

Research Article

Determinants of Households' Access to Improved Drinking Water Sources: A Secondary Analysis of Eswatini 2010 and 2014 Multiple Indicator Cluster Surveys

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Worldwide, millions of people still die from diseases associated with inadequate water supply, sanitation, and hygiene, despite the fact that the United Nations recognized access to clean drinking water and sanitation as a human right nearly a decade ago. The objective of this study was to describe the determinants of access to improved drinking water sources in Eswatini in 2010 and 2014. Using the Eswatini Multiple Indicator Cluster Surveys (EMICSs), data for 4,819 households in 2010 and 4,843 in 2014 were analyzed. Bivariate and multivariate complementary log-log regression analyses were conducted to identify the determinants of households' access to improved drinking water sources. The study found that households' access to improved drinking water sources significantly improved from 73.1% in 2010 to 77.7% in 2014 ($p < 0.0001$). In 2010, households whose heads were aged 35–54 and 55 years had lower odds of having access to improved drinking water sources than those with younger ones. In 2014, female-headed households had lower odds, while, in 2010, sex of the household head was not associated with access to improved drinking water sources. In both years, an increase in the number of household members was negatively associated with access to improved drinking water sources compared to those with fewer members. In both years, the odds of access to improved drinking water sources increased with an increase in the wealth index of the household, and households located in urban areas had higher odds of access to improved drinking water sources compared to those in rural settings. In both years, households from the Shiselweni and Lubombo regions had lower odds of access to improved drinking water sources. The government and its partners should continue to upscale efforts aimed at increasing access to improved drinking water, especially in rural areas, to reduce the disparity that exists between urban and rural households.

1. Introduction

Despite the fact that the United Nations General Assembly explicitly recognized access to clean drinking water and sanitation as a human right nearly a decade ago [1], each year, millions of people around the world (mostly children) still die from diseases associated with inadequate water supply, sanitation, and hygiene (WASH). Projections show that, by the year 2050, more than half of the world's

population will live under moderate water stress, with 80% of these located in developing regions [2]. Even though the proportion of the global population using improved drinking water sources stood at 91% in 2015 (a Millennium Development Goal (MDG) target achieved by the year 2010), 785 million people still lacked basic drinking water services in 2017 [3], while 159 million still collected drinking water directly from surface water sources (58% of whom live in sub-Saharan Africa) [4]. As many nations work towards

meeting target 6.1 of Goal 6 of the Sustainable Development Goals (SDGs), aimed at achieving universal and equitable access to safe and affordable drinking water for all by the year 2030 [5], it is important to document the determinants of access to improved drinking water sources in order to identify key areas and disparities that nations still need to address as they strive to meet this target.

Generally, drinking water is defined as water used for domestic purposes, such as drinking, cooking, and personal hygiene. However, in this study, we restricted our definition of drinking water to water used for drinking only, because the outcome variable in this study asked participants about their main source of water for drinking only. The World Health Organization (WHO) defines an improved drinking water source as a source that, by nature of its construction, adequately protects the water from outside contamination, in particular, from faecal matter, such as having a piped household water connection, a public standpipe, a borehole, a protected dug well, a protected spring, and/or rainwater collection [6]. Having access to improved water and sanitation is associated with lower morbidity [7, 8], lower mortality, and a lower risk of diarrhea among children (<5 years) [7, 9]. On the other hand, the risk of mortality from access to unimproved water sources is reportedly higher among children aged less than 5 years [10], while absent, inadequate, or inappropriately managed water services increase the risk of transmission of diseases like cholera, diarrhea, dysentery, hepatitis A, typhoid, schistosomiasis, and polio [4].

The effects of improved drinking water quality on early childhood growth have been well documented, whereby the risk of children being underweight is reportedly lower among children from households with improved drinking water than from those with unimproved water sources [11]. The World Bank [12] argued that when water comes from improved and more accessible sources, people spend less time and effort physically collecting it, and that allows them to be productive in other ways while enjoying greater personal safety as the need to make long or risky journeys to collect water is eliminated. In the long run, having improved drinking water sources also translates to less expenditure on health, as people are less likely to fall ill and incur medical costs [12]. Access to improved drinking water sources can also ensure better health and, therefore, better school attendance for children as they become risk free from water-related diseases [4].

Even though the target for safe drinking water was the first of all the MDGs to be met, disparities still exist between countries in sub-Saharan Africa and between rural and urban settings in those countries [13]. Previous research has shown that in Africa some of the factors associated with access to improved household water sources include the place of residence, wealth status [14–16], education, ethnicity, access to electricity, gender, water collection time, and the number of rooms in a household [17]. However, few of these studies have used more than one data collection point to examine the prevalence and determinants of access to improved drinking water sources. Investigating such patterns is beneficial for countries as it provides them with data

to assess the impact of national efforts towards meeting the SDG targets.

