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Spatial Distribution of Schistosomiasis and its associated risk factors among Preschool aged children in Temeke district, Tanzania

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ABSTRACT

Schistosomiasis is a public health problem common in poor communities that causes damage to the urinary tract and intestines among people as well as stunting among young children. Little is known about the prevalence and risk factors for schistosomiasis in pre-schoolers. This study aimed to determine the spatial distribution and geographical and clinical factors associated with schistosomiasis among pre-schoolers in Temeke district. Researchers conducted a secondary data analysis to determine the spatial distribution of schistosomiasis among preschoolers, a hotspot analysis to identify hotspot areas, and visited them to observe geographical factors associated with schistosomiasis. Researchers also conducted key informant interviews (KI) with community members to identify risk factors for schistosomiasis. Univariate and multivariate logistic regression models were used to find associations between dependent and independent variables. We analyzed 226 study participants, of whom 91 (40.27%) had a schistosomiasis infection and 135 (59.73%) had no infection. Of all, 113 (50.0%) of the participants were female, and 113 (50.0%) were male. Most participants lived within 1 km of the river. A total of 79 (34.96%) participants used river water. While 172 (76.11%) of participants used tap water for drinking, 53 (23.45%) used borehole sources for drinking water. In multivariate analysis, stunting and malnutrition were significantly associated with schistosomiasis infection. Spatial analysis identified clusters of schistosomiasis infection more in the northern part of Temeke district and fewer in the south of the district. The findings suggest a need for the establishment of a suitable control strategy for schistosomiasis in Temeke district, which will include all groups at risk, including preschoolers.

Key words: Schistosomiasis, Spatial analysis, Risk factors, Preschool aged children, Tanzania.

1. INTRODUCTION

Schistosomiasis is a chronic and deliberating disease caused by trematodes of the genus Schistosoma. Although five species of Schistosoma infect humans, Schistosoma mansoni, S. Haematobium and Schistosoma intercalatum were the three endemic species causing Schistosomiasis in Africa [1]. Schistosoma mansoni and S. Haematobium causes intestinal and urogenital schistosomiasis and is common in Sub-Saharan Africa [2, 3]. The parasite is transmitted to humans through specific freshwater snails that serve as intermediate hosts for the parasite [4]. The disease is responsible for causing considerable morbidity and mortality in endemic rural communities, where it also inflicts up to 4.5 million disability-adjusted life years (DALYs), according to World Health Organisation (WHO) estimates [5-6]. However, the majority of infections were encountered by inhabitants of Sub-Saharan Africa, and the United Republic of Tanzania is among the countries infected [7–9].

Although remarkable progress has been made in reducing the transmission and morbidity of schistosomiasis, it remains a global public health concern, particularly in Sub-Saharan Africa [6,10]. Tanzania has adopted WHO strategies for controlling schistosomiasis, and this has contributed to a significant reduction of infection from 90% to 51% by 2012 [8, 11]. Integrated control measures have been taken for schistosomiasis in some regions of the lake zone, such as the Mwanza region, where the strategy yielded a significant decline in the prevalence of Schistosoma mansoni among schoolchildren and adults, respectively [11]. Despite adopting the WHO control strategies for neglected tropical diseases, the elimination of schistosomiasis has not been achieved in Tanzania, partly due to leaving some vulnerable groups in the community untreated [12].

For several years, under the Mass Drug Administration (MDA), preschoolers were not included in the program due to a lack of evidence on the burden of infection among the population. The group is regarded as vulnerable and at high risk, like other groups in endemic areas where preschoolers are exposed to such risks. Therefore, this study aimed to establish the spatial distribution of schistosomiasis and associated risk factors. Specifically, the study aimed to identify hotspot areas and clinical features associated with schistosomiasis.

2. MATERIALS AND METHODS

2.1 Study design

The study gathered data from two segments: one was secondary data analysis from a population-based cross-sectional study conducted between 2015 and 2016 in Temeke district among preschool-aged children. Study data was provided by the TB-Dar project. The second data segment involved field data collection from the identified hotspots of infection.

2.2 Study setting

The study was conducted in Temeke district in Dar es Salaam city (Fig. 1) It is located in the southern part of the city [13], with an estimated human population of 1,368,881 and an area of 787 km2 [14]. The district has 21 wards, of which 3 (Keko, Sandali, and Temeke) are prone to regular flooding [15]. The district has bimodal rains: the long rain season, which falls between February and May, and the short rain season, which falls less predictably between October and January, with an average annual rainfall of 1042 mm. Two major rivers, namely Kizinga and Mzinga, cross the district, with their water used mainly for irrigation, washing, swimming, and other domestic purposes. Direct use of untreated water from those rivers may contribute to the transmission of schistosomiasis because only 68% of Temeke Municipality's population has access to safe and clean water from local and national authorities, while the rest use other sources, including rivers and boreholes [16]. The district has been receiving mass deworming programs coordinated by the Neglected Tropical Diseases Control Coordinator [17].

