Association of mother's handwashing practices and pediatric diarrhea: evidence from a multi-country study on community oriented interventions

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Summary

Introduction. *Improved hand hygiene in contexts with high levels of diarrheal diseases has shown to reduce diarrheal episodes in children under five years. A quasi-experimental multi-country study with matched comparisons was conducted in four rural districts/sub districts in Cambodia, Guatemala, Kenya and Zambia.*

Methods. *Community oriented interventions including health promotion for appropriate hand washing was implemented in the intervention sites, through community health workers (CHW) and social accountability mechanisms. Community councils were strengthened/established in all study sites. Using household surveys, information on mother's handwashing practices and diarrhea incidence of children 2 weeks preceding the study was obtained.*

Results and Conclusion. *Access to safe drinking water was reportedly higher for communities in Guatemala and Zambia (> 80%), than those in Cambodia and Kenya (< 63%), with significantly higher levels in intervention sites for Guatemala and Kenya. Improved sanitation was low (< 10%), for Kenya and Zambia, compared to Cambodia and Guatemala (> 40%); intervention sites reporting significantly higher levels, except for Zambia. Hand washing index; hand washing before food preparation, after defecation, attending to a child after defecation, and before feeding children was significantly higher for intervention sites in Cambodia, Guatemala and Kenya (Cambodia, 2.4 vs 2.2, p < 0.001, Guatemala, 3.0 vs 2.5, p < 0.001, Kenya, 2.6 vs 2.3, p < 0.001). Factors significantly associated with lower odds of diarrhea were; mother's marital status, higher educational status, one or more handwashing practices, wealthier quintiles, older (> 24 m), and female children. The findings suggest that caretaker handwashing with soap or ash has a protective effect on prevalence of diarrhea in children.*

Introduction

Diarrheal diseases continue to contribute to the major disease burden in children from low and middle- income economies, as the second leading cause of death [1]. Globally, 1.7 billion cases of childhood diarrheal cases are reported every year, resulting in an estimated 525,000 deaths of children under five years [2]. Diarrhea is also a leading cause of malnutrition in children under five [3]. Despite the impressive achievements in reducing child mortality by 69%, in 2015, governments and the development community have far to go in averting the 4.4 million deaths that have been projected for 2030 [4].

A recent systematic review on the evidence of handwashing and diarrhea prevention, reported that in Low and Middle-Income Countries (LMICs), handwashing promotion in communities prevents one quarter of diarrhea episodes with a higher effect size when soap was provided free of cost [5]. The standard practices for hand washing include before feeding a child, after defecating, or handling a child who has defecated and before cooking [6]. Specific times of hand washing have shown different outcomes of diarrhea episodes, as in a trial in rural Bangladesh where hand washing after defecation with and without soap had significantly higher odds of less diarrhea, but not before feeding a child, or after cleaning a child who had defecated [7]. Another study in rural Guatemala, reported no significant differences between intervention and control sites in self-reported hand washing practices, hygiene standards, prevalence of diarrhea and child growth following a three year water treatment and hand washing campaign [8].

Handwashing with soap, in low income economies has been challenged, primarily due to the constraints of time when mothers are busy, and the price of soap for all family members to consistently practice the behavior at all expected times [7, 9-10]. Only 17% of mothers with young children reported washing hands with soap after using the toilet, and 45% with water alone, in a 11-country review [11]. The objective of this study was to examine the association of mother's reported handwashing practices following community-oriented health promotion interventions on diarrhea in children under five years.

Methods

A multi-country assessment was conducted in Cambodia, Guatemala, Kenya and Zambia as part of a collaborative research study by the Johns Hopkins University, the National Institute of Public Health in Cambodia, Institute of Nutrition of Central America and Panama in Guatemala, Moi University School of Public Health in Kenya, and the Institute of Economic and Social Research at the University of Zambia.

In each country four districts or sub districts were selected from the World Vision Area Development Programs (ADP), 2 of the ADPs were assigned to the intervention and two matched ADP's to the comparison arms of the study (Tab. I). Matching was based on select socio-demographic and health profiles of the ADPs. An ADP is a defined geographic area, with a population ranging from 19,000 to 25,000, where World Vision implements a range of integrated health and developmental activities for 15-20 years. These may include health, nutrition, water and sanitation, food security, education, and child sponsorship/protection. Communities in the intervention sites, received a package of interventions including; a) household level health promotion by Community Health Workers (CHWs) focusing on timed and targeted counseling during pregnancy and early childhood and b) institution and or/support of social accountability mechanisms using Community Voice and Action and Community Scorecards, designed to strengthen community to health facility linkages, enhance community knowledge of health facility entitlements and support facility performance [12]. Facility and community management councils were established or strengthened through training and supportive supervision based on the Global Fund's Community Systems Strengthening Framework in all ADP sites [13]. Communities in the comparison ADPs also received routine services from the local district, World Vision and other Non-Governmental Organizations (NGOs), including Community Health Worker (CHW) services.

