Kulabako et al. BMC Infectious Diseases (2024) 24:797
https://doi.org/10.1186/s12879-024-09717-y

BMC Infectious Diseases

RESEARCH

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Understanding brucellosis: knowledge, perceptions, and self-reported prevalence among agro-pastoralists in Nakasongola, Uganda

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Abstract

Background Brucellosis is an infectious zoonotic disease that poses serious health threats around the world including Uganda. Brucellosis is caused by *Brucella* spp., the bacteria being transmitted via contact through skin breaks, via inhalation, or orally through the consumption of raw milk and other dairy products. The aim of this study was to investigate self-reported prevalence, knowledge, and perceptions towards brucellosis transmission, within agro-pastoralist communities in the Nakasongola district, central Uganda.

Methods This study employed a cross-sectional survey design. A semi-structured questionnaire was developed and administered to 398 participants selected through convenience sampling method. The survey gathered information on socio-demographic characteristics, knowledge of brucellosis transmission, symptoms, preventive measures, and self-reported prevalence of brucellosis. Qualitative data involved the use of six focus group discussions, identifying factors for transmission based on their perceived level of risk or impact using ranking by proportional piling.

Results A majority (99.2%, $n=398$) had heard about brucellosis and 71.2% were aware of the zoonotic nature of the disease. There were varied responses regarding transmission routes, symptoms, and preventive measures. Self-reported prevalence was relatively high (55.5%). Following adjusted analysis, factors such as subcounty, source of income, knowledge about symptoms of brucellosis, whether brucellosis is treatable, perception, and living close to animals were statistically significant. Participants from Wabinyonyi had 2.7 higher odds of reporting brucellosis than those from Nabiswera, aOR = 2.7, 95%CI 1.4–5.5. Crop farming and livestock had much higher odds of reporting brucellosis than those earning from casual sources, aOR = 8.5, 95%C 1.8–40.1 and aOR = 14.4, 95%CI 3.1–67.6, respectively. Those who had knowledge about symptoms had 6.9 higher odds of reporting brucellosis than who mentioned fever, aOR = 4.5, 95%CI 2.3–18.3. Likewise, living close with animals and handling aborted fetuses (aOR = 0.4, 95%CI: 0.17–0.86), (aOR = 0.2,95% CI: 0.07-0.0.42,) had significantly lower odds for self-reported prevalence compared to those who believed did not cause brucellosis. Risk factors identified included, handling of aborted

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fetuses and living in close proximity with animals. Overall, there was a moderate statistical agreement in the ranking across the focus groups discussion ($W^c = 0.48$, $p < 0.01$; $n = 6$).

Conclusion While awareness of brucellosis is high in the community, understanding of the transmission routes, clinical symptoms, and preventive measures varied. Investigating the understanding and assessing knowledge, perceptions and self-reported prevalence in this region indicated a necessity for risk communication strategies and community-based interventions to better control brucellosis transmission.

Keywords Brucellosis, Self-reported prevalence, Perception, Knowledge, Agro pastoralists, Uganda

Introduction

Brucellosis is an infectious zoonotic disease that poses serious health and socio-economic impacts [1]. Brucellosis is prevalent in many parts of the world with more than 500,000 human cases occurring globally every year [2]. World Health Organization (WHO) has prioritized brucellosis as a neglected zoonosis disease, which can cause disease in both animals and humans [3, 4]. Brucellosis is a food borne and an occupational disease [5]. Various types of *Brucella* spp. pose significant risks to public health, with *B. melitensis* and *B. suis* being more virulent to humans than *B. abortus* and *B. canis* [6]. Nevertheless, complications can arise from any *Brucella* species. Infections typically occur via skin abrasions through direct contact with infected animals or materials, involving blood, aborted fetuses and placenta, or uterine secretions from infected animals. Transmission can also happen through inhalation, or via the consumption of raw milk and other dairy products. While brucellosis can affect any individual from the general public, certain occupations, such as veterinarians, butchers, abattoir workers, meat inspectors, and farmers, are particularly susceptible to a higher risk of exposure and contracting the disease [7].