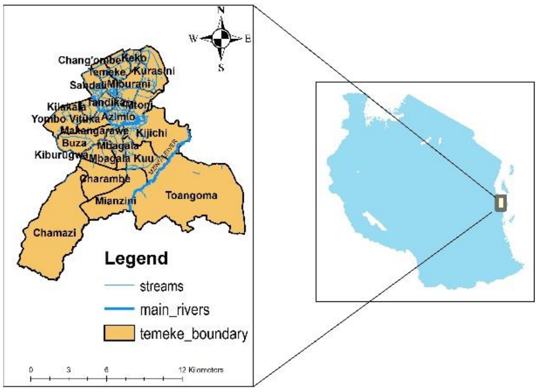

Figure 1 A map showing the location of Temeke municipality

2.3 Study population and sample size

The study included analyzing secondary data on preschoolers with complete socio-demographic and clinical information. Study participants were obtained from the previous population-based cross-sectional study [18], from which a purposive sub-sample of 226 preschoolers was drawn for the current study based on inclusion criteria.

2.4 Study and Laboratory Procedures

Children were attended by trained clinicians who collected socio-demographic and socio-economic information and medical histories. On the day of enrollment, parents or carers were given two empty containers labelled with the participants' unique identification number and asked to submit a fresh morning stool sample and urine sample of their child on the next day. Samples were transferred to a nearby laboratory within three hours of collection. Each stool sample was subjected to triplicate Kato-Katz thick smears and examined under a microscope by laboratory technicians for a species-specific diagnosis of helminth infection. Urine samples were tested for S. mansoni antigens using a point-of-care circulating cathodic antigen (POC-CCA). Samples detected with S. mansoni antigens and S. haemotabium eggs were identified as schistosomiasis-positive and vice versa.

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2.5 Inclusion criteria

The inclusion criteria for the pre-schoolers were: (i) age 6–59 months; (ii) living in Temeke district and being there for at least 6 months; (iii) having complete data on geographical coordinates; (iv) Participants who attend their treatment at Temeke hospital with clinical information available.

2.6 Exclusion criteria

The exclusion criteria for the study were: (i) the participants missing geographical coordinates; (ii) a lack of information on Schistosomiasis results; and (iii) Individuals above 5 years of age.

2.7 Data source and measurement

2.7.1 Data collection tools

An interview guide was used to collect qualitative information. Key informant interviews were conducted to gather risk factors associated with Schistosomiasis at the community level. Key informants were identified from hotspots and non-hotspot wards in the district. Two hotspot wards and two non-hotspot wards were purposefully and conveniently selected. Two households (one ten-cell leader and one influential person) from hotspot wards and two from non-hotspot wards were selected and interviewed. The information collected included water visiting habits by adults and children, usage of water from the river, understanding of schistosomiasis, and sources of water used for domestic activities. The interviews were audio tapped and incorporated into the main data set for further analysis. The locations of households were recorded using a handheld global positioning system (GPS) at an accuracy of 5m. These were used in distance analysis performed using GIS software for all households, where the distance was measured from the household to the nearest river.

2.7.2 Determination of Spatial distribution of Schistosomiasis

A data extraction tool was used to extract the data containing required information and parameters regarding geographical coordinates, schistosomiasis results, and clinical features from the previous population-based cross-sectional study. Thereafter, the extracted data was stored in the Excel software, filtered and cleaned to remove duplication, and missing data was treated accordingly. Only complete data was included in the spatial analysis. ArcGIS software (version 10.8; ESRI) was used to create distribution maps and perform exploratory spatial data analyses, according to Getis (2010) and Mlacha (2017). Thereafter, distribution maps by wards were created by using a spatial joining method that was obtained in the spatial analysis tool of ArcGIS. The maps were useful to identify hotspots for Schistosomiasis at ward level (Fig. 2). Hotspots were defined as spatially aggregated Ten Cell Units (TCU) with a significantly higher than average level of schistosomiasis infection (>6 cases of schistosomiasis)

