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Research Article

Multinomial Regression Modelling of Factors Determining Choice of Household Water Treatment Technology in Bindura Rural District of Zimbabwe

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Abstract: Household Water Treatment and Safe water storage (HWTS) are options for improving the biological quality of drinking water. A multinomial logistic regression was used to model household water treatment technologies of chlorination, boiling and bios and filtration against the most important socio-economic factors influencing choice of technology of treatment in Bindura rural district. Structured questionnaires were administered to 252 House Holds (HH) sampled from six district wards. Government assistance, Non-Governmental Organizations (NGOs) support, health club membership, training in hygiene were the most important factors influencing choice of household water treatment as shown by the Wald statistics; Log Likelihood ratios (-2LL) and corresponding p-values. The odds ratios for each factor also considered relative to the reference category (chlorination). Model goodness of fit tests showed that pseudo-R^2 of Negelkerke was 55.7% and the Cox and Snell R^2 was 43.5% indicating that the fitted model was adequate since almost 55.7% of the total variation is explained by the models. Log Likelihood ratios showed the significance of removing each factor and all factors were significant except for the household size factor. Training programs on health hygiene, water treatment and club membership should be enhanced to increase adoption of various treatment methods in the Bindura rural.

Keywords: Bindura, household water treatment technology, multinomial modeling, socio-economic factors

INTRODUCTION

In Africa, about 70% of the households in rural areas are living without sanitation facilities and 80% without access to improved drinking water sources (UNICEF/WHO, 2008). This is where the burden of disease associated with unsafe drinking water is borne mostly by the poor, the very young and the immune-deficient but is largely preventable (Trevett *et al*., 2005; Nath *et al*., 2006). Water is usually collected from unprotected sources and consumed without being treated putting people to health risk from water-borne diseases.

Household Water Treatment and Safe storage (HWTS) is an option for improving the quality of drinking water at household level especially where handling and storage of drinking water are necessary and recontamination is a risk (WHO/UNICEF, 2011). Water supply and hygiene programs provide barriers to pathogens breaking the cycle of disease transmission (Waddington *et al*., 2009). After such programs have been implemented in an area the incidence of diarrheal diseases is expected to decrease. Household Water Treatment (HWT) technologies can be used to eliminate or reduce transmission of pathogens is well documented (Nath *et al*., 2006; Classen, 2009; Waddington *et al*., 2009). In this study HWTS that were used by rural communities of Bindura district were assessed. A number of Non Governmental Organizations (NGOs) have been working in the district for the past decade in water supply and hygiene. There has been no independent assessment of water supply interventions in Bindura district to evaluate the factors that influence the choice of HWT option. Identifying populations that do not practice HWTS or acceptable hygiene behavior may help Water Supply and Hygiene (WSH) program implementers to effectively target their beneficiaries and evaluate their program effectively.

The Zimbabwean government recommended the bush pump (borehole) for rural community water supply and, chlorination for HWT. These prescribed technologies have proved to be not sustainable for the rural poor as replication; maintenance, replacement and/or self-funding are poor. It is against this background that prompted to assess the most influential factors that determined the adoption or non adoption of various HWT technologies in the selected wards. A multinomial logistic regression is a technique that basically fits multiple logistic regressions in a multi-category unordered response variable that has been

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coded. The multinomial logistic regression model allows the effects of the explanatory variables to be assessed across all the logit models and provides estimates of the multinomial logistic regression model. Socioeconomic factors are the major determinants of the choice of household water treatment method that can be adopted by the communities. Therefore there is need to assess the importance of the socio-economic factors considered in this study so as to appropriately enhance the adoption of HWT technologies in rural communities.

METHODOLOGY

Study area: Bindura district consists of 21 administrative wards. It has a maximum mean annual temperature of between 26 and 28°C and receives between 750 and 1000 mm of rainfall annually falling mainly from November to March. Records from the Ministry of Health and Child Welfare (MoHCW) Bindura district (Environmental health) showed that rural water supply and sanitation coverage for Bindura district were estimated at 58 and 25%, respectively.

Sampling and sample size: Forty-two households were randomly selected from each of the six wards (9, 10, 12, 13, 15 and 19) studied. A 30-item open-ended questionnaire was pre-tested to 9.9% of the households targeting the female head of the household in the study area. The modified tool was then administered to 252 rural households in unannounced visits. If the interview failed for some reason, the field team would revisit the household later. Questionnaire items were developed from Dzwairo *et al*. (2006) and WHO/UNICEF (2012) focusing on household demography, HWTS and barriers for their adoption by households in the six wards. Verbal consent to participate in the survey was sought at household level through the district office of MoHCW Bindura district office which also participated in the study.

