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In the Lake Zone of Tanzania, Behavioral Determinants Are Associated with Hygiene but Not Sanitation Practice

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Abstract

Understanding why individuals do or do not adopt optimal water, sanitation, and hygiene (WASH) practices is critical to designing successful behavior change interventions. However, policy makers and program implementers often fail to obtain the context-specific information on behavioral determinants of WASH practices. This two-stage, randomized survey among 5000 female primary caregivers in the Lake Zone of Tanzania assessed associations between behavioral determinants and a range of hygiene and sanitation practices. Behavioral determinants of hygiene were almost always significantly associated with cleaning one's own hands after cleaning the baby's bottom and being able to show at least one place where family members wash their hands. In regression models, those who knew when to wash their own hands (OR = 1.8, 95% CI: 1.5, 2.1) and their child's hands (OR = 1.5, 95% CI: 1.3, 1.7) and mothers who thought that their female friends washed their hands after cleaning the baby's bottom (OR = 5.5, 95% CI: 4.5, 6.7) were significantly more likely to frequently clean their own hands after cleaning the baby's bottom. This research suggests that in the Lake Zone of Tanzania, numerous determinants are associated with hygiene practices. Identifying context-specific determinants of WASH behaviors is the first step toward developing effective interventions.

Keywords

Behavioral Determinants, WASH, Tanzania

1. Introduction

Poor water, sanitation, and hygiene (WASH) contribute to sub-optimal health

and the impact of WASH practices on health and well-being is well documented [1] [2]. For example, hand washing with soap has been shown to reduce diarrhea risk by 48% and evidence suggests that proper use of latrines reduces diarrhea risk by 36% [3]. Improved household WASH facilities are associated with positive child nutrition health outcomes, including lower stunting and wasting rates [4]. Other studies have also shown associations between the practice of optimal WASH behaviors and reductions in respiratory infections and Neglected Tropical Diseases [2] [5].

Despite the positive impact of WASH practices on health, the prevalence of proper handwashing and other optimal WASH practices in the global South remains low. For example, only 19% of individuals globally and 14% of individuals in Africa wash their hands after contact with excreta [6]. Just 16% of those without access to safe drinking water treat their water at home using appropriate methods [7]. It is estimated that 673 million of the world's inhabitants defecate openly [8].

A systematic review of 148 studies suggests a number of factors associated with the uptake of WASH behaviors, including social norms and perceived behavioral control [9]. These determinants are part of the Theory of Planned Behavior (TPB), which provides a useful framework for understanding and predicting health behaviors generally and presents valuable constructs for understanding the determinants of WASH behaviors and practices specifically [10]. According to the TPB, the best predictor of an individual's behavior is his or her behavioral intention, which is determined by the theory's three main constructs: 1) the individual's attitudes and beliefs toward the behavior (e.g., whether the individual believes that WASH practices are important or necessary); 2) perceived subjective and social norms (e.g., whether the individual believes that significant others approve and are supportive of WASH practices and that WASH practices are supported generally by cultural norms and reinforced by peers); 3) perceived behavioral control (e.g., whether the individual believes he or she has both the access to necessary resources and the ability to properly engage in health-promoting WASH practices) [10]. Research based on the TPB can add clarity and understanding of an individual's uptake of optimal WASH practices by assessing the value placed on a specific behavior (attitudes and beliefs), gauging the individual's perception of the views and behaviors of significant others (subjective and social norms), and measuring the supposed ease with which specific behaviors can be performed or with which specific situations can be controlled (perceived behavioral control). Hulland and colleagues also include prominent constructs from other widely accepted health behavior change theories such as those included in the Health Belief Model (HBM), primarily perceived susceptibility and severity of disease, perceived benefits and barriers of taking action, and cost [9] [11]. Their review also identified knowledge of a given practice as a determinant of WASH behaviors and practices [9].

Multiple factors influencing whether individuals practice WASH behaviors have been noted in the research literature. Inadequate access to improved water

and sanitation is one of them [12]. Poor access to water affects nearly a billion people in sub-Saharan Africa alone [8]. However, additional factors consistent with behavior change theory influence WASH behaviors including perceived susceptibility and severity of disease, perceived benefits of and barriers to taking action, knowledge of a given practice, self-efficacy, social norms, cost, and the nature and quality of WASH programs themselves [9] [12]. These determinants are likely to vary by geographic setting, sociocultural context, and type of WASH behavior examined [9].

Challenges related to poor WASH present major health problems in Tanzania. For example, diarrhea is the leading cause of childhood death in Tanzania where households often lack access to basic water [13]. Less than half of the rural population in Tanzania has access to safe drinking water and 40% of households spend 30 minutes or more each day fetching water [14] [15]. It is estimated that poor hygiene is to blame for one-third of deaths in Tanzanian children under five years of age [13].

There is a paucity of rigorous research on the behavioral determinants of WASH. In a 2015 systematic review, Hulland and colleagues identified nearly 50,000 articles, but only 44 published papers met their inclusion criteria, including a focus on low- and middle-income countries, methodological rigor, and length of follow up of more than one year [9].

