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Original Research Article

Quantifying burden of disease caused by Tungiasis using disability adjusted life years metric among the children aged 5-14 years in Murang'a County, Kenya

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Tungiasis is a parasitic tropical disease caused by female *Tunga penetrans* which causes different disabilities among children. The objective of this study was to quantify health loss caused by the disease among children aged 5 to 14years using Disability Adjusted Life Years metric. A cross sectional descriptive research design was used for this study. Data on mortality was collected through verbal autopsy and desk top review of medical records. Morbidity was determined by physical examination of the children and sequelae reported by the children, parents and teachers. Measures of central tendencies and chi-square were used for data analysis. This study found that Tungiasis prevalence was 37% (74) in the endemic area but 44 % (153) among the children. A total of 0.3 Disability Adjusted live years were lost due to Mild Tungiasis while 2.51 Disability Adjusted Life Years were lost due to severe Tungiasis. However, there was zero mortality due to Tungiasis among the children aged 5-14 years. Severe Tungiasis caused greater loss of health 8.4 times more than loss of health resulting from mild Tungiasis. In order to reduce Burden of disease caused by Tungiasis, effective and sustainable management measures should be adopted.

Key words: Tungiasis, child, burden of disease, health state, sequel, disability weights, morbidity and mortality.

INTRODUCTION

Tungiasis is a parasitic tropical disease caused by female *Tunga penetrans* also known as sand flea or jigger flea. The disease code is B88.1 under International Classification of Diseases 10th Edition (WHO, 2008). Tungiasis causes loss of health due to various disabilities which include pain and itching , lack of sleep, difficulty in walking and grasping (Kehr et al., 2007; Feldmeier et al., 2004). Wounds are also common which create entry points of pathogens such as *Clostridium tetani ,Staphylococcus aureus, Enteroccousfaecalis, Streptococcus pyogenes*, *Pseudomona sp, Bacillus sp.,Bifermantaos sp. and Peptosterptococcus sp.* (Feldmeier et al., 2002). The disease is prevalent among children in Latin America, Caribbean and sub-Saharan Africa (Pampliglione et al., 2009; Ugoimboiko et al., 2008, Muehlen et al., 2003; Heukelbach et al., 2001). In the affected countries, millions of people are at risk of infection especially in stable endemic foci (Pampliglione et al., 2009; Feldmeier and Heukelbach, 2009; Heukelbach et al., 2001).

High level of morbidity has been described when an individual have high number of embedded female *T.penetrans* parasites (Feldmeier and Heukelbach, 2009). The resulting morbidity has been shown to reduce the children's ability to acquire basic education due to absenteeism, repetition and dropout (Ngunjiri et al., 2015). Although the disease causes morbidity, it has been described as a neglected disease since it receives minimal attention from health personnel and other stakeholders (Feldmeier et al., 2014). In general Neglected Tropical

Diseases are commonly prevalent among low socioeconomic groups hence contribute to burden of disease at national and global levels (Arden, 2008; Sachs and Hotez, 2006; Molyneux et al., 2005; Heukelbach, 2005).In these populations the magnitude of burden of disease caused by the neglected diseases may be attributed to the health seeking behavior within this social group. The nature of health seeking behavior among this low income groups can be explained through theories and models such as Theory of Reasoned Action which suggested that the strength of the intention and skills are important in carrying out a given action (Fishbein et al., 2002; Fishbein, 2000; Ajzen and Fishbein, 1980; Fishbein and Ajzen, 1975). Health Belief Model, also postulates that an individual will carry out a recommended health behavior; if he/she believes that it is a risk for acquiring a serious and severe negative health consequence and also simultaneously believe that the benefits of performing the recommended protective behavior are more than the costs of taking that action (Janz and Becker, 1984; Rosenstock, 1974). Similar beliefs and cost benefit analysis might be the cause of neglect for Tungiasis. In addition, the neglect may be further justified by the underestimated burden of disease, beliefs and norms among the patients suffering from Tungiasis and health care in endemic areas.

