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ABSTRACT

Epidemiologic and clinical data on the parasitic skin disease tungiasis are limited from sub-Saharan Africa, and virtually nonexistent from the East African region. We performed a community-based cross-sectional study in two villages in Kasulu district, western Tanzania. Study participants were examined for the presence of tungiasis and disease-associated morbidity. In total, 586 individuals >5 years of age were enrolled, and 249 (42.5%; 95% CI: 38.5–46.5) diagnosed with tungiasis. The ≥45 year-olds showed highest prevalence of tungiasis (71.1%) and most severe parasite load (median number of embedded fleas: 17.5; interquartile range: 15–22.5). Prevalence was slightly, but not significantly, higher in males than in females (45.3 vs 39.7%; p = 0.17). Itching (68.3%), pain (38.6%) and ulcers (30.1%) were common; 22.1% of individuals found it difficult to walk due to tungiasis, and in 21.3% loss of toenails was observed. Considering the high prevalence and considerable morbidity in the population, we conclude that tungiasis is a public health threat in the study villages and that the disease needs to be recognized by health authorities. Future studies on risk factors, animal reservoirs and evidence-based control measures are needed.

1. Introduction

Tunga penetrans (Linnaeus, 1758) is a small flea causing the parasitic skin disease known as tungiasis or 'jigger' infestation.[1] Tungiasis is common in many resource-poor populations in sub-Saharan Africa, the Caribbean and South America, where it occurs in rural communities and urban slums.[1–5]

Despite causing significant morbidity in resource-poor populations, tungiasis has not yet been regarded as a health threat by the scientific community, nor has it been listed officially as a neglected tropical disease. Nevertheless, tungiasis has been considered recently a neglected disease by several authors.[5,6] In fact, tungiasis may result in significant morbidity, manifesting itself in a number of symptoms, such as severe local inflammation, auto-amputation of digits, loss of nails, formation of fissures and ulcers, gangrene and walking difficulties.[2,3,7,8] Secondary infection makes infected individuals vulnerable to tetanus.[4,9]

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There have been several studies from Latin American, Caribbean and West African countries emphasizing the public health significance of *T. penetrans* infestations.[4–7,10,11] In sub-Saharan Africa, the disease has been shown to be common in poor communities in Nigeria, São Tomé & Príncipe and Cameroon, with high prevalences, parasite load and severe associated morbidity.[5,7,12,13]

It is believed that tungiasis reached East Africa and Tanzania in the late nineteenth century during the travels of Henry Morton Stanley and other colonialists, from western parts of the continent to the East.[10,12] However, the current epidemiological situation in East Africa is not known, and there are no systematic studies available from this region.

One case report of severe tungiasis from Tanzania and anecdotal evidence of refugees from this country suggest that tungiasis is a health threat in this region, similar to the West African countries.[8,14] In fact, tungiasis was reported from Tanzania repeatedly in travelers who had visited endemic foci within the country,[4,10] and in northern Tanzania *T. penetrans* fleas were found inside residences.[15] A study from Madagascar has shown that tungiasis is a major public health problem there, with cases occurring in all regions.[16] Lastly, there has been an increasing number of recent media reports on severe 'jigger' outbreaks occurring in rural Kenya and Uganda which claimed that, besides a considerable morbidity and social impact, tungiasis was causing a high case fatality rate.[17–20] These reports were published in public lay media and contain erroneous information about the disease and information on fatal cases that is not evidence-based. On the other hand, they indicate that this parasitic skin disease may cause considerable morbidity in rural areas, and how it is perceived in several parts of East Africa.

To raise awareness of tungiasis in Africa and Tanzania, there is an urgent need to describe the scale of this neglected problem, based on systematic data. Thus, we conducted a population-based study in rural western Tanzania to assess the tungiasis infestations situation in that region.

