income_salary	Salary

income_other	Other (e.g., gifts from others)
water1	Piped water into dwelling
water2	Piped water into yard/plot
water3	Public tap/standpost
water4	Tubewell/borehole
water5	Protected dug well
water6	Unprotected dug well
water7	Protected spring
water8	Unprotected spring
water9	Rainwater collection
water10	Bottled water
water11	Cart with small tank/drum
water12	Tanker-truck
water13	Surface water
water14	Machine dug, deep well
water15	Private water vendor
toilet1	Pit latrine with rudimentary platform (platform made with wood, and either NOT plastered, or poorly plastered so the pit is not properly sealed)
toilet2	Hanging toilet/latrine
toilet3	Pit latrine with solid platform of wood/logs and mud/dung plaster that properly seals the pit
toilet4	Pit latrine with concrete slab
toilet5	Pit latrine with concrete slab & water seal
toilet6	Composting toilet (toilet that ensures separation of urine, water, and excreta)
toilet7	Ventilated improved pit (VIP) latrine with concrete slab or solid platform that seals the pit
toilet8	Flush/pour flush to pit
toilet9	Flush/pour flush to septic tank
toilet10	Flush/pour flush to elsewhere
toilet777	Other
sh_toilet1	Shared - Pit latrine with rudimentary platform (platform made with wood, and either NOT plastered, or poorly plastered so the pit is not properly sealed)
sh_toilet2	Shared - Hanging toilet/latrine
sh_toilet3	Shared - Pit latrine with solid platform of wood/logs and mud/dung plaster that properly seals the pit
sh_toilet4	Shared - Pit latrine with concrete slab
sh_toilet5	Shared - Pit latrine with concrete slab & water seal
sh_toilet6	Shared - Composting toilet (toilet that ensures separation of urine, water, and excreta)
sh_toilet7	Shared - Ventilated improved pit (VIP) latrine with concrete slab or solid platform that seals the pit
sh_toilet8	Shared - Flush/pour flush to pit
sh_toilet9	Flush/pour flush to septic tank
sh_toilet10	Flush/pour flush to elsewhere
sh_toilet777	Other

Appendix D – Multivariable Model Equations

Research Question 1a

$$
\begin{aligned}
&qPHAT\ facial\ cleanliness\ score \\
&\quad = \alpha + \beta_1(Condition\ of\ HH\ wash\ station) + \beta_2(Overall\ water\ insecurity) \\
&\quad + \beta_3(Facial\ cleaning\ practice) + \beta_4(Water\ insecurity\ for\ facewashing) \\
&\quad + \beta_{5-15}(Behavioral\ factors\ for\ facewashing) \\
&\quad + \gamma_1(Education\ of\ primary\ caregiver) + \gamma_2(Education\ of\ head\ of\ household) \\
&\quad + \gamma_3(Wealth\ Index) + \gamma_4(Time\ of\ survey) + \gamma_5(Age\ of\ child) + \gamma_6(Sex\ of\ child) \\
&\quad + \gamma_7(Household\ Size) + \varepsilon
\end{aligned}
$$

Research Question 1b

$$
\begin{aligned}
&qPHAT\ hand\ cleanliness\ score \\
&\quad = \alpha + \beta_1(Condition\ of\ HH\ wash\ station) + \beta_2(Overall\ water\ insecurity) \\
&\quad + \beta_3(Hand\ cleaning\ practice) + \beta_4(Water\ insecurity\ for\ handwashing) \\
&\quad + \beta_{5-8}(Behavioral\ factors\ for\ handwashing) \\
&\quad + \gamma_1(Education\ of\ primary\ caregiver) + \gamma_2(Education\ of\ head\ of\ household) \\
&\quad + \gamma_3(Wealth\ Index) + \gamma_4(Time\ of\ survey) + \gamma_5(Age\ of\ child) + \gamma_6(Sex\ of\ child) \\
&\quad + \gamma_7(Household\ Size) + \varepsilon
\end{aligned}
$$