The disease burden caused by Tungiasis has been estimated in terms of sequel severity scores and prevalence (Morkve, 2013, Njau et al., 2012, Ngunjiri and Keiyoro, 2011, Pampliglione et al., 2009, Ugoimboiko et al., 2008; Kehr et al., 2007; Muehlen et al., 2003, Heukelbach et al., 2001). These descriptions are not universal and hence the burden is not comparable with that of other diseases in terms of Disability Adjusted Life Years (DALYS). For example some of the neglected diseases among all the age groups worldwide in the year 2010 had different number of cases, this included Africa Trypansomiasis 37,000, rabies 1,100 and 100 for yellow fever (Hotez et al., 2014). In Kenya, in the year 2009, approximately 2.7 million cases of Tungiasis among all age groups were reported by Africa Health and Development International (AHADI) Trust cited in (Ngunjiri and Keiyoro, 2011).Another source indicated 1.4 million cases of Tungiasis and 25% children being at risk of suffering from the diseasein Kenya (MOH, 2014). In a period of three years between the year 2007 and 2009 it was also estimated by AHADI that 275 people had died of Tungiasis related co morbidities and complications cited in Ngunjiri and Keiyoro (2011). This indicated that the disease was a health concern in Kenya. As a result, National policy guidelines have been developed on the management and control of Tungiasis in Kenya by the government through the Ministry of Health, Department of Environmental Health (MOH, 2014). In this regard, there is need to use a universal metric such as Disability Adjusted life years (DALYs) to estimate the burden of disease resulting from Tungiasis. This may enhance efforts put in place to manage, control and prevent Tungiasis. The objective of the study was therefore to estimate burden caused by Tungiasis among children aged 5-14 years using Disability Adjusted Life Years (DALYs) metric.

MATERIALS AND METHODS

The study was conducted in Kandara Sub County in Murang'a County, Central Kenya. The County covers an area of 930 Km^2, has a population density of 374 people per Km^2 and a total population of 942,581 according to the 2009 census, with a growth rate of 0.2 per annum. Majority of inhabitants' main economic activity is casual labor and small scale farming. This area was identified for this study because it has been recognized as an endemic area for Tungiasis in Kenya (MOH, 2014).

Descriptive cross-sectional research design ideals guided the study. Data collection was carried out from November, 2014 to August, 2015. A total of 384 children aged 5-14 years who met the inclusion criteria were recruited through simple random procedure from the 200 systematically randomly selected households (Fisher et al., 1998). A total of 19 children from ten households opted out of the study during data collection stage citing personal challenges in dealing with chronic Tungiasis.

The inclusion and exclusion criterion used in this study is as described in Ngunjiri et al., (2015) in which a household was included if there was a child aged 5-14 years. Both male and female children were included in the study. Those suffering from symptomatic Tungiasis must have had at least two clinical manifestations. In addition, confirmation of diagnosis was done by macroscopic examination for the presence of embedded female *T.penetrans*. Children suffering from severe physical disability and mental illness were excluded from the study. Children aged below 5 years and those above 14 years were excluded. Health facility was included if it was geographically positioned within the study area and the personnel willfully agreed to participate in the study. Level 4 and 5 hospitals were included if they were within or close to the study area. Two hospitals met these criteria, these were Murang·a level 4 Hospital and Thika level 5 Hospital .

The study had an ethical approval from Kenyatta National Hospital ethics research committee (KNH-ERC/A/163) and also a research permit to conduct the study was obtained from the Ministry of Education, Science and Technology ; National Commission for Science ,Technology and Innovations (NCST/RCD/12A/133). Authorization to carry out research at county level was granted by County Director of Health (MRG/VOL.1/68/16), County Commissioner (PUB.24/11/VOL.1/64) and County Director of Education (M'GA/CTY/GEN/64/VOL.I/102). Informed consent was given by all participants.

Diagnosis of symptomatic Tungiasis among the children

The participants were requested to clean their feet and hands for accurate macroscopic examination for embedded female *T.penetrans* (Ngunjiri et al., 2015). Tungiasis was

confirmed by the presence of the embedded female *T. penetrans at* various stages of development (Eisele et al., 2003). Those with open wounds benefited from antibiotic Grabac in powder form 10gm. They were also advised to seek medical care from the nearest health facility after macroscopic examination. Community Health workers were also informed about all cases of Tungiasis that were identified by the researchers. Those who had a co infection of *Tineacapitis*, benefited from whitefield's skin ointment 20g.

Determination of Disability Adjusted life years (DALYS) resulting from Tungiasis.

