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Assessment of tungiasis management knowledge in Kandara sub county, Kenya

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Abstract
Tungiasis (Jigger infection) is caused by penetration of female sand flea into the epidermis of the predisposed animal and the subsequent hypertrophy of the parasite. The objective of this study was to assess tungiasis management knowledge among the residents of Kandara sub-county in central. This was un-matched case-control study involving 776 individuals (388 cases & 388 control). Questionnaires were, administered among the participant to assess social demographic factors and tungiasis management knowledge. Univariate logistic regression was first applied to analyze the data. Odds ratio together with their CI and *P*- values were determined. All the variables that depicted significant differences between case and control were further analyzed in a multivariate logistic regression to establish which among them were independent. The case group was 2.1 times likely to state that fleas and dirt were the cause of tungiasis when compared to the control (2.1; 95%CI: 1.2-4.0; *P*< .001). There was generally very poor knowledge among the case individuals on how tungiasis is spread, prevented and treated (*P*< .001 in each). The study portrayed that there is poor knowledge on how to handle and manage tungiasis among Kandara residents.

Keywords: Tungiasis, *Tunga petetrans*, risk factors, management knowledge, poverty

1. Introduction
Tungiasis is a parasitic disease caused by the penetration of the female sand flea, *Tunga penetrans*, into the epidermis of the predisposed animal and the ensuing hypertrophy of the parasite [1, 2]. *Tunga penetrans* is a flea belonging to order siphonaptera in the pulicidae family. Tungiasis is a serious health problem of resource-deprived populations; in these communities, environmental settings encourage high infection rate [1, 3]. In such communities, social neglect is complexly, intertwined with inadequate healthcare behavior and poverty [1, 3]. According to Heukelbach *et al.* (2003), tungiasis is associated with a wide range of both chronic and acute morbidities. In Kenya, jigger infection is endemic in Nyanza, Coastal counties, western and central part of the country [4]. The prevalence in these regions ranges from 15 to 40% [4]. According to African Health and Development International (AHADI), an organization that endeavors to control tungiasis in Kenya, jigger flea may have infected over 2.7 million citizens [5]. Among these are children whose education has been, adversely affected.
Most of the diseases affecting the resource-deprived communities have gone on without much recognition [6]. These diseases have attracted less attention from medical authorities and researchers and thus termed neglected. Tungiasis is among such diseases [6]. According to a study conducted in Brazil, this ectoparasitosis is completely, neglected by health professionals and physicians do not enquire about it during consultation, unless prompted by the patient [6]. Most poor communities live in remote areas with no access to urbanized services. Due to their disadvantaged social status, these communities remain stigmatized [7]. The diseases associated with such communities can thus go untreated for a long time [7]. Jigger infection (Tungiasis) is highly prevalent in children between 5 and 14 years [7]. Among the middle class adults, the infection is low [6, 7]. According to a study conducted by Chadee in 1994, prevalence also increases among the elderly. Jigger infection has, also been reported in persons with mental disabilities and epilepsy [7]. Data concerning the effects of jigger infection is very scarce [7].
Tungiasis is a zoonosis that afflicts both domestic and peri-domestic animals such as pigs, dogs, rats and cats [2]. The risk of contracting the disease is high among persons who regularly encounter these animals, especially where human behavior and prevailing environmental factors abet exposure [2].

Tungiasis has causative co-factors such as changes in human demography, ecological changes, poor public health measures and international travel [8] .*Tunga penetrans*, the causative agent for tungiasis, thrives well in habitats with warm, dry soil [9]. Sand flea multiplies highly in stock farms, sandy beaches and stables [9]. Tungiasis tends to be, linked to negative health seeking behavior, poverty, indiscriminate waste disposal methods, and poor community participation in hygiene and sanitation education [4]. Poverty at household level has been, linked to the health status of the occupants as it limits the family's aptitude to access clean water, good quality housing, decent nutrition and sanitation [4]. The involved morbidities lender jigger infected people unproductive in general economic activities (Fig. 1). The victims are also unable to exercise their democratic rights like voting during local elections when their fingers are, jigger infected [4].

Tungiasis is associated with debilitating problems like gangrene, auto amputation of digits, loss of whole limbs and ulcers [9, 10, 11]. Super infection and tetanus were reported to have caused three cases of death in a jigger infection outbreak in Haiti [12, 13, 14, 15] .Jigger problem in Kandara Sub-County has been a recurrent health problem even after numerous interventions by the government. This was corroborated by the local public health professionals whose confessions indicated that tungiasis has become a perennial health predicament in the area. According to Coleman *et al*. (2009), successful interventions in combating chronic diseases like tungiasis can only be attained when the patients are equipped with necessary knowledge on how the disease is managed. This is necessary in order to enable them prevent the infection or treat it by themselves at its elementary stages, and thus evade the eventual health burden associated with the disease.