Household listing of all the communities in the 4 ADPS in each country was obtained. Required sample size was calculated to detect a significant difference in differences in the decline in severe malnutrition in children under-five, with a two-sided alpha of .05 (α = 0.05) and power of 80% (1-β = 0.80), factoring a non-response rate of 5% and design effect of 1.2. Using a multi-stage sampling procedure, communities were sampled in proportion to population size. Eligible households with children under five or women who had a delivery in the previous two years, were selected from each sampling unit. Standardized household survey instruments used by the Demographic Health Surveys, were modified for the study [14]. Interviews were conducted with heads of households to obtain information on socio-demographic characteristics, main source of drinking water and type of sanitation facility and food security. Subsequently, women, aged 15-49 years, who had delivered in the previous two years, or had children or were caretakers of children under five were interviewed to elicit information on reproductive history, handwashing with soap or ash and illness and preventive care-seeking practices for maternal, newborn and child health. In each household one child under the age of five years was randomly selected for the study. The sample for this study only included women who had delivered in the previous two years with a biological child under five years. Since there were variations in the sampling of children at baseline, this paper examines results from the final evaluation conducted between 2016-2017.

The survey teams received training on conduct of field surveys, informed consent and confidentiality procedures for ensuring ethical standards. Household survey instruments were field tested in a neighboring community that was not part of the study site. Informed consent was obtained from all study participants, ensuring confidentiality and disclosures of risks and benefits. Data security was ensured and all standard procedures for field quality control and data management was followed during the conduct of the study.

Diarrhea was defined as the mother's report of a diarrhea episode in children under five, two weeks preceding the survey. Four hand washing practices were included; after defecation, after attending to a child who had defecated, before food preparation and before feeding the child. Handwashing with soap or ash was specified. For the regression analysis, to determine the association of hand washing and diarrhea, we included key demographic, caretaker and child characteristics. Handwashing index was computed for 4 key handwashing practices; handwashing before cooking, after defecation, after attending to a child who had defecated and before feeding the child. All handwashing practices were weighted equally with a value of 1, with an index range of 0-4.

Standard quality control procedures were followed for data cleaning, verification and analysis, using STATA V14.2 [15]. Deidentified data was used for analysis. We first performed a descriptive analysis of socio-demographic factors, followed by reported incidence diarrhea in children and handwashing practices. Bivariate and multivariate logistic regression models were created to determine the association between reported diarrheal

Tab. I. Selected study sites in each country – districts/sub districts.

Study sites	Intervention sites		Comparison sites	
Cambodia	Chulkiri	Comapa	Prasath Balang	Tbeng Meanchey
Guatemala	Comapa	Nuevo Amanecer	Apas	Tinamit Junam
Kenya	Karemo	Katito	Kegonga-Ntimaru	Magunga
Zambia	Luampa	Magoye	Choongo	Nyimba

illness and known predictors including handwashing, access to safe water and sanitation. Cases with missing data for the independent variables were not included in the regression models. Wealth quintiles were constructed employing a principle component analysis with a combination of 10 household assets (television, radio, bicycle, etc.) and household type (roofing). We excluded safe water and sanitation from the wealth quintiles. The index was categorized into five categories of poorest, poor, middle, richer, and richest. Testing for collinearity was performed for the independent variables.

Ethical approval for the study was obtained from the Johns Hopkins Bloomberg School of Public Health's Institutional Review Board (IRB # 00004986) and the ethical and research review boards of the research institutions in each country.

Results

The final sample included 2,995 mother and child pairs in Cambodia, 1,992 in Guatemala, 2,581 from Kenya and 1,057 from Zambia. About 90% of the households were headed by males in Cambodia, Guatemala and Kenya, and more than 30% were headed by females in Zambia (Tab. II). Most women were between the ages of 20-36 years, 98% of the women were married in Cambodia, 55-65% in Guatemala, 84-93% in Kenya and 69-74% in Zambia. Except for Cambodia, where 40% were primiparas, most mothers included in the sample were multiparous. Fifty to sixty percent of the women in the sample had a primary school education. Seventy percent of the children were above six months of age.

Source of drinking water varied between countries ranging from piped water, ground water, well or spring wa-

Tab. II. Selected sociodemographic characteristics of study participants.