The burden of disease was estimated in terms of Disability Adjusted Life Years (DALY) metric. This consist two components morbidity and mortality (Murray et al., 2012b). In this study efforts were made to include both components. Morbidity was determined using principles of the method used forderiving Years Lived with Disability (YLD) for GBD 2010 (Murray et al*.,* 2012b). The sequelae were classified into corresponding health states which have specific disability weight(Salomon et al., 2012). Mortality was determined through two methods verbal autopsy and desk top review of hospital medical records to find out number of deaths caused by Tungiasis and compared with other diseases. These methods were in line with those used to determine global burden of disease by Murray et al., (2012b). The International Classification of disease 10th edition coding (ICD 10) was used to retrieve the morbidity and mortality cases associated with Tungiasis from medical records, whose code is B88.1 (WHO, 2008). Data analysis included descriptive statistics and Chi-Square test.

RESULTS

A total of 347 children aged between 5-14 years participated in the study from a sample of 384 children randomly drawn from 200 households. Of 74 (37%) households that were sampled there was at least one person who was diagnosed with Tungiasis. Among the 347 children who participated in this study 153(44%) were suffering from Tungiasis of whom 97(28%) were males and 56 (16%) were females. The most prevalent sequelae were lesions on hands and feet, itching and pain. Males were 8.9% more likely to be suffering from Tungiasis than their female counter parts who were 10% less likely to suffer from the disease. Children aged between 5 to 9 years were found to be 10.7% more likely to suffer from Tungiasis while those in the age bracket 10 –14 years were 6.8% less likely to suffer from Tungiasis.

Difficulty in walking was observed among the children who had multiple lesions on the sole, heel, beneath and on toes. The lesions caused by Tungiasis made it difficult for the children to wear shoes due to the pain although most of the children suffering from Tungiasis were noted to prefer wearing shoes in order to conceal resulting disfigurement.

The sequelae resulting from Tungiasis were classified into three health states as shown in Table 1.This study found that in some cases the children had lived with two health states for duration of 2.38 and 2.4 years compared with infectious disease post-acute consequences health state which had lasted 2.02 years (Table 1). Although infectious disease post-acute consequences health state had lasted for a shorter duration and had low frequency, its disability weight is the highest at 0.254 compared to disability weights of open wounds , short or long term, with or without treatment and disfigurement with itch or pain health states. The prevalence of Infectious disease: post-acute consequences health state was high among female children and children aged 5-9 years which had the same value of 3.46%.

Morbidity caused by Tungiasis among the children.

The total number of Years Lived with Disability (YLD) resulting from Tungiasis were 3.06 years for all the children aged 5-14 years in a population of 347 children. The health state with the highest contribution of the total YLDs was Infectious disease: post-acute consequences health state at 52.6% due to its high disability weight although it had the lowest prevalence. Disfigurement health state YLDs were at 40% which were lower than infectious disease post consequence health state but greater than open wound health state YLDs. The least YLDs were observed among female who also had the least number 1.42(6.5%) due to open wound: short term, with or without treatment. This is because the prevalence of two health states disfigurement with itch or pain and Open wound: short term, with or without treatment were lower among female children compared to their male counter parts as shown in Table 2. However, there was no statistical difference in Years Lived with Disability between gender and among age groups both at P value 0.199 which is greater than 0.001.

Tungiasis status was classified into two disease categories, mild and severe Tungiasis. Mild Tungiasis was defined by two health states open wound: short term, with or without treatment and Infectious disease: post-acute consequences. However, severe Tungiasis was defined by all the three health states presenting in an individual as indicated in Table 2. Mild Tungiasis YLDs were 10.7% compared to severe Tungiasis YLDs 89.3% hence greater loss of health due to severe Tungiasis wasnoted. Hence the disease burden caused by severe Tungiasis was higher by 78.6% compared to mild Tungiasis. This was also evident because in total the number of Years Lived withDisability among all the children attributed to severe Tungiasis was found to be 8.4 times greater than the 0.3 YLDs attributed to mild Tungiasis. The average duration of the two health states defining mild Tungiasis was shorter among the children suffering from mild Tungiasis compared to the duration of health states of children diagnosed with severe Tungiasis. The YLDs among the children for mild and severe Tungiasis are shown in Table 2.