In sub-Saharan Africa generally, and Tanzania specifically, where WASH-related health problems are disproportionately concentrated, individuals who implement programs, including government staff, donors, academicians, and others, need a more thorough understanding of the behavioral determinants of WASH [13] [16]. Without this understanding, programs and policies meant to reduce morbidity and mortality resulting from poor WASH practices can be ineffective and unsustainable [17] [18] [19]. To address gaps in understanding about the behavioral determinants of WASH practices, our study aims to:

1) Clarify the relationship between behavioral determinants of hygiene practices and WASH behaviors in five regions in Tanzania;

2) Elucidate the relationship between behavioral determinants of sanitation and a range of sanitation practices in five regions in Tanzania.

2. Methods

2.1. Field Procedures

This study uses data from a cross-sectional baseline survey conducted from January to February 2016 for IMA World Health's Addressing Stunting in Tanzania Early (ASTUTE) project. The project was implemented in five lake zone regions of Tanzania that are among the poorest and most marginalized in the country. The project sought to reduce stunting among children under 5 years of age. Data were gathered to inform program development and to establish a baseline from which to measure program impact.

Study participants included 5000 female primary caregivers of children ages 0

to 23 months. We recruited mothers from five geographic regions including Geita, Kagera, Kigoma, Mwanza, and Shinyanga (see Figure 1). We used two-stage probability proportional to size sampling, first at the district level and then at the level of the village or neighborhood (in urban areas), employing data from Tanzania's most recent (2012) census as the sampling frame. Once we randomly identified villages or neighborhoods, we selected 20 households from within each village/neighborhood using a spin-the-bottle strategy for randomly identifying an axis that interviewers could follow to identify the first household for interview. In rural areas, interviewers were required to identify houses at least 200 meters apart. In urban areas, we selected every fifth house for interview (in buildings with more than one eligible household, only one household was interviewed).

Ipsos Tanzania completed all translations to increase clarity and minimize language biases prior to training three research teams on how to effectively administer the questionnaire. Interviews took place at the caretaker's place of residence. We made three attempts to contact mothers in their residence, after which replacement households were selected. There were 150 refusals to participate among the five regions.

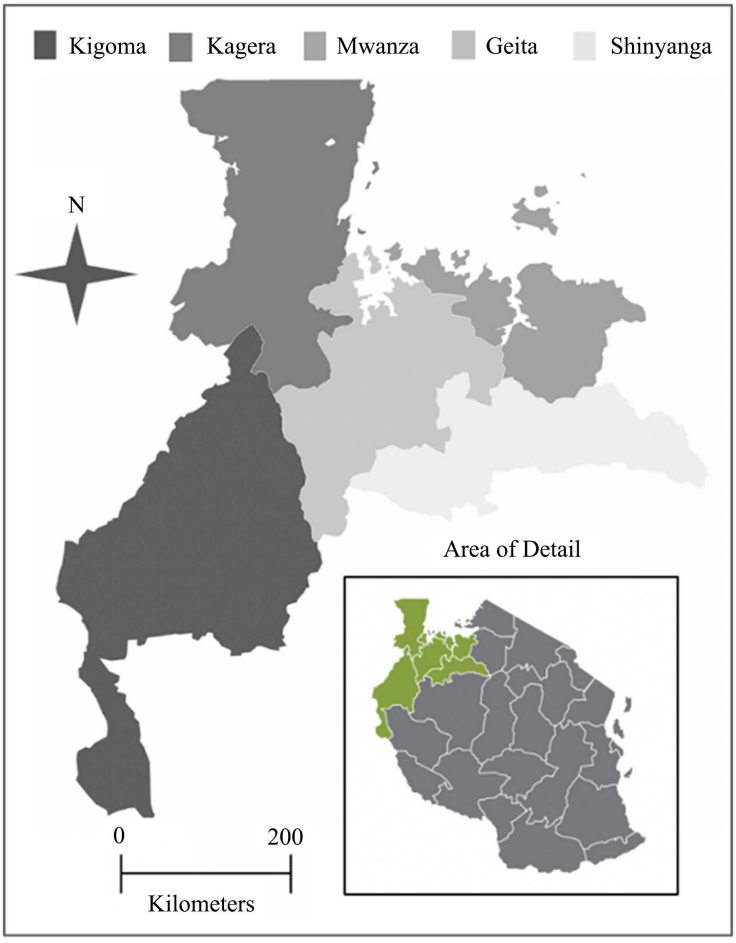

Figure 1. Tanzania lake zone region: ASTUTE map.

2.2. Ethical Approval

We obtained informed consent from all study participants—written if the mother was literate and by thumb print if not. The National Institute for Medical Research in Tanzania and relevant local government authorities authorized the research (NIMR/HQ/R.8a/Vol.IX/2344).

2.3. Measures

We used the same questions to gauge WASH behaviors as used in the 2015 Tanzania Demographic and Health Survey. With respect to WASH behavioral determinants, we modeled our questions on those developed as part of TPB and more broadly, elicitation procedures which have been used in a variety of settings [18] [20]. Questionnaire items were written in English, translated into Kiswahili, and then back-translated to English to ensure the original meaning was retained. We field-tested the survey instrument among mothers and fathers then revised and finalized it prior to administration by Ipsos Tanzania, which is part of a global data collection firm. We scripted the questionnaire onto a mobile data collection platform and uploaded it to Android mobile devices used for data collection.

Table 1 lists the types of information we collected. This included demographic data at the level of the child, mother, household, and community. We measured a wide range of behavioral determinants including knowledge indices for when to wash one's own hands and the child's hands, beliefs about whether children's hands needed to be washed, social and subjective norms about whether mothers thought their female friends washed their hands, perceived behavioral control measuring whether the mother felt able to keep the child out of the dirt, beliefs about the impact of children ingesting soil or feces, WASH access, and hygiene and sanitation practices.