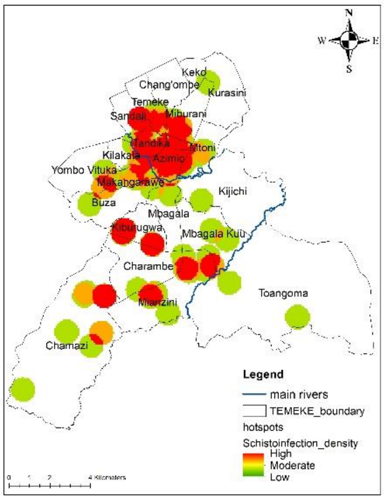

Figure 2. A map of Temeke municipality showing showing hotspot areas for schistosomiasis among pre schoolers

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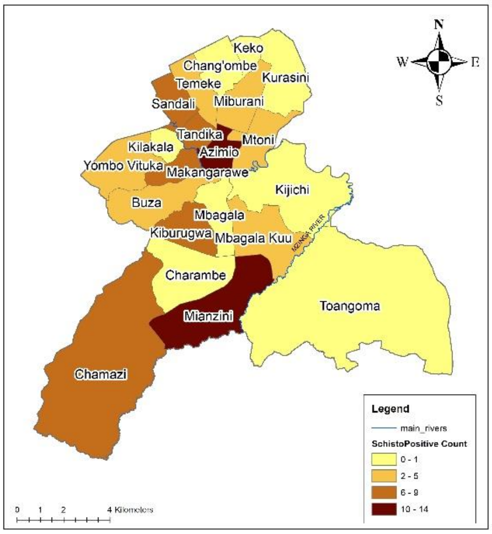

Figure 3 A map of Temeke municipality showing prevalence of schistosomiasis by wards among preschoolers

The global Moran's I statistics (MI) were employed to test for any prevailing spatial autocorrelations in Schistosomiasis densities. According to Getis et al. (2007; 2010), spatial autocorrelation occurs when there is clustering (+ve Z-score) or dispersion (-ve Z-score), and this is significant at $p \leq 0.05$. A p value > 0.05 suggests a homogeneous spatial pattern (random) [19, 20]. An observation was made in the environment to learn about the water contact practises of the residents as well as hygiene practises (Fig. 3).

2.7.3 Quantitative data analysis

The dependent variable was schistosomiasis infections (positive or negative). Independent variables were age, sex, weight, height, breastfeeding, weight loss, abdominal pain, splenomegaly, underweight, hematuria, malnutrition grade, malnutrition, immunization status, anemia, and stunting. A univariate logistic regression model was used to determine the association between dependent and independent variables. Independent variables with significant associations with dependent variables were used in the multivariate logistic regression model. Whether participants were schistosomiasis positive or negative, they were divided into two groups, namely, the infected group and the non-infected group. Univariate and multivariate logistic regression models were fitted to assess the association between schistosomiasis and different epidemiological characteristics among preschool-aged children. The threshold of a statistically significant difference at an alpha level of 0.05 was set. All analyses were performed in STATA software version 14. To ensure the high quality of the data, the researchers were careful during data analysis by ensuring proper treatment of the missing data to minimize bias.

2.7.4 Qualitative data analysis

During interviews, the voice was recorded using audiotape, and saturation was reached in the eighth interview when no more new themes were reported by the informants. The recorded audio and field notes taken during interviews were compiled for transcription and translation by a social scientist. The audios were transcribed using Swahili and then translated to English. Transcribed data were carefully read so as to capture the field data clearly. Multiple-level coding was performed using the thematic content analysis method adopted and modified from Graneheim and Lundman (2004). Coding considered mostly the concepts raised by Informants rather than questions from the Interview guide. Data were coded into categories and extracted for analyzing repeated topics explained by Informants.

2.8 Ethical consideration

The study obtained ethical approval from the Ifakara Health Institute Research Ethics Committee, reference no. IHI/IRB/No. 36-2021. Permission to use data was granted by the Principal Investigator (PI) of the TBDAR project. At the site, permission to conduct the study in the district was obtained from the Temeke District Executive Director

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3. RESULTS AND DISCUSSION

3.1.1 Social demographic characteristics

A total of 226 study participants (preschoolers less than 5 years old) were extracted and analyzed, and the overall prevalence for participants infected with Schistosomiasis was 40.27%. Out of 226 children, 50% (n = 113) were female and 50% (n = 113) were male. Their ages ranged from 6 to 58 months, with a median age of 27.5 IQR (17–42) months (Tab 1).

Table 1 Participant's Demographic Characteristics.