The disease prevalence in humans varies from country to country but tends to be in the range of 5–50% for example, 5% in Tanzania, 41% in Togo, 40% in Libya, and 11% in Uganda [8]. Brucellosis has been reported to be endemic in areas of South western Uganda and among agro-pastoralists in the cattle corridor, with a seroprevalence of 14% in cattle and 11% in humans [9] The district has over 400,000 livestock, with households having a herd population ranging from 50 to 200 indigenous/local domestic livestock with a cultural connection to their animals [10] and increased brucellosis prevalence percentages reaching up to 30% at the individual-animal level have been documented in this region [11]. Thus, living and sustaining life in this region also exposes the community to a socially risky environment because of its rural nature with poor health and social services, with livestock being a potential disease reservoir. It's therefore imperative to understand the knowledge and perceptions of the affected communities in Nakasongola.

Although studies done in Uganda indicate the presence of brucellosis, they have focussed on the prevalence among animals [12, 13], and brucellosis among humans at hospitals considering Health Management information System (HMIS) records and patients tested in government hospital [14, 15]. Human brucellosis is well known for its wide range of symptoms that are unspecific; and is often clinically indistinguishable from other infectious diseases, such as malaria, typhoid or Leptospirosis [16]. Diagnosing the disease therefore typically relies on laboratory tests which may not be accurate [17]. According to the health facility records in Nakasongola, laboratory diagnosis for the disease is based primarily on the febrile antigen *Brucella* agglutination test (BAT). In a recent study, the FBAT demonstrated relatively low specificity, with values ranging from 65.2 to 75%; this performance was notably poorer compared to other tests like the RBT [17]. Despite its shortfalls, BAT is used because of its availability, whereas other methods require appropriate infrastructure and are technically too complex for resource limited settings [18].

The understanding of self-reported prevalence is poorly documented leading to underreporting and poor estimation of brucellosis incidence in the region. Just like self-reported health [19], self-reported prevalence is used as a measure of health when more extensive measurements of health, such as health care and diagnostic services, are lacking. Also, there are variations in knowledge and perceptions of brucellosis across different regions and demographics. Studies conducted in various locations such as Namibia [20], Tanzania [21] and Uganda [22] reveal differing levels of knowledge, attitudes, and practices regarding brucellosis among different groups. Knowledge and perception may have huge implications on disease control, as they involve understanding, beliefs and a person's way of perceiving it [23]. Relevant knowledge fosters both the motivation to act and the capability to act appropriately and productively [24]. However, there is a gap in research concerning the knowledge, perceptions, and self-reported prevalence of brucellosis within the Nakasongola cattle corridor communities, posing a significant challenge for disease awareness and dissemination. Assessing knowledge, perceptions and self-reported prevalence in these communities could contribute to better risk communication strategies and interventions to improved control of brucellosis transmission.

Methods

Study area

Nakasongola district is located in the central region of Uganda on latitudes 055 N 1 40′ N and longitudes 31 55 E and 3250 E, and lies between 3400 and 3800 ft. above sea level (Fig. 1). The district has an estimated population of 181,795 of both crop and livestock farmers [25]. However, Nakasongola rangelands are predominantly used for livestock production (cattle, goat and sheep), under the communal grazing systems [26]. The district has 9 sub counties, and this study took place in three of the sub counties, Nabiswera, Nakitoma and Wabinyonyi (Fig. 1). The three sub-counties were selected because of the high cattle number and high seroprevalence against brucellosis, ranging from 4.5 to 19.5% in cattle, and rendering the communities susceptible to the disease [11]. The livestock sector contributes over 4.6% to Uganda's Gross Domestic Product(GDP) at the current prices of 2022/2023 [27] The projections of Uganda's transformative growth and GDP are expected to increase by 175% and consumption of livestock products to more than triple due to increased population growth thus impacting on the livelihood and public health. Nakasongola district GDP per capita(US dollars) is about 334 [28] hence strengthening the nexus between improved quality of life and the livestock economy. Anecdotal reports and district records indicate that livestock is a cash cow contributing over 40% to Nakasongola revenue: people derive their livelihood from beef and milk [29]. Livestock farming significantly contributes to the livelihoods of over 60% of Nakasongola District's population, indicating a substantial economic impact on the district's GDP [30].

