Improved water and household water purification practices among orphans and vulnerable children in a multi-sectoral empowerment program in Eastern province, Kenya

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ABSTRACT

Water quality is an important determinant of diarrheal illnesses, especially affecting children in sub-Saharan Africa. Orphans and vulnerable children (OVC) in sub-Saharan Africa are at increased risk of poor quality drinking water, and therefore of diarrheal illness. The present study assesses primary drinking water source and typical household water purification among OVC households involved in a multi-sectoral empowerment program in semi-rural Kenya. Findings show water purification practices, but not water source, significantly increase with more time in the program. Other factors associated with safer water include household income, orphan type, food consumption and security, school completion, psychological resilience, engaging in sexual intercourse with more than one partner in the past 12 months, and previous year's financial status. Incorporating water quality improvements in a community-based empowerment program such as the one described may be one method of improving water quality and decreasing diarrheal illnesses among OVCs in sub-Saharan Africa.

Key words | empowerment program, Kenya, orphans and vulnerable children, OVC, water, water purification

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INTRODUCTION

The United Nations Millennium Development Goals (MDGs) set aside goal seven to address environmental sustainability especially in relation to safe drinking water access and basic sanitation. Target 10 of goal seven states, 'To halve, by 2015, the proportion of people without sustainable access to safe drinking water and basic sanitation' (Millenium Project 2006). For water, the UN MDG target was met in 2010, with an impressive 2.3 billion people gaining safe drinking water access over 12 years. However, improving access has been uneven, with rural and lowest income communities falling behind. Despite the improvements to safe drinking water access over the past couple of decades, a half million total deaths each year worldwide are still attributed to unsafe or inadequate water consumption alone (World Health Organization 2014).

The mortality burden caused by diarrheal illnesses among children globally is particularly worrisome (Walker et al. 2013). The United Nations Children's Fund (UNICEF) recently proposed the year 2030 be set as a target for universal coverage for basic water access (United Nations Children's Fund (UNICEF)/World Health Organization (WHO) 2012). This target was included in the United Nations Sustainable Development Goals (SDGs), which replaced the MDGs at the end of 2015 as the next generation of development goals.

Water access is generally defined in three categories, 'unimproved', 'other improved', and 'piped' water (Clasen *et al.* 2007; Wolf *et al.* 2014). Piped water is generally piped to the household premises, reducing time required to fetch water, increasing the quantity of water, and in more developed areas ensuring less contaminated water (Clasen *et al.* 2007). Piped water has been found to reduce childhood diarrhea (Jalan & Ravallion 2003). In some countries, piped water has not been found to reduce microbacterial contamination beyond that of other improved sources (Onda *et al.* 2012). Other improved water sources include public taps, stand pipes, tube wells, boreholes, protected dug wells, protected springs, and rainwater collection (Bain *et al.* 2012).

Improved water sources significantly limit the probability of contamination by reducing exposure to outside air (Bain *et al.* 2014b), but may continue to pose some risk to consumers (Prüss-Ustün *et al.* 2014). Since even improved water sources may contain contamination, efforts to purify water remain important to reduce the risk of diarrheal infection and death (Clasen *et al.* 2007). Piped water has been found to be more likely contaminated in countries with lower per capita income and in more rural areas as compared to urban or semi-urban areas (Bain *et al.* 2014a). Correspondingly, efforts to reduce the burden of diarrhea, along with other water-borne diseases, benefit from increasing access to improved water and purifying water prior to consumption in high risk areas (Prüss-Ustün *et al.* 2014). Consistent use of household-based water treatment and safe water storage can reduce the incidence of diarrhea by 28–45% (World Health Organization 2014).

To reduce the risk of illness from contaminated water, household purification of water prior to consumption is recommended regardless of point source (Wright *et al.* 2004). Treating water by chlorination (Lule *et al.* 2005), filtration by biosand (Sobsey *et al.* 2008) or ceramic filters (du Preez *et al.* 2008), and boiling (Sodha *et al.* 2011) significantly reduce microbial loads in water, producing water that is safer for consumption. Baseline characteristics of the water are an important element in treatment efficacy (Lule *et al.* 2005), with post-treatment safety paralleling the degree of water contamination prior to treatment. Drinking water from an improved water source that has been decontaminated prior to consumption is important for reduction of household risk of diarrhea.

Geographic and household characteristics influence the probability that a household's primary source of drinking water comes from an improved water source and is appropriately treated prior to consumption. At the global geographic level, sub-Saharan Africa has a higher population-attributable fraction (0.38) of diarrheal illnesses due to inadequate water than any other World Health Organization region (Prüss-Ustün *et al.* 2014). As an example of household-level characteristics, a recent study in Ghana found that education, income, and household location significantly predicted use of improved water in urban areas (Mahama *et al.* 2014).

In sub-Saharan Africa, households with orphan and vulnerable children (OVC) may be at greater risk of diarrheal illness (Watts *et al.* 2007), although the literature on this point is limited. Paternal orphans in South Africa have significantly less access to improved water source than non-orphans, a difference that has not been found among maternal orphans (Case & Ardington 2005). The increased risk of non-piped water sources among paternal orphans has been explained by the lower earning potential of households missing an adult male (Ardington & Leibbrandt 2010). Limited access to piped water is significantly associated with reduction in completed schooling among OVC in South Africa (Chuong & Operario 2012). Factors influencing household efforts to purify water among OVC have not been explored in the literature.