Characteristics	Cambodia N = 2,995			Guatemala N = 1,992			Kenya N = 2,581			Zambia N = 1,057		
	I N = 1,254	C N = 1,741	p-value	I N = 898	C N = 1,094	p-value	I N = 1,485	C N = 1,096	p-value	I N = 588	C N = 469	p-value
	%	%		%	%		%	%		%	%	
Male head of household	89.9	89.5	0.759	90.6	92.6	0.120	86.4	89.6	0.014	45.2	68.8	0.000
Mother age												
15-19 y	3.9	4.7	0.317	7.7	8.7	0.417	8.7	7.2	0.167	15.6	16.4	0.735
20-36 y	88.3	86.6	0.174	79.2	79.2	0.993	84.2	86.4	0.112	71.3	72.9	0.549
37-49 y	7.8	8.7	0.368	13.1	12.2	0.512	7.1	6.4	0.451	13.1	10.7	0.222
Mother marital status												
Married	98.2	98.2	0.865	65.3	54.6	0.000	83.5	92.7	0.000	68.7	74.0	0.059
Single/ divorcee/ widow	1.8	1.8	0.865	34.7	45.4	0.000	16.5	7.3	0.000	31.3	26.0	0.059
Mother parity												
1st pregnancy	40.2	38.6	0.379	-	-	-	4.8	3.7	0.191	9.4	20.5	0.000
2 or more	59.8	61.4	0.379	100.0	100.0	-	95.2	96.3	0.191	90.6	79.5	0.000
Mother education												
No education	15.5	25.2	0.000	27.9	27.9	0.990	1.2	5.1	0.000	7.9	16.4	0.000
Primary	54.3	43.8	0.000	56.5	59.0	0.259	69.2	72.0	0.142	50.2	51.7	0.661
Secondary or more	30.3	31.0	0.679	15.6	13.1	0.109	29.6	22.9	0.000	41.9	31.9	0.002
Child gender												
Male	50.3	50.9	0.734	53.0	51.4	0.480	52.3	52.9	0.781	53.1	55.3	0.468
Female	49.7	49.1	0.734	47.0	48.6	0.480	47.7	47.1	0.781	46.9	44.7	0.468
Child age												
0-6 m	26.8	25.8	0.562	22.8	19.1	0.043	22.4	18.4	0.012	27.2	28.4	0.680
7-23 m	65.3	64.7	0.719	52.0	40.6	0.000	58.8	52.4	0.001	54.4	54.8	0.903
24-59 m	7.9	9.5	0.127	25.2	40.3	0.000	18.8	29.2	0.000	18.4	16.8	0.518
Wealth quintile												
1st	21.1	47.5	0.000	31.2	22.0	0.000	17.0	29.5	0.000	26.7	17.1	0.000
2nd	10.8	10.7	0.943	20.8	25.3	0.017	24.3	33.1	0.000	16.3	22.8	0.009
3rd	16.1	17.7	0.236	13.6	12.9	0.648	12.7	4.5	0.000	17.7	19.4	0.477
4th	25.3	13.6	0.000	16.8	22.3	0.002	20.6	18.7	0.228	25.9	24.3	0.565
5th	26.8	10.5	0.000	17.6	17.5	0.937	25.3	14.2	0.000	13.4	16.4	0.179

I: Intervention; C: Comparison.

ter, water provided by tankers or vendors, surface or rain water. Reported access to piped water was 90% in the intervention sites, and 57.7% in the comparison sites for Guatemala, the highest amongst all the countries. Intervention sites in Kenya also reported significantly higher access (21%) to piped water, compared to the comparison sites (6.3%). Access to safe water, classified based on Demographic Health Survey (DHS) definitions, was relatively high in both intervention and comparison sites for Guatemala and Zambia (83-99%), and <65% for Cambodia and Kenya (Tab. III). Ninety percent of the women in Cambodia and Guatemala reported 30 minutes or less to obtain water; the proportion for Kenya (< 54%), and Zambia (< 73%) were much lower. Intervention sites reported significantly higher access to safe water in Guatemala and Kenya (p < 0.001), and comparison sites were significantly higher for Cambodia and Zambia. Types of toilet facilities reported were shared or private or shared flush (40-60% in Cambodia and Guatemala), and traditional pit (85-98% in Kenya and Zambia). Open defecation outside the home was relatively common in Cambodia (40-48%) and Guatemala (11-19%).

Handwashing with soap or ash before food preparation was above 75% for Cambodia and 95% for Guatemala, with much lower levels for Kenya (60%) and Zambia (45%). More than 60% of women reported handwashing after defecation in all four countries, however, handwashing after attending to a child who had defecated was much lower for Cambodia and Zambia (29-45%). In Cambodia and Guatemala, hand-washing with soap or ash was much higher before food preparation (Cambodia 78-81%, Guatemala 95-96%) than after defecation (Cambodia 59-61% Guatemala 59- 70%). The trends were reversed for Kenya and Zambia where higher proportions reported handwashing after defecation than before food preparation. The results showed highly significant differences between intervention and comparisons sites for women in Guatemala, for both handwashing after defecation and attending to a child after defecation (after defecation 69.6% vs 59.4%, p < 0.001, after attending to a child who had defecated 70.7% vs 42.7%). Reported handwashing with soap or ash before feeding children was significantly higher for mothers in Cambodia, Guatemala and Kenya (p < 0.001) for the intervention sites. Except for Zambia, where the comparison sites performed better, for all the other countries the handwashing index was significantly higher in the intervention sites (Cambodia, 2.4 vs 2.2, p < 0.001, Guatemala 3.0 vs 2.5, p < 0.001, Kenya 2.2 vs 2.3, p < 0.001, Zambia 1.8 vs 2.0, p < 0.001). Almost 90% of the women in the intervention and comparison sites from all countries reported at least one handwashing practice.