Study design and sampling

A cross-sectional study was carried out between December 2023-February 2024 using a semi-structured questionnaire (*supplementary 1).* A multi-phase sampling was conducted for the survey with a selection of three sub counties that were purposively selected because of their cattle number [10] and high human brucellosis incidence (District Health Management Records). Parishes and villages were then selected, respectively, with the help of the veterinary extension worker in order to identify the sampled villages that are occupied by households as some villages were mainly farmland/grazing land. A total of 398 participants were then conveniently selected regardless of their health status. Nakasongola district is one of the hotspots for brucellosis in animals [32], therefore an exposure assessment was done entailing exposure

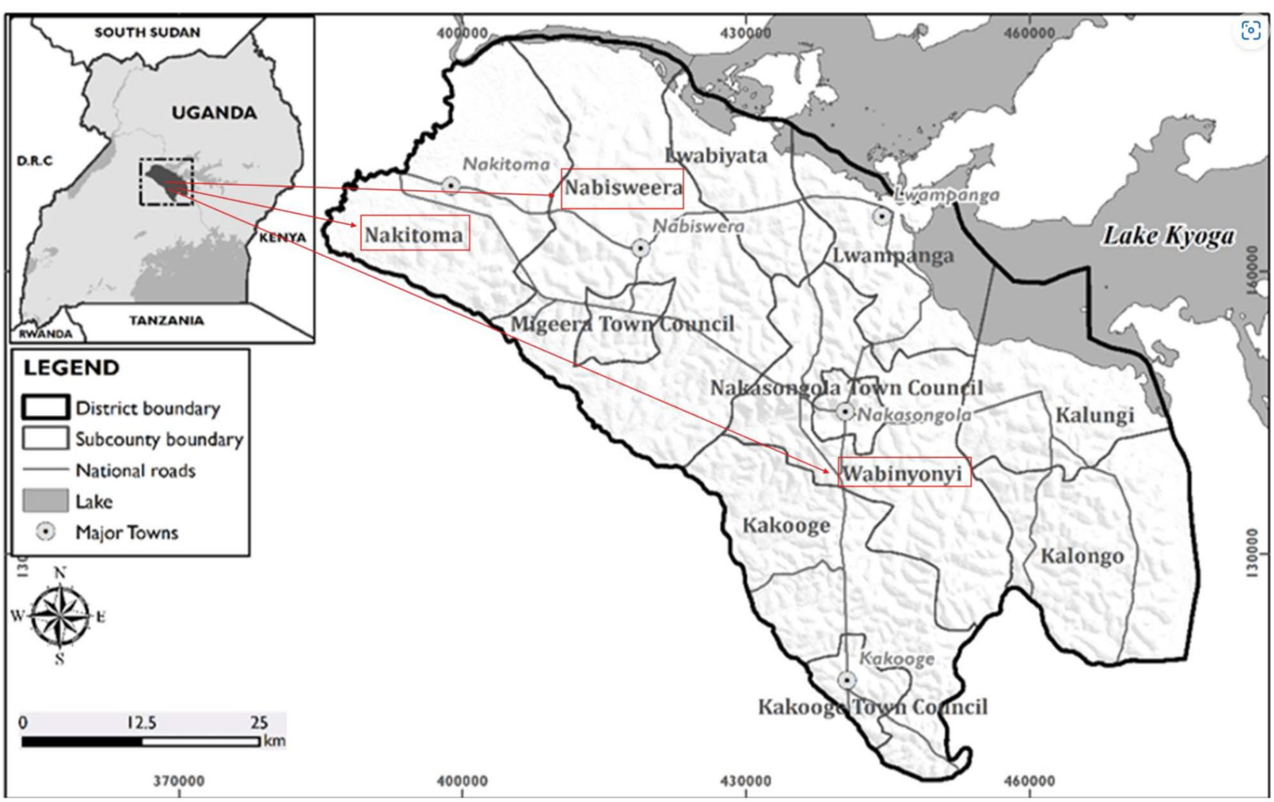

Fig. 1 Map of Nakasongola showing the two study areas (coloured) of Nakitoma, Wabinyonyi and Nabiswera sub counties. Source [31]

history like occupational risks, dietary practices and animal contact. This enabled the possible identification of individuals that have had a history of brucellosis. The sample size was determined by estimating the proportion of the population in the specific sub-counties [33]. The questionnaire was pretested among a population that had similar key characteristics to identify any anomalies and to ensure the questions were understood and elicited the necessary information. Interviewers were also trained about the objectives of the study and issues regarding ethics before data collection. Participants both in the survey and Focus group discussion (FGD) had to be living and working in the selected sub-counties for purposes of relevance, representativeness and eliciting data that is context-specific.