Given the presence of more than 40 million OVC across sub-Saharan Africa (United Nations Children's Fund (UNICEF) 2003), the known risks conferred by OVC status including lack of access to piped water (Case & Ardington 2005) and lower education (Andrews *et al.* 2006), and the global impact of diarrheal illnesses (Bain *et al.* 2014a), understanding factors predicting improved water source and household purification practices is essential for reducing the possible increased risk of diarrheal illnesses.

As the world moves forward to achieve the water, sanitation, and hygiene (WASH)-related objectives of the SDG, community-based programs specific for vulnerable populations will be vital to achieving universal drinking water access by 2030. Given the multifaceted and ecological influence on water access and water purification, community empowerment programs for OVC could be one way to address the needs of this under-served population. Utilizing empowerment programs that do not necessarily specifically focus on

clean water access but include it as part of a larger, multidisciplinary program can lend to water access sustainability and pooling of resources to most effectively meet several interwoven needs. In rural Kenya, social capital and collective action were shown to be an important part of instigating water-related behavioral change (Bisung *et al.* 2014). Social support networks and collective efficacy are important constructs for the success of water-related behavioral interventions in low and middle income countries. (Dreibelbis *et al.* 2013) Self-efficacy, knowledge, and risk perception are also important individual-level attributes to the social-behavioral models related to WASH. Programs, such as the one highlighted in this study, may be useful in improving safe drinking water-related behaviors, utilizing constructs in WASH social-behavioral models within the OVC community.

The importance of community involvement is currently recognized as part of the water-related SDG goal measures (United Nations 2015). Current literature exploring the impacts of community-based efforts to improve water quality is limited (Wolf *et al.* 2014), and would benefit from assessing predictors of water source and purification among a community-based program targeting OVC in sub-Saharan Africa.

METHODS

Study aim

The present study evaluates the association between use of improved water sources for primary drinking, household water purification practices and participation in a community-based empowerment program targeting OVC-sibling households. Covariates related to program activities, OVC well-being (economic and other socio-behavioral aspects), and demographic characteristics were included in further analyses to explore associations between these characteristics and the utilization of improved water and household purification practices.

Program description

The faith-based program, Zoe/Giving Hope, emerged in response to the orphan crisis in Rwanda following the genocide. In 2007, the program expanded to Kenya and operates in connection with the community health department of the Maua Methodist Hospital in Meru County. Currently, 1,200 families are officially enrolled in the program, 92.26% of which include at least one child under five years old. Families are represented in the program by a sibling, typically the oldest sibling, between the ages of 13 years and 22 years of age. Families are identified for program inclusion by leaders, pastors, tribal elders, elected politicians, teachers, and other community leaders within the community on the basis of orphan and financial status. Social workers visit with potential families to ensure included families are the most vulnerable within the community. Priority for program inclusion is given in the following order: double orphans (orphans who have lost both parents), siblings with abusive or very poor parents, single orphans (paternal or maternal – having lost a father or mother, respectively), and children of terminally ill parents.

New families enter the program every year for a three-year duration, during which time participants join working groups of roughly 20 families. Working groups meet weekly, allocate program resources, participate in a shared business or agricultural endeavor, and provide support from peers and mentors. Families decide a micro-enterprise to begin or expand, and are supported from program resources by receiving training, micro-grants, and sometimes a 'start-up kit' to begin a business. Working groups facilitate the distribution of resources, conditioning cash transfers on group-approved expenses that may include school fees, agricultural inputs, and medical needs. Weekly working group meetings include lessons on hygiene, finance, and other life essentials. Water quality is not a primary focus of the program, but is addressed by lessons on hygiene and sanitation.

Working groups from similar geographic regions meet every month to share insights and further decrease the stigma associated with orphan status. There are 12 regional locations in the Kenya program. Working groups enter the program at the same time, and group families have roughly equal program exposure. Regional meetings include program participants from all three active program years.

Study design

Data were collected by trained and paid program participants over 18 years old in a cross-sectional survey using a structured questionnaire in March 2014, before new

program participants had received program benefits. All interviews were conducted at one of 12 monthly regional meetings, and interviewers conducted interviews only at locations that were non-adjacent to their own region to reduce social response bias. All participants in attendance at their regional meeting were invited to participate, with 1,060 respondents providing informed consent and two participants abstaining. The present discussion represents one aim among others in the study of this program, and the sample size for this aim was 1,005 total or 335 per each of the three recruitment years.