The most striking aspect of this study is that some homes in the same neighborhood did not have jigger infection at all. In this study, tungiasis management knowledge was, assessed among Kandara residents to evaluate the extent to which they are able to handle this disease, which is endemic in the region. The study sought to establish the difference in this knowledge between the homes with and without tungiasis in order to create an informative reference for effective future interventions.

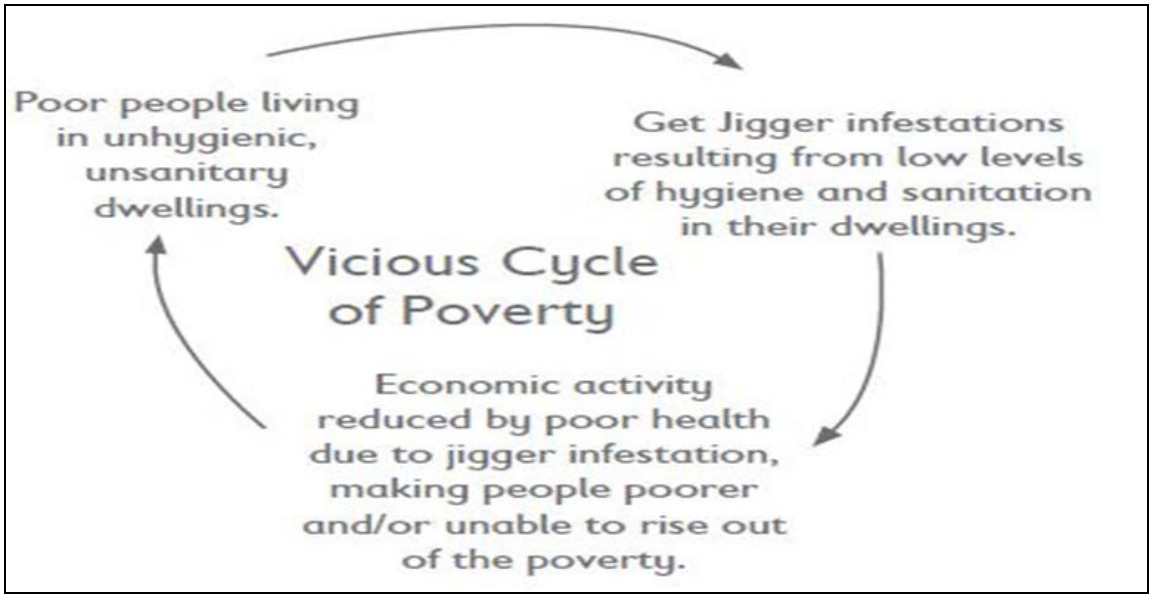

Fig 1: A poverty vicious cycle associated with tungiasis according to AHADI Kenya trust (2011)

2. Materials and Methods

2.1. Study area and population

This study was, conducted in Kandara sub-county in Muranga. Muranga County is among the jigger endemic areas in Kenya and thus Kandara served as a representative of all the sub-counties in the region. Kandara sub-county is about 60 km from, the capital city of Kenya, Nairobi. Muranga County has two rainy seasons, with the rain ranging between 1200 and 1600 mm. The temperature ranges between 21 and 35 °c. The region has a volcanic loam soil favorable for jigger flea multiplication. Kandara sub-county is exactly located at latitude 0 ° 54' 0 S and longitude 37° 0'0 E. The altitude is 5308 feet above the sea level. The sub-county has an area of approximately 236 sq km and a population of about 175098 people, according to 2019 national census. The resident community is, characterized by unemployment, overcrowding, and dilapidated housing mostly of mud walls. Illiteracy and poor hygienic conditions are also rampant. According to an observation made in prior visits to the study area, a good number of children remain at home during school days.

2.2. Ethical clearance

This study was, cleared by Kenyatta National Hospital and University of Nairobi (KNH/UoN) ethics and research committee. It was licensed by National Commission of Science, Technology and Innovation (NACOSTI).

2.3. Study design

A case-control study design was, used in this research.

2.4. Determination of sample size and the sampling method

A case-control study sampling design was employed to determine sample size based on field studies performed in Brazil, Kenya and Nigeria, and contained the following assumptions: case-control-ratio of 1:1; hypothetical proportion of controls with exposure 80%; least detectable odds ratio 1.5; power of the test 80%; confidence level 95%. This would require 776 participants (388 cases and 388 controls). To account for uncertainties and drop out, a sample of 800 individuals was picked. The sample size was calculated using Epi Info software developed by Centers for Disease Control (CDC).

2.5. Community entry
The study commenced with familiarization of the study team with the study area and population. Permission was first, sought from the local medical authorities and administrative leaders like chiefs and their assistants. This was, preceded by submission of ethical approval and permit copies to county administrators. Assistance of the area public health officer and the community health workers was, sought at the beginning of the study to help identify the people and homesteads with tungiasis.