2.4. Data Analysis

Upon completion of data collection, Ipsos Tanzania compiled survey results for cleaning and analysis. Missing data were dropped for data analysis. We created a composite asset indicator by summing the number of assets mothers had indicated they owned out of 13 possible items, including bicycles, cars, carts, radio, television, and so on. We also created a 7-item knowledge index for the mother knowing when to wash her own hands and a 4-item index for the mother knowing when to wash the child's hands. We used an 11-item index to gauge mothers' beliefs regarding the consequences of children ingesting soil or feces on the child's health.

Hygiene outcomes included whether the caregiver cleaned her own hands after cleaning the baby's bottom and where family members most often washed their own hands. Showing the interviewer where family members wash their hands is a better measure of actual handwashing than self-report [22]. Primary sanitation outcomes included whether the infant or child's feces were disposed of in a safe place, whether the mother had seen the child eat soil in the previous month, and a 5-item spot sanitation check (described in Table 1).

Table 1. Information collected as part of the baseline survey.

Demographics	
Child	Age, sex, and with whom the child lived at time of interview
Mother	Ethnicity, religion, years of schooling, literacy, and age
Household	Housing construction and assets ownership, number of other children in the family, and small and large livestock ownership
Community	Travel time to the nearest market and health facility
Behavioral constructs	Knowledge, subjective norms, and perceived behavioral control related to WASH Beliefs about the impact of the child ingesting soil or feces
Knowledge index	**7-item index for the mother knowing when to wash her own hands** 1) After latrine use 2) After assisting a child who has defecated 3) Before preparing food 4) Before eating food 5) Before feeding the child 6) After cleaning the compound, and 7) After contact with animal feces **4-item index for the mother knowing when to wash the child's hands** 1) After a nappy change or toilet use 2) After playing in the yard 3) Before feeding\eating time, and 4) When hands are visibly dirty Mother knew water and soap are needed to wash hands
Beliefs	Whether the mother believed the baby's hands did not need to be washed
Social norms	Whether the mother thought female friends washed their hands after cleaning the baby's bottom
Perceived behavioral control	Whether the mother felt able to keep the child out of the dirt
Beliefs	11 questions on the potential impact of ingesting soil or feces on the child's health (phrased in both the positive and negative) 1) Helps baby's immunity 2) Helps baby's gut/intestines 3) Makes baby strong 4) Makes baby grow poorly 5) Makes baby's brain develop poorly 6) Causes stomach ache 7) Causes diarrhea/illness 8) Causes worms 9) Causes baby to bite me/others 10) Causes baby to lose his/her teeth, and 11) It does nothing to baby's health.

Continued

WASH access	Whether the family could afford to buy soap Access to a handwashing station Toilet shared among community members
Hygiene practices	1) Whether the caregiver cleaned her own hands after cleaning the baby's bottom 2) Whether the caregiver was able to show where s/he and other family members most often washed their own hands (the proxy used globally to gauge handwashing, as opposed to self-report)
Sanitation and environmental cleaning practices	Whether the infant or child's feces were disposed of in a safe place per the World Health Organization (child uses toilet/latrine, feces are put/rinsed in the toilet/latrine, or buried. See Bawankule *et al.* 2017 [21]. Conversely, unsafe disposal of stools includes putting/rinsing children's feces in a drain/ditch, throwing them in the garbage, or left in the open Whether the mother had seen the child eat soil in the previous month **5-item spot sanitation check** 1) Area around house is swept 2) Floor inside the house is swept 3) Compound has livestock enclosures 4) No rubbish in the compound, and 5) Whether the inside of the house was clean

Stata 14.2 (College Station, Texas, USA) was used for all statistical analyses. We calculated chi-squares and t-tests to gauge bivariate associations between behavioral determinants and the WASH practices described above. We used logistic regression to determine whether associations described in bivariate analyses persisted after adjusting for standard covariates, as noted below. Initial models also included mother's age as a covariate; however, 355 mothers (7.1% of the overall sample) did not provide information on their age, so this variable was dropped from logistic regression models. For unadjusted odds ratios, there were two variables included in our models: one behavioral construct and one behavior. Regression models used to calculate adjusted odds ratios also included the child's age, mother's education, and household assets. It should be noted that our model construction was based on conceptual considerations. We also used logistic regression to assess the relative impact of behavioral determinants on behaviors. These models included conceptually related variables. For example, we entered four behavioral constructs into the model for washing one's own hands after cleaning baby's bottom: knowledge of when to wash own hands, knowledge of when to wash child's hands, knowledge of the importance of water and soap for washing hands, and subjective norms to determine whether the mother thinks her female friends wash their hands after cleaning the baby's bottom. For all models, we assessed goodness of fit using the Pearson chi-square goodness of fit statistic to determine the extent to which the model fit the data.

We also examined all behavioral constructs together. Thus, for frequently cleaning one's own hands after cleaning baby's bottom, we used a single logistic regression model that included the three knowledge constructs and the subjective norm to determine the impact of each construct relative to all the other relevant constructs.

3. Results

Mothers in our sample were young, predominantly Wasukuma ethnicity, and Christian (see Table 2). The majority of mothers had completed at least a primary school and were literate (Table 2).