Response variables

The interview recorded one of 14 different possible sources of primary drinking water for the respondent's household, using the Multiple Indicator Cluster Survey question (UNICEF 2013). Water source was recorded in two separate ways, reflecting current debates in the literature (Wolf *et al.* 2014). It is well established that water sources that limit exposure to outside air reduce contamination and provide protection against water-borne diseases (Bain *et al.* 2014b), but it is not clear how much safer piped water is compared to other improved, non-piped water in low- and middle-income countries (Wolf *et al.* 2014). Water source was therefore categorized as piped, other improved, and unimproved. Unimproved water included primary drinking water from unprotected wells or springs, carts with small tanks, tanker trucks, surface water, and bottled water. Piped water included water that was piped into a dwelling, yard or plot. Other improved water included water from tube wells, borehole wells, protected wells or springs, a public tap or standpipe.

Water purification prior to consumption was measured by asking respondents if they regularly treated water by boiling, chlorination, or filtration prior to drinking it. No effort was made to measure how regularly water was treated, appropriateness of water storage between purification and consumption or bacterial content of the water immediately prior to ingestion.

Covariate description

The primary measure of exposure to the program for the purpose of this study is the number of years in which a respondent has been active in the program. This was coded as 1, 2, and 3, representing participants in their first, second, and third program year. The measure was analyzed as a continuous variable.

To explore how the program functions with respect to water source and purification practices, we recorded and included in the analysis the following indicators: amount of money received, whether the respondent had received a start-up kit, had used program funds to begin a business, pay school fees, and invest in farm production. With the exception of the amount of money received, receipts of all program inputs were binary coded.

The financial, other socio-behavioral, and demographic-related aspects expected to be related to OVC well-being included factors related to nutritional adequacy and quality, school years completed, general self-efficacy (GSE), multiple sex partners in the past year, and household financial and economic circumstances. Each of the variables within these domains of OVC well-being were considered in statistical model development.

Measures of nutritional adequacy and quality included the World Food Program's food consumption score (FCS) (Wiesmann *et al.* 2009), food security, and food independence. The FCS records the number of days on which 14 different food items were consumed by the household. The items are then grouped by food category and assigned a weight based on caloric density and diversity, yielding a continuous measure which is then categorized as 'poor', 'borderline', and 'acceptable' according to validated thresholds (Wiesmann *et al.* 2009). Food security was recorded as the frequency with which a household went without sufficient food over the previous 12 months: 'often', 'sometimes', 'rarely', and 'never'. Food insecure was categorized as 'often' or 'sometimes' without sufficient food and food secure was defined as 'rarely' or 'never' without sufficient food. Primary source of food was recorded as 'grown', 'purchased', 'borrowed', and 'received as gift'. Food independence was defined as primary source of food that is 'grown' or 'purchased', indicating the degree of reliance on non-household food sources.

Years of school completed were recorded and included as a continuous variable in analyses.

Self-efficacy tends to be lower among OVC than non-OVC (Goodman *et al.* 2015a), and is an important determinant of many pro-health behaviors (Strecher *et al.* 1986).

We included the 10-item, four-point Likert-type scale from Schwarzer & Jerusalem (1995) to measure GSE (McDonald's $\Omega = 0.69$). It includes items like 'I can always manage to solve difficult problems if I try hard enough' and assesses a respondent's perception of her or his own ability to cope and adapt to life changes.

OVC have higher rates of some sexual risk behaviors than non-OVC (Goodman *et al.* 2015b), supporting the exploration of the association between sexual behaviors and safe water consumption within this vulnerable population. Impulsivity is an element of overall reckless behavior (Neumann *et al.* 2010), and we considered that engaging with multiple sex partners in the past year and not purifying water prior to consumption was plausibly associated through an unobserved latent construct such as impulsivity. The possibility of such an association among orphaned adolescents was further suggested by the importance of parental support to demote risk-taking behavior (Wills *et al.* 2004).

Household financial and economic circumstances included the past year's financial situation and estimated personal and household monthly income. The past year's financial situation question used the item from the World Values Survey (2005/2006): 'In the past year, did you: save money, just get by, spend some savings or borrow money from friends?' Due to the high correlation between personal and household monthly income, and a greater degree of certainty behind the personal than household monthly income, only estimated personal monthly income was included in analyses.

Demographic characteristics included household size (number of members), age, orphan status (maternal, paternal, double, or not orphan), years since most recent parental death, age at most recent parental death, and gender.

Data analysis

Three main comparisons drove our analysis. The first statistical model compared respondents who reported that they regularly purify water prior to consumption with respondents who reported they did not regularly purify water prior to consumption. The second model compared respondents whose primary drinking water source was an improved source (piped or otherwise) with respondents whose primary drinking water source was an unimproved source (e.g., surface/unprotected water, tanker truck, etc.). The third model compared respondents whose primary drinking water source was piped with respondents who had some other improved primary water source (e.g., a borehole or rainwater). Logistic regression models were used to make these comparisons, accounting for the hierarchical structure of the data at the level of the working group. In order to account for regional variation, we included each of the 12 regional locations in all regression models.

The modeling process followed the same strategy for each of the three models. Full models were assessed initially, and included all variables related to demographic, financial, food access and nutrient diversity, and socio-behavioral characteristics. Age, gender, income, and program participation were maintained in all models. Alpha cutoff for other variables was predetermined to be 0.05. To simplify interpretation, self-efficacy was recoded into deciles rather than kept on its raw scale.