Statistical analysis: Data was analyzed using a multinomial logistic regression in SPSS Version 16.0. Socio-economic factors were considered as the predictor or explanatory variables whilst the response variable was the three different water treatment methods used in the six wards.

RESULTS AND DISCUSSION

Figure 1 shows the percentage of households using different HWT technologies in Bindura rural district. Water chlorination method was practiced in all the six study wards. However the highest percentage of chlorination was observed in villages 10 and 19. About 40% (n = 42) of the households were practicing chlorination (Fig. 1) Boiling method was not widely practiced.

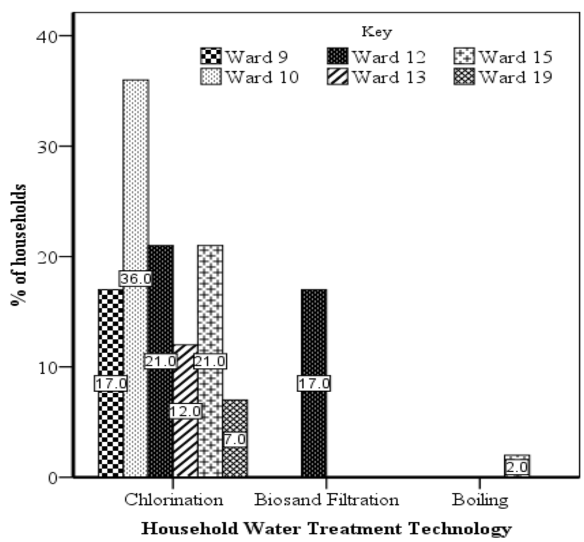

Fig. 1: Household water treatment technologies used in six wards of Bindura district

Table 1: Factors influencing choice of boiling HWT technology

Factor	B Regression coefficient	S.E.	Wald statistic	Sig (p-value)	Exp (B) Odds ratio
Intercept	2.823	1.703	2.748	0.097	
1- 4 Household size	-1.163	0.956	1.48	0.224	0.313
5- 8 Household size	-0.678	0.893	0.577	0.448	0.508
Trained in health hygiene	-2.422	1.419	2.913	0.088	0.089
Health club membership	1.563	0.732	4.568	0.033	4.784
Government assistance	-1.955	0.803	5.923	0.015	0.142
NGO assistance	2.566	1.485	2.983	0.084	13.008

Reference category is chlorination

Table 2: Factors influencing choice of bios and filtration HWT technology

Factor	B Regression coefficient	S.E.	Wald statistic	Sig (p-value)	Exp (B) Odds ratio
Intercept	15.213	1.753	75.296	0.00	
1- 4 Household size	-1.223	1.530	0.639	0.424	0.294
5- 8 Household size	-2.739	1.703	2.587	0.108	0.065
Trained in health hygiene	13.593	0.00	-------	-------	0.089
Health club membership	2.071	1.108	3.495	0.062	7.930
Government assistance	-3.652	1.515	5.809	0.016	0.026
NGO assistance	2.566	1.485	2.983	0.084	13.008

Reference category is chlorination

Boiling water option: The odd ratio (Exp (B)), of households receiving NGO support was 13.008 (Table 1). This shows that households receiving NGO support controlling for all other factors are 13.008 times more likely to boil their household water than chlorinating. There is strong evidence that receiving government support had a significant effect on the choice water treatment method (p = 0.015). The odds ratio of 4.784 (Table 1) was recorded for effect of health club membership indicating that households belonging to a health club were 4.784 times likely to boil their drinking water than chlorinating it. Similar studies by Nagata *et al*. (2011) revealed limited use of chlorination method due to aesthetic reasons, odor and taste of as well as religious beliefs. Households receiving government support have an odds ratio of 0.142 (Table 1) indicating that they are 0.142 times less likely to boil water relative to chlorination. This implies that because of government support, they are likely to chlorinate their water and not bother about boiling their water. This is well supported by the notion that households, especially those close to rural government health centers were receiving chlorine tablets freely for chlorinating drinking water. The other reason could be that boiled water was susceptible to recontamination if no proper storage is done (Classen, 2009). Equation (2) is the fitted multinomial model for the boiling water treatment option.