Mothers' knowledge of when to wash one's own hands varied considerably by activity: 79.0% of mothers knew to wash their hands after latrine use but only 8.3% knew to do so after contact with animal feces (Table 3). Two-thirds (65.8%) of mothers knew to wash their child's hands before feeding them but only one-quarter (26.1%) knew to do so after the child played in the yard. Few mothers (13.1%) knew that water and soap were needed to wash hands in a hygienic manner. Mothers had a somewhat unclear understanding of how soil or feces might affect the child's health (mean 5.1 out of a possible 10 points; Table 3). On average, mothers thought that their female friends did not wash their hands after cleaning the baby's bottom (mean = 3.7 on a 5-point scale). Similarly, mothers felt that they were neither able nor unable to keep the child out of the dirt (mean = 1.8 on a 3-item scale).

WASH practices related to hygiene and sanitation are included in Table 3. Nearly half (48.9%) of mothers reported cleaning their own hands after cleaning the baby's bottom (Table 3). On average, mothers were not able to show where family members washed their hands. The mean score was 0.4 on a scale of 0 - 6 (0 = the mother could not show any place where family members washed hands to 6 = the mother could show all places the interviewer specified). It should be noted that only a very few individuals had access to latrines; therefore, we did not include this information in our analyses. With respect to sanitation, three-fourths of mothers reported disposing of infant and child feces in a safe place; about half (54.2%) had not seen their children ingest soil or feces in the previous month; and maintenance of the compound varied considerably. For example, 71.4% maintained a clean interior of the house but only 11.8% had livestock enclosures (Table 3).

Per Table 4, the behavioral determinants of hygiene that we examined were almost always significantly associated with the two hygiene outcomes (cleaning one's own hands after cleaning the baby's bottom and being able to show at least one place where family members wash their hands). For the most part, associations were in the expected direction. For example, mothers who were more knowledgeable about when to wash their own hands were more likely than mothers with low knowledge to frequently clean their own hands after cleaning the baby's bottom and to be able to show at least one place where most family members wash their hands (Table 4).

Table 2. Mother's characteristics.

	Total n	Mean or %
Child		
Age (ref: 0 - 5 mo)	4924	35.6
6 - 11 mo		27.2
12 - 17 mo		22.4
18 - 23 mo		14.7
Sex (ref: male)	5000	49.5
Female		50.5
Child lives with mother	5000	93.1
Mother		
Ethnicity (ref: Wasukuma)	5000	42.7
Wahaya		12.7
Others		44.6
Religion (ref: Christian Protestant)	5000	8.9
Christian, Catholic		43.5
Christian, other		41.7
Muslim		5.9
Years of schooling, mother (ref: no education)	5000	19.1
Primary incomplete		11.9
Primary complete		56.2
Secondary or more		12.9
Maternal literacy (ref: no)	5000	26.3
Yes		73.7
Maternal age (ref: 15 - 19 y)	4645	10.8
20 - 29 y		54.8
30 - 39 y		27.7
40 - 49 y		5.8
50+ y		0.9
Household		
Household construction (index: 3 - 9; mean)	5000	5.3
Household asset ownership (index 0 - 13; mean)	5000	4.2
Community		
Access to market (travel time, minutes) (mean)	5000	27.8
Access to health facility (travel time, minutes) (mean)	5000	33.9

Table 3. Descriptive statistics for behavioral determinants, WASH access, and sanitation and hygiene practices.

	Total n	Mean or %
Behavioral constructs		
Knowledge: Knows when to wash own hands		
After latrine use (yes)	5000	79.0
After assisting a child who has defecated (yes)	5000	31.4
Before preparing food (yes)	5000	48.1
Before eating food (yes)	5000	74.8
Before feeding a child (yes)	5000	30.2
After cleaning the compound (yes)	5000	20.2
After contact with animal feces (yes)	5000	8.3
Index for knows when to wash own hands (mean)	5000	2.9
Knowledge: Knows when to wash child's hands		
After a nappy change or toilet use	5000	20.8
After playing in the yard	5000	26.1
Before feeding/eating time	5000	65.8
When hands are visibly dirty	5000	40.0
Baby's hands don't need to be washed	5000	8.1
Index for knows when to wash child's hands (mean)	5000	1.6
Knowledge: Knows water and soap are needed to wash hands	5000	13.1
Subjective norms: Mother thinks female friends wash their hands after cleaning baby's bottom (mean; range: 0 = all female friends through 5 = none of them)	5000	3.7
Perceived behavioral control: Able to keep child out of the dirt (1 = able, 2 = neither able nor unable, 3 = unable; mean)	4952	1.8
Beliefs: Understands how ingestion of soil or feces affects child's health (higher score = more accurate information; mean)	5000	5.1
WASH access		
Can afford to buy soap (yes)	4943	57.6
Access to a hand washing station (yes)	5000	3.2
Toilet shared among community members (no)	4994	22.0
WASH practices (Hygiene)		
Cleans own hands after cleaning baby's bottom		
Frequently	4911	48.9
Sometimes/rarely or never		51.1
Where family members most often wash their hands (range: 0 = no place, 6 = every place specified in questionnaire)	4764	0.4

Continued

WASH practices (Sanitation and environmental cleaning)		
Infant\child feces are disposed of in a safe place	5000	75.0
Mother has not seen child eat soil (last month vs. before)	4996	54.2
Spot sanitation check		
Area around house is swept	4929	43.9
Floor inside the house is swept	4430	70.9
Has livestock enclosures	4996	11.8
No rubbish in compound	4949	36.2
Appearance of inside of house is clean	4438	71.4

Table 4. Associations between behavioral determinants and hygiene practices.