With the exception of regional location, all variables that were included in final analyses are presented in Table 1 in a univariate fashion, comparing each related value within the higher strata of program participation to the value among respondents in their first year. In the case of using funds to cultivate land, the comparison is made only between respondents in years 2 and 3 because respondents in year 1 had not received funds with which to cultivate land.

Data were entered in EpiInfo v.7 and analyzed in STATA v.13.

Ethical review

The Committee for the Protection of Human Subjects at the University of Texas Health Science Center provided ethical review and approval for the use of program-collected secondary data for present analysis.

RESULTS

As can be seen in Table 1, roughly two-thirds of respondents were female. The median age for each of the three program

Table 1 | Description of model variables with tests of equality across years of program participation

	Year 1 (entered 2014)	Year 2 (entered 2013)	Year 3 (entered 2012)
Males (%)	37.88	28.03	36.47
95% CI	32.84, 42.93	23.84, 32.21	30.52, 42.42
Females (%)	62.12	71.97	63.53
95% CI	57.07, 67.16	67.79, 76.16	57.58, 69.48
Pearson χ2 (p)	REF	8.82 (0.003)	0.13 (0.72)
Age (median, years)	18	18	20
IQR	16, 19	17.2	18, 21
Wilcoxon rank-sum Z (p)	REF	−3.72 (<0.001)	−8.33 (<0.001)
Living father (%)	25.98	29.48	24.71
95% CI	21.41, 30.54	25.2, 33.75	19.38, 30.04
Pearson χ2 (p)	REF	1.2 (0.27)	0.13 (0.72)
Food consumption			
Poor (%)	39.89	39.41	19.37
95% CI	34.74, 45.03	34.85, 43.98	14.46, 24.27
Borderline (%)	21.08	23.42	20.16
95% CI	16.79, 25.37	19.47, 27.38	15.18, 25.14
Acceptable (%)	39.03	37.16	60.47
95% CI	33.90, 44.16	32.65, 41.67	54.41, 66.54
Pearson χ2 (p)	REF	0.67 (0.72)	33.92 (<0.001)
Food secure (%)	16.16	25.56	24.71
95% CI	12.33, 19.98	21.5, 29.62	19.38, 30.04
Pearson χ2 (p)	REF	10.47 (<0.001)	6.89 (0.009)
Self-efficacy score	31.98	32.39	32.82
95% CI	31.46, 32.51	31.84, 32.74	32.28, 33.35
Wilcoxon rank-sum Z (p)	REF	−0.827 (0.408)	−1.638 (0.102)
Multiple sex partners in past year (%)	10.86	12.11	15.29
95% CI	7.63, 14.1	9.07, 15.15	10.85, 19.74
Pearson χ2 (p)	REF	0.3 (0.58)	2.64 (0.10)
Number of completed school years (median)	6	7	7
IQR	4, 8	5, 8	5, 8
Wilcoxon rank-sum Z (p)	REF	−2.412 (0.016)	−1.931 (0.054)
Monthly income (household head, USD)[#]	6.02	12.05	16.87
IQR	3.61, 12.05	6.02, 24.10	8.43, 36.14
Wilcoxon rank-sum Z (p)	REF	−7.90 (<0.001)	−10.25 (<0.001)
Spend some savings (%)	9.4	18.94	19.11
95% CI (%)	6.33, 12.47	15.23, 22.64	14.16, 24.05
Pearson χ2 (p)	REF	14.08 (<0.001)	11.74 (<0.001)
Cultivated my land and bought planting seed (%)	0	24.44	33.33
95% CI (%)		20.66, 28.66	27.78, 39.39
Pearson χ2 (p)		REF	6.41 (0.01)

IQR, interquartile range.
FCS measured using World Food Programme measure of food consumption (Wiesmann *et al.* 2009).
Self-efficacy taken from GSE scale (Schwarzer & Jerusalem 1995), transformed into deciles for easier interpretation.
[#]Income recorded in Kenyan shillings and converted to US dollars using conversion rate 83 Kenyan shillings = 1 USD.

years was 18, 18, and 20, respectively. Only 25% of respondents had fathers that were still alive. Food consumption and security significantly increased with more program exposure. The median self-efficacy score did not change across program years in univariate analysis. Percentage of respondents reporting multiple sex partners in the past year did not change significantly across program years in univariate analysis. Monthly income and spending savings both increased with more time in the program.

Table 2 shows the multilevel logit model for participants reporting regular use of at-home water purification prior to consumption and relevant risk factors related to demographics, finances, regional location, and behavioral covariates.

After controlling for the other risk factors, the odds of reported use of at-home water purification increased significantly with the number of years of program participation. For every year increase in program participation, there was a 37% increase in the odds (OR = 1.37, 95% CI = 1.11–1.67) of using at-home purification compared to the 2014 cohort (those newest to the program). Female participants had over two-times higher odds (95% CI = 1.61–3.03) of using at-home water purification compared to their male counterparts. Age of participant was not significantly associated with use of at-home water purification. There was regional variation in the practice of water purification, with respondents in Kangeta reporting half the odds of reporting typical water purification compared to respondents in the comparison region. The opposite association was found comparing Athiru Ruujine to the comparison region.