Based on mother's recall, report of childhood diarrhea two weeks preceding the survey was 11-12% for Cambodia, 9-10% for Guatemala, 6-9% for Kenya, and 16-20% for Zambia. Children who were below six months had a lower prevalence in all four countries. Except for Kenya (Intervention 9.9%, Comparison 6.1%, p < 0.001), there were no significant differences in diarrhea based on mother's reports, between the intervention and comparison sites in Cambodia, Guatemala and Zambia.

In the univariate regression model, gender of household head, age of mother, parity of mother, and type of sanitation facility were not significantly associated with lower diarrhea incidence (Tab. IV). Variables that were significant were included in the multivariate regression model (Tab. V). Children whose mothers were married had a lower odds of diarrhea incidence, for Cambodia and Kenya (Cambodia OR 0.469 [0.226-0.974], p < 0.05, Kenya OR 0.566 [0.358-0.897, p < 0.05]), Mothers with higher education, secondary school or more (OR 0.361 [0.182-0.716, p < 0.01]) for Guatemala, those from the 4th or 5th wealth quintile, for Cambodia, and Zambia, 4th quintile for Guatemala and those reporting less than 30 minutes to drinking water source for Guatemala, reported lower incidence of diarrhea children. One or more handwashing practices for Cambodia and Guatemala, was associated with significantly less diarrhea in children. Male children in Zambia had a higher odds of diarrhea incidence and children younger than 2 years in Cambodia and Guatemala, had a higher odds of diarrhea incidence. Safe water source and sanitation did not show any significant differences in the odds of diarrhea illness in children. Women in the intervention sites in Kenya reported significantly higher incidence in diarrhea for children (OR 1.783, [1.215-2.616], p < 0.01).

Investments in community-oriented healthcare include strategies to ensure safe water sources, and appropriate sanitation facilities to prevent diarrhea in young children under five years. These water and sanitation interventions typically include health promotion at the household and community level for improving handwashing practices, as it has been evidenced to prevent one fourth of diarrhea episodes [5]. The results of the study provide some evidence of the community interventions to improve handwashing practices and reducing the incidence of reported diarrhea.

Reported access to safe water in the ADP, was much higher than the recent DHS 2014 figures for all countries except Cambodia (Guatemala DHS 66.1%, Intervention, 98.8%, Comparison, 83.2%, Kenya DHS 59.1%, Intervention, 62.9%, Comparison, 45.4%, Zambia DHS 46.6%, Intervention, 88.7%, Comparison, 97.8%). In comparison to recent DHS estimates, incidence of diarrhea for children under five was lower for all countries, the lowest reported for Guatemala, which could be partly attributed to the various community level interventions including community and household health promotion efforts, installation of water pumps etc. instituted by the program in these rural areas (Cambodia DHS 12.8%, Intervention, 8.4%, Comparison, 10%, Guatemala DHS 19.2%, Intervention, 5.9%, Comparison, 4.3%, Kenya DHS 15.2%, Intervention, 8.2%, Comparison, 7.5%, Zambia DHS 16.1%, Intervention, 9.2%, Comparison, 7.7%). Despite the bias in observational studies, as study participants are aware of being watched, when field workers observed food preparers wash hands before preparing the food in Bangladesh, it showed a reduction in the incidence of diarrhea in children under five years [7].

Tab. III. Water source, sanitation, hand washing practices and diarrhea episode for children under 5 years.

