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Risk factors associated with cystic echinococcosis in humans in selected pastoral and agro-pastoral areas of Uganda

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Abstract

Aim: It was to determine the risk factors responsible of occurrence of cystic echinococcosis (CE) of humans in the pastoral and agro-pastoral (PAP) in Uganda.

Materials and Methods: A cross-sectional study was conducted in districts: Moroto, Napak, Nakapiripirit and Amudat in Karamoja region; in agro-pastoral communities of Teso region, in the districts of Kumi and Bukedea; Nakasongola district in Central region and in Kasese district in the Western region. People were subjected to voluntary ultrasound screening for CE. Those found positive to CE on ultrasound screening were interviewed using a special designed form to find out the probable predisposing factors for acquisition of CE infection. Predisposing factors considered were location, age, sex, dog ownership, occupation, water source, and religion. Univariate and multivariate logistic regression analysis was performed to identify key risk factors.

Results: In Karamoja region, being female, age beyond 40 years and open spring water sources were the risk factors. While for Nakasongola age beyond 40 years was a risk factor. In Kasese dog ownership, age >60 years and being a Muslim were risk factors. In Teso region dog ownership and age >60 years were the risk factors.

Conclusion: Being a pastoralist, a female, increasing age beyond 40 years, open spring water sources, dog ownership and being a Muslim were the risk factors for CE in PAP areas in Uganda.

Keywords: agro-pastoral, cystic echinococcosis, humans, risk factors pastoral, Uganda.

Introduction

Echinococcosis is an endemic zoonotic infection found throughout the developing world [1,2]. It is a neglected emerging and re-emerging disease [3]. Cystic echinococcosis (CE) is caused by infection with the larval stage of the tapeworm *Echinococcus granulosus*. The definitive hosts of this parasite are carnivores which are infected when they ingest the organs of herbivores that contain hydatid cysts of this worm. The cysts of this worm once ingested develop into adult tapeworms in the carnivores. Infected carnivores shed this worm eggs in their feces which contaminate the soil, water, and food. The intermediate hosts the herbivores and humans get infected by ingesting this tapeworm eggs in contaminated objects. Once ingested by herbivores and humans, the eggs hatch and develop into cysts called hydatid cysts in their internal organs. The disease caused in humans is called hydatidosis. In humans, hydatidosis is most commonly found in people involved in raising herbivores together with carnivores mainly dogs which are allowed access to eat the tissues of herbivores containing hydatid cysts. Therefore, a high prevalence of CE has been associated with the pastoral communities such as Turkana, Toposa, Nyangatom, Hamar and Boran [4,5]. Pastoral and agro-pastoral (PAP) areas in Uganda present conditions likely to favor occurrence of CE among humans in Uganda. The WHO lists Uganda as one of the countries with high endemicity of CE [6]. However, there is not much information of CE situation in Uganda. A retrospective study conducted from 1967 to 1972 [7] found 23 cases of echinococcosis among the Karimojong, Lango, and Acholi people in Uganda. In another study [8], an average of 20 surgical cases per year has been seen in hospitals in Karamoja and Mbarara regions in Uganda. An earlier preliminary survey using ultrasound [8] found a prevalence of hydatidosis of 0.4%

(n=7) among 1605 people screened. Among the wild animals examined on postmortem in Queen Elizabeth National Park, Uganda, hydatidosis was found in 33.3% of lions, 10.4% of warthogs, and 17.2% of buffaloes [9]. Furthermore, hydatidosis had been reported in impala and goats in Lake Mburo National park [10]. In dogs, the prevalence of *E. granulosus* of 66.3% (n=217) had been reported on autopsy in Moroto district in Uganda [11].

A recent study done by Othieno *et al*. [12] in PAP areas in Uganda showed a prevalence of CE of 3.32% in Central Karamoja, 1.21% in Teso region, 2.15% in Kasese and 2.7% in Nakasongola districts, in Uganda on ultrasound screening. However, the risk factors for occurrence of CE in these areas were not known. The knowledge of risk factors for occurrence of CE is important for designing of practical appropriate measures for controlling CE in humans these areas.

It is against the above background that studies were done with the aim to determine which risk factors were associated with the occurrence of CE in humans in these areas.

