Scientific Research Publishing

Health, 2019, 11, 827-840
http://www.scirp.org/journal/health
ISSN Online: 1949-5005
ISSN Print: 1949-4998

Water, Sanitation, and Hygiene Factors Associated with Child Illness in Tanzania

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How to cite this paper: Verdeja, M., Thomas, K., Dorsan, G., Hawks, M., Dearden, K., Stroupe, N., Hoj, T., West, J., Crookston, B., Ezekial, M. and Hall, C. (2019) Water, Sanitation, and Hygiene Factors Associated with Child Illness in Tanzania. *Health*, **11**, 827-840.
https://doi.org/10.4236/health.2019.116066

Received: May 2, 2019
Accepted: June 23, 2019
Published: June 26, 2019

Abstract

Water, sanitation, and hygiene (WASH) are critical to ensuring health and preventing disease in Tanzania where approximately one-third of childhood deaths are related to poor hygiene. This study explored associations between WASH practices and childhood illness. Data came from a cross-sectional survey of 5000 female caregivers living in the Lake Zone region of Tanzania. Measures included self-reported presence of fever, diarrhea, cough and various WASH factors. Multiple logistic regressions were used. Thirty-seven percent of children experienced fever, 26% diarrhea, and 11% cough in the previous two weeks. Unimproved toilets were positively associated with fever (OR 1.25, CI 1.03 - 1.53, $p < 0.05$) and animal enclosures were negatively associated with diarrhea (OR 0.76, CI 0.61 - 0.96, $p < 0.05$). Unsafe disposal of a child's stool was associated with both fever (OR 0.77, CI 0.67 - 0.89, $p < 0.05$) and diarrhea (OR 1.18, CI 1.0 - 1.38, $p < 0.05$). Eating soil was associated with both fever (OR 2.02, CI 1.79 - 2.29, $p < 0.05$) and diarrhea (OR 2.23, CI 1.95 - 2.57, $p < 0.05$). Eating chicken feces was associated with both fever (OR 2.07, CI 1.66 - 2.58, $p < 0.05$) and diarrhea (OR 2.38, CI 1.9 - 2.98, $p < 0.05$). Water shortages were associated with fever (OR 1.21, CI 1.07 - 1.36, $p < 0.05$) and cough (OR 1.48, CI 1.22 - 1.81, $p < 0.05$). Policy makers and program designers should consider increasing access to water and sanitation to improve children's health.

Keywords

Tanzania, Water, Sanitation, Hygiene, Childhood Illness

1. Introduction

The first thousand days of life represent a critical developmental period in children and are fundamental to growth, health, and behavioral development [1]. These years also represent a peak period for deficiencies of certain micronutrients and common childhood illnesses such as diarrhea [2]. Poor nutrition is related to inadequate psychosocial stimulation, repeated infections, higher levels of morbidity and mortality, and can result in significant negative impacts including reduced work and school performance, as well as impaired cognitive abilities [3] [4] [5] [6]. Water, sanitation, and hygiene (WASH) are key to promoting health and preventing disease during this window of development. It is estimated that each year inadequate access to drinking water contributes to over 500,000 diarrhea-related deaths worldwide, with approximately 280,000 and 300,000 deaths attributed to inadequate sanitation and hand hygiene, respectively [7]. Approximately 60% of Tanzanians currently get their drinking water from an improved source [2]. Nevertheless, in the first year after construction, 40% of these water points were reported to be non-functional [2]. Additionally, 80% of Tanzanians rely on basic unimproved sanitation facilities [2]. Up to one-third of deaths in children under five years of age in Tanzania are related to poor hygiene, with the bulk of these deaths due to preventable diarrhea [7].