	Frequently cleans own hands after cleaning baby's bottom		Can show at least one place where most family members wash their hands	
Behavioral Construct	%	p	%	p
Knowledge: Knows when to wash own hands; higher number = more knowledgeable, index range:				
High (5 - 7)	60.9	<0.001	40.0	<0.001
Low (0 - 4)	46.8		32.9	
Knowledge: Knows when to wash child's hands; higher number = more knowledgeable, index range:				
3 - 5	56.8	<0.001	52.3	<0.001
0 - 2	47.2		30.1	
Knowledge: Knows water and soap are needed to wash hands				
Yes	29.4	<0.001	32.6	=0.475
No	51.7		34.1	
Subjective Norms: Mother thinks female friends wash their hands after cleaning baby's bottom				
All or most female friends	80.8	<0.001	43.4	<0.001
About half or less	43.4		32.3	

The relationship between the behavioral determinants of sanitation and sanitation practices was less clear. While most associations were statistically significant, many were in the unexpected direction. For example, those who had great-

er perceived behavioral control regarding keeping their children out of the dirt were less likely to keep the area around the house swept (Table 5). We note this an *unexpected* only because the TPB would suggest that perceived behavioral control for a particular behavior would correlate with engagement in said behavior.

Table 6 examines the relationship between behavioral determinants of hygiene and hygiene practices, first using regression models that do not adjust for mothers' characteristics and then accounting for age of child, mother's education, and household assets. Each cell in Table 6 represents its own regression model. Those who knew when to wash their own hands (OR = 1.8, 95% CI: 1.5, 2.1) and their child's hands (OR = 1.5, 95% CI: 1.3, 1.7), as well as mothers who thought that their female friends washed their hands after cleaning the baby's bottom (OR = 5.5, 95% CI: 4.5, 6.7), were significantly more likely than those who did not know about when to wash hands or who felt female friends did not wash their hands to frequently cleans own hands after cleaning the baby's bottom. A similar pattern was evident with respect to being able to show at least one place where family members washed their hands. These odds ratios were only slightly attenuated after adjusting for the covariates described above. Per results presented in Table 6, women who did not know that water and soap are needed to wash hands were less likely to clean their own hands after cleaning the baby's bottom.

Table 7 examines the relationship between behavioral determinants of sanitation practices, first using regression models that do not adjust for mothers'

Table 5. Associations between behavioral determinants and sanitation practices.

Sanitation Practices	Behavioral Determinants					
	Perceived behavioral control: Able to keep child out of the dirt			Beliefs: Understands how ingestion of soil or feces affects child's health[1]		
	% Yes	% No	p	% Mostly correct	% Mostly incorrect	p
Infant\child feces are disposed of in a safe place	77.6	72.5	<0.001	74.4	75.3	0.475
Mother has not seen child eat soil	42.9	49.6	<0.001	48.0	44.6	0.025
Area around house is swept	41.5	47.4	<0.001	38.1	46.9	<0.001
Floor inside house is swept	70.3	71.4	0.444	78.5	67.1	<0.001
Has livestock enclosures	10.7	13.2	0.007	12.6	11.4	0.206
No rubbish in compound	33.4	40.0	<0.001	32.3	38.1	<0.001
Appearance of inside of house is clean	71.0	71.7	0.606	79.2	67.4	<0.001

Table 6. Logistic regression models for the impact of behavioral determinants on hygiene practices; Odds ratios and 95% confidence intervals.

	Frequently cleans own hands after cleaning baby's bottom		Can show at least one place where most family members wash their hands	
Behavioral construct	OR (95% CI)	AOR (95% CI)	OR (95% CI)	AOR (95% CI)
Knowledge: Knows when to wash own hands	1.8 (1.5, 2.1)***	1.6 (1.3, 1.9)***	1.4 (1.2, 1.6)***	1.4 (1.2, 1.6)***
Knowledge: Knows when to wash child's hands	1.5 (1.3, 1.7)***	1.4 (1.2, 1.6)***	2.6 (2.2, 3.0)***	2.6 (2.2, 3.0)***
Knowledge: Knows water and soap are needed to wash hands	0.4 (0.3, 0.5)***	0.4 (0.4, 0.5)***	0.9 (0.8, 1.1)	1.0 (0.8, 1.2)
Subjective Norms: Mother thinks female friends wash their hands after cleaning baby's bottom	5.5 (4.5, 6.7)***	5.1 (4.2, 6.2)***	1.6 (1.4, 1.9)***	1.6 (1.3, 1.9)***

Note: OR = odds ratio. AOR = adjusted odds ratio. Separate models were run for each of the four behavioral determinants. Analyses adjust for age of child, mother's education, and household assets. * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

Table 7. Logistic regression models for the impact of behavioral determinants on sanitation practices, Odds ratios and 95% confidence intervals.