Research Question 2a

$$
\begin{aligned}
&qPHAT\ facial\ cleanliness\ score \\
&\quad = \alpha + \beta_1(Intervention\ Group) + \gamma_1(Education\ of\ primary\ caregiver) \\
&\quad + \gamma_2(Education\ of\ head\ of\ household) + \gamma_3(Wealth\ Index) \\
&\quad + \gamma_4(Time\ of\ survey) + \gamma_5(Age\ of\ child) + \gamma_6(Sex\ of\ child) \\
&\quad + \gamma_7(Household\ Size) + \varepsilon
\end{aligned}
$$

Research Question 2b

$$
\begin{aligned}
&qPHAT\ hand\ cleanliness\ score \\
&\quad = \alpha + \beta_1(Intervention\ Group) + \gamma_1(Education\ of\ primary\ caregiver) \\
&\quad + \gamma_2(Education\ of\ head\ of\ household) + \gamma_3(Wealth\ Index) \\
&\quad + \gamma_4(Time\ of\ survey) + \gamma_5(Age\ of\ child) + \gamma_6(Sex\ of\ child) \\
&\quad + \gamma_7(Household\ Size) + \varepsilon
\end{aligned}
$$

Appendix E – Multivariable Analysis Detailed Results

Table E.1 – Adjusted estimates, 95% confidence intervals and p-values for all variables included in the multivariable generalized linear model for facial cleanliness outcomes

Variable category	Level	Adjusted Coefficient	95% CI	p-value	
Household WASH conditions					
Household Washing Station (Reference = No washing Station)	At least one washing station present but w/o water (soap may or may not be present)	0.12	[-1.61, 1.84]	0.895	
	At least one washing station present w/ water only	0.78	[-0.97, 2.53]	0.381	
	At least one water station present with both water and soap/soap substitute	0.07	[-1.81, 1.96]	0.938	
Water Insecurity (HWISE)	(Continuous)	-0.08	[-0.12, -0.04]	< .001	*
Facial Cleanliness Practices					
Face Cleanliness Practices (Reference = Child's face not cleaned)	Child's face was cleaned/wiped without water or soap	0.4	[-1.36, 2.15]	0.659	
	Child's face was cleaned with water only	-1.35	[-3.07, 0.37]	0.123	
	Child's face was cleaned with soap and water	-1.11	[-2.82, 0.61]	0.207	
Water for Facial Cleanliness (Reference = No)	Did you have sufficient water for face cleaning?	0.54	[-1.54, 2.63]	0.609	
Psychosocial Factors					
Psychological capability	Risk to others	0.13	[-0.18, 0.45]	0.406	
	Risk to index child	-0.03	[-0.77, 0.70]	0.932	
	Benefit to index child	0.34	[-0.82, 1.50]	0.568	
	Ability to wash	-0.37	[-0.77, 0.03]	0.069	
Reflective motivation	Takes too much water	0.26	[0.10, 0.43]	0.002	*
	Use of water	-0.12	[-0.45, 0.20]	0.46	
Social opportunity	Cleanliness of social group	0.41	[0.15, 0.67]	0.002	*
	Belief in value of cleanliness	0.14	[-0.38, 0.66]	0.609	
Automatic Motivation	Commitment to washing	-0.61	[-0.99, -0.23]	0.002	*
	Plan for washing	0.03	[-0.53, 0.60]	0.912	
Intention analysis	Intention for washing	0.17	[-0.10, 0.44]	0.216	
Moderators					
Primary caregiver education level		0.6	[-0.06, 1.27]	0.074	
Head of household education level		0.71	[0.21, 1.21]	0.005	*
Survey Start time		-0.05	[-0.20, 0.10]	0.522	
Index Child Age		0.05	[-0.06, 0.17]	0.348	
Index Child Sex		-0.12	[-0.52, 0.29]	0.571	
Household Size		-0.18	[-0.33, -0.03]	0.018	*
Wealth quintile index		0.02	[-0.16, 0.19]	0.859	