2.6. Consenting
Participants were, requested to sign consent forms after voluntarily accepting to be involved in the study. Those who did not understand English were, requested to fill a Gikuyu (local language) version of the consent form. For very young children, those very old and the mentally handicapped, their respective guardians signed the forms. For the illiterate and those unable to write, a witness of their choice was, called in to assist. Selection of the participants was, based on inclusion and exclusion criteria.

2.7. Pretesting of data collection instruments
The questionnaires and data sheets for the study were pretested in a pilot study conducted in the same area. This helped to get feedback from the research subjects that would aid in improving the main study.

2.8. Inclusion and exclusion criteria
All kind of people qualified for this study, including children, the aged, the illiterate and mentally handicapped. This is because the assistance of a guardian and witnesses was, sought in case of children and other unique cases. Age was not a factor, as no substance or chemical was to be, applied on the jigger infected participants.

2.9. Study households and cohort recruitment
The case participants were, randomly picked from the six-kandara wards, with the assistance of Kandara Sub-county public health officer and his community health extension workers (CHEWS).Jigger control campaigns are common in Kandara sub-county and thus every CHEW has a data of all jigger infested homesteads in their respective wards. From this data base, 67 jigger infected individuals were randomly picked from each ward using randomly generated numbers. This made it possible to get a total of 400 case participants, so as to also take care of the loss that would follow-up. The case number of interest was 388. According to the 2019 national census, the average number of occupants per household in Kandara sub-county is 5. Though every infected person in the household was recommended for treatment at Kandara hospital, only 1 victim per household was picked for the study. This helped to include as many households as possible. From the immediate neighborhood (of each jigger infested home picked), five jigger free homesteads were earmarked for control selection and assigned some random numbers. From a pool of these five, one homestead was randomly picked to be part of the control. Thus, every ward also produced 67 homesteads for the control (ratio of 1:1). Both the heads of the case and control households were requested to fill specially designed questionnaires for the study. The geographical positions of the study households were located on Kandara map using a GPS (Figure 2).

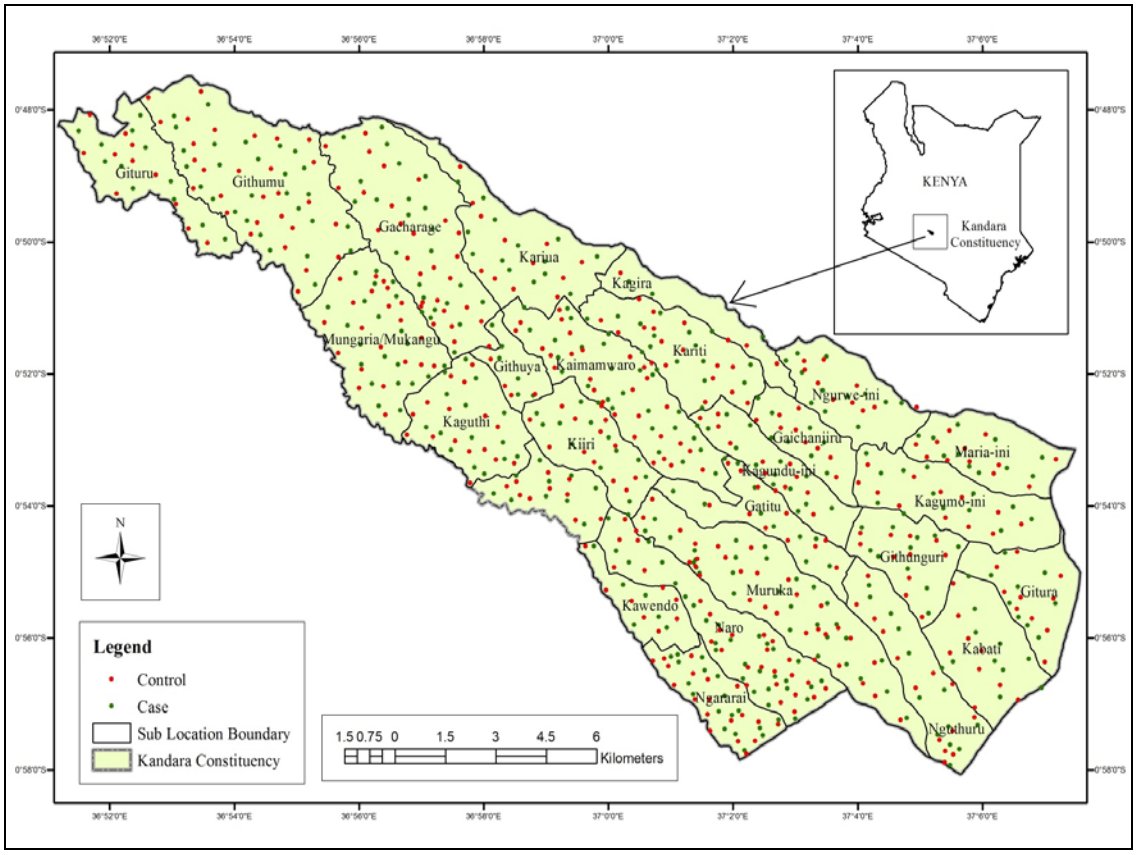

Fig 2: Kandara Sub County map by electoral and boundaries commission of Kenya. It is showing the location of the study homesteads according to GPS navigation during the study.