Participants for the focus group discussion were purposively selected within the three sub-counties, with the help of local village leaders, resulting in six focus groups with 8–10 participants each, in order to provide sufficient range of perceived risk factors for transmission of brucellosis. These leaders, being familiar with the community members, helped the researchers to identify individuals who could provide valuable insights into the perceived risk factors for the transmission of brucellosis. Participants in the FGD were mainly community members, volunteer health extension workers and these consisted of both males and females. The inclusion of both male and female participants in the discussions was not intended for gender disaggregation but for gender inclusion purposes in this particular study.

Data collection

For quantitative data, we used a semi-structured questionnaire that was interviewer-participant administered. The participants were asked if they had been diagnosed with brucellosis for a period of less or equal to 1 year prior to the study to elicit self-reported prevalence. To minimize the possibility of false self-reports; we requested for hospital/clinic/laboratory patient books from the participant. In Ugandan health system, a patient has got a copy of medical records in a small exercise book or printed laboratory findings-these indicate diagnosis, laboratory test and treatment. Follow up questions on the symptoms and treatment got were also asked to ascertain validity. Closed-ended questions were used to assess peoples' knowledge and perceptions on transmission and risk factors, prevention, symptoms and treatment of brucellosis. The questionnaire also captured the sociodemographic characteristics of the participants that included subcounty of residence, gender, age, education, and source of income.

Qualitative data was collected using FGDs, to generate information on risk perception. Six [6] FGDs were carried out. These FGDs took place within rural areas affected by brucellosis, primarily comprising volunteer extension workers, community leaders, as well as other community members aged 18 years and above. During the interaction, the participants were asked to identify and list what they perceived as the transmission and preventive measures for brucellosis. The listed factors were then written on cardboards after consensus within the group. We then used ranking by proportional piling [34] to rank the factors according to their most impactful occurrence. The results were based on consensus and despite the volunteer extension workers being more knowledgeable it was controlled during recruitment indicating their role and minimising dominance during the discussions. The FGDs took approximately between 1 and 2 h and participants gave their consent before commencement of the study. This was done after the study's purpose was read to them.

Data analysis

Prior to performing the data analysis, the data underwent a process of cleaning and coding as these are vital steps in preparing data for statistical analysis. The variables include demographic factors such as sub-county, age group, sex, and education, as well as factors related to respondents' knowledge and perceptions about brucellosis. For each variable, the number and percentage of respondents in each category who reported having a history of brucellosis (Yes) and those who did not (No) were reported. In order to evaluate possible history of brucellosis, participants were asked about their experiences of whether they have been diagnosed with brucellosis within a period of ≤ 1 year. These responses were then categorized to denote diseased levels, with (0) representing not diseased and (1) indicating diseased. Logistic regression was used to model the relationship between the outcome variable (history of brucellosis) and the predictor variables (demographic factors, knowledge and perceptions about brucellosis) with 95% confidence intervals (CI), and the statistical significance was determined by p-value ≤ 0.05 in the final model. The factors with a p-value of ≤ 0.25 were considered for inclusion in the multivariable logistic regression analysis. They included socio-demographic characteristics, such as sub-county of residence, education and source of income; knowledge-based factors such as awareness of clinical symptoms and the zoonotic nature of brucellosis, and whether brucellosis is treatable; perception-based factors (handling of aborted foetuses and materials, living close to animals) were considered for the multivariable logistic model ($p \leq 0.25$). These variables were retained in the model if the likelihood ratio test demonstrated statistical significance ($p \leq 0.05$). Moreover, a multivariable logistic regression analysis was conducted using the manual backwards Wald method. This approach aimed to evaluate the association between these variables and while controlling for the effect of other variables, hence predicting the final. The adjusted Odds Ratios (aORs) with 95% CI were computed from a multivariable logistic regression model allowing the researchers to control for potential confounding factors. All the statistical analyses were performed utilizing SPSS software version 26.0.

Qualitative data was analysed using Kendall's coefficient of concordance (W) [35], where level of agreement between focus groups was assessed. Every group was assigned the responsibility of pinpointing 4–5 risk factors and arranging them in order of importance. Data gathered on the average number of beans from each group was categorized into high, medium, and low risk levels in relation to risk factors of transmission of brucellosis. This task involved not only identifying these factors but also evaluating them based on their perceived level of risk or impact. The overall rank for each activity was then summarized using mean and ranked from the highest to the lowest.