Understanding the relationship between WASH practices and illness in children is vital to the design and implementation of effective public health programs. However, in Tanzania, limited human and financial resources as well as a lack of coordination between stakeholders are roadblocks to adequate water and sanitation facilities and proper hygiene [7]. Funded by the United Kingdom's Department for International Development (DFID) and implemented by IMA World Health, the Addressing Stunting in Tanzania Early (ASTUTE) program addresses improving WASH practices for mothers and fathers of children aged two and younger in Tanzania. ASTUTE aims to increase knowledge related to stunting prevention behaviors among pregnant women, caregivers, households, and community decision makers. As part of this project, a baseline survey was developed by Development Media International (DMI), a partner of IMA World Health. In addition to providing key baseline measures for monitoring and evaluation efforts, survey results have informed the design of key ASTUTE programmatic elements and strategies. Using this data, the purpose of the current study was to explore associations between WASH practices and self-reported childhood illness, including fever, diarrhea and cough.

2. Materials and Methods

2.1. Design

Data for this study came from a cross-sectional survey of mothers or primary female caregivers of children 0 - 23 months living in the Geita, Kagera, Kigoma, Mwanza, and Shinyanga regions of Tanzania, collectively known as the West and Lake Zone. The survey measured sociodemographic characteristics as well

as general knowledge and behaviors related to childhood health and nutrition.

2.2. Sample

The study sample consisted of 5000 mothers or other primary female caregivers of children 0 - 23 months of age and was carried out in January and February of 2016. Probability proportional to size sampling was used at the district level, based on the most recent Tanzania census (2012) as the sampling frame. Using power calculations, based on an estimated baseline exclusive breastfeeding rate of 52.4% across the 5 Lake Zone study regions, approximately 5000 mothers will need to be sampled at baseline and endline to give the study 80% power to detect an effect, at the 0.05 significance level. This sample size includes a 10% contingency to allow for incomplete/unreliable questionnaires or non-participation/refusals. Wards (multiple villages) and villages were then selected randomly. Households with a child 0 - 23 months, plus a mother or other primary female caregiver with responsibility for feeding the child were eligible to participate. Exclusion criteria included households that did not have at least one 0 - 23-month-old child living in the household at the time of the interview. The mother or primary caregiver was required to live in the household as well. The absence of the father in the household was not an exclusion criterion, however where present, they were also asked to undergo a short interview.

2.3. Procedure

Authorization to conduct the research and recruit study participants was obtained from local authorities, including Regional Medical Officers (RMOs) and/or District Medical Officers (DMOs). Ethical clearance was obtained from the National Institute for Medical Research (NIMR) in Tanzania. After enumerator training, the instrument was pilot tested, revised, and finalized. The survey team then traveled to wards and randomly selected towns or villages to administer the survey. Within each village, the Village Executive Officer or another village (rural areas) or street (urban areas) guide introduced the survey team to households. Interviews were conducted in Kiswahili which is the national language of Tanzania. The primary caregiver was the main target for participation in the questionnaire. A maximum of three attempts were made to visit households before they were substituted with replacement households.

2.4. Measurements

Participants were asked a series of demographic questions related to religion, ethnicity, marital status, and family size, age of children, educational attainment, and ownership of various assets. During analyses an asset index was constructed by summing the "yes" responses to 21 different questions relating to household ownership of various items, with possible scores ranging from 0 - 21. Assets included a bicycle, motorcycle, car or truck, animal drawn cart, boat with motor, boat without motor, radio, television, mobile phone, refrigerator, table, chairs,

bed, air conditioner, computer, electric iron, fan, power tiller, connection to the national electricity grid, active mobile banking account and owning more than one acre of agricultural land.

Participants were asked if their child had experienced fever, diarrhea, or cough/difficulty breathing during the past two weeks.

Two items related to toilets and waste disposal were included in this analysis: 1) type of toilet (unimproved or improved) and 2) disposal of child's stool (safe or unsafe) based on WHO definitions [8].

Three items related to drinking water were included in this analysis: 1) main source of household drinking water, 2) if the household purifies the water, and if yes, by what means, and 3) if the household experienced any domestic water shortages in the past 12 months. Water sources were classified as improved or unimproved based on WHO definitions [8].