2.10. Data analysis

Data was entered into excel spreadsheet where errors were checked and coding done. It was, then exported to SPSS (23.0) for a univariate logistic regression analysis. Odds ratio together with their 95% confidence intervals (CI) and P-values were, determined to ascertain the difference in knowledge management variables between case and control. Odds ratio were determined using 2x2 contingency tables. All the variables that depicted significant differences between case and control were further analyzed in a multivariate logistic regression to establish which among them were independent in the study.

3. Results and Discussion

3.1. Social- demographic characteristics

Table 1: Socio-demographic characteristics of the study

Variable	Case group number and % (n=388)	Control number and % (n=388)	P- value
Age in years			
<30	34 (8.7)	14 (2.7)	.008
31-40	68 (17.4)	100 (26.1)	
41-50	88 (22.3)	114 (29.9)	
51-60	96 (25.0)	68 (17.4)	
>60	103 (26.6)	92 (23.9)	
Gender			
Male	206 (53.3)	168 (42.9)	.047
Female	182 (46.7)	220 (57.1)	
Marital status			
Married	200 (53.3)	280 (75.0)	< .001
Single	96 (25.0)	34 (8.2)	
Widow	54 (13.6)	48 (12.5)	
Widower	30 (7.1)	12 (2.2)	
Divorced	8 (1.1)	12 (2.2)	
Income per month (KES)			
<5000	306 (81.5)	67 (16.3)	< .001
5000-10000	67 (16.3)	190 (50.0)	
>10000	15 (2.2)	131 (33.7)	
Source of income			
Formerly employed	8 (1.1)	17 (3.8)	< .001
Self employed	23 (5.4)	173 (46.4)	
Casual laborer	216 (57.6)	125 (33.3)	
Elderly fund	43 (10.9)	26 (6.0)	
Help from relatives	93 (24.5)	41 (10.4)	
Others	5 (0.5)	6(1.1)	
Education			
None	195 (51.9)	87 (22.3)	< .001
Primary and below	151 (39.9)	143 (37.5)	
Secondary	31 (7.7)	111 (28.8)	
Tertiary	11 (0.5)	47 (10.9)	
Religion			
Christian	361 (96.7)	367 (97.8)	.410
Muslim	7 (0.5)	9 (0.5)	
Traditionalist	11 (1.6)	0	
Other	9 (1.1)	12 (1.6)	

In this study, Most of the participants in the case group were casual laborers earning below 50US$ per month. More than half of this group did not have formal education at all. Majority of the control participants were able to earn between 50 and 100 US $ per month and had attained at least the primary level of formal education (Table 1).

3.2. Tungiasis management knowledge

Table 2: Univariate analysis of tungiasis management knowledge

Variable	Case number and %(N=388)	Control number and % (N=388)	OR (95% CI)	P- value
Cause				
Flea & curse	44 (11.4)	1(0.3)	50(6.8-361.2)	< .001
Flea	274 (73.9)	368 (94.8)	0.1 (0.1-0.2)	< .001
Flea & witch	9 (1.6)	1(0.25)	9.1(1.2-72.9)	.017
Flea & dirt	33 (8.2)	13 (1.8)	2.1 (1.16-3.99)	.002
Flea & insolation	4 (0.5)	1(0.3)	4.0(0.45-36.23)	.107
Flea & inheritance	8 (1.6)	1(0.3)	8.1(1.01-65.45)	.024
Flea & soil type	4 (0.5)	1(0.3)	4.0(0.45-36.23)	.107
Flea & insanity	8 (1.6)	1(0.3)	8.1(1.01-65.45)	.024
Flea & blood Type	4 (0.5)	1(0.3)	4.0(0.45-36.23)	.107
Body part infested				
Feet & hand	95 (25.5)	27 (6.0)	4.3(2.75-6.83)	< .001
Finger	8 (1.1)	5 (0.5)	1.6 (0.52-4.97)	.202