Variable	All, n (%) 226 (100)	Not Infected, n (%) 135 (59.73)	Infected, n (%) 91 (40.27)
Sex, n (%)			
female	113 (50.0)	61 (45.19)	52 (57.14)
male	113 (50.0)	74 (54.81)	39 (42.86)
Age in months, median (IQR)	27.5 (17-42)	29 (17-42)	23 (17-38)
Distance from the nearest river in meters, median (IQR)	1057.22 (666-2134)	1056.49 (648-1953)	1094.61 (675-2474)
Education, n (%)			
No	40 (17.7)	21 (15.56)	19 (20.88)
Primary	137 (60.62)	81 (60.00)	56 (61.54)
Secondary	42 (18.58)	28 (20.74)	14 (15.38)
University	7(3.10)	5 (3.7)	2 (2.2)
Using river water, n (%)			
Not using	147 (65.04)	89 (65.93)	58 (63.74)
Using	79 (34.96)	46 (34.07)	33 (36.26)
Family income, median (IQR)	300 (200-400)	300 (200-500)	300 (180-400)
Drinking water, n (%)			
Bore hole	53 (23.45)	29 (21.48)	24 (26.37)
Tap	172 (76.11)	105 (77.78)	67 (73.63)
Unknown	1 (0.44)	1 (0.74)	0 (0.44)
Toilet type, n (%)			
flush pour flush	2 (0.88)	1 (0.74)	1 (1.10)
flush Pour flush pit latrine	85 (37.61)	47 (34.81)	38 (41.76)
flush pour flush septic tank	71 (31.42)	44 (32.59)	27 (29.67)
open pit latrine	21 (9.29)	14 (10.37)	7 (7.69)
slab pit latrine	42 (18.58)	27 (20.00)	15 (16.48)
ventilated pit latrine	5 (2.21)	2 (1.48)	3 (3.30)

3.1.2 Descriptive statistics

The education level for most of the parents was primary school 60.62% (n=137). The distance from the child's home to the river ranged from 666-2134 meters, with the median distance being 1057.22 meters. Despite the fact that the majority of residents have access to tap water, 34% (n = 79) still use water from the river streams for domestic activities. Of all participants households, only 31.42% (n = 71) use a pour-flush septic tank (Tab 1).

3.1. 3 Bivariate analysis

During bivariate analysis to determine risk factors associated with schistosomiasis, it was found that there is an association between stunting and schistosomiasis, OR = 1.6, p = 0.041, 95% CI (1.019092–2.463511). Participants with malnutrition had a 2.6 times higher chance of having schistosomiasis than those without malnutrition, OR = 2.6, p = 0.039 at 95% CI (1.049411-6.670825) (Tab 2). However, it was determined that the difference in schistosomiasis infection between households located nearest the river and those located furthest to the river was not significant (p = 0.53; OR = 0.00005 at 95% CI (0.99–1.00). Although using river water was considered a risk factor, the current study did not find any significant difference between households using river water and those not using river water (P > 0.005).

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Table 2. Clinical features associated with schistosomiasis

Variable	All, n (%)	OR	P - value	95% CI
Weight, Mean ± SD	10.92±2.801	0.052	0.905	0.819613 – 1.000796
Height, Mean ± SD	85.11±11.33	0.976	0.056	0.953875 – 1.000644
Breastfeeding n, %				
Not breastfed	10 (4.42)	1.604	0.502	0.403788 – 6.37301
Breastfed	216 (95.58)			
Weight loss n, %				
No weight loss	205 (90.71)			
Weight loss	21 (9.29)			
Abnormal pain n, %				
No	219 (96.90)	0.584	0.526	0.110887 – 3.078535
Yes	7 (3.10)			
Splenomegaly n, %				
No	1 (20.00)	1		
Yes	49 (80.00)			
Underweight n, %				
Normal	167 (95.13)	1.462	0.054	0.992911 – 2.154522
Moderate	33 (14.60)			
Severe	26 (11.50)			
Anemia n, %				
No	215 (95.13)	0.84	0.787	0.238881 – 2.95886
Yes	11 (4.87)			
Stunting n, %				
Normal	180 (79.65	1.584	0.041	1.019092 – 2.463511
Moderate	28 (12.39)			
Severe	18 (7.96)			
Malnutrition n, %				
No	205 (90.71)	2.645	0.039	1.049411 – 6.670825
Yes	21 (9.27)			

3.1.4 Multivariate analysis

Two variables, stunting and malnutrition were found to be significantly associated with schistosomiasis. The variables were used to fit the best multivariate model. Clinical conditions such as stunting and malnutrition were identified to put a child at higher risk of being infected with schistosomiasis than normal children, with an OR =1.45, p = 0.041, 95% CI = 0.917459–2.291383 and an OR = 2.21, p = 0.039, 95% CI = 0.85009–5.7551, respectively.