Materials and Methods

Ethical approval

Permission and ethical approval was sought from Uganda's Ministry of Health Research Council and Makerere University College of Health Sciences Ethical and Institutional Review Board. Visitations to the selected districts were made to get permission from District leaders. District leaders and communities at the village level were earlier informed about the intended exercise. Through the district medical officers, district health inspectors, local leaders and village health committees, the volunteers were mobilized among communities in selected sub-counties, parishes and villages, respectively. Health centers IV, III or II were selected as screening areas. On the day of screening, discussions were first held with participants, explaining the purpose for screening. A portable ultrasound machine powered by a portable generator was used for screening. Designed forms were used to capture data from consented adults or assented guardians for the minors who participated in the study. Volunteers were assured of free diagnosis.

Methodology

A cross-sectional A survey was conducted from 2012 to 2014. The ultrasound screening for CE was done in the districts: Moroto, Napak, Nakapiripirit and Amudat in Karamoja region, Teso region in the districts of Kumi and Bukedea; Nakasongola district in central region and in Kasese district in the Western region. These districts were purposively selected to represent PAP areas in Uganda. A total number of 3636 volunteers were screened as shown in Table-1.

In a well-lit room, volunteers were asked to lie on the examination couch and expose the entire chest and abdomen. Examination gel was applied to the abdominal skin and an ultrasound examination probe. The entire abdominal cavity was scanned in four basic planes as described as transverse, sagittal, oblique subcostal and coronal supra-costal planes [13]. Those found positive were further interviewed using a special designed form to find out the probable predisposing factors for acquisition of CE infection which was a dependent variable. Predisposing factors (independent variables) considered for those who had CE were type of livestock production system, age, sex, dog ownership, occupation, water source, and religion. Variable considered according to the type of livestock production system was being pastoral or agro-pastoral. Pastoral areas were considered to be Karamoja region, Nakasongola district, and Kasese district. While Teso region was considered to be agro-pastoral area. For age to be considered as a risk factor, age groups were categorized into the following strata: below 20 years, 21-40 years, 41-60 years and >60 years. Variables considered for occupation was one being pastoralist, agro-pastoralist, business person, and having formal or informal employment. Water sources were categorized as being from the well, spring, bore hole, rivers, lake, dams, pools, and tap water. Religions considered were being a Catholic, Protestant, Pentecostal, any other Christian sects, Muslim, and Traditionalist.

Table-1: Distribution of people ultrasound screened for hydatidosis based on sex and region.

Regions	Males	Females	Total	Ratio (M.F)
Karamoja (North East)	580	1113	1693	1:1.9
Teso (East)	134	610	744	1:4.6
Nakasongola (Central)	166	429	595	1:2.6
Kasese (West)	437	167	604	1:0.4
Total	1317	2319	3636	1:1.8

Statistical analysis

Data were entered into Excel 16.0 and analyzed using R statistical software version 3.1.2 (The R Core Team, 2014). Univariate and multivariate logistic regression analysis was performed to identify the key risk factors for the occurrence of CE among those who were found positive on ultrasound scanning. The relationship between the risk factors and occurrence of CE was examined at 95% confidence interval. Variables of values of $p<0.05$ of less likeness of association with CE presence were considered statistically significant. Multivariate logistic regression analysis was performed per region on those variables which were found to have a significant association with CE occurrence on univariate analysis.

Results

There was a CE prevalence of 0.5±0.3% in South Karamoja (Amudat and Nakapiripirit districts), 3.32±1.3% in Central Karamoja (Napak and Moroto districts), 1.21±0.8% in Teso region, 2.15±1.2% in Kasese region, and 2.7±1.3% in Nakasongola region.

Pastoral areas (Karamoja, Nakasongola, and Kasese) had a very highly significantly (X^2=2342;

p<0.001) more CE in humans 2.73% (CI=2.0-3.4) than in agro-pastoral areas of Teso (1.2% (CI=0.4-2.0).

The univariate logistic regression analysis for CE risk factors in different regions was as shown in Table-2. Multivariate logistic regression analysis for the key risk factors for CE in different regions was as shown in Table-3.

In Karamoja, the prevalence of CE significantly varied with district of origin of respondent. Moroto and Napak districts had significantly higher prevalence of CE infection (p<0.05) than Amudat and Nakapiripirit. Nakapiripirit had a significantly lower CE prevalence (0.46%) than the overall mean (1.7%) for Karamoja. In Karamoja, significant differences in infection status exist among different age groups. Risk of CE infection increased with age. Age was identified to be a significant risk factor for CE infection. The use of springs as water sources increased the risk of CE infection by 2.8 times (Odds ratio [OR]=2.8) compared to other sources of water. Females were 2.69 times more likely to test positive (be infected) for CE than males (X^2=3.89, p<0.05). Multivariate logistic regression analysis on key risk factors (age, sex, water sources) for the occurrence of CE in Karamoja region was as shown in Table-3.