2. Material and methods

2.1. Study area and population

The present study was conducted in Nyansha and Nyakitonto villages, located at Kasulu district in the Kigoma region. The two villages have a population of about 7500 inhabitants (each village with approximately 3700 inhabitants in 600 households) and are comprised of poor communities lacking appropriate urban services, such as electricity, water supply and health facilities. Most of the houses are located in relatively large compounds. The roofs are made of grass materials and palm stems. Waste and sewage disposal systems are insufficient. Housing conditions are precarious and about two-thirds of houses have a sandy floor. Inhabitants practice subsistence farming including cultivating maize, cassava, bananas, beans, groundnuts and coffee. In addition, inhabitants keep pigs, goats, chickens, dogs, cattle and cats.

According to community leaders and personal observations, tungiasis infestation is highly common in the villages and is locally referred as *inzyogo*, which means 'the disease of the dirty people'.

The area has two main rainy seasons that run from November to December and February to May with a mean annual rainfall of 1100 mm. The annual minimum and maximum temperatures for the area are between 17 and 31 °C.

Study participants were permanent inhabitants of the study villages (defined as living in the villages for more than one year). A total of 586 individuals >5 years of age occupying 10% of households in the two villages were included by simple random sampling. This target population comprised of about 8–9% of the study villages' population.

2.2. Study design and data collection

The study was conducted as a cross-sectional study, carried out in August–September 2010, during the hot and dry season when prevalence of tungiasis is expected to be highest.[21] A preparatory phase was carried out in which questionnaires were pre-tested and aspects of the study were discussed and explained at community meetings.

Study participants were visited and the family members interviewed regarding socio-demographic variables, using a structured questionnaire in Swahili language. Family members were clinically examined for the presence of embedded *T. penetrans* by inspecting carefully legs, feet, hands and arms. To guarantee privacy, other topographical regions of the body were not examined. To minimize inter-observer bias, three members of the research team carried out the macroscopic examination of every individual in the study.

The 'Fortaleza classification'[22] was applied to diagnose tungiasis clinically: a circular, white lesion with a central black dot (4–10 mm diameter; vital flea); and a black thickening surrounded by necrotic tissue and partially or totally removed fleas leaving a characteristic, exposed sore in the skin (avital flea). The number and location of lesions were recorded.

In addition, symptoms and signs associated with acute and/or chronic *T. penetrans* infestations were recorded during clinical examination. This included information on oedema, ulcer, loss of toe nail, nail deformation, fissure, desquamation of the skin, erythema, pustule and suppuration. Difficulty in walking, itching and pain were also assessed.

2.3. Data analysis

Data were double entered using EpiData version 3.1 (EpiData Association, Odense, Denmark) to ensure quality of data and then exported to STATA version 10 (Stata Corporation, College Station, TX, USA) for analysis. Odds ratios with 95% CIs are presented to describe the strength of association of categorical variables. We applied the χ^2 test to describe the difference between relative frequencies, and the student's t-test to determine the significance of difference between groups of discrete variables.

Table 1
Association of tungiasis with socio-demographic characteristics in Kasulu district, northwest Tanzania (n = 586)

	n (%)	OR (95% CI)	p-value
Gender			
Female	115/290 (39.7)	Reference	
Male	134/296 (45.3)	1.29 (0.91–1.75)	0.169
Education			
Literate (primary and secondary)	49/128 (38.3)	Reference	
Illiterate/primary school not completed	200/457 (43.8)	1.27 (0.72–5.52)	0.187
Age group			
6–9 years	55/138 (39.9)	Reference	
10–14 years	69/198 (34.8)	0.81 (0.52–1.26)	0.350
15–24 years	15/55 (27.3)	0.57 (0.29–1.12)	0.103
25–34 years	43/87 (49.4)	1.47 (0.86–2.53)	0.159
35–44 years	35/63 (55.6)	1.89 (1.03–3.45)	0.039
≥45 years	32/45 (71.1)	3.71 (1.79–7.70)	0.001

2.4. Ethical clearance

The study was approved by the Ethical Committee of the Weill-Bugando University College of Health Sciences, Mwanza, Tanzania. Further ethical clearance was obtained from the Kasulu District Health Department under the district medical officer. Community meetings were held at the respective villages and community leaders of Nyansha and Nyakitonto approved the study. Participation in the study was voluntary, and informed written consent was obtained from all study participants or, in the case of minors, from their caregivers.