Four items related to hand washing behavior were included in this analysis: 1) how often they washed their hands after cleaning their baby's bottom, 2) if they believed water alone makes their hands clean, 3) if they could afford to buy soap, 4) whether a hand washing station was observed by the interviewer.

Six items related to animal feces were included in this analysis: Caregivers were asked 1) if the child had ever eaten soil, 2) if the child had ever eaten chicken feces, 3) if the child had eaten soil or chicken feces in the past month, 4) how able the caregiver was in preventing the child from eating soil or chicken feces, 5) if the household had any animal enclosures, 6) whether animal or human feces were observable in the yard by the interviewer.

2.5. Analysis

Statistical analyses were conducted using SAS version 9.4 (Cary, NC). Three separate outcome variables were examined: presence of fever, diarrhea, or respiratory illness in the child in the past two weeks. Predictor variables included access to improved water and sanitation, hand washing, and exposure to animal waste. Initial analyses were used to describe data. Chi-square test statistics were used for univariate analysis to determine relationships between predictor variables and outcomes as well as to identify potentially confounding relationships. T-tests were used for continuous variables. Results from the univariate tests as well as a review of the literature to identify conceptually important variables were used to determine which variables would be included in multivariate analyses.

Logistic regression was used to identify factors associated with childhood illness. Regression modeling was conducted separately for each of the three outcome variables (presence of child fever, diarrhea, or cough in the past two weeks) with each covariate. Adjusted and unadjusted models were examined, with the adjusted models accounting for potential confounders.

3. Results

The majority of respondents (54.8%) were between 20 - 29 years of age. Most

had received a primary education (68%), were literate (74%), and lived in rural settings (86%) (Table 1). Respondents comprised a wide range of ethnicities, with Wasukuma being the most represented (42.7%). The mean number of children in the household was 3.46.

Child fever (37%) was the most reported illness, followed by diarrhea (26%) and sick with cough, difficult or fast breathing (11%). Frequencies related to WASH resources, knowledge, attitudes, and beliefs are displayed in Table 2.

Having seen their child eat soil (OR 2.07, CI 1.66 - 2.58) and having seen their child eat chicken feces (OR 2.02, CI 1.79 - 2.29) were positively associated with fever in both the unadjusted and adjusted models (Table 3). Having an unimproved toilet (OR 1.25, CI 1.03 - 1.53) was associated with fever in the past two weeks. The same was true for never (OR 1.36, CI 1.03 - 1.8), sometimes (OR 1.3, CI 1.08 - 1.56) or rarely (OR 1.24, CI 1.07 - 1.43) washing hands after cleaning baby's bottom. Experiencing water shortages in the past 12 months (OR 1.21, CI 1.07 - 1.36) were positively associated with the presence of fever. A negative association was found between fever and safe disposal of a child's stool (OR 0.77, CI 0.67 - 0.89). Purifying water, having an improved source of water, and having a hand washing station were not found to be significantly associated with fever.

Having seen your child eat soil (OR 2.23, CI 1.95 - 2.57) and having seen your child eat chicken feces (OR 2.38, CI 1.9 - 2.98) were positively associated with diarrhea in both unadjusted and adjusted models (Table 4). Safe disposal of a child's stool (OR 0.81, CI 0.69 - 0.95) and having animal enclosures (OR 0.76, 0.61 - 0.96) were found to have a negative association with diarrhea. Water source, purification of water, and handwashing after cleaning baby's bottom were not significantly associated with diarrhea.

Having domestic water shortages in the last 12 months (OR 1.48, 1.22 - 1.81) was positively associated with cough. Never (OR 1.83, CI 1.21 - 2.78) or rarely (OR 1.52, CI 1.21 - 1.9) washing hands after cleaning the baby's bottom were both found to be positively associated with having a cough in the last 12 months (Table 5).

Table 1. Participant demographics.