Hand	4 (0.5)	1(0.3)	4.0(0.45-36.23)	.106
Feet	68 (17.9)	11 (2.2)	7.3 (3.79-14.00)	< .001
All parts	10 (2.2)	296 (79.3)	0.008(0.004-0.016)	< .001
Sole	10 (2.2)	1(0.3)	10.2(1.3-80.3)	.013
Toe & fingers	84 (22.3)	33 (8.2)	2.9 (1.93-4.56)	< .001
Soul & hands	4 (0.5)	1(0.3)	4.0(0.45-36.23)	.106
Toes	16 (3.8)	1(0.3)	16.6(2.19-126.14)	.003
Heel	89 (23.9)	18 (3.8)	6.1 (3.60-10.38)	< .001
Sign				
Edema	163 (43.5)	158 (42.4)	1.1 (0.79-1.40)	.357
Hyperkeratosis	39 (9.8)	57 (14.7)	0.64 (0.42-1.00)	.025
Hypertrophic nail rim	26 (6.5)	47 (12.0)	0.52 (0.32-0.86)	.005
Suppuration	38 (9.8)	57 (14.7)	0.63 (0.41-0.97)	.019
Loss of digits	28 (7.1)	13 (2.7)	2.24 (1.1-4.4)	.009
Distorted Gait	64 (16.8)	39 (9.8)	1.8 (1.1-2.7)	.004
Rushes	4 (0.5)	1(0.3)	4.0(0.45-36.23)	.106
Ulcer	22 (5.4)	17 (3.8)	1.3(0.7-2.5)	.206
Nail Loss	4 (1)	1(0.3)	4.0(0.45-36.23)	.106
Symptom				
Pain	147 (38.0)	107 (27.7)	1.0 (0.8-1.4)	.42
Not Aware	1(0.3)	7 (0.5)	1.14(0.02-1.15)	.033
Itching	162 (42.4)	177 (46.7)	0.8 (0.6-1.3)	.401
Pruritus	79 (19.6)	97 (25.0)	0.7 (0.4-1.2)	.210
Diagnosis				
Inspection	388 (100.0)	388 (100.0)	-	-
Prevention				
Prayers	29 (6.5)	9 (0.5)	3.4(1.58-7.28)	< .001
Cleanliness	23 (4.9)	233 (59.6)	0.042 (0.026-0.067)	< .001
Not aware	269 (71.7)	27 (6.0)	30.2(19.33-47.24)	< .001
Wearing shoes	67 (16.8)	129 (33.9)	0.41 (0.29-0.58)	< .001
How spread				
Not aware	61 (15.8)	11 (2.2)	6.4 (3.31-12.35)	< .001
Flea Jumping	261 (70.1)	65 (16.8)	10.21 (7.26-14.35)	< .001
People	17 (3.8)	20 (4.3)	0.84(0.44-1.64)	.307
Dogs	11 (2.2)	89 (23.4)	0.1 (0.05-0.18)	< .001
All animals	1(0.3)	131 (34.8)	0.01(0.001-0.036)	< .001
Chickens	32 (7.6)	71 (18.5)	0.4 (0.26-0.63)	< .001
Goats	6 (0.5)	1(0.3)	6.1(0.73-50.72)	.05
Treatment				
Chemicals	49 (12.5)	198 (51.1)	0.33 (0.23-0.23)	< .001
Jellies	9 (2.2)	159 (40.8)	0.03 (0.02-0.07)	< .001
Extracting	329 (84.8)	31 (8.2)	64.2 (40.5-101.7)	< .001
Use tobacco	2(0.5)	1(0.25)	2.0(0.18-22.2)	.29
Associated health problem				
Not aware	243 (65.2)	14 (3.3)	44.8 (25.27-79.30)	< .001
Sadness	23 (5.4)	38 (9.8)	0.58(0.34-0.99)	.024
Anemia	1(0.3)	20 (4.9)	0.147(0.01-0.36)	.002
Deformity	38 (9.8)	75 (19.6)	0.45(0.29-0.69)	< .001
B. Weakness	7 (1.1)	62 (16.3)	0.1 (0.04-0.21)	< .001
Digit auto-amputation	0	0	-	
Feel cold	17 (3.8)	28 (7.1)	0.59 (0.31-1.1)	.05
Insomnia	49 (12.5)	87 (22.8)	0.5 (0.34-0.73)	.05
Immobility	11 (2.2)	24 (6.0)	0.44 (0.21-0.92)	.014
Tetanus	1(0.3)	40 (10.3)	0.02(0.003-0.16)	< .001
Solution				
Cleanliness	1(0.3)	6 (0.5)	0.16(0.02-1.37)	.05
Not aware	332 (89.1)	12 (2.2)	185 (94.8-362.5)	< .001
Extracting	0	0	-	-
Counseling	10 (1.6)	28 (6.5)	0.34(0.16-0.71)	.002
Hospital	16 (3.3)	224 (59.8)	0.03 (0.02-0.05)	< .001
Prayers	6 (0.5)	1(0.3)	6(0.73-50.72)	.05
Good nutrition	24 (5.4)	118 (31.0)	0.15 (0.10-0.24)	< .001

Table 3: Multivariate analysis of tungiasis management knowledge variables with significant differences