In Nakasongola region, univariate analysis showed advanced age >40 to be associated with increased risk of CE infection (Table-2). Those >60 years of age were about 11 times (OR=10.9) more likely to be positive for CE than those aged 21-40 years of age, while those between 41 and 60 years were about 7 times (OR=6.9) more likely to be CE-positive than those between 21 and 40 years of age. Although not statistically significant, males were found to be about 2 times (OR=2.05) more likely to be positive for CE than females. Multivariate logistic regression analysis for key risk factors for the occurrence of CE (age beyond 40 years) in Nakasongola was as shown in Table-3.

In Teso region (Bukedea and Kumi), univariate logistic regression analysis showed occurrence

Table-2: Univariate logistic regression analysis for significant risk factors for occurrence of CE in different pastoral and agro-pastoral areas.

Region	Risk factor	Number examined	Percentage CE prevalence	OR (95% CI)	p value
Karamoja region	Age 41-60	383	3.4	2.0 (0.96-4.10)	0.0417*
	Age<60	80	5.0		0.031*
	Sex: Being female	1138	2.28	2.69 (1.03-7.03)	0.0433*
	Sex: Male	580	0.9		
	Water source being spring	368	4.3	2.61 (1.07-5.77)	0.0173
Nakasongola region	Age 41-60	96	7.2	2.8 (0.96-7.5)	0.0297*
	Age<60	33	13.7	4.96 (1.14-16.77)	0.0169*
	Sex: Being male	166	4.2	2.05 (0.9-3.2)	0.063^{NS}
	Sex: Females	429	2.1		
Teso region	Age<60	76	5.26	4.52 (0.99-16.7)	0.025*
	Dog ownership	196	3.57	10.09 (1.89-100.42)	0.0018**
	Sex: Being male	134	2.23	2.30 (0.2-3.4)	0.058^{NS}
	Sex: Females	610	0.98		
Kasese region	Age<60	16	6.25	3.2 (0.07-25.02)	0.038*
	Dog ownership	207	5.3	11.07 (2.38-103.77)	0.0002***
	Being a Muslin (religion)	41	9.7	4.89 (1.10-16.88)	0.0183*

NS=p>0.05 not significant, *p<0.05 significant, **p<0.01 highly significant, ***p<0.001 very highly significant. CE=Cystic echinococcosis, OR=Odds ratio, CI=Confidence interval

Table-3: Multivariate logistic regression analysis for significant risk factors for CE in different pastoral and agro-pastoral areas.

Region	Variable	OR	SE	Z value	p value
Karamoja region	Intercept coefficient	499,884	0.723	7.88	3.34e-15***
	Age 40-60	122.46	0.768	2.718	0.0066**
	Age<60	405.6	0.878	2.972	0.0021**
	Water source being spring	10.8	0.448	2.309	0.02*
Nakasongola region	Intercept coefficient	40,271	0.711	6.481	0.15e-11***
	Age 40-60	235.5	0.830	2.856	0.0043**
	Age<60	540.7	0.780	2.860	0.0086**
Teso region	Intercept coefficient	14,856	0.843	4.950	7.42e-07*
	Age<60	47	0.787	2.106	0.0352*
	Dog ownership	120.5	0.814	2.558	0.0105*
Kasese region	Intercept coefficient	12.59e91	1.357	6.024	17e-09***
	Age<60	402.7	0.233	2.598	0.0037**
	Dog ownership	121.34	0.800	2.605	0.0092**
	Being a Muslin (religion)	114.3	0.750	2.743	0.0061**

*p<0.05 significant, **p<0.01 highly significant, ***p<0.001 very highly significant. SE=Standard error, CE=Cystic echinococcosis, OR=Odds ratio

CE infection was associated with dog ownership and advanced age >60 years (Table-2). Those >60 years were more likely to be positive for CE (OR=4.5) than other age groups of respondents. Dog ownership associated significantly with increased risk of CE infection (OR=10). Although not statistically significant, males were found to be about 2.27 times (OR=2.3) more likely to be positive for CE than females. Multivariate logistic regression analysis for key risk factors (age, dog ownership) for the occurrence of CE in Teso region (Bukedea and Kumi) was as shown in Table-3.