	Behavioral Determinants			
Sanitation Practices	Perceived behavioral control: Able to keep child out of the dirt, yes vs no		Beliefs: Understands how ingestion of soil or feces affects child's health, mostly correct vs mostly incorrect	
	OR (95% CI)	AOR (95% CI)	OR (95% CI)	AOR (95% CI)
Infant\child feces are disposed of in a safe place	1.3 (1.2, 1.5)***	1.5 (1.3, 1.7)***	1.0 (0.8, 1.1)	0.9 (0.8, 1.0)
Mother has not seen child eat soil	0.8 (0.7, 0.9)***	0.8 (0.7, 1.0)**	1.1 (1.0, 1.3)*	1.1 (0.9, 1.2)
Area around house is swept	0.8 (0.7, 0.9)***	0.8 (0.7, 0.9)***	0.7 (0.6, 0.8)***	0.7 (0.6, 0.8)***
Floor inside house is swept	1.0 (0.8, 1.1)	0.9 (0.8, 1.0)	1.8 (1.5, 2.1)	1.8 (1.5, 2.1)***
Has livestock enclosures	0.8 (0.7, 0.9)**	0.8 (0.7, 0.9)**	1.1 (0.9, 1.3)	1.0 (0.8, 1.2)
No rubbish in compound	0.8 (0.7, 0.8)***	0.8 (0.7, 0.9)***	0.8 (0.7, 0.9)***	0.8 (0.7, 0.9)***

Continued

Appearance of inside of house is clean	1.0 (0.8, 1.1)	0.9 (0.8, 1.1)	1.8 (1.6, 2.1)***	1.7 (1.5, 2.0)***

Note: OR = odds ratio. AOR = adjusted odds ratio. Separate models were run for both behavioral determinants. Analyses adjust for age child, mother's education, and household assets. * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$; in some cases, when rounded to the nearest one decimal place, OR and AOR 95% CIs include 1.0 but are actually less than or greater than 1 and significant.

characteristics and then accounting for age of child, mother's education, and household assets. Each cell in Table 7 represents its own regression model. Those who perceived they were able to keep child out of the dirt were significantly more likely to dispose of infant/child feces in a safe place (OR = 1.3, 95% CI: 1.2, 1.5), to report having not seen the their child eat soil (OR = 0.8, 95% CI: 0.7, 0.9), and keeping the area around their house swept (OR = 0.8, 95% CI: 0.7, 0.9). Little change was observed between the unadjusted and adjusted models related to perceived behavioral control. In the adjusted model, understanding how ingestion of soil or feces affects child's health was only significant with keeping the area around the house clean (OR = 0.7, 95% CI: 0.6, 0.8). Per results presented in Table 7, perceived behavior control related to keeping a child out of the dirt was predictive of all sanitation practices and a stronger predictor of these practices than beliefs related to how ingestion of soil or feces affects a child's health.

Table 8 examines the relationship between behavioral determinants of hygiene (considered together) and hygiene practices, first using regression models that do not adjust for mothers' characteristics and then accounting for age of child, mother's education, and household assets. Those who knew when to wash their own hands (OR = 1.5, 95% CI: 1.3, 1.8) as well as mothers who thought that their female friends washed their hands after cleaning the baby's bottom (OR = 5.3, 95% CI: 4.3, 6.4) were significantly more likely than those who did not know about when to wash hands or who felt female friends did not wash their hands to frequently clean their own hands after cleaning the baby's bottom. In contrast, mothers who knew water and soap were needed to wash hands were *less* likely to clean their own hands after cleaning the baby's bottom. Adjusting for covariates did not appreciably alter these associations. Mothers who could show at least one place where most family members washed their hands were significantly more likely than mothers who could not show a place to know when to wash the child's hands (OR = 2.5, 95% CI: 2.1, 3.0) and think that their female friends washed their hands after cleaning baby's bottom (OR = 1.5, 95% CI: 1.3, 1.8). There was almost no change in odds ratios after adjusting for covariates.

Table 9 examines the relationship between behavioral determinants of sanitation practices (considered together), first using regression models that do not adjust for mothers' characteristics and then accounting for age of child, mother's

Table 8. Summary logistic regression models for the impact of behavioral determinants on hygiene practices; Odds ratios and 95% confidence intervals.

	Frequently cleans own hands after cleaning baby's bottom		Can show at least one place where most family members wash their hands	
Behavioral construct	OR (95% CI)	AOR (95% CI)	OR (95% CI)	AOR (95% CI)
Knowledge: Knows when to wash own hands	1.5 (1.3, 1.8)***	1.4 (1.2, 1.7)***	0.9 (0.8, 1.1)	1.0 (0.8, 1.2)
Knowledge: Knows when to wash child's hands	1.1 (0.9, 1.3)	1.1 (0.9, 1.3)	2.5 (2.1, 3.0)***	2.6 (2.2, 3.0)***
Knowledge: Knows water and soap are needed to wash hands	0.4 (0.3, 0.5)***	0.5 (0.4, 0.6)***	1.0 (0.9, 1.3)	1.1 (0.9, 1.3)
Subjective Norms: Mother thinks female friends wash their hands after cleaning baby's bottom	5.3 (4.3, 6.4)***	5.0*** (4.1, 6.1)	1.5 (1.3, 1.8)***	1.5 (1.2, 1.7)***

Note: OR = odds ratio. AOR = adjusted odds ratio. Analyses adjust for age of child, mother's education, and household assets. * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

Table 9. Summary logistic regression models for the impact of behavioral determinants on sanitation practices, Odds ratios and 95% confidence intervals.

