Association Between WASH Factors and Viral Loads in ART Experienced Persons Living with HIV in South Africa

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Abstract

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Human Immunodeficiency Virus (HIV) is a disease that weakens the immune system making it more susceptible to other opportunistic diseases (16). 39 million people are living with HIV worldwide in 2022 (2). HIV is more prevalent in lower income areas, which in many cases translates to lack of access to safe WASH (8). We aim to examine potential association between various WASH with viral failure in medicine adherent people with HIV (PWH) living in KwaZulu-Natal, South Africa.

A secondary analysis was performed using de-identified data from a parent nested case-control study conducted in South Africa during the years of 2014 to 2018. A matched 1:2 case control study was conducted on patients recruited from a rural and peri-urban hospital in KwaZulu-Natal, with cases defined as individuals who experienced viral failure. WASH related questions were asked at baseline and examined to extrapolate the effects of WASH factors to an individual's viral load status.

The resulting data subset consisted of 98 cases and 199 controls. The univariate analysis showed no statistically significant association between drinking water and viral failure. Surface and unimproved drinking water had odds ratios of [OR = 1.40, 95% CI (0.40, 4.54)] and [OR = 0.82, 95% CI (0.47, 1.43)] respectively. Sanitation [OR = 1.84, 95% CI (0.63, 5.27)], drinking water contamination [OR = 1.14, 95% CI (0.58, 2.20)], lack of water treatment [OR = 0.95, 95% CI (0.33, 3.13)], and unimproved access to handwashing [OR = 0.82, 95% CI (0.50, 1.34)] was also statistically nonsignificant to viral failure. A multivariate analysis was then conducted with the new model producing higher odds ratios for unimproved drinking water source [aOR = 0.84, 95% CI (0.45, 1.51)] , lack of water treatment [aOR = 0.97, 95% CI (0.32, 3.29)], drinking water contamination by hand [aOR = 1.24, 95% CI (0.59, 2.53)], and unimproved sanitation [aOR = 1.90, 95% CI (0.61, 5.76)]. Odds ratios for Surface Water [aOR = 1.37, 95% CI (0.36, 4.79) and unimproved hand washing access [aOR = 0.73, 95% CI (0.42, 1.26)] decreased. All results remained nonsignificant, but odds ratios of greater than one is present in three of the variables**.** Although no significant association between viral failure and WASH were found, further research is needed to ascertain the effects of safe WASH against viral failure amongst PWH.

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Introduction

Human Immunodeficiency Virus (HIV) is believed to have existed in the world as far back as the 1800s when hunters in Central Africa came into contact with the blood of chimpanzees (1). According to the World Health Organization (WHO), 39 million people are living with HIV worldwide in 2022 with more than two thirds living in the African region (2). Although there is no cure for the disease, progress has been made to control a person's HIV-1 plasma RNA viral load, or the amount of HIV cell-free virus circulating in the blood (3). Virologic response is a good indicator of the health of someone living with HIV (4). Plasma viral load that exceeds 1000 copies/ml from two measurements within a three-month interval constitutes what can be defined as viral failure (5). Consequently, viral suppression is defined as having less than 200 copies/ml of HIV to blood (6). People living with HIV are at a greater risk for different diseases as the virus affects an individual's immune system, particularly CD4+ T lymphocyte levels (7). HIV is more prevalent in areas where the populace generally has lower socioeconomic status, which can translate to lack of access to safe WASH (8). Unsafe water, sanitation, and hygiene (WASH) are directly linked to increased risk for many diseases, both communicable and non-communicable, which can in turn result in virologic failure in people with HIV (PWH) (7, 9).

Literature Review

To date, very few studies have been performed to identify possible associations between safe WASH and HIV viral load for PWH who regularly take antiretroviral therapy (ART). Because the route of transmission for HIV is known to be through bodily fluids, a direct association between WASH and HIV viral load has been rarely, if at all, examined beyond unsafe WASH increasing the risk of acquiring waterborne opportunistic infections (10,11). In South Africa, 75% of PWH are receiving ART but only 69% have achieved viral suppression (12, 13). In addition, it is reported that although access to ART has increased and expanded, virologic failure has increased in places where there is high ART coverage (14, 15). Some reasons associated with the persistent cases of virologic failure include poor medication adherence, obesity/malnutrition, tuberculosis co-infection, and drug resistance (14, 15). There currently exists a large gap in knowledge regarding the effects of poor WASH to HIV viral loads in people who regularly take ART medications.

