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Research Article

Household Environmental Contamination with Soil-transmitted Helminths and Its Determinants Among Residents of Peri-urban Areas in Jimma City, Oromia, Ethiopia

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Abstract

Introduction: Soil-transmitted helminth (STH) infections are among the most common and widespread neglected tropical diseases (NTDs) in Ethiopia and globally. They are transmitted by eggs present in human faeces, which contaminate the soil in areas where sanitation is poor. This study aimed to determine soil contamination rate, and associated risk factors among residents of Peri-urban kebeles in Jimma city, Oromia, Ethiopia, 2021 Methods: A community-based cross-sectional study was conducted in Peri-urban kebeles of Jimma city from May to June 2021. A total of 459 soil samples were collected from 153 households compounds (children's playground, toilet area, and Refused dumps site) using a systematic random sampling. The collected soil samples were then examined microscopically using optimized soil straining flotation method. Data on Socio-demographic and predisposing factors were collected using a semi-structured questionnaire and checklist. The data were entered into Epidata and exported to SPSS for further analysis. Descriptive statistics were used to summarize household characteristics. Logistic regression was performed to determine the risk factors associated with STH contamination. The level of statistical significance was set at $P < 0.05$. Results: The overall soil contamination rate in at least one location within a household was 39.2% with Ascaris was being the predominant species (35.9%). The most contaminated site with any of the Soil-transmitted helminth eggs was the refuse damp site (21.6%) followed by the Toilet area (18.3%), and the children's playground (7.8%). Multivariate analysis confirmed that unimproved toilet facilities, having a domestic animal, and self-reported history of STH infection were a significant predictors of soil contamination with Soil-transmitted helminths. Conclusion and recommendation: The current study finding indicated that STH eggs were prevalent in the environments of a peri-urban community of Jimma city. This wide range of soil contamination suggested that the community was at a high risk of acquiring STH infection. This suggests a need to strengthening the existing comprehensive approaches aimed to prevent and control STH infection and STH environmental contamination. These approach should focus on large scale deworming to reduce the infection burden, improving WASH to reduce environmental contamination and promoting health education aimed to alter behavior to reduce environmental contamination and risk of infection.

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Keywords

Soil Contamination Rate, STHs, Risk Factors, Peri-urban, Southwest Ethiopia

1. Introduction

Soil-transmitted helminths (STHs) are a group of intestinal nematodes composed of Ascaris lumbricoides (roundworm), Trichuris trichiura (whipworm), Necator americanus, and Ancylostoma duodenale (hookworms). In the life cycle of these nematodes, the soil provides favorable conditions for developing infective stages. Also, the soil gives protection for the infective stages for a period, during which it may be brought into contact with a susceptible individual through the mouth or the skin [1, 2].

Soil-transmitted helminth is transmitted through food, water, soil, and/or contaminated fingers, or percutaneous by larvae, depending on the species [3], *Ascaris and Trichuris* infections spread via an environmentally mediated fecal-oral transmission route, through ingestion of a larvated eggs that incubated in soil. Hookworm infection is transmitted through the skin by larvae that hatch from eggs after incubation in the soil. *Ancylostoma duodenale*, a hookworm species, can also be transmitted by the ingestion of larvae [4]. Once STHs enter the human body system, they chronically infect children and result in chronic malnutrition and anemia leading to physical and mental abnormalities [1].

Globally, over 1.5 billion people are estimated to be infected with soil-transmitted helminths leading to an estimated 3.3 million disability-adjusted life years, and more than five billion people in the world are at risk of infection from (STHs) Tropical and subtropical areas of the Sub-Saharan Africa (SSA), the Americas, China, and East Asia are the most affected regions and carry the highest burden of STH infection [5-9].

In 2010, it was estimated that 112 countries and territories were endemic to STH [10]. This number was revised in 2019 to 92 STH-endemic countries in need of preventive chemotherapy (PC), based on ongoing epidemiologic data and modification of estimation parameters. Preschool, SAC and women of reproductive age are the three demographic groups with the greatest risk of STH-related morbidity. According to the WHO. 310 million preschoolers, 762 million SAC, and 688 million reproductive age women (including 69 million pregnant) women were thought to be at risk of STH infection and hence, in need of (PC) [5, 11]. STH infections are linked to illiteracy, lack of sanitation, illiteracy, poverty, poor environmental hygiene, poor health, and overpopulation in general [12].