The Eswatini government has made efforts to provide safe drinking water to its population through various measures, such as drilling boreholes throughout the country; however, such initiatives have been hampered by the high poverty rate as locals often do not afford to pay for the maintenance of these boreholes, further perpetuating the problem of inadequate safe drinking water in the country. Even though one of the goals set out in the National Development Strategy includes achieving universal access to safe water, the country is still far behind in achieving its targeted 100% coverage by the year 2022 [12]. Therefore, it is necessary to investigate the determinants of access to improved drinking water sources in the country. This will enable stakeholders to identify underlying factors associated with the disparities so that national efforts can be directed at addressing those underlying factors. However, there is a scarcity of published studies from Eswatini that could provide data to inform programming related to access to improved drinking water sources, since even the available Eswatini 2010 and 2014 Multiple Indicator Cluster Survey (EMICS) reports present descriptive data and do not present inferential statistics. For that reason, this study was conducted to (1) describe the prevalence of access to improved drinking water sources among households in 2010 and 2014 in Eswatini and (2) identify the determinants of access to improved drinking water sources in Eswatini in these years.

2. Materials and Methods

2.1. Study Context. Eswatini is a landlocked country in Southern Africa surrounded by Mozambique on the east and South Africa on the western side, measuring 17364 km², with a population of about 1.1 million, 78% of whom live in rural areas [18]. The country has an overall population growth rate of 1.8%, a per capita Gross Domestic Product (GDP) of US\$2,776, with the main drivers of the economy being agriculture and manufacturing, yet 63% of the population lives below the poverty line. The literacy level stands at 87.5%, while unemployment stands at 28.1%. The primary development challenges for the country include a high rate of poverty and inequality [19]. The country's surface water resources are estimated at 4.5 km³/year, with 42% originating from South Africa, while an estimated 78% of the rural population depends on groundwater supply. The country is prone to climate-related shocks, such as droughts, with the most recent one (El Niño) occurring in 2015/2016. This drought left the country with extremely low water levels in dams, coupled with drying up of rural boreholes, forcing the government to ration water and resulting in many communities relying on external water supply support [12].

The number of people with access to improved water in Eswatini is low, especially in rural areas (63%), with tap water making up 44% of rural supply, groundwater at 31.5%, and surface water up to 21% [20]. Countrywide, for most households (62%), adult females or children usually collect drinking water when the source is not on the premises (which is usually the case in about 50% of rural households)

[21]. Such low access to improved drinking water sources could be a contributing factor to the high childhood mortality and morbidity in Eswatini compared to other countries in sub-Saharan Africa [22], as the infant mortality rate stands at 50 deaths per 1,000 live births while the under-five mortality rate is at 67 deaths per 1,000 live births [21]. In-country reports show that the lack of safe water quality accounts for 200 deaths among children per year [23].

2.2. Study Design and Data Source. This study was a secondary analysis of data from the 2010 and 2014 EMICSs. The MICS is an international initiative by the United Nations Children's Fund (UNICEF) to assist countries in collecting and analyzing data to fill data gaps for monitoring the situation of children, women, and men in developing countries. It is a cross-sectional household survey conducted every three to five years to enable countries to capture rapid changes in key indicators such as those related to health, education, and mortality. In MICS, data are collected using standardized survey tools through face-to-face interviews among nationally representative samples of households [24].

2.3. Sampling Design and Study Samples. The 2010 EMICS was based on a nationally representative sample of 5,475 households selected from 365 clusters, also known as enumeration areas (EAs) in the four regions of the country. Among the sampled households, a total of 4,834 households were successfully interviewed, which included 4,956 women aged 15–49 years and 4,646 men aged 15–59 years. The overall household response rate was 95%. A detailed description of the sampling design for the 2010 EMICS is available elsewhere [25].

In the 2014 EMICS, a total of 347 EAs and 5,211 households were selected for the survey. The urban and rural areas within each region were identified as the main sampling strata. Within each stratum, a sample of 15 households was selected systematically using probability proportional to size in each EA, stratified by region, urban, and rural. A total of 4,762 women (15–49 years) and 1,459 men (15–59 years) were successfully interviewed from 4,865 households. A detailed description of the sampling design for the 2014 EMICS is available elsewhere [21].