Two risk factors related to financial and food security were significantly associated with use of at-home water purification. Participants who reported being food secure also had greater odds of regularly using at-home water purification methods (OR = 1.32, 95% CI = 1.13–1.55. Respondents that spent savings in the last year has a nearly 2.5-fold increase in odds of using at-home purification compared to counterparts who did not spend savings in the last year.

Significant socio-behavioral aspects included overall self-efficacy and multiple sex partners in the past year. For every decimal increase in GSE score, participants had 6% increased odds of using at-home purification. More

Table 2 | Reported regular at-home water purification prior to consumption, program participation and risk factors, multilevel logit model

(*n* = 988)	OR	95% CI	
Program year	1.37**	1.106	1.668
Gender (female = 1)	2.206***	1.606	3.031
Food consumption category	1.287***	1.095	1.514
Self-efficacy, decile	1.064**	1.01	1.121
Multiple sex partners in past year	0.301***	0.143	0.632
Spending savings in past year	2.453***	1.643	3.664
Multiple sex partners * Gender	2.701*	1.072	6.805
Age, years	1.027	0.969	1.088
Township/region			
Amwamba Chief	1	REF	
Antuanduru	0.671	0.259	1.736
Antubetwe	1	0.98	1.02
Athiru Ruujine	2.569*	1.149	5.74
Kageta	0.406**	0.217	0.761
Kanuni	0.821	0.388	1.736
Kiengu	1.515	0.695	3.301
Kipkona	1.085	0.589	2
Maua	1.064	0.554	2.042
Mutuati	0.343	0.108	1.089
Nchungulu MCK	1.163	0.531	2.548
Nija Chief's camp	1.006	0.594	1.702
Random intercepts	Coef.		SE
Working group	0		0
Global Wald (p)	120.01(<0.001)		

*Indicates *P* < 0.05; **indicates *P* < 0.01; ***indicates *P* < 0.001.
Program year includes three levels, each corresponding to the number of years participants have been involved in program.
Food consumption category taken from World Food Programme measure (Wiesman *et al.* 2009).
Self-efficacy taken from GSE scale (Schwarzer & Jerusalem 1995), transformed into deciles for easier interpretation.

strikingly, those who reported having multiple sex partners in the past year had nearly half the odds (OR = 0.33, 95% CI = 0.16–0.69) of using at-home water purification than those who did not report having multiple sex partners in the last year. Significant interaction between gender, multiple sex partners, and water purification was found. Among respondents with multiple sex partners in the past year, females had much greater odds of reporting they regularly purified water than did males.

The multilevel logit model for participant use of improved versus unimproved water source and other related co-factors are presented in Table 3. In contrast to the model from Table 2, program year and gender were not significantly associated with use of improved water source over other unimproved sources. Again, age was also not significant when controlling for other factors in the model. However, several socio-economic indicators were significantly associated. Participants who had a living father

Table 3 | Improved water vs unimproved water, program participation and risk factors, multilevel logit model

(*n* = 924)	OR	95% CI	
Program year	0.978	0.712	1.344
Completed school years	1.066*	1.006	1.13
Living father (yes = 1)	1.676**	1.174	2.391
Self-efficacy, decile	1.087**	1.025	1.153
Reported monthly income, $	1.009[t]	0.999	1.02
Spend savings in past year	1.087	0.704	1.678
Gender (female = 1)	0.823	0.586	1.157
Age, years	0.97	0.907	1.037
Township/region			
Amwamba Chief	1	REF	
Antuanduru	0.685	0.157	2.978
Antubetwe	1.02	0.98	1.02
Athiru Ruujine	0.198**	0.056	0.696
Kageta	1.003	0.339	2.963
Kanuni	0.216**	0.071	0.662
Kiengu	0.921	0.263	3.231
Kipkona	0.87	0.299	2.526
Maua	0.919	0.314	2.691
Mutuati	1.524	0.187	12.445
Nchungulu MCK	1.131	0.228	4.443
Nija Chief's camp	0.621	0.255	1.515
Random intercepts	Coef.		SE
Working group	0.485		0.168
Global Wald (p)	21.69(0.003)		

[t]Indicates *P* < 0.1; *indicates *P* < 0.05; **indicates *P* < 0.01; ***indicates *P* < 0.001.
Program year includes three levels, each corresponding to the number of years participants have been involved in program.
Self-efficacy taken from GSE scale (Schwarzer & Jerusalem 1995), transformed into deciles for easier interpretation.
Living father indicates whether the respondent's father is still living or not. Reported monthly income was measured in Kenyan shillings (KES) and converted to US dollars (81KES = 1USD).

(including maternal orphans and non-orphans) had 1.68 (95% CI = 1.17–2.39) greater odds of using an improved water source compared to participants without a living father (paternal and double orphans). Reported monthly income approached significance (OR = 1.01, 95% CI = 1.00–1.02), and spending savings in the last year was not significantly associated.