There are several diagnostic techniques used for epidemiological and clinical diagnosis of STH it ranges from simple direct wet mount to sophisticated molecular techniques. However, they vary in their sensitivity, cost, simplicity, and applicability. WHO recommends the KK technique for detecting STHs [8, 11, 13-15].

Ethiopia is one of the SSA countries ranked as thirteenth-highest STH disease burden, one-third of its population is infected with *A. lumbricoides*, one-quarter with *T. trichiura*, and one in eight with hookworms that are accounts for second-highest Ascariasis, third-highest hookworms, and fourth highest Trichuriasis infections in SSA [16]. From a public health perspective, soil examination is an effective substitute for stool examination in epidemiological surveys for STH infection. Almost all published studies conducted on STH in Ethiopia were mainly based on faecal (clinical) samples taken from individuals, with only a few studies including soil (environmental) samples. Therefore, this study was undertaken to determine soil contamination rate, and associated risk factors among residents of Peri-urban kebeles in Jimma city, Oromia, Ethiopia.

2. Methods and Materials

2.1. Study Design and Setting

A community-based cross-sectional study design was employed in peri-urban area of Jimma city, from May to June 2021. The town is the capital of the Jimma zone and it is located 356 kilometers away to the southwest of the national capital city of Ethiopia, Addis Ababa. The town lies in the climatic zone locally known as woyna dega and the dominant agricultural products in the area are corn, teff, and coffee. Its geographical location is 7° 4′ North Latitude and 36° 5′ East Longitude, and an altitude of 1750-2000 m above sea level; temperature range of 20-30$^{o}{}_{C}$ and average annual rainfall of 800-2500mm^3 the total population of Jimma city is estimated to be 205,384 in 2018. There are 104,745 females and 100,639 males among them. Regarding the health service organizations, there are five hospitals, four health centers, and forty-one private clinics are currently located in Jimma city, the town is divided into 17 kebeles (12 urban and 5 peri-urban kebeles). Those Periurban kebeles are Bore, Kofe, Hora gibe Jiren and Ifa bula, it have 5281 households.

2.2. Sample Size and Sampling Procedure

The sample size was determined using a single population proportion formula and assuming 11.25% soil contamination rate of STH from a previous study conducted in Jimma city [17]. By using a marginal error of 5%, 95% confidence interval. The total sample size was calculated to be 153 households. All the five kebeles in the peri-urban areas of Jimma city were included in the study. Then, using the stratified random sampling method, the sample size for each kebeles (stratum) was determined by a proportionate allocation to the total number of households in the kebeles. Finally, households in each of the five peri-urban kebeles were selected and included in the study (Figure 1).

$$n = \frac{Z_{\alpha}{}^{2} p\,(1-p)}{d^2}$$

P=11.25% - soil contamination rate among government and private schools in Jimma city [17].

$$n = \frac{(3.8416)\,(0.1125)\,(0.8875)}{0.0025} 153.4239 \sim 153$$

A total of 459 soil samples were collected from the compounds of 153 households, one soil sample was collected from each of three selected areas such as (children playground, toilet area and refuse dump sites) of households in the peri-urban kebeles of Jimma city.

2.3. Qualitative Data Collection and Processing

Data on household characteristics were collected by using a pretested semi-structured questionnaire and checklist prepared for this study. The questionnaire was first prepared in English and then translated into the local language (Afan Oromo). Trained health extension workers collected the qualitative data and soil samples from each of the Households after obtaining informed consent.

2.4. Soil Sample Collection and Examination

Soil samples were collected from 153 households of Peri-urban kebeles, from three selected areas such as (children playground, toilet area and refuse dump site). About 100-200g of soil sample was collected from a depth of 2-3 cm using a hand shovel, stored in airtight plastic bags labeled with numbers and transported to the NTD laboratory of Jimma university. Microscopic was examined for eggs of the helminths using straining Zinc Sulphate floatation technique, which is optimized by Tadege B et al, 2022 [18]. And the Parasites were identified up to the genus level.