In 2022 alone, an estimated 1.3 million people acquired HIV and 630,000 lives have been claimed by HIV related causes (10). These figures are estimated as the definitive cause of death is often difficult to determine. HIV infects the human body by binding to receptors on CD4 T lymphocytes and destroying them, which weakens the immune system making it more susceptible to other opportunistic diseases (16). Due to this characteristic of the disease, CD4 count measurement has long been used as an indicator of how much the disease has progressed, with healthy levels ranging from 500 to 1500 cell/mm^3 (7). HIV is transmitted through bodily fluids such as blood, semen, vaginal fluid, and breastmilk (10).

South Africa has the highest number of PWH worldwide (14,17). The overall prevalence of HIV in South Africa determined from a 2017 survey was 14% or around 7.9 million of the country's population (17). This estimate decreased to around 7.6 million in 2022, with actual numbers difficult to ascertain due to lack of awareness or diagnosis (12, 13). Some factors that contribute to the high rates of the disease are early sexual debut (first sexual encounters occurring at ages below 15) and the disparate relationship age between a young female and a male (5+ years older) (17). The most prevalent mode of transmission of HIV in South Africa is through heterosexual encounters, including sex work where the prevalence of HIV is 62.3% (12, 13, 17). In 2017, antiretroviral (ARV) exposure was 62.3% overall, with the lowest percentage in those between the ages of 15-24, where exposure was only at 39.9% (17). Data show that young men and women (age < 32) were more likely to experience virologic failure than those over 32, irrespective of peri-urban or rural residence (18). Over the past decade, there has been a significant decrease in mortality from HIV in South Africa. This decrease can be attributed to the rollout of the largest HIV treatment program in the world with a focus on universal test and treat policy, and educational programs to promote chronic disease management (14, 18). Further, epidemiologic evidence suggests that PWH are living longer (17, 18).

It is highly recognized that safe water, sanitation, and hygiene (WASH) are a crucial aspect of an individual's health and well-being (9). Despite the challenges the world faces regarding drinking water, it is imperative to realize that water is not a privilege but a necessity for life (19). Unsafe WASH is directly correlated to acquisition of various waterborne diseases such as diarrhea, cholera, and typhoid (20). Malaria, a disease that occurs at the highest rates amongst PWH, is found to also be associated with poor WASH (20). Mosquitos carrying the malaria infection breed in unprotected stagnant water in homes and can facilitate the spread of the disease. Although important achievements have been made in the field of WASH, progress is extremely slow, and access to basic WASH for economically disadvantaged and marginalized groups remains a challenge for many countries in the world (19).

As of 2022, over 1.5 billion people worldwide did not have access to basic sanitation such as private toilets and latrines, and an estimated 419 million practiced open defecation (21). In 2021 the WHO reported that over 2 billion people lived in water-stressed countries, where the demand for water exceeds the sustainably available amount. This situation has become exacerbated by climate change and population growth (22, 23). South Africa, as an example, is a country that has experienced severe drought within the past decade (24). The lack of access or availability of safe water may influence people's decisions on what should and should not be a priority, which in turn could increase the risk of contracting diseases. It was further reported in 2022 that at least 1.7 billion people globally drank water from a source that was contaminated by feces, which poses a great threat to the health and well-being of the individual (22). Improvements in WASH could significantly decrease the transmission of diseases with a particular impact for those individuals with HIV (20).

In many African countries, barriers to WASH persists such as inadequate funding, population growth, and lack of knowledge of diseases, wealth inequality, and rural urban inequalities (25, 26). What is consistent between many countries in Africa, however, is that people living in rural areas are the most affected by these barriers (26). A study that examined the WASH coverage in

25 sub-Saharan African countries concluded that combined basic Sustainable Development Goals (SDG) for water and sanitation, or the United Nations goal of universal availability and sustainable access to water and sanitation, was close to zero for rural areas in many countries, while overall coverage was 4% (25). This represents 921 million people who lacked access to water and sanitation (25, 27). The lack of basic WASH infrastructure in rural communities is a major contributor to poor health outcomes compared to urban areas that are more developed (26).

In South Africa, only 46.3% of households had piped water in their dwellings while almost 3% still collected water from unprotected sources like rivers, streams, or stagnant water pools in 2018 (28). Furthermore, interruptions to water supply service are common for some provinces receiving water from a municipality (28). Issues with sanitation are also present; many households do not have proper sanitation facilities and use bucket toilets (28). Research on WASH system sustainability in rural communities in one municipality in South Africa found that although facilities are available in the communities, its conditions are poor due to overuse and non-maintenance (29). The effects of this are exacerbated by the fact that rural communities use the water for many aspects of life which includes personal use, farming, and caring for animals (29).