Table 1. Tungiasis sequelae and their corresponding health states

Tungiasis Sequel	Health state	Duration In average years	No. of male children	No. of Female children	No. children aged 5-9years	No. children aged 10-14 years
Difficulty in walking, Deformed feet Lose of toe nails and finger nails Itching, Pain, Persistent pain, Burning sensation, Inflammation, Pus, Pain while wearing shoes, Unable to write	Disfigurement: level 1 with itch or pain	2.38	95	55	73	77
Lack of sleep, stigma, Docile, Fear of being stepped on, Reduced playing level, Withdrawal, Isolation, Headache	Infectious disease: post-acute consequences (fatigue, emotional lability, insomnia)	2.02	10	12	12	10
Lesions on feet ,heels and toes, Lesion on hands	Open wound: short or long term, with or without treatment	2.4	83	53	68	68

Infectious disease: post-acute consequences health state for mild Tungiasis had lasted for an average of 2.02 years while among children diagnosed with mild Tungiasis the same health state had an average duration of one year which was more than 50% less. Another observation was that with every unit increase in duration, Years Lived withDisability decreased by 2.5 times. This is because the Infectious disease: post-acute consequences health state which had the greatest disability weight lasted for a shorter period after the onset of the disease and diminished in chronic state. This explains the difference in loss of health between severe and mild Tungiasis in which case high burden of disease was suffered by few individuals for a long time.

Mortality caused by Tungiasis

In Murang′a level 4 Hospital outpatient record data on Tungiasis were under public health department and incidences ofdiseases were reported per budgetyear (July to June). The outpatient data on Tungiasis for 2014/2015 budget year and the month of July for 2015/2016 budget year indicated a mean of 204 cases of Tungiasis among school age children. Inpatient data indicated one Tungiasis case of a child aged seven years. Malnutrition and intestinal worms were also important causes of morbidity among the children aged 5-14 years from the inpatient data.

The results from verbal autopsy and desk top review of inpatient records of level 4 and level 5 hospitals on mortality indicated that no deaths were caused by Tungiasis among children aged 5-14 years. Therefore, the number of Years of Life Lost (YLL) due to the disease was zero.

Disability Adjusted Life Years among the children aged 5-14 years caused by Tungiasis

In this study Disability Adjusted Life Years **(**DALYs) due to Tungiasis were equivalent to Total number Years Lived with Disability (YLD) as shown in Table 2. This is because it was observed that the disease did not directly cause deaths and hence YLL was zero. Severe Tungiasis had a 2.51 DALYscompared to mild Tungiasis which had 0.3 DALYs. The total DALYs lost due to severe Tungiasis had a high proportion from male children and those aged 5-9 years.

DISCUSSIONS

Disability Adjusted Life Year (DALY) is an important metric of quantification of the Burden of Disease due to the Years of Lifelived with disability (YLD) component that describes the non-fatal outcome of the disease. The estimated burden of disease resulting from Tungiasis was high among children who suffered severe Tungiasis which had lasted for more than two years. This could imply that there were continued infestations by the female *T.penetrans* and efforts geared towards managing the disease were inadequate. The burden of disease caused by Tungiasis was observed in

Table 2. Years Lived with Disability among children caused by mild and severe Tungiasis

Tungiasis Status	Health state	Duration in yrs	Disability weight	YLDs 5-14yrs	YLDs Male	YLDs female	YLDs 5-9yrs	YLDs 10-14yrs
Mild Tungiasis	Open wound: short term, with or without treatment	2.13	0·005	0.08	0.06	0.02	0.04	0.04
	Infectious disease: post-acute consequences (fatigue, emotional lability, insomnia)	1	0·254	0.22	0.15	0.07	0.07	0.15
Total Mild YLDs				**0.3**	**0.21**	**0.09**	**0.11**	**0.19**
Severe Tungiasis	Disfigurement: level 1 with itch or pain	2.5	0·029	0.71	0.40	0.31	0.38	0.33
	Infectious disease: post-acute consequences (fatigue, emotional lability, insomnia)	2.02	0·254	1.68	0.81	0.88	0.95	0.73
	Open wound: short term, with or without treatment	2.55	0·005	0.12	0.07	0.05	0.065	0.058
	Total YLDs for severe Tungiasis			**2.51**	**1.28**	**1.24**	**1.395**	**1.12**

both male and female children aged 5-14 years. Although there was no statistical difference between the burden of diseases suffered by male children and female children, this study, found that male children were more likely to suffer from Tungiasis compared to their female counterparts. This may be because in most cases male children did not report to their health care givers when infested with *T.penetrans or* had less contact hours with the care providers or else could tolerate post-acute consequences than the female children. Alternatively, during focus group discussion it was observed that boys paid less attention to their personal hygiene compared to girls. In a related study by Ngunjiri et al., (2015) both sexes were found to be equally prone to the disease.