	Percent (*N* = 5000)	*Total* (*N* = 5000)
Setting		
Urban	14.0	700
Rural	86.0	4300
Age		
15 - 19	10.8	540
20 - 29	54.8	2740
30 - 39	27.7	1385
40 - 49	5.8	290
50+	0.9	45

Continued

Ethnicity		
Wasukuma	42.7	2135
Wahaya	12.7	635
Waha	20.0	1000
Wahangaza	2.2	110
Wasubi	2.4	120
Wanyambwa	4.9	245
Other	15.1	755
Caregiver can read		
Yes	74	3700
No	26	1300
Highest Level of Education		
No Education	19.1	955
Complete/Incomplete Primary	68	3400
Complete/Incomplete Secondary	11.9	595
High School+	1.0	50
Marital Status		
Never Married	5.8	290
Married Monogamous	71.0	3550
Married Polygamous	5.8	290
Informal Union	8.5	425
Widowed	2.0	100
Divorced	0.6	30
Separated	6.3	315
Religion		
Christian (Catholic)	43.5	2175
Christian (Pentecostal)	14.6	730
Christian (Protestant)	8.9	445
Christian (Other)	16.3	815
Muslim	10.8	540
Other/No Religion	5.9	295
Children		
Total	Mean: 3.5	
Under 5	Mean: 1.6	
5 - 18	Mean: 1.7	

Table 2. Access to WASH resources and WASH knowledge, attitudes, and beliefs.

Question	*Response*	*N* (*Percent*)
Toilet		
Toilet type	Unimproved	4268 (85.36)
	Improved	732 (14.64)
Disposal of child stool	Unsafe	1238 (24.81)
	Safe	3751 (75.19)
Drinking Water		
Household water source	Unimproved	2113 (42.26)
	Improved	2887 (57.74)
Household purifies water	No	3578 (71.56)
	Yes	1422 (28.44)
Household water shortages for domestic use during the past 12 months	No	2451 (49.08)
	Yes	2542 (50.91)
Hand Washing		
Wash hands after cleaning baby bottom	Frequently	2401 (48.89)
	Sometimes	678 (13.81)
	Rarely	1519 (30.93)
	Never	313 (6.37)
Hand washing with water alone makes your hands clean	No	4346 (87.48)
	Yes	622 (12.52)
Can afford to buy soap for hand washing when needed	No	2097 (42.42)
	Yes	2846 (57.58)
Soap at the hand washing station	No soap	64 (40.25)
	Yes soap	95 (59.75)
Animal Feces		
Seen child eat soil	No	2709 (54.22)
	Yes	2287 (45.78)
Seen child eat chicken feces	No	4610 (92.31)
	Yes	384 (7.69)
Observed their child eating soil or chicken feces in the past month	No	184 (47.79)
	Yes	201 (52.51)
Able to stop their child from eating soil or chicken feces	Able	2658 (53.68)
	Neither	717 (14.48)
	Unable	1577 (31.85)
Feces (human or animal) visible in the yard (observed)	No	399 (57.25
	Yes	298 (42.75)

Continued

Sick		
Child sick with fever in the past two weeks	No	3151 (63.07)
	Yes	1845 (36.93)
Child experienced diarrhea in the past 2 weeks	No	3704 (74.09
	Yes	1295 (25.91)
Child sick with cough, difficult or fast breathing in the past two weeks	No	4462 (89.29)
	Yes	535 (10.71)

Note: Improved toilets include flush or pour flush toilets, and pit latrines (83.6%). Unimproved toilets include having no facility, use of field or bush. Improved water sources include water piped to house, piped public water, rainwater, protected well, and protected spring water (78%). Unimproved water sources include unprotected well water, unprotected spring or surface water (22%).

Table 3. Unadjusted and adjusted logistic regression models for self-reported fever.