For each year increase in school attendance there was a 6.6% increase in the odds of using an improved water source (95% CI = 1.01–1.13). Self-efficacy was again significantly associated with use of improved water sources in the Table 3 model. Controlling for other risk factors, each decile increase in GSE score increased the odds of using improved water by 8.7% (95% CI = 1.03–1.15). There were observable geographic differences in access to improved water, with respondents from Kanuni and Athiru Ruujine reporting significantly lower odds of improved water access.

Among participants that used some source of improved water source (*n* = 607), Table 4 shows the multilevel logit model of participant use of piped water versus other improved water sources with other covariates. Similar to comparisons between use of improved and unimproved sources in Table 3, program year and age were not significantly associated with access to piped water on the premise when controlling for the other risk factors. Reported monthly income was not significantly associated with using piped compared to other improved sources. Individuals who were classified as food secure had twice the odds of using piped water compared to individuals classified as food insecure. Those who utilized program funds to cultivate land also had lower odds of using piped water compared to those who used program funds for other reasons (OR = 0.37, 95% CI = 0.23–0.58). Two regions were associated with lower odds of piped water, Kiengu and Kipkona.

DISCUSSION

The primary aim of this study was to assess the associations between safe water and participating in a community-based empowerment program targeting OVC families, represented by an older sibling in the program who is often the head of household. Safe water access was measured through two

Table 4 | Piped vs other improved water, program participation and risk factors, multi-level logit model

(*n* = 607)	OR	95% CI	
Program year	1.079	0.798	1.458
Cultivate land with program funds	0.365***	0.228	0.583
Food secure (yes = 1)	1.832**	1.189	2.824
Reported monthly income, $	0.993	0.982	1.004
Gender (female = 1)	0.904	0.619	1.32
Age, years	0.986	0.911	1.068
Township/region			
Amwamba Chief	1	REF	
Antuanduru	1.36	0.362	5.105
Antubetwe	1.14	0.96	1.32
Athiru Ruujine	0.718	0.227	2.276
Kageta	0.995	0.434	2.283
Kanuni	0.372	0.129	1.076
Kiengu	0.319*	0.114	0.889
Kipkona	0.36**	0.16	0.808
Maua	0.769	0.333	1.781
Mutuati	1.551	0.302	7.978
Nchungulu MCK	0.953	0.321	2.831
Nija Chief's camp	0.815	0.4	1.662
Random intercepts	Coef.	SE	
Working group	0.068	0.089	
Global Wald (p)	35.85(<0.001)		

*Indicates P < 0.05; **indicates P < 0.01; ***indicates P < 0.001.
Program year includes three levels, each corresponding to the number of years participants have been involved in program.
Reported monthly income was measured in Kenyan shillings (KES) and converted to US dollars (81KES = 1USD).

important factors: regular use of at-home water treatment and use of improved water sources. Although program participation was not shown to be significantly associated with improved water source, both simple and multivariable logistic regression found that longer program participation was associated with safer drinking water, principally through increased household water purification practices. This positive association may be a result of the health and hygiene education classes incorporated into the program. However, the exact mechanism of this association was not explored in this study. The program has been shown to improve other determinants of health such as household income and food security (Goodman *et al.* 2014) in the OVC population, further supporting this type of intervention

model and its ability to positively affect multiple areas related to OVC heath and economic outcomes.

Water purification model

The study further explored other respondent sociodemographic and economic factors to elaborate on the relationship of program participation with OVC well-being indicators and safe water access. Three multilevel logistic analyses were presented. The first approach compared length of time spent in the program with reported use of at-home water purification, modeled with other behavioral and socio-economic factors. In addition to longer program exposure, being female, having improved food consumption, increased GSE, and spending savings as opposed to saving money were associated with increased odds of reporting household purification of water prior to consumption. Contrarily, having more than one sexual intercourse partner in the previous year was associated with significantly decreased odds of typically purifying water prior to consumption. Finally, respondents from one of the regions with significantly lower odds of improved water had significantly higher odds of water purification. This may be a sign of successful water safety promotion in the area given the lack of improved water sources.

There are several possibilities that could explain the gender discrepancy in reported use of at-home water purification. Females tend to carry more burden of care within OVC households (Akintola 2006; Olowu 2012). It is possible that they are more familiar with water purification practices within the household, thus leading to a possible systematic response bias among males to under-represent water purification practices, females to over-represent water purification practices, or both. It is also possible that female heads of households are more likely to purify water prior to consumption than are males in Meru culture. It is possible that females within this population offer more diligent care, or are more concerned with learning how to prevent disease, or other factors related to water purification behavior that lead to odds of typical water purification that are twice those of male respondents. The differences related to the more diligent use of water purification among males and females are theorized to be linked with differences in perceived risk in behavioral models. A study conducted by

the Environment for Development Initiative in Kenya (Onjala *et al.* 2013) found a similar association with male heads of household having decreased likelihood of water purification for unimproved water sources as compared to female heads of household. However, peer-reviewed literature on the differences between genders in perceptions of riskiness of untreated drinking water and its relationship to water purification and improvement prioritization is somewhat limited, especially in the OVC population. Further study of risk perceptions and other constructs related to behavioral models could illuminate new pathways for interventions and behavioral change, especially among OVC males.