A study conducted in 2014 interviewed different nonprofit organizations to determine whether safe WASH practices were integrated in their HIV/AIDS programs (30). The study found that integration of WASH in HIV programs is lacking in many non-profit organizations operating in many countries in Africa, including South Africa (30). WASH interventions are not prioritized in many programs because a direct correlation between WASH factors and HIV as a disease is missing in literature (7). Very few, if any, have examined direct association between WASH factors and HIV but instead examine other waterborne diseases that PWH are more susceptible to. Results from the study showed that WASH activities such as water treatment, handwashing, and sanitation interventions conducted by the organizations to integrate WASH into the HIV/AIDS programs are extremely varied and, in some cases, missing (7).

These organizations face many barriers but a factor common to those interviewed is that funding for WASH related activities is limited or unavailable (7). Funders are extremely restrictive on where the budgets are allocated so a focus on evidence-based interventions instead of prevention is heavily favored. ART has been empirically proven to be effective in managing HIV and preventing transmission of the disease (31); therefore, it is difficult to "sell" an intervention that does not provide immediate measurable results. However, as the life expectancy of PWH increases, a critical need to look beyond extending life to ensuring that quality of life remains high arises (7). Exploration of potential association between safe WASH and HIV viral failure is imperative as current evidence is mixed and limited (11). We aim to examine whether various WASH factors are associated with viral failure in medicine adherent PWH living in KwaZulu-Natal, South Africa.

Methods

Data

A secondary analysis was performed using de-identified data from a parent nested case-control study conducted in South Africa during the years of 2014 to 2018. The parent study aimed to quantify drug resistance and identify the socio-economic and psychological factors associated with virologic failure within the target population (32**)**. Enrollment in the study occurred between 2014 and 2016 at two sites, RK Khan (RKK) hospital in Chatsworth, eThekwini Municipality and Bethesda (BTD) hospital in uMkhanyakude Municipality both located in KwaZulu-Natal Province, ZA. Cases and controls were matched based on multiple factors such as age, gender, race, duration of ART and study site with a ratio of 1:2 cases to control. The questionnaire included WASH related questions that assessed respondents' access to water, sanitation, hygiene, and knowledge regarding treatment and potential contamination of drinking water.

Analysis

Subset data from the aforementioned study were downloaded, cleaned, and statistically analyzed using R programming language version 4.3.2 and RStudio version 2023.12.1+402. From a study sample of 1000 individuals, the data were filtered to include individuals that were a part of the case–control component. WASH variables relating to water contamination by hand, water treatment, and handwashing access (no water classified as unimproved) were dichotomized; along with sanitation as none reported open defecation; while drinking water source was categorized between improved, unimproved, and surface water all according to the Joint Monitoring Program standards (33). Comparisons between those with "safe" (free of contaminants such as excreta), and "unsafe" (sources and facilities that are unprotected or missing that can pose a potential for illness) WASH were used to extrapolate the effects of WASH access and behaviors to an individual's viral load status (33). Descriptive statistics of the sample population such as gender, study site, race, and ethnicity were calculated based on frequency and faceted between cases and controls. In addition, descriptive statistics were calculated for each WASH factor category to show the distribution of respondents with case-control groups.

Logistic regression was then conducted to quantify potential association between the different WASH factors and virological failure. Univariate analysis was performed with each WASH factor, which provided an unadjusted odds ratio of each factor in relation to the outcome of being a case or control. "Sanitation" consisted of 95% of respondents reporting an improved sanitation facility. Using multivariate logistic regression, a model was created to determine the factors that have the greatest association in relation to the outcome. The results were subsequently used to determine an association between various WASH factors and virologic failure for participants.

Results

Demographics

The resulting data subset consisted of 297 individuals from the original study population of 1000, 98 of whom experienced virologic failure (cases) while 199 did not (controls). A higher percentage of cases and controls were recruited from the peri-urban hospital setting than the rural setting, relative to the number of participants recruited from each site at 165:132 respectively. Out of the participants recruited, 174 (59%) were females, among whom 53 were identified as cases. Additionally, 123 (41%) were males, with 45 being cases. Only a small percentage of the study population, 4.4%, reported being of a different race than Black, which represents 96% of the case-control study participants. The largest number of participants were Zulu (79%) followed by Xhosa (13%), with 11% of participants hailing from other ethnicities in the region (Table 1).