Results

Demographic characteristics of study participants

A total of 398 participants were surveyed comprising of 219 (55%) females and 179 (45%) males. In this study, Wabinyonyi sub-county had the highest number of participants 148/398 (37.2%), slightly over a third of the participants in the survey. There were 132 (33.2%) respondents from Nabiswera, and 118 (29.6%) from Nakitoma. Most of the participants had attained primary education 179/398 (45%) as their highest level of education with the minority 53/398(13.3%) having no formal education. The majority of participants 153/398(38.4%) in this study were in the age bracket (25–34 years). Farming was a major source of income, with 183/398(46%) of the participants engaged in livestock farming, and 104/398(26.1%) were engaged in crop farming as shown in Table 1.

Knowledge aspects regarding brucellosis transmission and prevention

The findings showed that 99.2% of the participants reported that they have heard about brucellosis, while only 0.8% indicated they did not. Among the clinical symptoms, fever was reported by 21.4% of respondents, malaise by 10.6%, and pain by 51.5%, while 15.8% of respondents reported experiencing both fever, malaise and pain. The majority (71.1%) of respondents believed that brucellosis affects both humans and animals, while 17.8% believed it affects only humans. The majority of the participants 95.5% believe that brucellosis is treatable. Most respondents (68.1%) indicated the use of conventional medicine for treatment, while some (11.6%) preferred herbs, and 18.6% used both. Proper cooking of milk and meat was reported by 51.5% of respondents as a preventive measure, while 31.9% mentioned proper hygiene, as illustrated in Table 2.

Perceptions of risk factors for transmission of brucellosis

In Tables 3 and 86.2% of the participants believed that drinking raw milk may cause brucellosis, while only 12.1% believed it does not. The vast majority (96.0%) of participants believed that eating meat of sick animals causes brucellosis. A significant proportion (66.8%) of

Table 1 Socio demographic characteristics of the participants

Variable	Category	Freq. (*n* = 398)	Percent (%)
Subcounty	Nabiswera	132	33.2
	Nakitoma	118	29.6
	Wabinyonyi	148	37.2
Gender	Female	219	55
	Male	179	45
Age	18–24	23	5.8
	25–34	153	38.4
	35–44	111	27.9
	45–54	74	18.6
	55 and above	37	9.3
Education	None	53	13.3
	Primary	179	45
	Secondary	128	32.2
	University/Tertiary	38	9.5
Source of Income	Casual worker[#]	14	3.5
	Crop Farmer	104	26.1
	Livestock	183	46
	Others[*]	97	24.4

*other: Traders, business stalls, charcoal business; [#]Casual worker: no specified source of income

Table 2 Frequencies of knowledge among the study participants

Variable	Category	Freq ($n=398$)	Percent (%)
Heard about brucellosis	No	3	0.8
	Yes	395	99.2
What are the symptoms	Fever	85	21.4
	Malaise	42	10.6
	Pain*	205	51.5
	All the above	63	15.8
	I don't know	3	0.8
Who does it affect	Humans	71	17.8
	Animals	33	8.3
	Both	283	71.1
	I don't know	11	2.8
Is brucellosis treatable	No	6	1.5
	Yes	380	95.5
	I don't know	12	3.0
Where do people go for treatment	Medicine	271	68.1
	Herbs	46	11.6
	Both	74	18.6
	I don't know	7	1.8
How can it be prevented	Proper cooking of milk and meat	205	51.5
	Proper hygiene	127	31.9
	All the above	63	15.8
	I don't know	3	0.8

*=Joint pain, headache and backache

Table 3 Perceptions of risk factors of brucellosis

Variable	Category	Freq. ($n=398$)	Percent (%)
Does drinking raw milk causes brucellosis	No	48	12.1
	Yes	343	86.2
	I don't know	7	1.8
Does eating meat of sick animals cause brucellosis	No	9	2.3
	Yes	382	96.0
	I don't know	7	1.8
Does living close with animals cause brucellosis	No	126	31.7
	Yes	266	66.8
	I don't know	6	1.5
Does handling of aborted fetuses cause brucellosis	No	72	18.1
	Yes	319	80.2
	I don't know	7	1.8

participants believed that living close with animals may cause brucellosis, while 31.7% believed it does not.

Factors for self-reported prevalence, knowledge and perceptions of brucellosis transmission

The prevalence of self-reported brucellosis among the participants being diagnosed with brucellosis in the period of ≤1 year prior to the study was 221 (55.5%), while 177 (44.5%) reported to have not been diagnosed with brucellosis (Table 4).