3. Results

A total of 586 individuals were included in the study (median age: 14 years; interquartile range [IQR] 10–29 years); 290 (49.5%) were female and 296 (50.5%) were male. Three hundred and eighty-two (65.2%) were Christians, 185 (31.6%) Muslims, and 19 (3.2%) belonged to traditional religious groups. Only 22 (3.8%) were employed (primary school teachers and small businesses). Four hundred and fifty-seven (77.9%) of the participants were illiterate or did not complete primary school.

In total, 249/586 (42.5%; 95% CI 38.5–46.5) were infested with jigger fleas. Prevalence was slightly, but not significantly, higher in males than in females (Table 1). The higher age groups showed the highest prevalences, with more than 70% in the >45 year-olds (Table 1) and also most severe parasite loads (Table 2).

A total of 3284 lesions were counted in the infested individuals, with a mean number (standard deviation) of 13.15 ± 7.3 lesions (median 15; IQR 7–16). Of the total number of lesions, 1967 (59.9%) were vital and 1317 (40.1%) avital. Overall, 3001 (91.4%) lesions were located on the feet; 8.4% (21/249) of the individuals presented with lesions on ectopic sites, which occurred only on the hands. The mean and median numbers of lesions stratified by gender, education level and age groups are shown in Table 2.

Twenty-eight (11.2%) of the infested individuals had 1–5 lesions (mild infection intensity), 212 (85.1%) had 6–30 lesions (moderate infection intensity) and nine (3.6%) individuals harbored more than 30 lesions (heavy infection intensity). The maximum number of lesions encountered in one individual was 165 penetrated fleas.

Signs and symptoms associated with tungiasis were considerable, and severe in some cases. Itching, pain and ulcers were the most common findings (Table 3). About one-fifth had lost toenails, and a similar number found it difficult to walk; superinfection was observed clinically in 17% of cases.

4. Discussion

This is the first community-based cross-sectional study on tungiasis and associated morbidity in endemic areas of Tanzania. The data show that tungiasis is a public health

Table 2
Number of lesions by gender, education level and age group among study population with tungiasis (n = 249)

	n	Mean of lesions (standard deviation)	Median no. lesions (interquartile range)	p-value
Gender				
Female	115	13.1 ± 7.9	15 (6–18)	0.368
Male	134	13.2 ± 6.6	15 (8–16)	
Education level				
Literate (primary and secondary)	49	15.8 ± 6.4	15 (10–20)	0.0031
Illiterate/primary school not completed	200	12.6 ± 7.3	12.5 (6–16)	
Age groups				
6–9 years	55	9.2 ± 6.5	6 (4–16)	<0.0001
10–14 years	69	10.2 ± 5.8	8 (7–13)	
15–24 years	15	12.8 ± 5.0	15 (10–15)	
25–34 years	43	15.9 ± 6.2	15 (15–20)	
35–44 years	35	17 ± 6.9	15 (15–20)	
≥45 years	32	19.2 ± 6.3	17.5 (15–22.5)	

Table 3
Signs and symptoms in tungiasis-infested individuals (n = 249)

Signs and symptoms	n	%
Itching	170	68.3
Pain	96	38.6
Ulcers	75	30.1
Difficulty walking	55	22.1
Deformations of nails	55	22.1
Loss of toenails	53	21.3
Bacterial superinfection[a]	42	16.9
Desquamation	31	12.4
Fissures	28	11.2

[a] Characterized by suppuration, oedema and smell.

concern in a rural community in western Tanzania. The prevalence of 42.5% observed is within the range of prevalences reported recently in poor communities in Brazil, Cameroon and Nigeria.[2,3,6,7,13,21] Variations in climatic, socio-economic and cultural factors from one epidemiological setting to another can contribute to variations in prevalence.[5,21,23] Even within the same area, tungiasis may reach very high prevalences in one community but be virtually absent in another close by where, for example, housing conditions may be slightly better or animal reservoirs not that common.[23] Thus, our study exemplifies high prevalence, parasite load and morbidity in two rural villages, but future studies are needed to identify major geographical areas at risk in Tanzania.