In this study, for both years, the target population was household heads aged 15 years and above. In the 2010 sample, nine household heads had missing responses on their education level; one did not report the main source of drinking water and five reported other main sources of drinking water not listed in the questionnaire; hence they were excluded from the analysis; thus, data for 4,819 households' heads were retained in the analysis for the 2010 sample. In the 2014 EMICS, 18 heads of households had missing data on their education level, two did not report their main sources of drinking water, and another two reported other main sources of drinking water not listed in the questionnaire; hence these were excluded from the analysis, making the remaining sample analyzed to be 4,843 for 2014.

2.4. Variables

2.4.1. Dependent Variable. The dependent variable in this study was "household access to improved drinking water sources." It was generated as a binary variable (coded as 1 if the household had access to improved drinking water sources and 0 if it had no access to improved drinking water sources). In 2010, there were 3,582 (73.1%) households that had access to improved drinking water sources. In 2014, 3,488 (77.7%) households had access to improved drinking water sources. In both of the EMICSs, household heads were asked to report if they had access to any of the following improved drinking water sources as their main source of drinking water: piped water into the dwelling, water piped to a yard or plot, piped water to a neighbour, a public water tap or standpipe, a borehole or tube well, a protected well, a protected spring, rainwater, and/or bottled water. In this study, heads of households who answered "yes" to any one of the improved drinking water sources options was deemed to be having access to improved drinking water sources.

2.4.2. Explanatory Variables. Potential determinants of access to improved drinking water sources were identified during the literature review [16, 26, 27], and these included age of the household head (15–34, 35–54, 55, and above), sex of the household head (male, female), education level of the household head (no education, primary, secondary, high school, and tertiary), household size (1–3, 4–6, 7, and more), household wealth index (poorest, poor, middle, rich, and richest), place of residence (rural/urban), and region (Hhohho, Manzini, Shiselweni, and Lubombo). Other available potential explanatory variables in EMICS (such as the distance of water source from the household and how long it took in minutes to reach the water source) were excluded in the analysis because they had extensive missing data.

2.5. Statistical Analysis. Stata 15 [28] was used to perform descriptive and explanatory analyses for each survey year. First, univariate analysis was performed to estimate the distribution of the sample and proportion of households with improved drinking water sources and households with no access to improved drinking water sources along with $p < 0.05$ for a Chi-square test for comparison of household characteristics by access to improved drinking water status. All analyses were weighted to account for sampling variations in the cluster, due to the complex nature of the sampling design of the EMICSs. A two-sample, two-tailed z -test was performed to determine if the difference in the weighted proportions of households' access to improved drinking water sources between the two survey years was statistically significant. Second, a bivariate logistic and complementary log-log regression analyses (i.e., crude models) were run with each of the explanatory variables regressed against the outcome to determine which variables to include in the final model [29]. Third, multivariate logistic models were fitted and later validated with complementary log-log regressions (clog log). The *clog log* model was appropriate for the data because the probability of households'

access to improved water sources is very large [30]. Following the literature [31–33], model coefficients were exponentiated to derive crude odds ratios (COR) with their 95% confidence intervals (CI). In the final model, results were reported using adjusted odds ratios (AORs) and their 95% CIs, at an alpha level of 0.05 in both models. Akaike Information Criterion (AIC) and Bayesian Information Criterion (BIC) were used for model selection. The model with the smallest AIC and BIC was considered to be the best fit model of the two models under consideration. The model fit statistics for the complementary log-log models are shown in Table 3. The *clog* log models had the lowest fit statistics in both survey years, AIC (4250.86) and BIC (4367.50), in 2010, while, in 2014, we have AIC (4495.19) and BIC (4611.93). The model fit statistics suggested that the *clog* log model was the parsimonious model, and therefore the results from the *clog* log model were interpreted. For the results of the logistic regression, see Table S1 for comprehensive analysis.

2.6. Ethical Considerations. The study datasets are publicly available from the UNICEF website (<https://mics.unicef.org/surveys>) and were deidentified of all participants' identifiers before being deposited in the UNICEF data repository. The Eswatini Central Statistics Office ensured ethical compliance during the implementation of the surveys, including the application for protocol approval from the Scientific and Ethics Committee of the Ministry of Health in Eswatini.

3. Results

3.1. Sociodemographic Characteristics of the Samples. Table 1 shows the distribution of the study sample by survey year. Of the total sample of households heads included in the analysis in 2010 (4,819) and 2014 (4,843), there was a relatively similar distribution of the heads of households aged 35–54 years (38.9% in 2010 and 39.6% in 2014). Slightly above half (53.4% in 2010 and 52.6% in 2014) of the households had males as their heads. A majority of the households, 29.1% in both 2010 and 2014, had their heads having a primary school level education. Just over a quarter (26% in 2010) and 21.6% in 2014 of the households were classified under the richest quartile. As expected, a majority of the households were located in rural areas (56.7% in 2010 and 73.5% in 2014) (Table 1).