Characteristics	Cambodia N = 2,995			Guatemala N = 1,992			Kenya N = 2,581			Zambia N = 1,057		
	I N = 1,254	C N = 1,741	p-value	I N = 898	C N = 1,094	p-value	I N = 1,485	C N = 1,096	p-value	I N = 588	C N = 469	p-value
	%/ mean	%/ mean		%/ mean	%/ mean		%/ mean	%/ mean		%/ mean	%/ mean	
Water source												
Piped	10.3	7.1	0.003	90.0	57.7	0.000	21.0	6.3	0.000	7.7	2.2	0.000
Ground	16.7	30.7	0.000	-	0.4	a	21.0	7.0	0.000	75.0	94.9	0.000
Well	19.3	42.2	0.000	8.7	30.6	0.000	20.7	41.1	0.000	11.8	1.6	0.000
Spring	0.3	5.0	0.000	0.8	3.0	0.000	28.2	30.8	0.154	1.1	0.9	a
Tank/tanker	6.2	0.5	0.000	0.2	5.2	0.000	0.7	0.5	a	-	-	.
Surface	34.1	10.1	0.000	0.1	0.6	a	8.0	14.2	0.000	4.4	0.4	a
Rain	4.8	0.7	0.000	0.1	0.1	a	0.1	0.2	a	-	-	.
Purified	-	-	.	0.1	0.3	a	-	-	.	-	-	.
Vendors	8.2	3.6	0.000	-	2.1	a	0.2	-	a	-	-	.
Safe source[1]	47.2	53.7	0.000	98.8	83.2	0.000	62.9	45.4	0.000	88.7	97.8	0.000
Minutes to get water[2]												
< 30 m	-	-	-	96.6	93.8	0.004	53.0	51.1	0.368	71.8	72.6	0.779
≥ 30 m	-	-	-	3.4	6.2	0.004	47.0	48.9	0.368	28.2	27.4	0.779
Toilet facility												
Private flush	48.1	37.9	0.000	41.8	31.8	0.000	1.6	0.6	a	0.5	-	a
Shared flush	11.2	13.7	0.046	4.6	8.4	0.000	2.6	1.8	0.176	-	0.6	a
Traditional pit	0.2	0.5	a	36.6	36.2	0.830	86.1	92.7	0.000	94.5	98.5	0.000
Open backed	-	0.2	a	5.5	4.4	0.279	6.5	1.1	0.000	0.5	-	a
Defecation outside home	40.5	47.7	0.000	11.4	19.2	0.000	3.2	3.8	0.411	4.4	0.9	a
Other	-	0.1	a	0.2	-	a	-	-	.	-	-	.
Improved Sanitation[3]	59.3	51.5	0.000	46.3	40.2	0.006	4.2	2.4	0.008	0.5	0.6	a
HW practice												
Before food preparation	77.9	81.4	0.020	96.0	94.9	0.235	66.1	61.4	0.015	44.0	44.8	0.813
After defecation	61.3	59.0	0.209	69.6	59.4	0.000	79.9	63.1	0.000	67.5	72.3	0.093
After attending child defecation	39.2	41.9	0.147	70.7	42.7	0.000	62.0	65.0	0.124	28.7	45.0	0.000
Before feeding children	61.0	41.0	0.000	64.5	51.0	0.000	54.8	40.3	0.000	35.0	34.3	0.811
HW index[4]	2.4	2.2	0.000	3.0	2.5	0.000	2.6	2.3	0.000	1.8	2.0	0.001
1 or more practice	96.7	96.1	0.352	99.6	98.6	0.026	97.1	93.0	0.000	87.2	97.0	0.000
Diarrhea past 2 w (0-5 y)	11.4	12.1	0.547	10.3	9.5	0.548	9.9	6.1	0.000	16.2	20.3	0.089
Children 0-6 m	26.8	25.8	0.562	22.8	19.1	0.043	22.4	18.4	0.012	27.2	28.4	0.680
Diarrhea in past 2 w (0-6 m)	8.4	10.0	0.425	5.9	4.3	a	8.2	7.5	0.772	9.2	7.7	a

I: Intervention; C: Comparison; HW: Handwashing. [1] Safe water: piped water, (public) hand pump, covered well, protected spring, rain water and purified water for Cambodia, Kenya, Guatemala, and Zambia, and water from vendors for Cambodia, Kenya, and Guatemala. Unsafe water: open well, unprotected spring, tank/tanker water and surface water for Cambodia, Zambia, Guatemala, and Kenya, and water from vendors for Zambia. [2] 0 minute if water source is within the house/plot. [3] Improved toilet facilities: private flush and shared flush. Not improved toilet facilities: traditional/modern pit, open backed and defecation in field/outside house. [4] Hand wash index (0-4): before food preparation, after defecation, after attending to a child defecation, and before feeding children. [a] p-value not computed due to low sample size.

In our study we found variations of practice based on healthcare context. For Cambodia and Guatemala, a higher proportion of women reported handwashing before food preparation than after defecation or attending to a child after defecation. However, for Kenya and Zambia the trends were reversed where a higher proportion reported handwashing after defecation. This may be due to the types of hygiene prevention interventions,

Tab. IV. Bivariate logistic model of mother's handwashing practice and reported diarrhea in children under 5 years.