WASH Factors

Answers to questions regarding access to safe WASH are summarized and distribution of each is represented in Table 2 and Table 2b. Close to 70% of the participants reported having an improved drinking water source, but it is important to note that 12 individuals (4%) reported surface water as a source of drinking water. Further, 68% of individuals who reported having an improved water source were participants from RK Khan, which is located in the peri-urban township of Chatsworth. Almost 95% of participants reported having an improved sanitation facility, and only 5.1% reporting unimproved sanitation. However, the percentage of individuals with unimproved sanitation was over 8 times higher for those from rural areas compared to those from peri-urban, though only 44% of those recruited were from Bethesda hospital.

Only about half of the participants had access to an improved hand washing area, with a clear disparity between those who live in rural (24%) and peri-urban (81%) communities. Moreover, 15% of respondents admitted to touching their drinking water with their hands, thereby leading to potential contamination, with numbers higher for those in rural communities. Additionally, only 5% of the participants took any measures to treat their drinking water, despite 31% using either surface water or an unimproved drinking water source.

Univariate Analysis

A univariate analysis was conducted for each WASH factor specified in Table 2. There were three participants that did not respond to the question regarding water treatment, who were excluded from the analysis of that variable. The total number of participants analyzed are defined in Table 3. Drinking water was assessed on two levels: surface water [OR = 1.40, 95% CI (0.40, 4.54)] and unimproved drinking water [OR = 0.82, 95% CI (0.47, 1.43)] with no statistical significance. Although an odds ratio of greater than one was observed amongst those who utilize surface water, only 12 individuals reported this as their primary source of drinking water.

In this study, 95% of participants responded as to having an improved sanitation facility, which may have contributed to insignificant association between viral failure and unimproved sanitation even with a positive odds ratio [OR = 1.84, 95% CI (0.63, 5.27)]. Similarly, drinking water contamination [OR = 1.14, 95% CI (0.58, 2.20)], lack of water treatment [OR = 0.95, 95% CI (0.33, 3.13)], and unimproved access to hand washing [OR = 0.82, 95% CI (0.50, 1.34)] did not yield a significant association to cases of viral failure amongst ART experienced individuals living with HIV. It is also important to note that only 5% of respondents reported treating their water prior to consumption.

Multivariate Analysis

A multivariate analysis was performed incorporating all WASH variables without eliminating any from the model as shown in Table 4. The new model produced a higher odds ratios for unimproved drinking water source compared to the reference improved water source [Unimproved aOR = 0.84, 95% CI (0.45, 1.51)] , lack of water treatment compared to those who treat their water prior to consumption [aOR = 0.97, 95% CI (0.32, 3.29)], drinking water contamination by hand compared to those who do not touch their drinking water [aOR = 1.24, 95% CI (0.59, 2.53)], and unimproved sanitation versus improved [aOR = 1.90, 95% CI (0.61, 5.76)] albeit failing to produce significant results. On the other hand, odds ratio for surface water [aOR = 1.37, 95% CI (0.36, 4.79)] and unimproved hand washing access [aOR = 0.73, 95% CI (0.42, 1.26)] both decreased. Results remain non-significant; however, odds ratios of greater than one is present in three of the variables.

Discussion

Access to safe WASH is essential to ensuring better quality of life for all people, particularly those with HIV. However, very little research was found discussing the role WASH factors play in the health of PWH. Many times, WASH is undervalued and not prioritized in programs aimed to combat HIV (30). Because HIV is not transmitted through water as other diseases such as cholera or typhoid, the link between WASH and HIV is often overlooked (34). However, in places where inadequate WASH is all but uncommon, PWH experience more severely the adverse effects of inadequate WASH due to their suppressed immune system (35). It is important to realize that optimal WASH factors collaborate to promote the health and well-being of PWH while poor WASH have the capacity to adversely impact it (34).