In a proposed integrated behavioral model for water, sanitation, and hygiene (IBM-WASH) (Dreibelbis *et al.* 2013), perceived threat, knowledge, and self-efficacy were important constructs at the individual scale of the model. The significant association between increasing GSE and water treatment found in this study supports the IBM-WASH model.

Respondents with acceptable food consumption had odds of water purification that were higher than respondents with poor food consumption. It is possible that there are latent factors, or residual confounders, creating the association between the two health determinants. For example, the absence of certain household stressors may increase food consumption and allow more time for water purification. It is also possible that psychological or cognitive factors related to increased food consumption mediate the relationship between food consumption and water purification practice. Factors potentially explaining this association may include cognitive function, depression, or self-esteem as these factors have been found to be related to both life adversity and adherence to other pro-health behaviors (DiMatteo 2004; Bärnighausen *et al.* 2011). It is also possible that those who purify water have a lower household disease burden, making more time for growing food and economic pursuits with which to purchase food.

Respondents who spent savings in the past year had lower odds of piped compared to other improved water. Having savings to spend indicates the respondent is likely less vulnerable to financial shocks than not having savings (Barrett *et al.* 2001; Chowa & Ansong 2011). It is possible that having saved funds to spend indicates a greater degree of planning and future-orientation, which may also promote

water purification. More study of the associations between financial vulnerability and IBM-WASH behaviors among OVC is warranted.

Respondents with more than one sex partner in the previous year had significantly lower odds of typically purifying water prior to consumption. Water purification and fewer sex partners may represent concern for personal health, or knowledge of pro-health behaviors, and could also indicate a tie to perceived threat and knowledge understood within an IBM-WASH framework. To our knowledge, this is the first paper to identify an association between these two behaviors in the OVC population of sub-Saharan Africa. Both behaviors are important for health, individually and combined. Risky sexual behavior increases the chances of contracting HIV, thereby rendering the individual into an immune-compromised state even more susceptible to water-borne diarrheal diseases, such as cryptosporidiosis, which can be deadly for HIV-infected individuals (Wanyiri *et al.* 2014).

Although the study data does not allow deep exploration of psychosocial factors potentially connecting sexual and environmental risk exposures, lack of parental support may generate a wide range of predisposing factors among OVC. Recent studies in high-income contexts have established the crucial role parental involvement and support play in lowering risk behaviors of children. One important construct predisposing adolescents towards risk behaviors in the context of limited parental supervision and support is impulsivity (Neumann *et al.* 2010). Impulsivity predates high-risk behaviors (Verdejo-García *et al.* 2008), and is generally higher among males than females (Stoltenberg *et al.* 2008). The present study found significant effect moderation between multiple sex partners and gender. The finding that males are less likely to report water purification before consumption is significantly amplified when participants engage with multiple sex partners. Young men who may be more likely to engage in risky sexual behavior may also be likely to have risky water consumption habits. In addition to the IBM-WASH construct of risk perceptions, impulsivity may also play a role in this interaction. Given the importance of impulsivity to a wide range of developmental and pro-health behaviors (Hofmann *et al.* 2008), and the importance of parental involvement to demoting impulsivity among males especially, it is curious that it has received such

little research in the context of sub-Saharan African OVC. These data indicate the need for further evaluation of impulsivity among OVC in Kenya and across the sub-continent.

Insofar as propensity to riskier behavior is partially driven by lack of parental involvement among orphans, an assertion that is currently unexplored in the sub-Sahara African context, empowerment programs like the current program under study may simulate parental support and lower impulsivity or other psychosocial mechanisms leading to overall riskier behavior. Skovdal *et al.* (2013) found that community involvement in cash transfer programs was considered to approximate 'good parenting or guardianship' among Zimbabwean orphans. IBM-WASH programs may be beneficial to OVC in programs similar to the community-health clubs found elsewhere (Whaley & Webster 2011). Such programs may simultaneously target collective and individual self-efficacy alongside impulsivity or other potential mediators of orphanhood and riskier WASH- and other sector behaviors. This area requires further study, but is suggested by the association between multiple sex partners, water purification and the modification of this association by gender.

Improved vs unimproved water source model

The second model examined the use of any improved source to use of an unimproved source for primary drinking. The model showed that increased personal monthly income, overall self-efficacy, and more school completion predicted higher odds of improved water source usage. Participation in the program itself did not significantly predict use of improved or unimproved water.

As found previously (Case & Ardington 2005), paternal orphans had significantly lower odds of improved water compared to maternal orphans. Previous explanations of this association have revolved around a reduction in household earnings. A measure of household earnings was attempted in the present study, although data collectors indicated respondents had more certainty about personal income than household income. Given the high degree of correlation between the two measures, personal income was preferred for developing statistical models. Personal income did not explain the association between paternal orphanhood and lower odds of improved water, perhaps

implicating the lost accumulation of wealth, in addition to income, accompanying a paternal death. Other factors may explain the association in addition to loss of household earnings. This study is the first to replicate the finding that paternal orphanhood and unimproved water are associated in Kenya, strengthening the need for further investigation of this association.