	Behavioral Determinants			
Sanitation Practices	Perceived behavioral control: Able to keep child out of the dirt, yes vs no		Beliefs: Understands how ingestion of soil or feces affects child's health, mostly correct vs mostly incorrect	
	OR (95% CI)	AOR (95% CI)	OR (95% CI)	AOR (95% CI)
Infant\child feces are disposed of in a safe place	1.3 (1.2, 1.5)***	1.5 (1.3, 1.7)***	0.9 (0.8, 1.1)	0.9 (0.8, 1.0)
Mother has not seen child eat soil	0.8 (0.7, 0.9)***	0.8 (0.7, 1.0)**	1.1 (0.9, 1.2)	0.7 (0.6, 0.8)***
Area around house is swept	0.8 (0.7, 0.9)***	0.8 (0.7, 0.9)***	0.7 (0.6, 0.8)***	0.7 (0.6, 0.8)***
Floor inside house is swept	0.9 (0.8, 1.1)	0.9 (0.8, 1.0)	1.8 (1.6, 2.1)***	1.7 (1.4, 1.9)***
Has livestock enclosures	0.8 (0.7, 0.9)**	0.8 (0.7, 0.9)**	1.1 (0.9, 1.3)	1.0 (0.8, 1.2)
No rubbish in compound	0.8 (0.7, 0.8)***	0.8 (0.7, 0.9)***	0.8 (0.7, 0.9)***	0.8 (0.7 0.9)***
Appearance of inside of house is clean	1.0 (0.8, 1.1)	0.9 (0.8, 1.1)	1.9 (1.6, 2.2)***	1.7 (1.5, 2.0)***

Note: OR = odds ratio. AOR = adjusted odds ratio. Analyses adjust for age child, mother's education, and household assets. * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

education, and household assets. Those who perceived they were able to keep child out of the dirt were significantly more likely to dispose of infant/child feces in a safe place (OR = 1.3, 95% CI: 1.2, 1.5) but *less* likely (and often, significantly so) to report not seeing their child eat soil, sweep the area around the house and the floor inside the house, have livestock enclosures, and not having rubbish in the compound. Mothers who understood how ingesting soil or feces affected the child's health were more likely than mothers who did not understand to maintain a clean appearance inside the house (including a swept floor) but significantly less likely to maintain a cleanly appearance in the compound (unswept area outside the house and no rubbish in the compound). There was almost no change in odds ratios after adjusting for covariates.

4. Discussion

The aim of this paper was to better understand the relationship between behavioral determinants and a range of hygiene and sanitation practices. We found that behavioral determinants (knowledge about washing one's own hands and the hands of the child, knowing that soap and water are needed to wash hands, and thinking that female friends wash their hands after cleaning the baby's bottom) were almost always significantly associated with the two hygiene outcomes of interest (frequently cleans own hands after cleaning the baby's bottom and can show at least one place where family members wash their hands). These relationships remained largely unchanged after adjusting for measures of socioeconomic status and the age of the child. In contrast, determinants of sanitation practices (perceived behavioral control related to keeping the child out of the dirt and correct understanding of how ingestion of soil or feces affects the child's growth) were mostly not positively correlated with sanitation practices. It is important to note that few households in this sample had handwashing stations. When access to handwashing stations is rare handwashing behaviors will subsequently be less frequent. This is consistent with the TPB which would anticipate less handwashing stemming from low perceived behavior control for health-promoting WASH behaviors because of limited access and resources.

Examining knowledge variables individually, mothers' knowledge of when to wash their own hands was generally high, particularly so for knowledge of washing hands after latrine use and prior to eating. However, knowledge related to washing hands after cleaning the baby's bottom, before feeding a child, after cleaning the compound, and following contact with animal feces was very low.

With respect to the relationship between knowledge and hygiene and sanitation practices, our results yielded somewhat mixed results: knowledge was almost always associated with hygiene practices but not sanitation behaviors. While there are numerous studies on the relationship between behavioral determinants and WASH practices, most of these are not observational studies but rather occur within the context of program interventions. Additionally, a majority of the research about behavioral determinants focuses on hygiene rather than sanitation.

Similar to our findings about the importance of knowledge for the uptake of hygiene behaviors, Seimetz and colleagues report that in India a WASH campaign had a large impact on knowledge about the perceived benefits of washing hands and that knowledge, coupled with improvements in other behavioral determinants, played a major role in explaining improvements in behavioral intentions related to handwashing [23]. These findings are consistent with the HBM which theorizes that perceived benefits can be an important motivator for engaging in health-promoting practices. Conversely, a lack of knowledge can lead to misperceptions related to health behaviors and may discourage desired practices. Yogananth and Bhatnagar found that in India, personal beliefs and misconceptions about the health benefits of toilet use were significantly associated with open defecation [24].

Often, knowledge is a weak determinant of behavior and, as a construct, knowledge is missing from the TPB. While knowledge can help shape attitudes and underlying behavioral beliefs, particularly related to anticipated health outcomes, knowledge alone has not been found to be a strong predictor of behavioral intentions [25]. For example, in Uganda, Curtis and colleagues found that just 14% of mothers washed their hands with soap after using the toilet, but 84% felt that it was what one should do [26].

We acknowledge that our results correlating knowledge with hygiene behaviors may be short-term and vary from several previous studies. For example, in contrast to our findings, a study of handwashing including Ugandan nurses yielded mixed results. Mothers participating in the study were attended to by trained nurses who were more likely to wash their hands properly after educational sessions, but both short and long-term behavior change was far from universal [27]. Other studies show that a hygiene intervention was successful in raising hygiene awareness but not handwashing [28]. Some studies show that knowledge of how to wash hands effectively is one of many determinants that affect handwashing practice and these likely include the availability of a handwashing station, perceived susceptibility, and other determinants [12].