Among the factors assessed using multivariate logistic regression, staying in the subcounty of Wabinyonyi had significantly higher odds (cOR=2.7, 95% 1.63–5.51 $p=0.005$ of the self-reported prevalence compared to those in Nabiswera. The cOR of 4.6 suggests that crop farmers were 4.6 times more likely to have a history of brucellosis compared to casual workers. This association was statistically significant ($p=0.024$. After adjusting for other variables in the model, the (aOR) increased to 8.5 ($p=0.007$). Similarly, those involved in livestock were 6.5 times more likely to report a history of brucellosis compared to casual workers (cOR=6.5, $p=0.005$). After adjustment, aOR increased to 14.4 ($p=0.001$). Participants reporting all the symptoms (fever, malaise, and pains) were significantly more likely to have a history of brucellosis compared to those reporting only fever (cOR=10.8). After adjustment, the odds ratio decreased slightly to 6.9 (aOR), but remained highly statistically

Table 4 Population characteristics, self-reported prevalence of brucellosis among agropastoral communities in Nakasongola district of Uganda (*N* = 398) analysed using bivariable and multivariable-logistic regression

		History of Brucellosis*			
Variable	**Category**	**No = 177(44.5)**	**Yes = 221 (55.5)**	**cOR (95%CI), *p*-value**	**aOR (95%CI), *p*-value**
Subcounty	Nabiswera	66 (50)	66 (50)	Ref	
	Nakitoma	66(55.9)	52(44.1)	0.7(0.48–1.29), 0.349	0.9(0.48–1.93), 0.922
	Wabinyonyi	45(30.4)	103(69.6	2.2(1.40–3.73), 0.001	2.7(1.36–5.51), 0.005
Age group	18–24	9(39.1)	14(60.9)	Ref	
	24–34	71(46.4)	82(53.6)	0.7(0.3–1.8), 0.515	
	35–44	56(50.5)	55(49.5)	0.6(0.25–1.57), 0.325	
	45–54	27(36.5)	47(63.5)	1.1(0.42–2.92), 0.819	
	55 and above	14(37.8)	23(62.2)	1.0(0.36–3.07), 0.920	
Sex	Female	94(42.9)	125(57.1)	Ref	
	Male	83(46.4)	96(53.6)	0.8(0.58–1.29), 0.491	
Education	None	20(37.7)	33(62.3)	Ref	
	Primary	69(38.5)	110(61.5)	0.9(0.51–1.82), 0.915	
	Secondary	70(54.7)	58(45.3)	0.5(0.026–0.97**)**, 0.039	
	University/Tertiary	18(47.4)	20(52.6)	0.6(0.28–1.56), 0.359	
Source of Income	Casual	11(78.6)	3(21.4)	Ref	
	Crop farmers	46(44.2)	58(55.8)	4.6(1.22–17.54), 0.024	8.5(1.79–40.14), 0.007
	Livestock	66(36.1)	117(63.9)	6.5(1.75-24-13), 0.005	14.4(3.07–67.6), 0.001
	Others	54(55.7)	43(44.3)	2.9(0.77–11.13), 0.117	3.3(0.75–16.49), 0.111
Symptoms	Fever	61(71.8)	24(28.2)	Ref	
	Malaise	24(57.1)	18(42.9)	1.9(0.88–4.12), 0.102	2.2(0.83–5.86), 0.109
	Pains	77(37.6)	128(62.4)	4.2(2.44–7.33), < 0.001	4.5(2.27-18-25), < 0.001
	All the above	12(19.0)	51(81.0)	10.8(4.92–23.72), < 0.001	6.9(2.63–18.25), < 0.001
	I don't know	3(100)	-	-	
Who does it affect	Humans	28(39.4)	43(60.6)	Ref	
	Animals	22(66.7)	11(33.3)	0.3(0.14–0.77), 0.011	
	Both	116(41.0)	167(59.0)	0.9(0.55–1.59), 0.812	
	I don't know	11(100)	-	-	
Is brucellosis treatable	No	1(16.7)	5(83.3)	Ref	
	Yes	168(44.2)	212(55.8)	0.2(0.03–2.18), 0.211	0.1(0.03–0.7), 0.015
	I don't know	8(66.7)	4(33.3)	0.1(0.01–1.17), 0.067	29(13.23–63.6), < 0.001
Drinking raw milk cause brucellosis	No	26(54.2)	22(45.8)	Ref	
	Yes	145(42.3)	198(57.7)	0.6(0.88–2.96), 0.122	
	I don't know	6(85.7)	1(14.3)	0.1(0.02–1.76), 0.146	
Total Knowledge	Poor	13(59.1)	9(40.9)	Ref	
	Good	164(43.6)	212(56.4)	1.8(0.78–4.47), 0.161	
Total Perception	good	130(68.4)	60(31.6)	Ref	
	Poor	47(22.6)	161(77.4)	7.4(4.75–11.59), < 0.001	26.8(12.42–58.3), < 0.001
Where do people go for treatment	Medicine	111(41.0)	160(59.0)	Ref	
	Herbs	25(54.3)	21(45.7)	0.5(0.031–1.09), 0.092	
	Both	34(45.9)	40(54.1)	0.8(0.48–1.37), 0.442	
	I don't know	7(100)	-	-	
Eating sick animals causes brucellosis	No	4(44.4)	5(55.6)	Ref	
	Yes	167(43.7)	215(56.3)	1.0(0.27–3.8), 0965	
	I don't know	6(85.7)	1(14.3)	0.1(0.01–1.61), 0.113	
Living close with animals causes brucellosis	No	62(49.2)	64(50.8)	Ref	
	Yes	110(41.4)	156(58.6)	1.3(0.89–2.1), 0.144	0.4(0.17–0.86), 0.019
	I don't know	5(83.3)	1(16.7)	0.2(0.02–1.71), 0.139	-
Handling of abortus causes brucellosis	No	33(45.8)	39(54.2)	Ref	
	Yes	138(43.3)	181(56.7)	1.1(0.64–1.79), 0.779	0.2(0.07–0.42), < 0.001
	I don't know	6(85.7)	1(14.3)	0.1(0.02–0.20), 0.073	-