In Kasese region, univariate logistic regression analysis for CE risk factors showed that there was association of prevalence of CE with age >60 years, dog ownership and being a Muslim were significantly associated with increased likelihood of CE infection. Multivariate logistic regression analysis for key risk factors (age, dog ownership, and being a Muslim) for occurrence of CE in Kasese region was as shown in Table-3.

The variation CE prevalence with age in different regions in Uganda was as shown in Figure-1. The percentage of households owning dogs according to regions was as shown in Table-4. There was high proportion of households keeping dogs in Karamoja than Teso (χ^2=68.4, p<0.001) and Nakasongola region (χ^2=35.6, p<0.001).

Discussion

This study has shown that pastoral areas of Karamoja, Nakasongola, and Kasese had very highly significant more CE infection prevalence in humans than in agro-pastoral areas of Teso region. Pastoralism and herding have been found to be risk factors for prevalence of CE elsewhere. Pastoralism has been a risk factor for the occurrence of CE among the Turkana in Kenya, Toposa and Bouya people in Sudan, and Nyangatom in Ethiopia [4]. Higher prevalence of CE has been reported among nomadic Tibetan communities in China [14-16]. Earlier on pastoralism had been reported as risk factor for CE among pastoralists in Kasese district, Uganda [17,18]. This could be explained by the fact that among pastoralist, livestock keeping was the major activity. Dog-human-livestock interactions were intensive among these communities. Dogs were often kept for security reasons [15,19,20].

It was found that CE prevalence increased with age in all districts with more vulnerable age being age beyond 60 years (Table-2 and Figure-1). In Karamoja, there was clear positive linear trend of increase of CE prevalence with age with the disease appearing at all age groups including those aged below 20 years (Figure-1). Whereas, in Nakasongola and Kasese CE significant first appearance was among those beyond age of 40 years. On contrary, in Teso the disease first appeared among those beyond 60 years. In all districts, CE prevalence was most prevalent among those beyond 60 years. Nakasongola had a highest CE prevalence among those who were beyond the age of 60 years. These findings agreed with what had been observed elsewhere among animal keepers in Denizil, Turkey [21] communities in Ningxia Hui Autonomous Region in China [19,22], among Tibetans in China [15,16] and in Central Ethiopia [23]. This finding was also consistent with the findings in Thessaly region, Central Greece [24] where humans beyond age 65 were significantly associated with seropositivity to IgG antibodies to *E. granulosus*. The high chances of being infected with CE increased with age this could be attributed to increased exposure to worm eggs over a long period. A study similar to this was conducted in Kyrgyzstan and arrived at the same conclusion [25]. Furthermore, the age-dependent increment in infection rate of CE is supported by apparent lack of parasite-induced immunity of naturally infected hosts [14] therefore a chance of getting infected with increasing age is summative.

Karamoja region showed sexual dimorphism to the prevalence of CE, with females having a significantly higher prevalence than males (Table-2). This finding was similar to what had been observed among Turkana, in Kenya [26-28]. Elsewhere similar findings have been reported [15,19,21-23]. This could be due to fact that women were more likely to get in contact with feces of dogs because their daily chores involved activities like fetching water, fruit and vegetable picking, tilling of land to grow crops, weeding of crops, eating of raw tubers like cassava and potatoes without washing and plastering of houses with mud. However, attempts have been made to clarify the role

Table-4: Percentage of households owning dogs according to regions.

Regions	Total number of households	Households owning dogs	Percentage of households owning
Karamoja region	722	465	64.4
Teso region	745	216	29
Nakasongola region	408	132	32.4

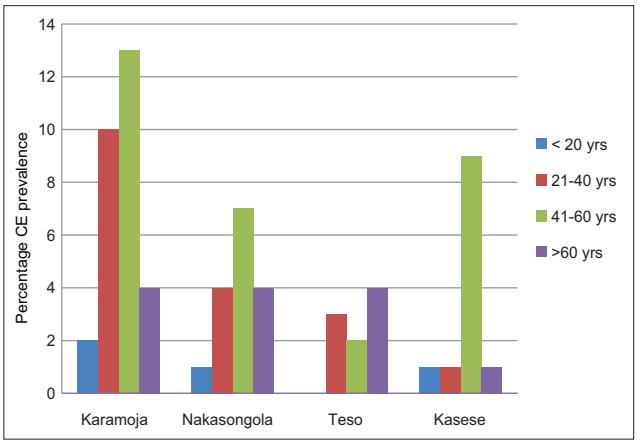

Figure-1: Variation of cystic echinococcosis prevalence with age in various regions.

of sexual dimorphism in CE susceptibility by carrying out experimental infections of mice with hydatidosis [29]. It was demonstrated that feminine hormones (estradiol) could be facilitating success of establishment of CE infection.