Variables	Cambodia	Guatemala	Kenya	Zambia
	OR [CI]	OR [CI]	OR [CI]	OR [CI]
Gender of household head (ref. female)	1.000	1.000	1.000	1.000
Male household head	1.021 [0.983-1.060]	0.982 [0.936-1.030]	0.984 [0.952-1.016]	1.016 [0.969-1.066]
Age of mother (ref. age < 24 years old)	1.000	1.000	1.000	1.000
Age 24-49	1.000 [0.974-1.027]	0.990 [0.962-1.018]	0.981 [0.959-1.003]	1.045 [0.997-1.096]
Parity of mother (ref. multiparity)	1.000	1.000	1.000	1.000
First pregnancy	1.014 [0.991-1.039]	1.000 [1.000-1.000]	1.050 [0.996-1.107]	0.940 [0.879-1.005]
Marital status (ref. Not married)	1.000	1.000	1.000	1.000
Currently married	0.934 [0.856-1.019]	1.018 [0.991-1.045]	0.947*** [0.917-0.978]	1.046 [0.993-1.102]
Mother's education (ref. none)	1.000	1.000	1.000	1.000
Primary	1.023 [0.993-1.055]	0.972 [0.943-1.002]	1.026 [0.958-1.099]	0.921 [0.847-1.001]
Secondary and more	1.027 [0.994-1.062]	0.935** [0.896-0.976]	1.012 [0.943-1.086]	0.921 [0.845-1.004]
Wealth quintile (ref. poorest)	1.000	1.000	1.000	1.000
2nd (poor)	1.020 [0.980-1.062]	0.999 [0.962-1.037]	0.988 [0.958-1.018]	0.979 [0.911-1.053]
3rd (middle)	0.962* [0.930-,0.996]	1.011 [0.967-1.057]	0.991 [0.950-1.033]	0.930 [0.864-1.001]
4th (richer)	0.969 [0.937-1.001]	1.046* [1.006-1.088]	1.006 [0.973-1.040]	0.967 [0.903-1.035]
5th (richest)	0.976 [0.943-1.009]	0.984 [0.945-1.025]	0.986 [0.955-1.019]	0.886** [0.819-0.957]
Child age (ref. 0-23 m)	1.000	1.000	1.000	1.000
Child 24 m-59 m	0.927*** [0.888-0.968]	0.944*** [0.914-0.974]	0.997 [0.971-1.024]	0.988 [0.922-1.058]
Child gender (ref. female child)	1.000	1.000	1.000	1.000
Male child	1.020 [0.996-1.044]	1.009 [0.982-1.035]	0.986 [0.965-1.007]	1.065** [1.016-1.117]
Intervention (ref. comparison)	1.000	1.000	1.000	1.000
Intervention group	0.993 [0.970-1.016]	1.008 [0.982-1.035]	1.038*** [1.016-1.061]	0.960 [0.915-1.006]
Safety of water source (ref. unsafe water)	1.000	1.000	1.000	1.000
Safe water source	0.999 [0.976-1.023]	0.957 [0.916-1.000]	1.011 [0.989-1.033]	1.020 [0.931-1.117]
Minutes to get water (ref. < 30 m)		1.000	1.000	1.000
≥ 30 minutes		1.064 [0.999-1.134]	1.020 [0.998-1.043]	1.023 [0.967-1.083]
Toilet facility (ref. not improved)	1.000	1.000	1.000	1.000
Improved facility	0.992 [0.969-1.015]	1.019 [0.992-1.046]	0.950 [0.896-1.007]	0.986 [0.724-1.344]
Number of HW practices (Ref. none)	1.000	1.000	1.000	1.000
1	0.968 [0.906-1.033]	0.817** [0.708-0.944]	0.987 [0.933-1.044]	0.963 [0.880-1.054]
2	0.929* [0.871-0.990]	0.811** [0.702-0.938]	0.953 [0.903-1.006]	1.032 [0.943-1.129]
3	0.906** [0.849-0.966]	0.861* [0.743-0.998]	0.975 [0.921-1.031]	1.027 [0.927-1.137]
4	0.959 [0.896-1.026]	0.818** [0.709-0.944]	0.943* [0.893-0.995]	1.052 [0.943-1.174]

OR: Odds Ratio CI: 95% Confidence Interval; HW Handwashing ; * p < 0.059; ** p < 0.01; *** p < 0.001.

where handwashing stations were constructed beside the latrines to foster appropriate behaviors in some of the ADP sites.

Caretakers in intervention sites received targeted counseling from CHWs, about the importance of handwashing practices as part of the maternal newborn and child health package of interventions. Other community oriented complimentary activities were included in the intervention package with community voice and action and community councils to improve hygiene and handwashing practices. The comparison sites also received the routine CHW services and were supported through community council activities. In a majority of World Vision ADPs, handwashing promotion is integrated especially if there are focused efforts on improving the infrastructure for safe water and sanitation facilities with

handwashing stations. Community and facility councils were engaged in promoting appropriate hygiene behaviors and facilitated the construction of water pumps and shared toilet facilities in some ADPs. Hence this may have resulted in improved handwashing and other behaviors in comparison sites. Controlling for confounding factors, our study did not show a difference in the odds of diarrhea between intervention and comparison sites, except for Kenya, where children in the intervention sites showed higher odds of diarrhea. A study in rural Guatemala, which deployed community health promoters to improve water treatment and hand washing found no significant differences between the intervention and comparison sites for reported hand washing practices, hygiene standards, prevalence of diarrhea and child growth [8]. Interestingly another study in Kenya, which evaluated the effect of CHW and commu-

Tab. V. Multivariate logistic model of mother's handwashing practice and reported diarrhea in children under 5 years.