Table 2 shows the results of the overall prevalence of access to improved drinking water sources and the distribution of the study samples by explanatory variables in each survey year, with the corresponding Chi-square *p* values. The overall access to improved drinking water significantly improved from 73.1% (95% CI: 71.8–74.4) in 2010 to 77.7% (95% CI: 76.4–78.9) in 2014 ($p < 0.0001$). Households' access to improved drinking water sources was significantly different by sex of the household head in both survey years (55.8% vs. 44.2% in 2010 and 56.7% vs. 43.3 in 2014, $p < 0.001$ in both years). In both survey years, there were also significant differences in households' access to improved drinking water sources by age, household size, educational level of household head, location of the household by urban

vs. rural, region, and wealth index (all $p < 0.001$ in both years).

3.2. Determinants of Households' Access to Improved Drinking Water Sources. Table 3 depicts the bivariate and multivariate *clog* log results. In the multivariate model, in 2010, households with a household head aged 35–54 years (AOR = 0.87, 95% CI: 0.78, 0.97) and those aged 55 years and older (AOR = 0.80, 95% CI: 0.70, 0.90) were less likely to have access to improved drinking water sources than those with a household head aged 15–34 years, holding other variables constant in the model. However, in 2014, there was no significant association between the age of the household head and household access to improved drinking water sources.

In 2014, households, whose heads were female, were less likely to have access to improved drinking water sources (AOR = 0.91, 95% CI: 0.83, 0.99), holding other covariates constant in the model. There was no significant association between the sex of the household head and household access to improved drinking water sources in 2010. Households (HH) with 4–6 members vs. those with 1–3 members were less likely to have access to improved drinking water sources (AOR = 0.89, 95% CI: 0.80, 0.98) in 2010. In 2014, those HH with 4–6 and with 7 and more members were less likely to have access to improved drinking water sources (AOR = 0.88, 95% CI: 0.79, 0.97) and (AOR = 0.87, 95% CI: 0.76, 0.99), respectively, compared to those with 1–3 members. In 2010, compared to households in the poorest wealth quartile, those in the poor quartiles (AOR = 1.68, 95% CI: 1.44, 1.97), middle (AOR = 2.02, 95% CI: 1.74, 2.36), rich (AOR = 2.63, 95% CI: 2.25, 3.07), and richest quartiles (AOR = 3.71, 95% CI: 3.11, 4.43) were more likely to have access to improved drinking water sources. The odds of access to improved drinking water sources by wealth index were even higher in 2014, for the rich (AOR = 2.98, 95% CI: 2.55, 3.50) and richest (AOR = 4.58, 95% CI: 3.76, 5.57), holding all other variables constant in the model. Households located in urban areas had higher odds of access to improved drinking water sources compared to those in rural areas (AOR = 1.70, 95% CI: 1.54, 1.88) in 2010 and (AOR = 2.13, 95% CI: 1.87, 2.42) in 2014. In 2010, households from the Manzini (AOR = 0.73, 95% CI: 0.65, 0.83), Shiselweni (AOR = 0.53, 95% CI: 0.47, 0.61), and Lubombo (AOR = 0.67, 95% CI: 0.59, 0.76) regions were less likely to have access to improved drinking water sources, compared to households in the Hhohho region. Similarly, in 2014, households from the Shiselweni and Lubombo regions were less likely to have access to improved drinking water sources than those from the Hhohho region (AOR = 0.67, 95% CI: 0.59, 0.75) and (AOR = 0.73, 95% CI: 0.64, 0.84), respectively (Table 3).

4. Discussion

This study found an overall increase in the proportion of households accessing improved drinking water sources between 2010 and 2014 and that several determinants

TABLE 1: Distribution of the study samples (unweighted) by survey year.