3.1.5 Qualitative analysis results

Under this section four theme were obtained when researchers looked for geographical factors associated with schistosomiasis. During interviews, most participants declared to use river water due to various factors, including the high cost of tap water, easy access to river water for refreshment purposes, and migration from endemic areas to Dar es Salaam. These were the most common themes among key informants. All themes were considered factors exposing preschoolers to schistosomiasis due to the fact that the usage of untreated river water is a predisposing factor for preschoolers to schistosomiasis infection.

3.2 Discussion

High exposure to infested water bodies makes preschool children in the region the most affected group, and besides its clinical implications, it contributed to their growth retardation [21]. A number of factors that range from political, demographic, social, economic, environmental, climatic, and cultural trends are known to determine the transmission of schistosomiasis directly or indirectly [22]. High infection prevalence has been correlated with coming into contact with infested water bodies in various ways [23].

From the current study, the overall prevalence of schistosomiasis under the preschool age was 40.27%. A similar trend was reported by King (2010) and Munisi et al. (2016), where the prevalence was highest among schoolchildren in endemic areas.

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However, most of these studies exclude preschoolers despite their being vulnerable to all possible risk factors [24]. Therefore, the high prevalence reported among preschoolers in Temeke district calls for the inclusion of this group in any intervention programs.

This study presents a clustered distribution for schistosomiasis infection; the clusters were found most in the north-central part of the district, which was characterized by a number of streams (Fig. 2). Similar findings were also obtained from the cross-sectional survey conducted in Kwale County, Kenya, where a clustered pattern for Schistosoma haematobium infection among children was found in schools nearest to the rivers, which are suitable for propagation of intermediate host snails [25]. Also, under the current study, more households with infected children were found in the north and central parts of the district than in the southern part. This may be attributed to the two major rivers found crossing the area, which the residents use for different community activities. High exposure to infested water bodies occurred to preschoolers, especially during off-school days when they tend to accompany the schoolchildren for swimming, playing, and washing in those water bodies.

Despite Temeke district being a big municipality, 34% of the population does not have access to tap water provided by the Dar es Salaam Water and Sanitation Authority (DAWASA), which is a local authority responsible for water distribution in the city. This may predispose a significant proportion of the population to rely on water from other sources, such as rivers, that may not be safe for domestic activities. Therefore, families may consider tap water for cooking and drinking while other water-related activities opt for river water. This calls for authorities to expand water distribution to increase coverage. Also, preschoolers and schoolchildren may be prohibited from playing in water bodies that may predispose them to waterborne diseases, especially in high population densities where hygiene and sanitation are poor.

The study also demonstrated clinical conditions such as malnutrition (14.29%) and stunting (12.09%) to be significantly associated with schistosomiasis (P 0.05). Similar findings were reported by [26] where children were stunted, had impaired cognitive development, and had increased susceptibility to co-infection. This calls for integrated intervention programs for both preschoolers and schoolchildren so as to improve the quality of life in those endemic areas.

This study had some limiting factors since it used secondary data, like the exclusion of a large number of participants due to failure to meet inclusion criteria. This led to a small sample size in the analysis, which affected the generalizability of the results. A smaller sample size affects results by having low statistical power. In Addition, due to financial shortages, field data collection used only one method, which was key informants' interview.

Despite these limitations, the study managed to come up with the distribution maps for schistosomiasis among preschoolers in Temeke municipality. As well, the study revealed some factors that put preschoolers at risk of acquiring the named infection. Information is useful in developing the control strategy for the infections in the district. However, the results from this study open the door for more research to be conducted in urban settings other than Temeke municipality to profile these neglected tropical diseases, particularly among preschoolers. This will create room to come up with the strategy that has cut the chain of transmission since the early ages. In turn, this will improve the health of young children and improve their quality of life, such as proper growth and improvement in performance at school when they start attending school.

4. CONCLUSION

Preschoolers are equally infected with schistosomes, so all interventions should consider this group vulnerable. The study has demonstrated clusters of schistosomiasis infection among preschoolers in the north and central parts of Temeke district. These are hotspots that may need further evaluation to establish key drivers and develop appropriate control strategies to cover all age groups at risk.

Competing interests

The authors declare no competing interests.

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