	Cambodia	Guatemala	Kenya	Zambia
	OR [CI]	OR [CI]	OR [CI]	OR [CI]
Marital status (ref. Not married)	1.000	1.000	1.000	1.000
Currently married	0.469* [0.226-0.974]	1.116 [0.782-1.592]	0.566* [0.358-0.897]	1.590 [0.967-2.614]
Mother's education (ref.none)	1.000	1.000	1.000	1.000
Primary	1.082 [0.764-1.532]	0.690 [0.474-1.004]	0.960 [0.330-2.792]	0.759 [0.402-1.434]
Secondary and more	1.435 [0.980-2.102]	0.361** [0.182-0.716]	0.844 [0.278-2.564]	0.826 [0.410-1.664]
Wealth Quintile (ref. poorest)	1.000	1.000	1.000	1.000
2nd (poor)	1.290 [0.867-1.919]	1.129 [0.680-1.874]	0.750 [0.462-1.217]	0.653 [0.360-1.183]
3rd (middle)	0.667 [0.444-1.001]	1.221 [0.680-2.193]	0.809 [0.418-1.566]	0.304*** [0.150-0.614]
4th (richer)	0.652* [0.429-0.992]	2.051** [1.248-3.372]	1.091 [0.664-1.792]	0.470* [0.251-0.878]
5th (richest)	0.699 [0.457-1.071]	0.939 [0.507-1.740]	0.933 [0.541-1.608]	0.255** [0.106-0.618]
Child age (ref. 0-23 m)	1.000	1.000	1.000	1.000
Child 24 m-59 m	0.445** [0.263-0.753]	0.478*** [0.328-0.696]	1.012 [0.690-1.484]	0.717 [0.417-1.233]
Child gender (ref. female child)	1.000	1.000	1.000	1.000
Male child	1.126 [0.871-1.454]	1.011 [0.723-1.415]	0.931 [0.663-1.308]	1.788** [1.150-2.780]
Intervention (ref. comparison)	1.000	1.000	1.000	1.000
Intervention group	1.034 [0.781-1.368]	1.123 [0.778-1.621]	1.783** [1.215-2.616]	0.706 [0.450-1.108]
Safety of water source (ref. unsafe water)	1.000	1.000	1.000	1.000
Safe water source	0.912 [0.704-1.181]	0.780 [0.422-1.442]	1.187 [0.834-1.691]	1.122 [0.463-2.715]
Minutes to get water (ref. < 30 minutes)	-	1.000	1.000	1.000
$\geq$ 30 minutes	-	2.009* [1.046-3.862]	1.150 [0.813-1.626]	1.204 [0.755-1.920]
Toilet facility (ref. not improved)	1.000	1.000	1.000	1.000
Improved facility	1.058 [0.798-1.404]	1.189 [0.828-1.707]	0.396 [0.094-1.674]	1.000 [1.000-1.000]
Number of HW practices (ref. none)	1.000	1.000	1.000	1.000
1	0.650 [0.352-1.203]	0.197* [0.053-0.725]	0.933 [0.408-2.133]	0.707 [0.293-1.708]
2	0.541* [0.295-0.991]	0.189* [0.050-0.711]	0.478 [0.210-1.088]	1.710 [0.732-3.991]
3	0.414** [0.222-0.771]	0.327 [0.086-1.251]	0.757 [0.327-1.753]	1.305 [0.511-3.334]
4	0.763 [0.403-1.443]	0.222* [0.061-0.807]	0.485 [0.209-1.124]	1.140 [0.397-3.275]
N	2179	1452	1739	539

OR: Odds Ratio; CI: 95% Confidence Interval; HW: Handwashing ; * p < 0.059; ** p < 0.01; *** p < 0.001.

nity unit interventions in diarrhea prevention, water and sanitation showed that there was a higher odds of diarrhea prevalence in areas where CHW performance was high [16]. Apparently CHW and community unit interventions were focused more on high diarrhea prevalence sites. As in the Kenya study, our results suggest that the CHW and community promotion strategies improved hand-washing, but did not decrease diarrhea incidence when controlled for other factors.The study from Ethiopia showed a 35% reduction in diarrheal diseases in children under five for households who received health promotion messages given continuously for six months with the distribution of soap [4].

A previous study showed decreased diarrhea incidence in these rural areas for Cambodia, Guatemala and Kenya (comparison sites only), and Zambia (intervention sites only) following community oriented interventions [17], but did not include the effect of handwashing practices, and the sample included all children, not only those with biological mothers. It must be noted that overall hygiene in the household environment is also a critical contributor to diarrhea incidence aside from mother's handwash-

ing practices. Recommendations for handwashing at all four times, may not be feasible as reported in other studies [7], but health promotion messages could emphasize washing hands before food preparation and after defecation or attending to a child who has defecated. To enhance the effectiveness of handwashing interventions, washing hands only at the most critical times, to interrupt pathogen transmission, and promoting handwashing with water alone has been recommended [7]. Similar to another study in Bangladesh, where women were questioned about handwashing with soap or ash, in our study a higher proportion of women in Kenya and Zambia reported handwashing after defecation, than before preparing food [7]. This practice was the reverse for Cambodia and Guatemala, where a high percentage reported handwashing before food preparation than after defecation. A dose effect was observed with the number of reported handwashing practices and diarrhea incidence for Cambodia and Guatemala as in the Bangladesh study [7].