This analysis aimed to identify potential association between various WASH factors and experiencing viral failure for persons with HIV. Due to the univariate analysis of each WASH factor generating non-significant results, performing a stepwise variable selection was not a viable option. The analysis showed that there was a potential association between certain WASH factors and viral failure. Although the univariate and multivariate analyses of direct association between inadequate WASH and viral failure did not yield statistical significance, the importance of effective and adequate WASH practices cannot be underestimated. As an example, water contamination by hand yielded an odds ratio of [OR = 1.14, 95% CI (0.58, 2.20)] in the univariate analysis and [aOR = 1.24, 95% CI (0.59, 2.53)] in the multivariate analysis indicating a positive directionality albeit non-significant. Although the association between this WASH factor and viral failure cannot be established, studies have found that water contamination increases the risk associated with diseases such as diarrhea (36). There are contradicting studies regarding malabsorption of ART medications for PWH, with one study reporting that diarrhea does not have an impact on viral loads in medicine adherent individuals and another reporting the opposite (37, 38). However, the study conducted in Haiti posits that diarrhea may be a result of treatment failure, perhaps due to a decrease in adherence caused by symptoms like gastrointestinal issues that might hinder an individual's desire to take the medication (38). People with HIV are at a greater risk for comorbidities like diarrheal diseases because of their weakened immune system (36). HIV is a disease that renders people vulnerable to opportunistic waterborne infections, particularly in less developed countries, as such the potential impact of WASH cannot be ignored (34).

Limitations

The original study's goal was to quantify drug resistance and identify the socio-economic and psychological factors associated with virologic viral failure. As such, it was matched on age, gender, race, duration of ART and study site. It was not matched on socio economic factors, which could influence the results of this analysis. Furthermore, the questions regarding WASH factors ideally would be more robust in order to represent a more comprehensive picture of the participants' access and behaviors to adequate or inadequate WASH. It would be beneficial to obtain behavioral variables such as hand washing behaviors, hand soap use, open defecation, etc.

Other limitations of the study include the skewness of responses to the questions and the overall sample size of the study. Nearly 95% of participants reported improved facilities, a small percentage reporting treatment of water for consumption (5.1%), and a mere 4.1% reporting using surface water as a source of drinking water. A more representative analysis could not be made due to the lack of variation in response. This highlights the importance of socioeconomic status within this study. A larger sample size will allow for more variation in responses and representativeness of data. In addition, we also face limitations of social desirability bias. Factors such as “water contamination” are difficult to ascertain due to subconscious habits people have. An interviewer led questionnaire might prompt respondents to report having improved WASH practices as it is deemed more socially acceptable. Furthermore, the questionnaire addressing WASH access and behaviors were conducted at ART initiation. A follow up survey on the same variables did not occur, which makes it possible for some of these factors to have changed for respondents considering the study spanned several years.

Conclusion

Despite the decrease in both the morbidity and mortality of HIV, millions of people each year are still affected by the disease and its comorbidities, particularly in low- and middle-income countries. However, few studies exist aimed at understanding the potential direct association between WASH and HIV viral loads. Although this analysis was unable to draw a significant association between viral failure and WASH, more studies should be conducted in lower SES countries to see if lack of safe WASH is associated with viral failure amongst people with HIV. Access to safe and quality WASH is an important variable in ensuring a good quality of life for people all throughout the world, but more specifically for those with HIV.

Public Health Implication

Understanding that there is a probable association between WASH and viral failure could and should influence how we look at public health efforts relating to HIV. Interventions should be tailored to not only address HIV with medication but to ensure that water, sanitation, and hygiene are not overlooked. HIV is not just a solitary affliction; it frequently increases susceptibility to other illnesses that can profoundly impact an individual's well-being. Particularly in low and middle-income countries, this includes preventable communicable waterborne diseases that can be mitigated with safe access to WASH.

Appendix

Joint Monitoring Program Definition for Improved and Unimproved WASH (cited in reference)
Water

1. **Improved Drinking Water Sources** - Have the potential to deliver safe water free of contaminants.
2. **Unimproved Drinking Water Source -** Sources such as unprotected wells or springs, and populations drinking.
3. **Surface Drinking Water Source -** Water directly from a river, dam, lake, stream or irrigation canal.

Sanitation

1. **Improved Sanitation Facilities -** Designed to hygienically separate excreta from human contact.
2. **Unimproved Sanitation Facilities** - Use of pit latrines without a slab or platform, hanging latrines or bucket latrines.
3. **Open Defecation** - Disposal of human feces in fields, forests, bushes, open bodies of water, beaches and other open spaces or with solid waste.