Although not statistically significant, in Teso and Nakasongola regions, males were 2.3 and 2.1 times respectively (Table-2) more likely to have CE than females. This could be attributed to the fact males have intimate relationship with dogs especially during hunting expeditions and as security guards as they move with their livestock during dry season.

Unprotected open spring water sources have been shown to be a risk factor in occurrence of CE in Karamoja (Table-2). These water sources were shared with livestock and dogs. Intensity of sharing water increases during water shortage periods during the dry season and drought. The Karamojong practice transhumance form of pastoralism, in which livestock moved and concentrated in a few watering points available during dry periods. A similar situation had been observed in Chinese families where there was unique clustering of CE in Ningxia Hui Autonomous Region [1,22] and among Tibetans, China [14-16]. Elsewhere water source as being a risk for CE has been reported among Turkana [4,30].

Dog ownership was found to be a risk factor in Kasese and Teso region. On contrary in Nakasongola, dog ownership was not shown as risk factor among those who were infected with CE. Dog ownership has been reported as a risk factor of CE among Turkana, Kenya [4,30,31], the Chinese communities [14-16,19,22] and in Morocco [32]. In Kasese and Teso region, the households owning dogs were few as compared to those in Karamoja (Table-4), there was a positive correlation between those having CE and those owning dogs. Earlier studies [17,18] reported dog ownership to be a risk factor for CE in Kasese district. On contrary, in Karamoja region, there was no correlation between those having CE and those owning dogs. This was because there was high proportion of households owning dogs; hence, there was no significant difference in proportion of households owning dogs both in CE infected and CE non-infected households. This means that dog ownership was a risk factor for CE in Karamoja which could not be elucidated by the statistical analysis performed. A recent study [20] reported a prevalence of *E. granulosus* of 14.4% using copro-polymerase chain reaction of among dogs in Moroto district, Karamoja region. On post-mortem, the prevalence of 66.3% had earlier on been reported among dogs in Karamoja [11]. *E. granulosus* infection risk factors for dogs in Karamoja have been reported to be as free access to slaughter places including home slaughter, high livestock populations and lack of knowledge about epidemiology of CE [20].

Religion especially being a Muslim was a risk factor in Kasese region (Table-3). This could be due backyard slaughter of livestock done during religious festival Idi fitri and Idi Aduha. This has been shown to be true among Muslim family clusters in China [22] North Africa and Middle East [33-36]. This was because whenever there were home slaughters dogs were fed on hydatid cysts from the offals. This finding agreed with earlier findings [16,17] made in Kasese district.

From this study, it became apparent that CE was widespread in PAP areas in Uganda, requiring immediate attention. Being a pastoralist, female, increasing age, water source, dog ownership, and being a Muslim were found to be the risk factors. There was, therefore, a need to create awareness of the hazards of CE to the local communities in PAP areas. Furthermore, the local communities and health workers need to be educated about the risk factors promoting the occurrence of CE. CE screening and treatment units according to WHO standards [2] should be established in these areas. Best model(s) of carrying out CE screening and treatment needs to be identified and adopted. This study, therefore, serves as an entry point for this disease to be considered as a serious medical issue in Uganda so that a policy and strategic management plan for CE can be created.

Conclusion

In conclusion, being a pastoralist, a female, increasing age beyond 40 years, open spring water sources, dog ownership and being a Muslim were the risk factors for CE in PAP areas in Uganda.

Authors' Contributions

EO: Participated in research design; field data collection, management and analysis; manuscript development and revision. ALO: Study design, field data collection and reading of manuscript. EM: Study design and manuscript reading. PO: Study design, field data collection and analysis; and manuscript revision. MC: Study design, data collection and manuscript revision. LO: Study design, data collection and manuscript revision. FOI: Study design, field study and manuscript reading. LSA and FE: Study design and manuscript revision. MO: Developed overall CE study concept, participated in study design, field data collection, data analysis, manuscript development and revision. All authors have read and approved the final manuscript.

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Competing Interests

The authors declare that they have no competing interests.

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