Table E.2 – Adjusted estimates, 95% confidence intervals and p-values for all variables included in the multivariable prediction model for hand cleanliness outcomes

Category	Variable	Level	Adjusted Coefficient	95% CI	p-value	
Household WASH conditions						
	Household Washing Station (Reference = No WASH Station)	At least one washing station present but w/o water (soap may or may not be present)	0.49	[-0.98, 1.95]	0.516	
		At least one washing station present w/ water only	0.65	[-0.85, 2.15]	0.393	
		At least one water station present with both water and soap/soap substitute	1.46	[-0.48, 3.39]	0.139	
	Water Insecurity (HWISE)	(Continuous)	-0.05	[-0.10, 0.00]	0.051	
Hand Cleanliness Practices						
	Hand Cleanliness Practices (Reference = Child's hands were not cleaned)	Child's hands cleaned with water only	-0.19	[-0.94, 0.55]	0.61	
		Child's hands were cleaned with water and soap	0.3	[-0.33, 0.92]	0.348	
	Water for Hand Cleanliness (Reference = No)	Did you have sufficient water for hand cleaning?	-0.63	[-2.18, 0.91]	0.421	
Psychosocial Factors						
	Psychological capability	Risk to others	-0.07	[-0.82, 0.69]	0.862	
		Ability to wash	0.17	[-0.01, 0.35]	0.057	
	Reflective motivation	Takes too much water	0.26	[0.12, 0.41]	< .001	*
	Automatic motivation	Commitment to washing	0.12	[-0.19, 0.43]	0.435	
Moderators						
	Primary caregiver education level		0.97	[0.11, 1.82]	0.026	*
	Head of household education level		0.18	[-0.50, 0.86]	0.6	
	Survey Start time		-0.16	[-0.29, -0.03]	0.014	*
	Index Child Age		0.08	[-0.03, 0.19]	0.138	
	Index Child Sex		-0.46	[-0.85, -0.06]	0.024	*
	Household Size		-0.04	[-0.21, 0.14]	0.694	
	Wealth quintile index		-0.03	[-0.27, 0.21]	0.83	

Table E.3 – Adjusted estimates, 95% confidence intervals and p-values for all variables included in the causal association model for facial cleanliness outcomes.

Parameter	Adjusted Coefficient	95% CI	p-value	
Intervention Group	0.12	[-0.23, 0.47]	0.506	
Primary caregiver education level	0.47	[-0.07, 1.02]	0.088	
Head of household education level	0.31	[-0.03, 0.65]	0.07	
Start time	-0.04	[-0.15, 0.08]	0.531	
Index Child Age	0.09	[0.02, 0.16]	0.012	*
Index Child Sex	-0.35	[-0.65, -0.06]	0.018	*
Household Size	-0.09	[-0.22, 0.05]	0.2	
Wealth quintile index	-0.03	[-0.18, 0.11]	0.633	

Table E.4 – Adjusted estimates, 95% confidence intervals and p-values for all variables included in the causal association model for hand cleanliness outcomes.

Parameter	Adjusted Coefficient	95% CI	p-value	
Intervention Group	0.05	[-0.37, 0.46]	0.831	
Primary caregiver education level	0.47	[-0.11, 1.04]	0.111	
Head of household education level	0.4	[-0.10, 0.90]	0.12	
Start time	-0.05	[-0.16, 0.05]	0.324	
Index Child Age	0.1	[0.01, 0.18]	0.022	*
Index Child Sex	-0.46	[-0.73, -0.19]	< .001	*
Household Size	0.07	[-0.08, 0.21]	0.37	
Wealth quintile index	-0.11	[-0.35, 0.12]	0.356	