Given that income increased significantly with more time in the program, and increased income is associated with improved water, it would be expected that program participation would be significantly associated with improved water use in the simple logistic regression model. Secondary analysis (not shown) removed income from the model, and the coefficient showing the association between program participation and improved water did not change. This suggests that access to improved water may more readily increase income, rather than the inverse.

Homophily, or the extent of similarity within a social network (McPherson *et al.* 2001), is one social network characteristic that has been associated with personal health behaviors (Centola 2011) and resource allocation (Hulbert *et al.* 2000). This similarity (homophily) is activated in the working group decision to allocate resources for land cultivation. Further research into the dynamics involved in program working groups, and how these dynamics may be related to pro-health behavior, such as household water purification, and increase access to improved water sources would hopefully clarify this association.

As found in other areas of rural Kenya, social networking and collective action were necessary but insufficient constructs in improving water access sources in vulnerable communities (Bisung *et al.* 2014). It was suggested that influencers from higher ecological planes, such as the efficiency of governmental water management, policy, and unequal access to necessary resources hindered the progression of access to improved drinking water sources. This current study supports these findings, and illuminates the underlying inequalities that exist in the OVC community. While the program is able to improve behaviors related to safe drinking water through personal decisions more within the control of the individual (personal use of at-home water treatment), other environmental influences might be involved in gaining access to improved drinking water sources. This will be a key issue for consideration as the world moves forward in

the WASH-related SDG and achieving universal improved water access by 2030.

Piped vs other improved water source model

As it is not certain whether there is a reduction in risk associated with using piped water as opposed to other protected, improved sources, the second model assessed factors associated with piped compared to other improved sources.

The covariates found to be associated with the odds of having piped water as opposed to other improved water, and the fact that these covariates largely differed from the any improved vs unimproved model, were interesting. Respondents who used program funds to cultivate land for agricultural purposes had significantly lower odds of piped water compared to respondents who did not use funds for this purpose. This finding may point to a benefit of community-based allocation of resources: those with greater need for program resources may have higher odds of receiving them, and respondents with piped water may have lower need of resources to cultivate land compared to respondents with other improved water sources. Food insecurity was lower among those with piped water, supporting the interpretation that those with other improved water sources had a greater need to cultivate their land in order to increase crop production.

Economic security measures, including monthly income, using savings, and food security indicators are generally well associated throughout all the models. Programs addressing these targets, especially those that address collective efficacy and community-based decision-making, are well poised to be included in an overall strategy to improve aspects of IBM-WASH. Although the program aims may not explicitly focus on improving water source and community action to increase access to improved water sources, this and similar interventions could in the future be excellent launching points for such efforts due to built-in concepts of community-based decision-making and collective efficacy.

Limitations

Many of the limitations of this study relate to those typically involved with survey-based research. Response biases, including recall bias, social desirability bias, and information bias, are likely involved in data collection. Respondents may be uncertain whether they typically purify water, may wish to be perceived as healthier or of higher status using improved water, or may be unaware of water purification or water source as these responsibilities may belong to other household members. These biases apply not only to the response variables – water source and household purification practice – but also would apply to covariates included in the model.

Misclassification bias may affect interpretation of results. Water purification that involved chlorination, boiling, or filtration were categorized together, but each of these types of water purification practice may differentially affect the safety of drinking water (Clasen *et al.* 2007). Categorizing these water purification practices together may obscure the degree of risk of diarrheal and other illnesses in the sample population. The primary intent of the present study was to assess whether participation in a specific program model could be associated with water source and household purification practices, with a secondary intent of discovering what factors related to health and well-being of Kenyan OVC might be associated with these two behaviors. There is sufficient evidence from this study that the program and other factors are associated with water quality, warranting further study which may include the degree of residual contamination of water typically consumed in program households.

The study participants were drawn from the program participants who attended their regional meeting. Since some program participants were not represented at the regional meeting, and thus could not be included in the study, there is the potential for selection bias since individuals who attended the regional meeting may have different characteristics from those who did not attend the meeting. However, the population that did not attend the meeting was small, minimizing the potential for significant influence on the study outcomes.

Finally, a comparison group drawn from the OVC community that did not participate in the program would have been beneficial in order to strengthen the associations seen between program participation outcomes and water purification. Secondary analyses using propensity score matching showed significant program effects, but were not used in primary analysis due to the hierarchical structure of the data.

CONCLUSION

Community-conditioned cash transfer programs combining other elements of psychosocial support, household economic empowerment, and life skills training targeting OVC find support for the prospect of improving household water quality. Such improvements may improve health outcomes, especially diarrheal illnesses affecting children, but this is beyond the reach of the present study. Other factors associated with improved water source include: school, orphan type, food consumption and security, GSE, household income and the past year's financial situation. Unexpectedly, respondents who reported more than one sex partner in the previous 12 months had significantly lower odds of reporting using piped as opposed to unimproved water, and purifying water prior to consumption. The present study demonstrates the multi-sectoral nature of water quality, as it is associated with economic, nutritional, psychological, educational, and behavioral factors.

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First received 18 August 2015; accepted in revised form 2 December 2015. Available online 5 January 2016