2.5. Data Analysis

The collected data were checked for completeness and consistency manually before entering into a computer. Then the questionnaire was coded and entered into Epidata version 3.1, then exported into SPSS version 25 for analysis. Socio-demographic and economic, environmental factors, were treated as categorical variables and were presented as frequencies and percentages. Both bivariate and multivariable logistic regression analyses were employed. Bivariate logistic regression analysis was used to identify the candidate variable between one explanatory variable and outcome variable at p values ≤ 0.25. Multivariate logistic regression analysis was performed to predict factors, which had associated during bivariate logistic regression. Those variables with a p-value less than 0.05 AOR at 95% confidence interval were considered statistically significant.

3. Results and Discussion

3.1. Results

1. Household Characteristics of Peri-urban Community

Out of the 153 households that participated in the study, about, 95.4% and 80.4% of the households lived in mud-plastered houses with earthen floors. More than half of the households (59.5%) used improved toilet facilities. About, (95%) and (88.9%) of households had access to a protected source of water for drinking and domestic use, respectively. About, (89.5%) and (96.1%) of the households used improper solid and liquids waste disposal systems, more than half of the households (56.2) had more than five individuals per household. About, 87.6% of household toilet floors were earthen/sand. About, (92.2%) of households toilets had lids or covers, about, (56.2%) of households had children < 5 years, and 46.5% of children had used the potty for defecation. About, 73.3% of households reported that they have safely disposed of their children's faeces. About, (15%) of the households had visible faecal matter in their compound. based on observation. About 48(31.4%) households had domestic animals in their compounds and regarding the wealth status of the Households (38.6%) of them had low income, as shown in (Table 1).

Table 1. *Household characteristics of Peri-urban community of Jimma city, Ethiopia, 2021.*

Variables	Categories	Frequency	Percentage
Types of houses	Mud plastered	146	95.4
	Stone walls	7	4.6
House floor types	Earthen	123	80.4
	Cement	30	19.6
Toilet facilities	Improved	91	59.5
	Unimproved	62	40.5
Drinking water sources	Protected	14 6	95.4
	unprotected	7	4.6
Sources of water	Protected	136	88.9

Variables	Categories	Frequency	Percentage
for domestic use	unprotected	17	11.1
Solid waste disposal system	Proper	16	10.5
	improper	137	89.5
Liquid waste disposal system	Proper	6	3.9
	improper	147	96.1
Types of Toilet Floors	Earthen/sand	134	87.6
	cement	19	12.4
Toilet has lids/cover	Yes	12	7.8
	No	141	92.2
Family size	<5	67	43.8
	>5	86	56.2
Under 5-year children	Yes	86	56.2
	No	67	43.8
Child defecation sites	Safe[a]	57	66.3
	unsafe	29	33.7
Child feces disposal site	Safe[b]	63	73.3
	Unsafe[c]	23	26.7
Presence of domestic animals in the compounds	Yes	46	31.4
	No	105	68.6

Safe child defecation[a]:-toilet facility and Use child potty
Safe disposal[b]:- Put/rinsed in toilet or latrine
Unsafe disposal[c]:- Thrown into garbage and left in the open field

2. Soil contamination rate

Out of 459, soil samples collected from three different sites (children's playground, toilet area, and Refuse damp site of 153 households living in Peri-urban kebeles, (Bore, Kofe, Hora gibe, Jiren, and Ifabula) 15.9% of all soil samples were contaminated with at least one specious of STH eggs and the identified parasites were Ova of *Ascaris* and *Trichuris*. The most contaminant STH was *Ascaris spp* 68 (14.8), followed by *Trichuris* 9(1.9%). The prevalence of STH soil contamination in at least one location within a household was 39.2% [95% CI: 31.4 - 47.1] and *Ascaris* was the predominant detected parasite in households (35.9%). the most contaminated site with any STH egg was Refuse damp site 33(21.6%), followed by Toilet area 28(18.3), and children's playground 12(7.8) as presented in (Table 2). The highest soil contamination was found in Hora gibe Kebele followed by Ifabula, Bore, Kofe, and the list contaminated was Jiren (Figure 1).