	Unadjusted	*Adjusted*
Variable	*OR* (95% *CI*)	*OR* (95% *CI*)
Unimproved toilet	1.94 (1.01 - 1.41)*	1.25 (1.03 - 1.53)*
Unsafe disposal of child's stools	0.76 (0.66 - 0.87)*	0.77 (0.67 - 0.89)*
Unimproved water source	0.99 (0.88 - 1.16)	1.0 (0.87 - 1.14)
Does the household purify water	1.07 (0.94 - 1.22)	1.05 (0.91 - 1.21)
Household water shortages for domestic use during the past 12 months	1.19 (1.06 - 1.34)*	1.21 (1.07 - 1.36)*
Hand washing station observed	1.08 (0.78 - 1.5)	1.6 (0.75 - 1.52)
How often do you wash your hands after cleaning baby bottom		
Frequently	-	-
Never	1.51 (1.19 - 1.91)*	1.36 (1.03 - 1.8)*
Rarely	1.22 (1.06 - 1.34)*	1.24 (1.07 - 1.43)*
Sometimes	1.25 (1.05 - 1.5)*	1.3 (1.08 - 1.56)*
Have you ever seen your child eat soil	2.1 (1.87 - 2.63)*	2.02 (1.79 - 2.29)*
Have you ever seen your child eat chicken feces	1.98 (1.61 - 2.45)*	2.07 (1.66 - 2.58)*
Do you have any animal enclosures	0.86 (0.72 - 1.03)	0.89 (0.74 - 1.08)

Note: Adjusted logistic regression models controlled for the following demographic variables: setting, ethnicity, religion, education, marital status, age, and socioeconomic status; * = $p < 0.05$.

Table 4. Unadjusted and adjusted logistic regression models for self-reported diarrhea.

	Unadjusted	*Adjusted*
Variable	*OR* (95% *CI*)	*OR* (95% *CI*)
Unimproved toilet	0.9 (0.75 - 1.07)	0.9 (0.72 - 1.11)
Unsafe disposal of child stool	0.79 (0.68 - 0.92)*	0.81 (0.69 - 0.95)*

Continued

Unimproved water source	0.97 (0.86 - 1.11)	0.96 (0.83 - 1.11)
Does the household purify water	0.91 (0.79 - 1.04)	0.91 (0.78 - 1.06)
Household water shortages for domestic use during the past 12 months	0.92 (0.81 - 1.05)	0.96 (0.84 - 1.1)
Hand washing station observed	0.91 (0.64 - 1.3)	0.94 (0.64 - 1.38)
How often do you wash your hands after cleaning baby bottom		
Frequently	-	-
Never	1.09 (0.83 - 1.42)	1.0 (0.73 - 1.37)
Rarely	1.12 (0.97 - 1.3)	1.18 (1.0 - 1.38)*
Sometimes	1.05 (0.86 - 1.27)	1.13 (0.92 - 1.39)
Have you ever seen your child eat soil	2.37 (2.08 - 2.7)*	2.23 (1.95 - 2.57)*
Have you ever seen your child eat chicken feces	2.35 (1.9 - 2.91)*	2.38 (1.9 - 2.98)*
Do you have any animal enclosures	0.75 (0.61 - 0.92)*	0.76 (0.61 - 0.96)*

Note: Adjusted logistic regression models controlled for the following demographic variables: setting, ethnicity, religion, education, marital status, age, and socioeconomic status; * = $p < 0.05$.

Table 5. Unadjusted and adjusted logistic regression models for self-reported cough.