Variable	Adjusted OR (95% CI)	P- value
Cause		
Flea only	1.0	
Other	42.2 (0.1- 360.1)	.278
Body part infested		
All parts	1.0	
Other	530.0 (32.1-87.3)	< .001
Symptoms		
Edema	1.0	
Other	1.1 (0.2-6.2)	.920
Prevention		
Cleanliness/wearing shoes	1.0	
Other	42.7 (5.5-332.9)	< .001
Spread		
Any animal	1.0	
Other	11.1 (2.1-59.6)	.005
Treatment		
Jelly	1.0	
Other	49.3 (4.1-598.4)	.002
Associated health problems		
At least one	1.0	
Others	4.4 (0.8-23.5)	.080
Solution		
Hospital	1.0	
Other	32.9 (3.0-356.8)	.004

1.0 = Reference

Other=parameters showing significant difference in the category

The case group was 64.2 times likely to use extraction as means of treating tungiasis when compared to control (64.2; 95% CI:40.5-101.7; *P*<.001).They were also 44.8 times likely to be unaware of other health problems associated with jigger infection (44.8;95%CI: 25.27-79.30; *P*< .001).Both the case group and the control however seemed to be aware of how the disease is diagnosed (Table: 2 & Figure: 3).After multivariate analysis, all the variables appeared to be independent parameters of management knowledge risk factor except the cause, symptoms and associated health problems (Table 3).

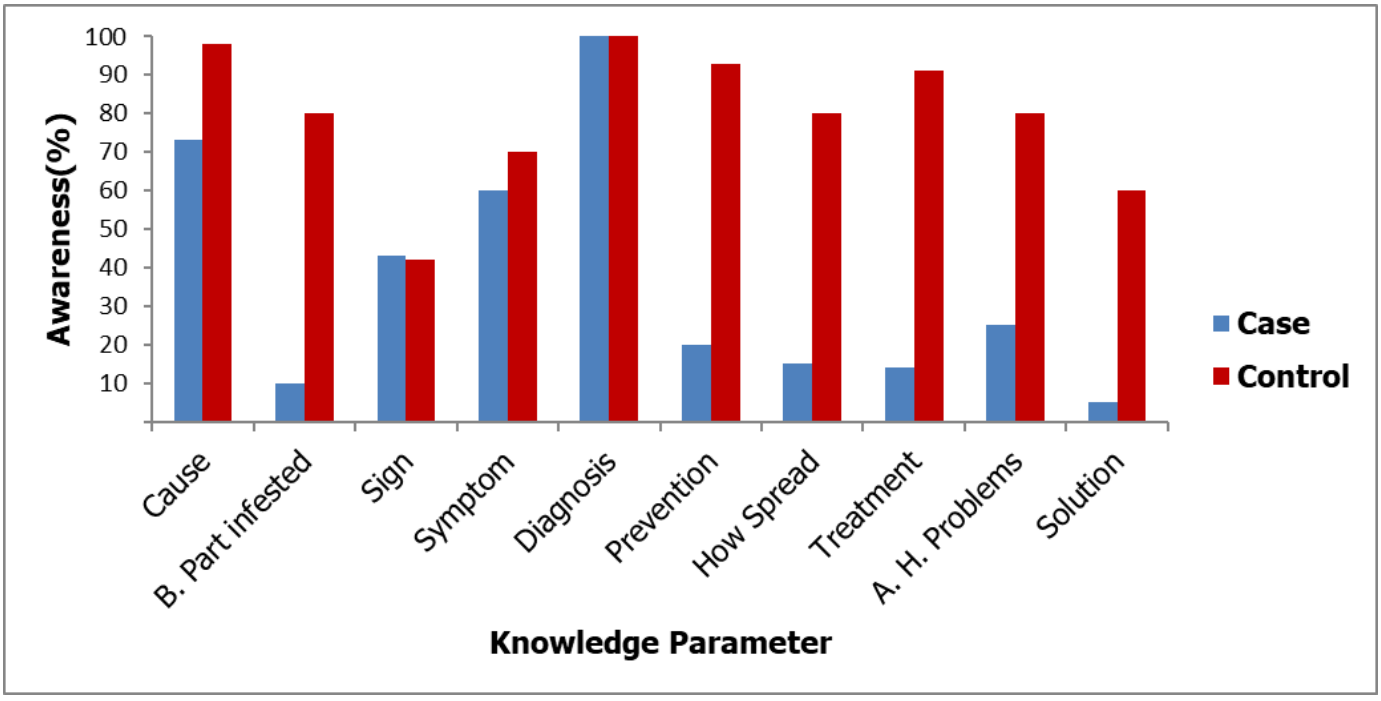

Fig 3: This graph demonstrates the general awareness of tungiasis management knowledge between case and the control