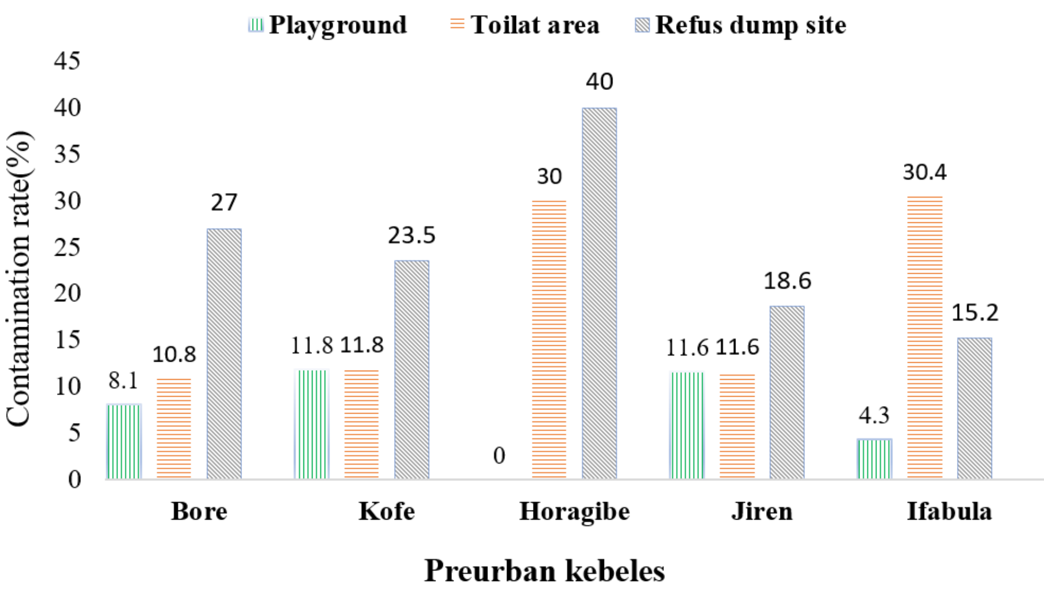

Figure 1. *Soil-transmitted helminth contamination rates in different sampling sites of Peri-urban kebeles Jimma city, Oromia, Ethiopia, 2021.*

Table 2. *Soil-transmitted helminth contamination rates according to soil sampling sites of peri-urban kebeles, Jimma city, Oromia, Ethiopia, 2021.*

Sampling site	№ of soil examined	ANY STH N (%)	Ascaris spp N (%)	Trichuris spp N (%)
Children playground	153	12(7.8)	11(7.2)	1(0.7)
Toilet area	153	28(18.3)	25(16.3)	3(2.0)
Refuse dump sites	153	33(21.6)	32(20.9)	5(3.3)
Total samples	459	73(15.9)	68(14.8)	9(1.9)

3. Factors associated with soil-contamination rates

To identify factors affecting soil contamination by soil-transmitted helminths, bivariate and multivariate logistic regression analyzes were performed. Accordingly, bivariate analysis was performed to avoid confounding effects before multivariate analysis, and variables whose p-value was ≤ 0.25 were considered candidate variables for multivariate analysis. Variables like Study sites/kebeles from where the samples were collected, Age of school-age children, family size, types of toilet facilities, history of STH infection among School-age children within a year, place where children <5 years defecate, stool disposal site for children <5 years, presence of toilet lid/cover, types of toilet floor, presence in the compound, and Presence of domestic animals within the household were a candidates for multiple logistic regression at OR with 95% CI and P-value ≤ 0.25.

Finally, multiple logistic regression analysis was performed by placing variables that were candidates by bivariate analysis using SPSS by the Backward: RL method and variables with P-value < 0.05 were fitted in the final model. Among variables entered multiple logistic regressions (self-reported Deworming status of school-age children, Children defecation site, presence of visible faeces in the compound, and Presence of domestic animal within the household) showed a statistically significant association with the presence of any STH eggs in the soil. At AOR with 95% CI and P-value <0.05.

By putting all other variables constant, the likelihood of soil contamination with soil-transmitted helminths was 3.35 times higher in soil collected from the households that possessed unimproved toilet facilities than the household that used improved toilet facilities (AOR=3.35; 95% C.I: 1.17-9.56, p=0.024), 3.95 times in the soil collected from the households who had a domestic animal in their compounds than those who did have domestic animals (AOR=3.95; 95% C.I: 1.25-12.44, p=0.019), and 3.19 times in households who had school-age children who had a history of STH infection within one year than their counterparts (AOR= 3.19; 95% C.I: 1.11-9.12, p=0.03).