	Unadjusted	*Adjusted*
Variable	*OR* (95% *CI*)	*OR* (95% *CI*)
Unimproved toilet	0.99 (0.77 - 1.27)	0.98 (0.72 - 1.33)
Unsafe disposal of child stool	1.0 (0.82 - 1.23)	0.94 (0.76 - 1.18)
Unimproved water source	0.94 (0.78 - 1.13)	0.95 (0.77 - 1.18)
Does the household purify water	1.02 (0.84 - 1.25)	01.2 (0.96 - 1.5)
Household water shortages for domestic use during the past 12 months	1.57 (1.31 - 1.89)*	1.48 (1.22 - 1.81)*
Hand washing station observed	1.07 (0.64 - 1.82)	1.23 (0.7 - 2.24)
How often do you wash your hands after cleaning baby bottom		
Frequently	-	-
Never	1.29 (0.9 - 1.85)	1.83 (1.21 - 2.78)*
Rarely	1.28 (1.04 - 1.56)*	1.52 (1.21 - 1.9)*
Sometimes	0.89 (0.67 - 1.2)	0.98 (0.72 - 1.34)
Have you ever seen your child eat soil	1.13 (0.95 - 1.35)	1.16 (0.96 - 1.4)
Have you ever seen your child eat chicken feces	1.3 (0.96 - 1.78)	1.36 (0.99 - 1.89)
Do you have any animal enclosures	1.09 (0.83 - 1.25)	1.04 (0.77 - 1.4)

Note: Adjusted logistic regression models controlled for the following demographic variables: setting, ethnicity, religion, education, marital status, age, and socioeconomic status; * = $p < 0.05$.

4. Discussion

The purpose of this study was to explore WASH practices and their association with the presence of self-reported fever, diarrhea, and cough in the past 2 weeks. The presence of fever and diarrhea are predictive of undernutrition, which presents serious long-term prospects of growth failure, cognitive impairment, diminished immunity, recurrent infections, and worsening undernutrition [4] [5] [6] [9]. When resources are limited, a developing infant physiologically prioritizes survival and maintenance above growth [10]. The cycle linking illness and undernutrition to physical and cognitive impairment is currently part of multiple studies attempting to determine directionality as well as further implications. Scrimshaw et al. first proposed that repeated infections interact with undernutrition to cause a cycle of infection and undernutrition [11]. McDade posited that infants face a resource allocation trade-off between maintenance (fighting infection and physiological repair) and growth [12]. The Etiology, Risk Factors, and Interactions of Enteric Infections and Malnutrition and the Consequences for Child Health Study, known as MAL-ED, have been established at sites in eight countries with historically high incidence of diarrheal disease and undernutrition. MAL-ED findings confirm that many childhood infections cause intestinal inflammation by altering intestinal barrier and absorptive function. The resulting undernutrition is associated with growth faltering and deficits in cognitive development and compromised immunity [9] [13]. The Sanitation Hygiene Infant Nutrition Efficacy (SHINE) study identified environmental enteric dysfunction (EED) as a major underlying cause of both stunting and anemia. Chronic inflammation is the central characteristic of EED which is primarily caused by high fecal ingestion due to living in conditions of poor water, sanitation, and hygiene [14]. These studies help to establish the bidirectional connection between undernutrition and child illness.

Associations between ingesting soil and chicken feces with fever and diarrhea in the current study highlight the importance of training parents to monitor the ways in which their children interact with their surroundings. These findings are consistent with studies conducted in other resource-poor settings. Studies in Zimbabwe have observed periodic childhood ingestion of soil and chicken feces and identified pathogenic bacteria in 37% of soil and 17% of chicken feces in such households [15] [16]. An in-depth behavioral observation study in Peru recorded an average of nearly four episodes of ingestion of chicken feces by children during a 12-hour period [17]. Consumption of soil alone among children in low-income countries, where pathogen densities are highest, has also been found to be common [18]. Whereas this continues to be an issue, future efforts should focus on shaping parents' knowledge and attitudes and parents' knowledge and awareness of sanitation may be lower than that of water and handwashing [19]. Additional efforts to support parents' efforts to prevent their children's consumption of soil and chicken feces may also be needed. In this study, one-third (32%) of the respondents indicated that they were unable to stop children from eating soil or feces, suggesting a lack of self-efficacy and a

need for training and support. Environmental factors such as dirt floors and free-ranging animals present challenges for many households in the Lake Region of Tanzania. Nearly a tenth of households had feces visible in the yard during the interview.