3.3 Discussion

In this survey, the highest percentage of participants in the case group was of 60 years old and above, agreeing with what Muehlen and others observed in 2003 (Table 1). According to these researchers, marked increase in infection in the old people is caused by factors other than their normally compromised immune system. It is, attributed to behavior with age and different exposure [17]. This study also depicted that most of the control participants were in the middle class (41-60 years age group). This concurred with Muehlen *et al.*

(2003) findings that middle class people may not be largely infected as majority of them are working individuals who spend most of the time outside the endemic community. They also may have diverse disease related behaviors; they do thorough inspection and extract embedded fleas more scrupulously [17]. In this study, marital status was not significant, with most of the control and case participants being in the married category. Gender difference was however significant with most of the jigger infested households heads being males. Whereas in some studies males seem more prone to jigger infection than female, some have found females being more vulnerable or no gender difference at all [18, 17, 19]. In this study, poverty featured prominently as a factor exacerbating jigger infection, with most of the infected household heads being casual laborers and earning below 50US $ per month(Figure.4). Majority of the control individuals were self- employed with most of them (above 75%) earning more than 50US $ per month. This concurred with studies conducted by many researchers on poverty as a factor aggravating the ectoparasitosis [20, 21, 22 ,23, 24].

Fig 4: A 55-year-old man encountered during the study with the background depicting extreme poverty. On the right is his jigger infected right foot showing some of tungiasis signs; hypertrophic nail rims, fissures, ulcers and hyperkeratosis

More than half of the jigger infested households heads did not have formal education at all. Above 70% of the control, household heads had at least attained the primary level of formal education. This concurred with a study conducted by Kimani, Nyagero and Ikamari in 2012 where they reported that jigger infected people are normally from meager educational background [29]. In other studies, disability and other forms of health problems associated with jigger infection have been reported to hinder acquisition of formal education [25, 26, 27].In this study, religious differences did not feature out as a factor influencing jigger infection. In another study, however, there are, some sects that have been, reported to view parasites-like jigger flea-as organisms of equal rights to man before God and thus tampering with their lives would result to sin. Such sects do not present their health problems to hospitals [9, 10].

The outcome of this study depicts that most of the individuals in the control were aware that tungiasis is caused by a flea (Table 2). They were also aware that a dirty environment aggravates the infection. However, participants in the case group gave many responses as the causes of the disease. There were those who indicated that tungiasis is an inherited disease. There were others who were of the, believe that blood type is also a factor in jigger infection. Others still observed that insanity and isolation could cause the disease. There was also, a section of the case group that, said tungiasis could come about due to witchcraft or a curse. This agrees with a study conducted by Kimani, Nyagero and Ikamari in 2012, where 12% of participants reported that there are people from specific families who must suffer from tungiasis due to their blood type and inheritance [29]. In this study, which they conducted in central Kenya, half of the respondents believed that myths and culture are associated with jigger infection. The results of this study can also compare to another one conducted at Fortaleza in Brazil whereby the local people were more jigger infected than migrants due to traditional believes [28]. The study however disagrees with one conducted in Kisii county, western Kenya, where respondents believed that presence of jiggers in a homestead is a sign of impending wealth, and thus no cause for alarm [30]. Difference in knowledge about the cause of tungiasis between the two groups, nevertheless, did not feature out as an independent parameter after multivariate analysis.

Majority among the case group believed that jiggers infect feet, hands and heels. It was however a general observation among the control participants that *Tunga penetrans* can infect any part of the body. This was consistent with another study conducted by Heukelbach and others in 2002 where jigger victims had poor knowledge concerning body parts normally infected [31]. Knowledge difference on signs and symptoms between the two groups was not significant in this study. It was a common knowledge in both groups that the principal sign of jigger infection is edema (Fig. 5). The two groups also agreed in almost equal proportions that other signs include hyperkeratosis, suppuration, loss of digits, ulcers, and distorted gait (Fig.4). The two groups also indicated pain, itching and pruritus as the main symptoms of tungiasis. This is in agreement with many studies on tungiasis, especially one conducted in 2012 by Gitau, Oyieke and Mathenge [9, 10]. Just like these three researchers, found

out in their study, both the control and the case groups were, in agreement that diagnosis of tungiasis is by inspection (Fig. 3). This was also in agreement with another study conducted by Pampiglione and others in 2009 [32].

Fig 5: The first picture shows a jigger infected girl encountered in the study with edema around the nails. The second one is of a man whose right foot was largely, infected including the ankle and the heel.

Most of the case participants were not aware of the means applied in preventing jigger infection. The control group however observed that general cleanliness- including wearing of shoes- is the chief means of preventing jigger infection. Although wearing closed shoes remain a most effective means of preventing jigger infection, poor Kandara residents may not afford to buy them due to financial constraints. The most effective preventive measure would be one that target the off-host stages in the soil like regular pouring of water on the floor. Another reliable means would be spraying the floor with liquid insecticides or mixing the soil with insecticidal dusts [46]. Any chemical means of prevention among poor people would however be possible if only the government intervened to provide the right application knowledge and meet the financial aspect of the intervention.