| Variables | 2010 N = 4819 n (%) | 2014 N = 4843 n (%) |
|--|---------------------------|---------------------------|
| <i>Age of HH in years *</i> | | |
| 15–34 | 1596 (33.1) | 1302 (26.9) |
| 35–54 | 1870 (38.8) | 1920 (39.6) |
| 55 and above | 1353 (28.1) | 1621 (33.5) |
| <i>Sex of HH</i> | | |
| Male | 2574 (53.4) | 2548 (52.6) |
| Female | 2245 (46.6) | 2295 (47.4) |
| <i>The highest education level of HH</i> | | |
| No education | 888 (18.4) | 909 (18.8) |
| Primary | 1402 (29.1) | 1409 (29.1) |
| Secondary | 1003 (20.8) | 1003 (20.7) |
| High school | 894 (18.6) | 827 (17.1) |
| Tertiary | 632 (13.1) | 695 (14.4) |
| <i>Household size</i> | | |
| 1–3 | 2423 (50.3) | 2248 (46.4) |
| 4–6 | 1496 (31.0) | 1630 (33.7) |
| 7 and more | 900 (18.7) | 965 (19.9) |
| <i>Household wealth index</i> | | |
| Poorest | 774 (16.1) | 976 (20.2) |
| Poor | 721 (15.0) | 935 (19.3) |
| Middle | 904 (18.8) | 975 (20.1) |
| Rich | 1021 (21.2) | 911 (18.8) |
| Richest | 1399 (29.0) | 1047 (21.6) |
| <i>Place of residence</i> | | |
| Rural | 2733 (56.7) | 3561 (73.5) |
| Urban | 2086 (43.3) | 1282 (26.5) |
| <i>Region</i> | | |
| Hhohho | 1232 (25.6) | 1340 (27.7) |
| Manzini | 1362 (28.3) | 1340 (27.7) |
| Shiselweni | 1078 (22.4) | 1135 (23.4) |
| Lubombo | 1147 (23.8) | 1028 (21.2) |

Notes: *HH: household head; some percentages do not add to 100% due to rounding-off.

accounted for households' access to improved drinking water sources in the two survey years. The observed improvement in households' access to improved drinking water sources is in line with SDG number six, to ensure universal access to clean water by 2030 [3]. The observed improvement in access to improved water sources in Eswatini may be attributed in part to the positive effects of national efforts aimed at improving access to safe water in communities more so because both surveys were conducted before the 2015/2016 El Niño drought, which would have diluted such effects, thus making it difficult to observe any gains. Worth noting is that this study reports a higher prevalence of household access to improved drinking water sources in both survey years compared to those reported in 2010 (which was 67.3%) and 2014 (which was 72%) EMICS reports [21, 25]. The discrepancies could be due to differences in the definitions of improved drinking water sources in this study vs. the original definitions in the EMICSs. In this study, the definition of the outcome variable was limited to water sources used for drinking only, similar to other studies [26, 27], while, in the MICS reports, improved

drinking water sources include water used for drinking and other domestic purposes. However, the prevalence of access to improved drinking water sources reported in this study is comparable (at 74%) to those reported in a majority of countries in sub-Saharan Africa (SSA) [26, 34, 35].

Evidence from a study done in several SSA countries suggested that the older the household head, the less likely the household had access to improved drinking water sources [36]. This study found that, in both survey years, the older the household head, the lower the chances of having access to improved drinking water sources. For example, households headed by persons aged 35–54 and 55 and above were less likely to have access to the improved drinking water sources. One plausible explanation for this finding could be that, in our sample, a majority of older household heads (i.e., 35 years and older) were from poor households and mainly from rural areas and therefore could not afford improved drinking water sources (see Table 1, 2014 sample).

The study also found that households that were headed by females were less likely to have access to improved drinking water sources. Similar to other developing countries [36, 37], men in Eswatini often make decisions on water management even though women are responsible for water collection. In different traditional settings, women still hold very little influence in committees for boreholes and other community water projects [36, 38]. This finding conflicts with most studies, which found that female-headed households were more likely to have access to improved drinking water sources [14, 26, 39]. The reason could be that a majority of the households with low access to improved drinking water sources in our study were located in rural areas, where most of the HH are headed by females, many of whom are housewives and therefore do not have adequate financial resources to acquire improved drinking water sources. In Eswatini, about 70% of the population lives in rural areas, yet more than 60% of the population lives below the poverty line [19].

Education is regarded as a socioeconomic indicator [40]. Current evidence in literature indicates a positive relationship between the educational attainment of the household head and the likelihood of having access to improved drinking water sources [39]. Contrary to the literature, this study found no significant difference in household access to the improved drinking water source by the education level of the household head, possibly because affordability seemed to be the main issue for many HH with access to unimproved water sources in this study sample, especially in rural areas. Similar to a multicountry study conducted in SSA, whereby households with small sizes were found to be more likely to have access to improved drinking water sources [14], this study also found that household size significantly predicted households' access to improved drinking water sources in both survey years. Larger household sizes translate to huge water consumption and increased expenditures in water bills and maintenance fees. Households in poor traditional settings tend to have high fertility, validating the presumption of a potential positive causal relationship between poverty and high fertility in developing countries [41]. In this study, the higher the socioeconomic status of a household, the higher the odds of

TABLE 2: Distribution of household characteristics by access to improved drinking water sources in each survey year.