In the present study, we reported the highest prevalence in the ≥45 years' age group (71.1%) with lower prevalences in the younger age groups. Studies from endemic areas for tungiasis have usually reported an S-shaped age prevalence pattern, with highest prevalences in the 5–14 year-olds, lower prevalences in adults, and again an increase in the elderly.[7,25] The increased prevalence with advanced age has been attributed previously to disease-related behavior and higher exposure to the flea: the poor-sighted elderly would have more difficulty taking out embedded fleas than young people, and also commonly use resting places which are considered preferred breeding sites of the flea, such as underneath shady trees.[5]

We did not observe any significant gender differences in prevalence, similar to the Nigerian study.[5] In fact, gender differences may vary from community to community, according to local habits, environmental exposure and gender-specific behavior increasing transmission, such as walking barefoot or playing football in the sand. Consequently, in some settings, females were observed to be more affected, in other areas males or, similar to our setting, no gender differences were observed.[2,3,10,26] Similarly, the observed difference in infection intensity in our study could partly be explained by variation in exposure to the parasite and associated risk factors.

Typically, *T. penetrans* affects various parts of the human host, but most lesions are found on the feet.[27–30] Ectopic tungiasis lesions can also be seen on other parts of the body such as the hands, elbows, neck, buttocks and the genital region.[29,32] In our study, about 8% of individuals had tungiasis-associated lesions on hands – a fact which should be taken into consideration when diagnosing and treating infestations in endemic communities.

Tungiasis-associated morbidity such as difficulty walking, deformation of toenails, ulcers and loss of toenails were commonly reported. The overt clinical manifestations associated with *T. penetrans* infestations have been reported by various studies from other endemic areas.[4,7,13,32] Importantly, superinfection and formed ulcers can act as the port of entry for pathogenic bacteria such as *Clostridium tetani* which can cause severe complications and death in non-vaccinated individuals.[9,31] Tungiasis has also important psycho-social consequences. Besides stress for the affected individuals and suffered stigma, these types of lesions in primary schoolchildren may result in school absenteeism and adult individuals may be forced to suspend their economic activities such as agriculture or trades.[32]

Since the disease affects rural communities highly stricken by poverty and poor housing, improvement in housing structures and hygiene such as cementing floors inside houses and offering waste collection services will provide an effective approach not only for controlling tungiasis but also for other parasitic diseases such as schistosomiasis and malaria.[5,33,35] In 2002 Heukelbach et al.[35] recommended integrated actions for the control of tungiasis, involving clinicians, public health specialists, veterinarians and biologists, and also that the animal reservoirs should be considered.[34] The animals seem to be crucial in sub-Saharan communities for transmission dynamics and may be used as a specific target for interventions.[5,24,35]

Our study is subject to limitations, as a single study in one community does not necessarily reflect the situation in other communities. Clearly, in future surveys, other areas should be included. In fact, unpublished observations (HD Mazigo, E. Bahemana) indicate that the ectoparasitosis is not only endemic in Kasulu district but also causes severe morbidity in communities in Kagera (Ngara and Muleba districts), Iringa (Makete district), Arusha (Arumeru district), Tanga (Handeni district) and Ruvuma (Mbinga district) regions. In addition, for logistical reasons we only included individuals >5 years of age, and thus data should analyzed with care regarding small children.

In conclusion, this study has shown that tungiasis is a public health concern in the study villages with their populations living under extreme poverty and that the disease is associated with considerable morbidity. Future studies on risk factors, animal reservoirs, and treatment seeking behaviors of affected populations are required for planning and designing integrated control measures in endemic communities in Tanzania.

Authors' contributions: HDM, JH, LLM, EJK, conceived and designed the study, drafted the first version of the manuscript and made final revisions. EB, HDM and OD organized field data collection and clinical examination of the participants. BRK, JH and ETK analyzed and interpreted the data. All authors revised the manuscript critically for intellectual content and approved the final version to be published.

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