Hygiene

1. **Basic** - Availability of a handwashing facility with soap and water at home
2. **Limited** - Availability of a handwashing facility lacking soap and/or water at home.
3. **No facility** - No handwashing facility on premises

Table 1: Demographic Statistics Stratified by Case Status

Characteristic	**Overall**, N = 297[1]	**case**, N = 98[1]	**control**, N = 199[1]
Study Site			
RK Khan	165 (56%)	54 (55%)	111 (56%)
Bethesda	132 (44%)	44 (45%)	88 (44%)
Gender			
Female	174 (59%)	53 (54%)	121 (61%)
Male	123 (41%)	45 (46%)	78 (39%)
Race			
Black	284 (96%)	90 (92%)	194 (97%)
Other	13 (4.4%)	8 (8.2%)	5 (2.5%)
Ethnicity			
Zulu	226 (76%)	69 (70%)	157 (79%)
Xhosa	37 (12%)	13 (13%)	24 (12%)
Other	34 (11%)	16 (16%)	18 (9.0%)

[1] n (%)

Table 2: WASH Access and Behavior

Characteristic	**Overall**, N = 297[1]	**case**, N = 98[1]	**control**, N = 199[1]
Drinking Water Source			
Improved	204 (69%)	69 (70%)	135 (68%)
Unimproved	81 (27%)	24 (24%)	57 (29%)
Surface Water	12 (4.0%)	5 (5.1%)	7 (3.5%)
Sanitation			
Improved	282 (95%)	91 (93%)	191 (96%)
Unimproved	15 (5.1%)	7 (7.1%)	8 (4.0%)
Hand Washing Access			
Improved	157 (53%)	55 (56%)	102 (51%)
Unimproved	140 (47%)	43 (44%)	97 (49%)
Water Treatment [Yes]	15 (5.1%)	5 (5.1%)	10 (5.0%)
Drinking Water Contamination by Hand [Yes]	45 (15%)	16 (16%)	29 (15%)

[1] n (%)

Table 2b: WASH Access and Behavior by Peri-Urban vs Rural

Characteristic	**Overall**, N = 297[1]	**Bethesda (Rural)**, N = 132[1]	**RK Khan (Peri-Urban)**, N = 165[1]
Drinking Water Source			
Improved	204 (69%)	65 (49%)	139 (84%)
Unimproved	81 (27%)	55 (42%)	26 (16%)
Surface Water	12 (4.0%)	12 (9.1%)	0 (0%)
Sanitation			
Improved	282 (95%)	119 (90%)	163 (99%)
Unimproved	15 (5.1%)	13 (9.8%)	2 (1.2%)
Hand Washing Access			
Improved	157 (53%)	24 (18%)	133 (81%)
Unimproved	140 (47%)	108 (82%)	32 (19%)
Water Treatment [Yes]	15 (5.1%)	15 (11%)	0 (0%)
Drinking Water Contamination by Hand [Yes]	45 (15%)	25 (19%)	20 (12%)

Table 3: Univariate Analysis Summary

Characteristic	N	OR[1]	95% CI[1]	p-value
Drinking Water Source	297			
Improved		—	—	
Surface Water		1.40	0.40, 4.54	0.6
Unimproved		0.82	0.47, 1.43	0.5
Sanitation	297			
Improved		—	—	
Unimproved		1.84	0.63, 5.27	0.3
Drinking Water Contamination by Hand	297			
No		—	—	
Yes		1.14	0.58, 2.20	0.7
Water Treatment	294			
Yes		—	—	
No		0.95	0.33, 3.13	>0.9
Hand Washing Access	297			
Improved		—	—	
Unimproved		0.82	0.50, 1.34	0.4

[1] OR = Odds Ratio, CI = Confidence Interval

Table 4 Multivariate Analysis

Characteristic	**OR**[1]	**95% CI**[1]	**p-value**
Sanitation			
Improved	—	—	
Unimproved	1.90	0.61, 5.76	0.3
Drinking Water Source			
Improved	—	—	
Surface Water	1.37	0.36, 4.79	0.6
Unimproved	0.84	0.45, 1.51	0.6
Water Treatment			
Yes	—	—	
No	0.97	0.32, 3.29	>0.9
Drinking Water Contamination by Hand			
No	—	—	
Yes	1.24	0.59, 2.53	0.6
Hand Washing Access			
Improved	—	—	
Unimproved	0.73	0.42, 1.26	0.3

[1] OR = Odds Ratio, CI = Confidence Interval

Null deviance = 370; Null df = 293; Log-likelihood = -183; AIC = 380; BIC = 406; Deviance = 366; Residual df = 287; No. Obs. = 294

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