Sources of water for drinking differed between countries, and there was also a wide variation in use of safe sanita-

tion facilities. A binary variable of safe and unsafe water and sanitation source was computed in the multivariate regression model and showed no significant differences in the odds of diarrhea illness in children. Another study from Guatemala, also reported no significant findings of home water treatment and diarrhea incidence but reported a reduction in diarrhea incidence of 20-22% when household members reported consumption of bottled water for drinking [18]. Diarrhea incidence among children without access to piped water was reported at 32.2% in the same study. Our findings showed that mothers from both intervention (90%) and comparison (57.7%) sites reported very high levels of piped water in Guatemala, compared to other countries. This may have resulted in reduced diarrhea incidence as reported in other studies [19, 20]. Mothers in Guatemala who reported 30 or more minutes to fetch water, had twice the odds of diarrheal episodes, but this was not significant for other countries, though higher levels were reported. Minutes to fetch water was reported to be a key factor associated with diarrheal incidence in children in a study in Ethiopia [21].

Diarrhea incidence in households with sanitation infrastructure was reportedly lower than those with no infrastructure in the Guatemala study [18]. In this study, Private flush facilities, was reported by 42% of the mothers in the intervention and by 32% in the comparison sites, which could have also reduced the illness incidence. However, the multivariate model showed no significant differences in the odds of lower diarrhea incidence when mothers reported improved sanitation.

Relative to other studies, showing a decline in diarrheal incidence in older children [7, 16], this study showed children under 2 years had higher odds of diarrhea.

Though a significant effect was only evident for Zambia when controlled for other factors, male children had higher diarrhea incidence than female children. This observation was also reported in other studies in Guatemala, Kenya and Ethiopia, hypothesizing that male children have greater environmental exposure, than female children [16, 18, 21].

Unlike other studies reported in the literature on hand washing, we did not perform structured observations of hand washing practices [7], as biases can be introduced due to direct observations. Water storage and water treatment practices have been shown to be predictors of diarrheal illness, but these measures were not included in our study [8, 21]. The cross-sectional study design could be another potential limitation, as causal relationships cannot be determined. However, a study in Burkina Faso reported consistent handwashing practices of mothers whose children had defecated, following repeated measures on different days [22]. The data only included biological mothers and child pairs, and patterns of diarrhea incidence could have been different for children who did not have biological mothers. It must be noted that child feeding especially for children under two years is performed by other members of the family and not just the mothers. Hence these results suggest that health promotion interventions need to be directed to the broader community and other family members.

Child's diarrhea episode was based on mother's report and not defined by three or more loose or watery stools in 24 hours or blood in stools. The recall period of 2 weeks may have introduced another source of bias, unlike the study in Guatemala where the recall period was 48 hours [8]. Although not feasible, given the minor variations in protocols, a difference in difference analysis, controlling for baseline values would have provided true effects of the intervention. We did not control for malnutrition, which has been shown to exacerbate diarrhea episodes [23] nor was the analysis controlled for breastfeeding practices which has been shown to be a protective factor in some studies [24-27]. Household and personal hygiene, and water storage facilities were also not included in the assessments. We focused on handwashing with soap/ash similar to the study from Ethiopia [21]. We did not enquire about handwashing alone, without soap/ash, which may have provided additional evidence on handwashing with water, as soap is an expensive commodity for most rural communities in low and middle-income economies, though ash may be more readily available. Point-of-use water treatment has shown significant reduction in diarrhea incidence in some studies, which may be another limitation in the safe water construct used in this study [28, 29].

Conclusions

Based on the 2010 World Health Organization (WHO) and United Nations Children's Fund (UNICEF) report, it is estimated that 900 million people worldwide lack access to improved drinking water [30]. To compliment the health intervention strategies to improve service utilization for basic maternal neonatal and child health, World Vision embraces the sustainability development goals for comprehensive development and provides a platform for multidimensional development strategies, including the construction of water pumps, safe sanitation facilities, promoting hand washing and hygiene practices to enable healthy behaviors, and mitigate the burden from preventable illnesses such as diarrhea in rural communities. Community oriented strategies through CHW and social accountability mechanisms foster healthy behaviors, as the study showed significantly higher handwashing index in all intervention sites, except for Zambia.

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Conflict of interest statement

The study was conducted as a Third-Party Evaluation by Johns Hopkins University, National Institute of Nutrition, Cambodia, Institute of Economic and Social Research, Zambia, Institute of Nutrition for Central America and Panama, Guatemala, and Moi University, Kenya. Research teams from each of these institutions were involved in the study design, data acquisition, and analysis through the contract. AE wrote and made the interpretations of the findings. AE, YJ, and CC were partially funded by the grant for conducting the research. AG and JC were employed by World Vision.

Authors' contributions

AE wrote the manuscript, YJ performed the analysis of the data and prepared the tables. CC conducted the field work. AG and JC were involved in the conceptualization of the research interventions. AE and CC were engaged in the execution of the research study. AG, YJ, CC and JC reviewed and edited the final version.

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