Extraction was almost a common method of treating tungiasis among the case individuals, agreeing with what kimani and others reported in 2012 [29]. Jigger infected people normally use unsterilized instruments like thorns, pins, scissors, nails, knives, needles and sharp pieces of wood to extract jigger lesions [29, 33]. This means of extracting jiggers cause blood to ooze from the body creating good entry points for bacteria and viruses including those of hepatitis B(HBV) and C(HCV). It is also a good channel of HIV transmission especially where these instruments are shared[33].The medically recommended therapy is removing the embedded flea with a sterilized needle followed by application of antibiotics in case of eventual bacterial infection[43]. This therapy may however not apply in a case of severe infection as it may not be possible to trace every embedded flea on the body. Again this may cause general body ulceration in case the many points of extraction are infected with bacteria. There are reports of successful treatment with a single dose of oral ivermectin at 0.2 mg/kg body weight [48]. Topical as well as oral ivermectin has been, proved an effective treatment for human ectoparasitosis such as tungiasis, pediculosis, scabies, and cutaneous larva migrans [41,42, 43, 47]. Oral thiabendazole at 25mg/kg body weight daily for 10 to 12 days has been, administered with success against generalized tungiasis [12]. Going by the levels of poverty in Kandara Sub-County, accessing these chemicals is a big problem. Again with high levels of illiteracy, knowledge needed on how to use such chemicals is insufficient among kandara residents.

Without proper and timely treatment, secondary contagions are common [12, 33, 34]. Pathogenic bacteria have been isolated from jigger lesions: *Enterobacter agglomerans*, *Clostridium tetani*, pathogenic *staphylococcus aureus*, *Streptococcus pyogenes*, *Klebsiella aerogenes*, *Escherichia coli*, among others [35, 36, 37]. Jigger infestation is thus associated with tetanus in non-vaccinated persons. In a study conducted in Sao Paulo state in Brazil, point of lesion has been associated with 10% tetanus entry [11]. A few of the case participants however, responded that jellies and chemicals could be, used in treating the disease. Differences in knowledge on how to prevent and treat tungiasis, between the case and control, came out as independent factors after multivariate analysis (Table 3).Knowledge difference on associated health problems between the two groups was not independent after multivariate analysis. Majority among the case group did not know any health problem associated with jigger infection. The control individuals however mentioned a number of health problems associated with tungiasis, which included tetanus, anaemia, insomnia, immobility and general body weakness. Insomnia is a leading health problem in tungiasis due to the constant pruritus and itching associated with the disease [44].These two symptoms normally intensifies at night when the victim is relaxing. This interferes with the sleep resulting to fatigue, concentration problems and bad mood during the day when the infected person should be busy in economic activities [44] .Long term insomnia may result to anxiety and other mental disorders. Severe infection may cause anemia as *T. penetrans* suck blood almost permanently [45].

Knowledge difference on solution to tungiasis between the two groups was independently significant in this study (Table 3). Whereas the case group individuals did not know the best solution to tungiasis, it was a common knowledge among the control participants that the best solution to jigger infection is presenting the case to the hospital, alongside eating nutrient rich diets. There was, however a percentage of case participants who said that prayers were the only means of solving jigger problem as no other way could work, according

to them. This confirms what many researchers have observed about tungiasis; that the disease is a function of ignorance, poverty and negligence [29, 39, 40]. Most of the participants in the case group indicated that jigger flea move from one place to the other by jumping. A small section however did not know at all how jiggers are, spread from one person to the other. Among the control individuals, a large number responded that besides jumping, almost all animals are involved in the spread of tungiasis, all these concurring with studies conducted by several researchers in Africa and Brazil [39, 38, 40, 18]. Difference in knowledge between case and control on how the disease is spread was also an independent parameter in this survey.

4. Conclusion

The results of this study depict an enormous deficiency in knowledge on how to manage tungiasis among the jigger infected residents of Kandara sub-County (Figure 3). They also reveal poverty and poor education as major factors that aggravate jigger problem in this part of central Kenya. These findings suggest a need for profound education by government and other stakeholders on factors exacerbating tungiasis in this region. The government of Kenya should liaise with community based organizations, schools and churches in the area and educate the local Kandara community on ecologically based measures that would help in preventing the flea from breeding and establishing itself in their environment. They should also be taught on basic body cleanliness measures that would help keep the jigger flea at bay. All these would enable the local people to be in the front line in combating jigger menace in the area, rendering any intervention as mere reinforcement in tungiasis control. Introduction of poverty mitigation measures in the area is also called for, especially by use of community development fund (CDF) provided through the Kenyan parliament to boost the economic welfare of the citizens. Eradication of poverty is a key measure in the control of jigger problem.

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