Having a cough in the past 2 weeks was associated with poor handwashing behaviors and water shortages or water insecurity. In 2011, an estimated 768 million people relied on "unimproved" water supplies, which are thought to have high levels of pathogen contamination [7] [8]. Many more use sources that may technically be classified as "improved" yet are still unsafe for consumption [20]. Nearly half the current study's participants reported water shortages in the last 12 months. Access to safe, functional, and improved water points remains low in Tanzania, where only 60% of the population obtains drinking water from an improved source. In previous studies, about two-thirds of all piped water users in urban areas reported that they were unable to access water for at least one day in the previous two weeks [21]. General or periodic water shortages may impact one's ability to engage in desired WASH disease-prevention practices. Education and skill development interventions may be useful in raising awareness but are unlikely to result in measurable impacts if infrastructure issues persist.

5. Recommendations

The importance of proper WASH practices for prevention of childhood illness was confirmed in this study. These findings point to practical recommendations which can be implemented by households with limited resources in rural areas. Certainly, policies and programs in Tanzania should aim to broaden individuals' access to improved toilet facilities, soap, and easy-to-adopt water purification methods. Such policies and programs should also encourage the proper disposal of human feces, especially infants' feces, which are not considered "dangerous" in Tanzania. Animal waste, including chicken feces, is of concern. Programs and policies should focus on limiting animals' access to the household and its environs, which is where infants and young children are most likely to spend time on the ground. Such efforts might include confining animals to cages, regularly sweeping compounds, and keeping children out of the dirt. Covering dirt floors with straw, mats, or more permanent materials can also mitigate children's exposure to animal waste. More regular and attentive child supervision might decrease the likelihood of eating soil; thus, encouraging husbands and grandparents to assume greater responsibility for household duties, including childcare, can be helpful in reducing the risk of child illness.

Adoption of such recommendations and behaviors is challenging. For example, in Tanzania, to prevent theft, animals are usually kept indoors; cages are rarely used owing to the cost of providing separate food for livestock; and heavy workloads prevent routine cleaning of toilets and compounds. Behavioral determinants of WASH practices identified in this study include low self-efficacy, limited knowledge, and beliefs that prevent families from practicing proper hy-

giene and sanitation. Successful programs will need to address these and other barriers to the adoption of healthy WASH behaviors. While the exact mix of policies and programs should be determined by context-specific research, including formative research, interventions will likely include media to increase knowledge and improve norms; support groups and other group-based learning, including work with schools, religious organizations, and the government's cash transfer programs; and individual counseling at health facilities and in the home which is needed to overcome the unique challenges families face as they attempt to adopt healthy behaviors.

6. Limitations

This study has several limitations. The data do not represent all of Tanzania, but rather represent rural Tanzanian populations in the West and Lake Zone. The cross-sectional nature of the study and low response rates for some variables also limited the research. Cases of fever, diarrhea, and cough were self-reported and not substantiated by a clinician. The study's strengths include a large sample size, randomization of subjects, and the breadth of information available to researchers.

7. Conclusion

This study examined associations among childhood disease and various WASH conditions and behaviors in rural Tanzania. Findings generally confirm the benefits of improved WASH behaviors and practices. The importance of improved sanitation, especially preventing children from eating soil and animal feces as well as properly disposing of human waste was confirmed. Behavioral determinants of WASH practices need to be explored more thoroughly, both in East Africa and elsewhere, given their association with child morbidity, undernutrition, and underdevelopment.

Acknowledgements

This project was funded in part with UKaid from the British people (Grant PO 6803). Salary support for co-authors comes from UKaid, IMA World Health, and Brigham Young University. UKaid supported Development Media International (DMI) via IMA World Health. DMI created the survey instrument and collected all study data. The funders had no role in study design, data analysis, decision to publish, or preparation of the manuscript.

Conflicts of Interest

The authors declare no conflict of interest.

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