Table 3. *Bivariate and multiple logistic regression analysis results of factors associated with the soil-contamination rate among Households in Peri-urban kebeles of Jimma city, Southwest, Ethiopia, 2021.*

Variables	Categories	Soil-transmitted helminths		COR (95% CI)	P-value	AOR (95% CI)	P-value
		Positive № (%)	Negative № (%)				
Kebeles	Bore	13(35.1)	24(64.9)	0.84(0.34-2.06)	0.709	0.80(0.20-3.20)	0.760
	Kofe	6(35.3)	11(64.7)	0.84(0.26-2.70)	0.781	0.55(0.06-4.69)	0.592
	Hora gibe	7(70)	3(30)	3.63(0.82-15.88)	0.087	4.90(0.42-57.06)	0.204
	Jiren	16(37.2)	27(62.8)	0.92(0.39-2.17)	0.852	0.27(0.05-1.34)	0.110
	Ifabula	18(39.1)	28(60.9)	1		1	
Age of SAC	5-10 years	36(33.0)	73(67.0)	1		1	
	11-15 years	24(54.5)	20(45.5)	2.43(1.19-4.97)	0.015*	1.58(0.39-6.27)	0.515
Family size	≤ 5	20(29.9)	47(70.1)	1		1	
	>5	40(46.5)	46(53.5)	2.04(1.04 -4.01)	0.037*	1.73(0.51-5.80)	0.374
Toilet facilities	Improved	29(31.9)	62(68.1)	1		1	

Variables	Categories	Soil-transmitted helminths		COR (95% CI)	P-value	AOR (95% CI)	P-value
		Positive № (%)	Negative № (%)				
	Unimproved	31(50.0)	31(50.0)	2.13(1.09-4.15)	0.025*	3.35(1.17-9.56)	0.024**
History of STHs at SAC	Yes	39(53.4)	34(46.6)	3.22(1.63-6.34)	0.001*	3.19(1.11-9.12)	0.03**
	No	21(26.2)	59(73.8)	1		1	
Children < 5 years in the HH	Yes	36(41.9)	50(58.1)	1.29(0.66-2.49)	0.448	-	-
	No	24(35.8)	43(64.2)	1		1	-
Place for defecation	Safe	19(33.3)	38(66.7)	1		1	
	Unsafe	17(58.6)	12(41.4)	2.83(1.12-7.12)	0.027*	2.63(0.90-7.71)	0.077
Stool disposal site	Safe	21(33.3)	42(66.7)	1		1	
	Unsafe	15(65.2)	8(34.8)	3.75(1.37-10.24)	0.010*	2.88(0.95-8.71)	0.060
Toilet has lid/cover	Yes	2(16.7)	10(83.3)	1		1	
	No	58(41.1)	83(58.9)	3.49(0.73-16.54)	0.115*	0.35(0.03-3.38)	0.371
Toilet floor	Earthen/sand	56(41.8)	78(58.2)	2.69(0.84-8.54)	0.093*	2.75(0.27-28.17)	0.392
	Cement	4(21.1)	15(78.9)	1		1	
Visible faeces in compound	Yes	14(60.9)	9(39.1)	2.84(1.14-7.06)	0.026*	2.19(0.49-9.72)	0.299
	No	46(35.4)	84(64.6)	1		1	
Presence of domestic animals	Yes	25(52.1)	23(47.9)	2.17(1.08-4.36)	0.029*	3.95(1.25-12.44)	0.019**
	No	35(33.3)	70(66.7)	1		1	

3.2. Discussion

Soil samples collected from Peri-urban kebeles of Jimma city revealed various soil contamination rates. This widespread contamination of soil samples with STHs eggs, unidentified larvae, and some nematode eggs are of greater epidemiologically and public health importance.

Out of the soil samples collected from 153 households' compounds, soil contamination with STH in at least one sampling location within a household was 39.2%. This finding is comparable with the studies conducted in Southeast, Nigeria 30.7% [19] and Philippines 41.33% [20]. However, it was lower than those studies conducted in Jimma, Southwest Ethiopia 73% [18], Ibadan, Southwest, Nigeria 54.9% [21], and Kogi state, Nigeria 50.6% [22] and Orang Asli, Malaysia 100% [23]. However, the finding of this study is higher than the finding of the study conducted in Jimma, Ethiopia 11.25% [17], and West regions of Cameroon; MiFi District, 12% [24], Dschang 7.75% [25], and Bazou Western, Cameroon 3.3% [26]. Generally, the variation in the contamination rate, and the distribution of these STH species among the different Environment might be due to differences in the socio-demographics and socioeconomic factors, Environmental factors, and individual factors that may affect the distribution of STH in the Environment.