Multinomial regression models derived: In general the multinomial equation is:

$$\text{Log}\frac{\Pr(Y = j)}{\Pr(Y = j')} = \alpha + \sum_{i=1}^{i=k} \beta_i X_i \quad (1)$$

where,

- Y = Household water treatment technology
- j = The identified water treatment technology
- j' = The reference water treatment technology (Chlorination)
- X_i = The i^{th} factor
- Bi = The estimated regression coefficient for each X_i factor
- α = The regression intercept or constant

For the option of Boiling HWT, the multinomial logit regression equation is:

$Log\frac{\Pr(Y=Boiling)}{\Pr(Y=Chlorination)} = 2.823 - 1.16$ (1 - 4*HH size*) – 0.68(5-8*HH size*) -2.42 *Hygiene trained* + 1.56 *Health club membership* – 1.96 *Govt assistance* + 2.57 *NGO assistance* (2)

Bios and filtration: A unit increase in household numbers for the 5-8 household size category results in a decrease in log odds of bios and filtration by -0.678 (Table 2). This implies that for a unit increase in household members, households are likely to choose chlorination method rather than the boiling method. This could be as a result of the labor involved in boiling and also the unavailability of firewood that is used as a source of fuel for boiling. Health club membership had an odds ratio of 7.390 (Table 2), showing that households belonging to a health club were 7.390 times more likely to do bios and filtration than chlorination. This observation could be attributed to the proposition that bios and filtration was donor supported by NGOs. It could also be that households could learn from their community support leaders, village health workers or other members within their health clubs encourage each other in using them. There is little statistical evidence, p-value = 0.062 (Table 2), to suggest that belonging health club membership had a significant effect on the choice of household water treatment method. Government support is the most important factor determining the choice of bios and filtration method with a Wald statistic of 5.809 followed by health club which has a Wald statistic of 3.495 (Table 1). There is statistical evidence to suggest that government support, NGO support and health club had a significant effect on the choice of household water treatment method as shown by the corresponding p-values in Table 2. There was no statistical evidence to support the idea that number of household members. Equation 3 is the fitted multinomial model for the bios and filtration water treatment method.

For the option of Bios and filtration technology, the multinomial logit regression equation is:

$Log\frac{\Pr(Y=Biosand\ filtration)}{\Pr(Y=Chlorination)} = 15.21 - 1.22$ (1 - 4 *hhld size*) -2.74(5-8*hhld size*) + 13.59 *Hygiene trained* +2.07 *Health club membership* – 3.65 *Govt assistance* +2.57 *NGO assistance* (3)

Model goodness of fit tests: Multinomial regression Pseudo-R^2 values show that Negelkerk R^2 was 55.7% and Cox and Snell was 43.6% (Table 3). This shows that according to Negelkerk R^2 about 55.7% of the total variability in this study is being explained by the fitted multinomial model. Generally, results show that health club membership; government assistance and NGO assistance were the most important factors determining the choice of household water treatment method based on the Wald statistic and Chi-square statistic from the Likelihood Ratio tests. Overall Log likelihood ratios depict that government assistance is the most influential factor based on the Chi-square value of 7.498 followed by NGO assistance with a Chi-square value of 14.410. Belonging to a health club contributed considerably very well with a Chi-square statistic of 7.192 (Table 3). There is strong evidence from Table 3, that government assistance, NGO assistance and health club significantly affected household water treatment choice.

Table 3: Likelihood ratio tests for factors influencing choice of HWT technologies

Effect	Model fitting criteria -2Log likelihood of reduced model	df	Chi-square (statistic)	Sig (p-value)
Intercept	55.416	0		0.000
Household size	60.317	4	4.901	0.298
Trained in health hygiene	58.821	2	3.405	0.182
health club membership	62.608	2	7.192	0.027
Government assistance	70.214	2	14.798	0.001
NGO assistance	69.826	2	14.410	0.001

The effect of individual or groups of explanatory variables on the response was assessed by comparing the deviance statistics (-2LL) for the nested models. Information about the significance of each individual explanatory variable is typically displayed in Table 3. Removing Government assistance from the full model changes the deviance by 70.214, a change which is highly significant. Similarly, removal of NGO assistance and Belonging to a health club factors significantly changes the deviance statistics.

CONCLUSION AND RECOMMENDATIONS

Government and NGO support, health club membership and training households are critical to enhancing adoption of HWT technology in Bindura rural district. It is recommended that health and hygiene education and HWT water treatment should be encouraged to enhance the adoption of various treatment technologies in the Bindura rural. Active community participation in water supply interventions and functional health clubs in areas such as Bindura rural may reduce diarrheal diseases. Policy makers should also consider advocating for increased government and NGO support to rural communities through free distribution of chemicals such as aqua tabs.

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