Social and subjective norms are powerful in predicting and reinforcing the adoption of healthy behaviors. For WASH messaging and other promotional activities to be effective, it is essential that individuals perceive that WASH-related behaviors are commonly practiced, and that people close to them and whose views they value think they should engage in such behaviors. Interventions targeting social and subjective norms are most effective when those delivering the message enjoy a high degree of social status, are trusted, and share a similar heritage or background with those for whom the intervention has been designed [29]. DeBuck and colleagues concluded that community-based solutions are more effective than social marketing [30]. Our findings suggest that subjective norms were significantly associated with handwashing practices based on mothers' perception of how many of their female friends wash hands after cleaning their baby's bottom. Contzen and Masler similarly found that social norms, along with attitudes, abilities, and self-regulation, explained significant variance

in handwashing in Ethiopia and Haiti [31].

In our study, measures of perceived behavioral control or self-efficacy included the ability to keep a child out of the dirt, being able to afford soap, and access to a hand washing station. Results were mixed, yet generally not supportive of WASH practices. Just over half of mothers could afford soap; there was almost no access among this study sample to hand washing stations, and a majority of mothers felt unable to limit a child's contact with dirt. As others have noted, perceived behavioral control is a powerful determinant of behavior. For example, as noted previously, Contzen and Mosler found that one's abilities and self-regulation were associated with significant increases in explained variance in handwashing [31]. When individuals receive programmatic messages emphasizing the importance of health-promoting behaviors, and yet lack perceived behavioral control, they can experience heightened levels of anxiety, shame, and learned helplessness [32]. Behavioral interventions targeting both attitudinal factors (*why* specific behaviors are important) and ability factors (*how* to engage in those behaviors within the context of available resources) is consistent with behavior change theory and increases perceived behavioral control [33]. Mosler refers to the *how* part of knowledge essential for increasing self-efficacy as *action knowledge* and recommends that WASH interventions specifically aim to increase one's ability or aptitude for WASH behaviors through the teaching of this knowledge [33].

Perceived benefits can be an important motivator to adopt optimal WASH practices. Yogananth and Bhatnagar found that in India, personal beliefs and misconceptions about the health benefits of toilet use were significantly associated with open defecation [24].

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Limitations

We used project baseline data from a large survey to explore the relationship between behavioral determinants and hygiene and sanitation practices among women in a specific geographic region of Tanzania. Rigorous WASH research is challenging, and results are often mixed. The current study adds to the extent literature and benefits from a large sample size and observational data. These findings provide useful information to those interested in understanding what influences WASH behaviors as well as program planners and policy makers who are tasked with improving hygiene and sanitation. However, our study has several key limitations. These include a small number of indicators measuring behavioral determinants and hygiene and sanitation behaviors. The majority focused on WASH-related knowledge, with a more limited number measuring social norms and perceived behavioral control. Future research using the TPB as a

theoretical framework should include measures of behavioral beliefs and attitudes. This study was also limited by no direct measure of whether a given household had a toilet, only if one was observed and only whether the toilet was shared with others. Similarly, few households with handwashing stations in this study sample limited the ability to conduct additional analyses. Additionally, data are cross-sectional, thus limiting our ability to draw conclusions about how behavioral determinants at one point in time influence hygiene and sanitation practices. Even so, we note that midline and endline assessments have been planned, the sample size is large, the survey was carried out by an independent organization, and we were conservative in our analyses: we only examined associations between behavioral determinants for hygiene and hygiene practices (e.g., knowing when to WASH one's own and child's hands and knowing that water and soap are needed relative to being able to demonstrate where family members wash their hands) and associations between behavioral determinants for sanitation practices (e.g., able to keep child out of the dirt and understanding how ingestion of soil or feces affects child's health). Finally, this study used a spin-the-bottle strategy for randomly identifying the axis interviewers followed in identifying the first household for interview. This method is known as EPI-sampling, and while widely used and accepted by the WHO and UNICEF for childhood immunization programs, it is not the gold standard and is less effective when the sample includes household with a wide age range of children [34]. However, this method was deemed appropriate for the current study given both the narrow child age range necessary for household inclusion and the rural Lake Zone region where data collection occurred.

5. Conclusion

Our results suggest a strong relationship between knowledge about handwashing, the subjective norm construct of the TPB, and two outcomes of interest: cleaning one's own hands after cleaning the baby's bottom and being able to show at least one place where family members washed their hands, an internationally agreed-upon indicator of actual handwashing practices. In contrast, there was an inconsistent relationship between the determinants of sanitation practices, including perceived behavioral control construct of the TPB related to keeping the child out of the dirt, correct understanding of how ingestion of soil or feces affects the child's growth, and seven sanitation outcomes. It is likely that a range of behavioral determinants affects individuals' hygiene and sanitation practices. Other research in Tanzania, suggests that for sanitation, these include respondents' perceptions about the importance of hard work and improving their lives over many years [35]. Alternatively, sanitation practices include both sanitation and environmental cleaning with the latter having a strong relationship with behavioral constructs. WASH interventions are likely to benefit from formative research that identifies the various factors associated with the uptake of good hygiene and sanitation practices in a given context and programs should

be designed and implemented in accordance with the determinants that are particularly important.

Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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