| Characteristic | 2010 water sources | | | 2014 water sources | | |
|--|---------------------|-----------------------|----------------|---------------------|-----------------------|----------------|
| | Improved (weighted) | Unimproved (weighted) | <i>p</i> value | Improved (weighted) | Unimproved (weighted) | <i>p</i> value |
| <i>Total</i> | 3582 | 1237 | | 3488 | 1355 | |
| <i>Prevalence</i> | 73.1 (71.8, 74.4) | 26.9 (25.6, 28.2) | | 77.7 (76.4, 78.9) | 22.3 (21.1, 23.6) | |
| <i>Age of the HH in years **</i> | | | <0.001 | | | <0.001 |
| 15–34 | 1342 (36.2) | 254 (19.9) | | 1025 (33.0) | 277 (20.7) | |
| 35–54 | 1423 (39.2) | 447 (36.8) | | 1414 (40.8) | 506 (38.3) | |
| 55 and above | 817 (24.6) | 536 (43.3) | | 1049 (26.3) | 572 (41.0) | |
| <i>Sex of HH</i> | | | <0.001 | | | <0.001 |
| Male | 2010 (55.8) | 564 (45.5) | | 1916 (56.7) | 632 (46.4) | |
| Female | 1572 (44.2) | 673 (54.5) | | 1572 (43.3) | 723 (53.6) | |
| <i>The highest education level of HH</i> | | | <0.001 | | | <0.001 |
| No education | 515 (15.9) | 373 (30.0) | | 519 (12.6) | 390 (27.6) | |
| Primary | 908 (26.1) | 494 (40.0) | | 900 (23.7) | 509 (38.1) | |
| Secondary | 785 (22.0) | 218 (17.7) | | 743 (21.3) | 260 (19.4) | |
| High school | 788 (20.8) | 106 (8.5) | | 707 (23.8) | 120 (9.2) | |
| Tertiary | 586 (15.2) | 46 (3.9) | | 619 (18.6) | 76 (5.8) | |
| <i>Household size</i> | | | <0.001 | | | <0.001 |
| 1–3 | 1996 (53.2) | 427 (33.4) | | 1789 (56.0) | 459 (34.3) | |
| 4–6 | 1028 (29.6) | 468 (38.4) | | 1097 (29.7) | 533 (38.7) | |
| 7 and more | 558 (17.1) | 342 (28.2) | | 602 (14.3) | 363 (27.0) | |
| <i>Household wealth index</i> | | | <0.001 | | | <0.001 |
| Poorest | 312 (9.6) | 462 (37.5) | | 416 (8.9) | 560 (39.0) | |
| Poor | 438 (13.7) | 283 (23.1) | | 571 (13.2) | 364 (28.1) | |
| Middle | 656 (18.9) | 248 (19.5) | | 700 (17.8) | 275 (20.6) | |
| Rich | 847 (23.8) | 174 (14.1) | | 791 (27.3) | 119 (9.4) | |
| Richest | 1329 (34.0) | 70 (5.8) | | 1010 (32.8) | 37 (2.8) | |
| <i>Place of residence</i> | | | <0.001 | | | <0.001 |
| Rural | 1652 (55.9) | 156 (9.1) | | 2248 (53.3) | 1313 (95.7) | |
| Urban | 1930 (44.1) | 1081 (90.9) | | 1240 (46.8) | 42 (4.3) | |
| <i>Region</i> | | | <0.001 | | | <0.001 |
| Hhohho | 1061 (29.5) | 171 (16.9) | | 1074 (26.8) | 266 (20.3) | |
| Manzini | 1129 (37.2) | 233 (23.6) | | 1071 (43.3) | 269 (25.8) | |
| Shiselweni | 602 (14.5) | 476 (35.4) | | 668 (11.4) | 467 (27.7) | |
| Lubombo | 790 (18.8) | 357 (24.2) | | 675 (18.5) | 353 (26.3) | |

Notes: *p* value < 0.05 for a chi-square test; *Z-test *p* value comparing two proportions is significant at < 0.0001 (not shown); HH: household head; some percentages do not add to 100% due to rounding-off.

access to improved drinking water sources, implying that rich households have better access to resources and therefore have the better financial capacity to afford access to improved water sources [14, 16, 42].