In this study mild and severe Tungiasis were defined in relation to the number of health states and duration of individual health state. This differed from other definitions in which symptoms were used to define mild and severe Tungiasis (Ngunjiri et al., 2015). A patient was considered to have mild Tungiasis if he or she had open wounds and infectious post consequences health states and severe Tungiasis if the patient was diagnosed with all the three health states open wounds, infectious post consequences and disfigurement level with itching or pain (Salomon et al., 2012). This study found that mild and severe Tungiasis among the children aged 5-14 years caused different levels of morbidity.

The total number of Tungiasis cases is compared with other causes of morbidity such as intestinal worms and malnutrition among the children aged 5-14 years in the study area. Tungiasis can therefore, be considered to be equally important cause of morbidity among children. This indicates that more effort should be geared towards its control and management. This is despite zero cases of mortality among the children aged 5-14 years and all other age groups contrary to the 297 deaths that had been associated with Tungiasis in Kenya by AHADI cited in Ngunjiri and Keiyoro (2011). However, the non-fatal outcomes such as open wounds are risk factors to potentially fatal secondary infections pathogens such as *Clostridium tetani* (Feldmeier et al., 2002).

The burden of disease caused by Tungiasis can also be related with the burden caused by schistosomiasis which cause high morbidity compared with its mortality (Hotez et al., 2014; WHO, 2008). Further, Tungiasis had estimated 205 cases among children aged 5-14 years in the study area, 25 % of the children at risk of suffering from the disease and 1.4 million cases in Kenya (MOH, 2014).This can be benchmarked with other neglected diseases in the year 2010 such as such as Africa Trypansomiasis with 37,000 symptomatic cases, rabies 1,100 cases and 100 cases of yellow fever (Hotez et al., 2014). This shows that Tungiasis is a cause of morbidity which should be addressed through sustained and effective mechanisms by the government and health care providers (MOH, 2014). The estimation of Tungiasis DALY may also be improved if all the stake holders keep formal records. Although the burden of disease caused by Tungiasis is less compared to malaria which causes high morbidity and mortality it lowers quality of life among the children due to health loss. The children who are at school going age could have their academic achievements compromised (Ngunjiri et al., 2015).

Lack of motivation among Tungiasis patient to seek medical care may be explained by individuals' skill and strength of intention which is a function of attitude and subjective norm as explained in Theory of Reasoned Action (Ajzen and Fishbein, 1980; Fishbein and Ajzen, 1975) and

also perceived benefit and cost for engaging in a behavior ((Janz and Becker, 1984; Rosenstock, 1974). In this case Tungiasis patient are likely not to seek medical care due to their attitude and that of the people close to them who may perceive the disease as a negligible condition without serious outcome. This would limit the strength of their intention to seek medical care and distort their cost benefit analysis of seeking help from health facilities. This may also be the case for the health care providers who are supposed to put intervention measures in place to prevent, control and manage Tungiasis. These factors could have made Tungiasis to remain a neglected disease although it is causing quantifiable burden among children in endemic areas (Feldmeier et al., 2014). Tungiasis causes high morbidity among few individuals for an average duration of more than two years. This results in loss of quality life especially among children particularly in regard to participation in education activities (Ngunjiri et al., 2015).

In conclusion, DALY caused by Tungiasis was mainly attributed to YLD since no deaths were caused by the disease. It was also observed that male children were more likely to suffer from Tungiasis compared to the female children aged 5-14 years. On the otherhand, children aged between 5-9 years were also more likely to suffer from Tungiasis than the children aged 10-14 years. Infectious disease: post-acute consequences and open wound were the health states which defined mild Tungiasis while severe Tungiasis had an additional health state disfigurement mild with itching or pain. Severe Tungiasis health states had lasted for a longer time than mild Tungiasis health states. Children aged 5-14 years had suffered from disabilities caused by severe Tungiasis for an average of more than two years. This caused high morbidity although no deaths could be attributed to Tungiasis among the children aged 5-14 years.

This study would recommend that, Tungiasis should be demystified among health providers and communities, improvement on capacity building among health care providers in the management of Tungiasis and improve available medical records on Tungiasis. This might enhance management of thedisease andsubsequently reduce the burden of disease caused by the condition.

Further research may include quantification of burden of disease caused by Tungiasis at National and Global level using DALY metric. This should be applicable to all the age groups and should include measures of other heath states said to be related to Tungiasis infection such as anemia.

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