Regarding the prevalence of STH species, this study confirmed that. *Ascaris species* was the Predominant contaminant parasite in the soil sampling sites. Even though there was a difference in the contamination rate, our observation agreed with several studies conducted in Jimma, Southwest Ethiopia [17], and elsewhere in the world [19, 20, 22-24, 26, 27] This is the fact that female *Ascaris spp* can produce approximately 200,000 eggs per day, remain viable in moist soil for several years and the eggs are very resistant to harsh environmental conditions.

Regarding the soil sampling site, the highest levels of soil contamination were observed in refused dump sites followed by toilet areas and children's playground. This finding agreed with the studies conducted in Nigeria [12, 27-29] that reported the refuse dump site was the highest location where parasites occur. Such a high incidence of parasites around refuse dump sites in this study might be because of improper waste deposal systems, including unsafe disposal of children's feces with habits of open defecation by children around refused damp sites.

In this study, Self-reported STH infection among school-age children, types of toilet facility, and having domestic animals in the household were significantly associated with the presence of STH eggs in the soil. The odds of soil contamination with soil-transmitted helminths were 3.35 times higher in soil collected from the households that possessed unimproved toilet facilities than the households that used improved toilet facilities. This finding agrees with a cross-sectional study conducted in Southwest Cameroon [30], and a cluster randomized controlled trial and risk factor analysis in Kenya [31]. An unimproved latrine facility was associated with an increased prevalence of STH eggs in the soil.

The odds of soil contamination with soil-transmitted helminths were 3.19 times higher in households that had school-age children who had a history of STH infection within one year than their counterparts. A similar finding was reported in a study conducted in Kenya [32]. Self-reported STH infection among school-age children was associated with increased odds of STH contamination.

This study also found that the odds of STH contamination were 3.95 times higher in soil collected from households with domestic animals in their compounds than its counterparts. Which agrees with a cross-sectional study conducted in Malaysia [33]. indicated that the presence of domestic animals in the household was associated with STH infection in children., a cluster randomized controlled trial and risk factor analysis in Kenya [31] Discovered that the number of dogs kept by a household was associated with increased STH eggs in soil. Another study tells as domestic animals like dogs may also mechanically carry infectious eggs on their fur [34].

4. Conclusion and Recommendation

4.1. Conclusion

The findings of the current study demonstrated that STH egg contamination was prevalent in the soil environment of the peri-urban community of Jimma City. This wide range of soil contamination rates suggests that the community in this area is at a high risk of acquiring STH infection and indicates a vicious circle between humans and the environment, thus posing a significant challenge to the national targets of eliminating soil-transmitted helminths (STH) as public health problems.

4.2. Recommendation

The findings of this study revealed that soil contamination with STH was prevalent in the study setting, which suggests that strengthening the three strategy to prevent and control the transmission of the disease such as: - large scale deworming to reduce the infection burden, improving WASH to reduce environmental contamination and promoting health education aimed to alter behavior to reduce environmental contamination and risk of infection. In the future, researchers should conduct studies to address factors, which not addressed by this study, and on the other, hand longitudinal studies should be conducted to identify direct causal factors of soil contamination rate and molecular techniques should be used so that parasites eggs are identified to the Species levels as this accurately indicates the degree to which the household environment is contaminated by human or zoonotic parasites.

Abbreviations

AOR	Adjusted Odds Ratio
OR	Odds Ratio
SSA	Sub-saharan Africa
STH	Soil-transmitted Helminthes
WHO	World Health Organization

Ethics Approval and Consent to Participate

Ethical clearance was obtained from JU Research and Ethics Review Board (IRB) (Reference No. IHRPGN/357/21 and permission to conduct the study was obtained from Jimma town Health Bureau. Consent was obtained from each household head prior to involvement in the study. Confidentiality of household's information was maintained during data collection, analysis.

Conflicts of Interest

The authors declare no conflicts of interest.

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