The findings in this study also showed that there were higher odds of access to improved drinking water sources among households in urban areas (a 43 points increase between the two years), in line with studies conducted in Ghana and Vietnam, whereby households in urban areas were also found to have higher odds of access to improved drinking water sources [27, 43]. The scarcity of improved drinking water in rural areas is well documented and is evidenced by the high prevalence of waterborne illness in rural areas such as diarrhea, schistosomiasis, trachoma, and intestinal helminths which can be attributed explicitly to unsafe water, poor sanitation, and the lack of hygiene [39]. Improvements in the water supply or water quality have been cited to be one of the effective interventions to reduce diarrheal diseases up to one third [40]. The finding of

Shiselweni and Lubombo households having lower odds of access to improved drinking water sources was not surprising, considering that these two regions are less developed and have more rural settings compared to the Hhohho and Manzini regions, which further highlights that unaffordability might be the main issue in many households. Other studies have also reported disparities among regions in different countries concerning household access to improved drinking water supply [27, 42].

4.1. Strengths and Limitations. This study is among the first to document the determinants of improved drinking water sources in Eswatini. The study analyzed data collected at two time points using similar survey methods, which enables direct comparisons between the two survey points. The study findings provide evidence of national progress towards meeting the SDG 6 target. In the two EMICSSs, households were drawn from all the four administrative regions in the

TABLE 3: Bivariate and multivariate results of the determinants of households' access to improved drinking water sources in 2010 and 2014.

| Variables | The year 2010 | | The year 2014 | |
|--|----------------------------------|--------------------|----------------------------------|--------------------|
| | Complementary log-log regression | | Complementary log-log regression | |
| | COR (95% CI) | AOR (95% CI) | COR (95% CI) | AOR (95% CI) |
| <i>Age of the HH (years)</i> | | | | |
| 15–34 | 1 | 1 | 1 | 1 |
| 35–54 | 0.76 (0.70, 0.83)* | 0.87 (0.78, 0.97)* | 0.82 (0.75, 0.90)* | 0.93 (0.83, 1.04) |
| 55 and above | 0.52 (0.47, 0.58)* | 0.80 (0.70, 0.90)* | 0.62 (0.57, 0.69)* | 0.99 (0.87, 1.13) |
| <i>Sex of the HH</i> | | | | |
| Male | 1 | 1 | 1 | 1 |
| Female | 0.79 (0.74, 0.86)* | 1.10 (0.91, 1.09) | 0.81 (0.75, 0.87)* | 0.91 (0.83, 0.99)* |
| <i>The highest education level of the HH</i> | | | | |
| No education | 1 | 1 | 1 | 1 |
| Primary | 1.14 (1.02, 1.28)* | 0.92 (0.81, 1.04) | 1.21 (1.08, 1.37)* | 1.01 (0.88, 1.16) |
| Secondary | 1.66 (1.46, 1.87)* | 0.92 (0.80, 1.07) | 1.66 (1.46, 1.87)* | 1.00 (0.85, 1.17) |
| High school | 2.28 (2.01, 2.59)* | 0.95 (0.80, 1.11) | 2.42 (2.13, 2.75)* | 1.09 (0.91, 1.30) |
| Tertiary | 2.74 (2.37, 3.18)* | 0.99 (0.82, 1.21) | 2.63 (2.29, 3.02)* | 0.84 (0.68, 1.03) |
| <i>Household size</i> | | | | |
| 1–3 | 1 | 1 | 1 | 1 |
| 4–6 | 0.68 (0.62, 0.74)* | 0.89 (0.80, 0.98)* | 0.68 (0.63, 0.74)* | 0.88 (0.79, 0.97)* |
| 7 and more | 0.58 (0.53, 0.65)* | 0.91 (0.80, 1.03) | 0.55 (0.50, 0.61)* | 0.87 (0.76, 0.99)* |
| <i>Household wealth index</i> | | | | |
| Poorest | 1 | 1 | 1 | 1 |
| Poor | 1.83 (1.57, 2.13)* | 1.68 (1.44, 1.97)* | 0.50 (0.36, 0.64)* | 1.44 (1.25, 1.67)* |
| Middle | 2.46 (2.13, 2.83)* | 2.02 (1.74, 2.36)* | 0.86 (0.73, 0.99)* | 1.94 (1.68, 2.24)* |
| Rich | 3.27 (2.84, 3.76)* | 2.63 (2.25, 3.07)* | 1.41 (1.28, 1.55)* | 2.98 (2.55, 3.50)* |
| Richest | 5.36 (4.65, 6.18)* | 3.71 (3.11, 4.43)* | 1.85 (1.71, 1.99)* | 4.58 (3.76, 5.57)* |
| <i>Place of residence</i> | | | | |
| Rural | 1 | 1 | 1 | 1 |
| Urban | 2.70 (2.49, 2.91)* | 1.70 (1.54, 1.88)* | 3.40 (3.05, 3.79)* | 2.13 (1.87, 2.42)* |
| <i>Region</i> | | | | |
| Hhohho | 1 | 1 | 1 | 1 |
| Manzini | 0.95 (0.86, 1.06) | 0.73 (0.65, 0.83)* | 1.12 (1.02, 1.23)* | 0.96 (0.86, 1.08) |
| Shiselweni | 0.43 (0.38, 0.48)* | 0.53 (0.47, 0.61)* | 0.52 (0.46, 0.57)* | 0.67 (0.59, 0.75)* |
| Lubombo | 0.65 (0.58, 0.73)* | 0.67 (0.59, 0.76)* | 0.72 (0.65, 0.80)* | 0.73 (0.64, 0.84)* |
| Observations | | 4819 | | 4843 |
| <i>Model fit</i> | | | | |
| AIC | | 4250.86 | | 4495.19 |
| BIC | | 4367.50 | | 4611.93 |

Notes: COR=Crude odd ratio, AOR = Adjusted odds ratio, *significant at $p < 0.05$, and HH = household head.

country using a multistage sampling design, which ensured that the households were representative of each region and subsequently of the entire country, thus enhancing the generalizability of the findings. This study also accounted for the complex sampling design of the two surveys in the analysis through weighting, which further increased the internal and external validity of the study. Therefore, power for inference can be regarded as the strength of this study due to the national representativeness of the data and the large sample size.

Despite the above mentioned strengths, the study is not immune to a number of limitations. First, the findings should be interpreted with caution since, by their design, MICs are cross-sectional and therefore cannot establish causality between the explanatory variables and households' access to improved drinking water sources. Second, even though the definition of the outcome variable was drawn from that of the joint monitoring program of the water supply of the WHO

and UNICEF, the use of the phrase "improved water" should not be mistaken to mean clean water. Third, recall bias and misreporting cannot be ruled out in the MICs as participants have to recall or provide estimates for some of the variables, such as household size and wealth. Desirability bias can also not be ruled out as participants may have misreported their age, wealth, and education level, which would reduce or amplify the real effects of the explanatory variables on the outcome variable, thus introducing information bias. Lastly, the study cannot be free from residual confounding as some variables cannot be said to be perfectly measured in MICs, since it was not possible to analyze all the potential explanatory variables identified in literature as this study was a secondary analysis; hence variable selection was limited to the available variables in the two MICs and by the amount of missing or nonmissing data for those variables. However, Eswatini complies with the procedures of MICs; hence these limitations cannot outweigh the strength of the study.

5. Conclusions and Recommendations

The study found that the proportion of households with access to improved drinking water sources increased significantly from 73.1% in 2010 to 77.7% in 2014. The findings showed that, among the demographic factors, households headed by persons older than 34 years and by females were less likely to have access to improved drinking water sources. The study also found that the odds of households' access to improved drinking water sources were lower among households with more than three persons and that households' wealth index was positively associated with improved drinking water sources. The study further showed that regional and urban-rural disparities in access to improved drinking water sources still exist in Eswatini.

In light of the findings, several recommendations are proposed. Even though the results showed that the country is on track towards meeting SDG and strategic national targets regarding access to improved drinking water, there is a need for the government and its partners to continue to upscale efforts aimed at increasing access to improved drinking water, especially in rural areas to reduce the disparity that exists between urban and rural households. The Ministry of Health should continue advocating for the use of family planning commodities in the country to maintain small household sizes so that resources remain optimal for families to be able to afford all necessities, such as access to an improved water source. There is also a need to focus on households in the lower wealth categories by proposing practical and affordable means of accessing improved water sources, such as educating them about rain-water harvesting techniques and providing them with the financial support to acquire and maintain storage facilities for the harvested water. Such education campaigns could be conducted by engaging already existing programs such as the Rural Health Motivators' program (i.e., community health workers) and Community Development Officers program (for resource mobilization) so that such efforts do not add an extra financial burden to the government. Lastly, future studies should collect more explanatory variables and conduct multilevel analysis to tease out community and regional level effects of the determinants on access to improved drinking water sources.

Data Availability

The 2010 and 2014 Multiple Indicator Cluster Survey datasets can be accessed from the UNICEF data website at <http://mics.unicef.org/>.

Conflicts of Interest

The authors declare that they have no conflicts of interest to declare.

Authors' Contributions

MSS conceived the research idea, performed the statistical analysis, wrote the methods, results, and discussions, and

prepared the initial draft of the manuscript; MCS conducted the literature review and wrote the introduction, methods, and discussion. KV and EZ critically reviewed the manuscript and contributed to the study design and manuscript writing. All authors reviewed and approved the final manuscript.

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Supplementary Materials

The logistic regression model results have been provided as a supplementary file (Table S1: logistic regression results). (*Supplementary Materials*)

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