Table 4 (continued)

Variable	Category	History of Brucellosis* No = 177(44.5)	Yes = 221 (55.5)	cOR (95%CI), *p*-value	aOR (95%CI), *p*-value
How can brucellosis be prevented	Proper cooking of milk and meat	77(37.6)	128(62.4)	Ref	
	Proper hygiene	85(66.9)	42(33.1)	0.3(0.19–0.47), < 0.001	
	All the above	12(19.0)	51(81.0)	2.5(1.28–5.09), 0.009	
	I don't know	3(100)	-	-	

*Self-reported cases of Brucellosis

Table 5 Community perceptions of factors associated with with risk of transmission of brucellosis and prevention in Nakasongola district, Uganda, 2023. Proportional piling scores for the five identified risk factors are indicated for each group ($n = 6$). The overall rank was derived from the mean score across all groups

Perceptions on Brucellosis	FGD1	FGD2	FGD3	FGD4	FGD5	FGD6	Mean score (M^n)
handling of aborted fetuses causes brucellosis	36	37	38	30	32	31	34.0^1
living close with animals cause brucellosis	23	25	34	27	31	27	27.8^2
drinking raw milk causes brucellosis	17	10	6	18	10	20	13.5^3
boiling milk prevent brucellosis	24	10	12	14	6	9	12.5^4
eating meat of sick animals cause brucellosis		18	10	11	21	13	12.2^5

$M^{(n)}$ where n is the rank, Wc 0.48, $p < 0.01$

[i]interpretation of Kendall's coefficient of concordance: $W < 0.34$, $P > 0.05$ (weak agreement); $W = 0.34–0.48$, $P < 0.05$ (moderate agreement); $W > 0.48$, $P < 0.01$ (strong agreement). *FGD* Focus Group

significant. reporting pains were significantly more likely to have a history of brucellosis compared to those reporting fever (cOR = 4.2; $p < 0.001$) indicating strong statistical significance. After adjustment, the odds ratio increased to 4.5 (aOR), $p < 0.001$. Participants with poor perception had 27 higher odds more for experience of brucellosis compared to those with good perception (OR = 26.8, 95% CI: 2.-58.3, $P = 0.001$). Participants who answered 'Yes' to living close with animals (OR = 0.4, 95% CI: 0.17–0.86, $p = 0.019$) and to handling aborted fetuses and materials (OR = 0.2,95% CI: 0.07-0.0.42, $p < 0.001$) had significantly lower odds for self-reported prevalence: Table 4.

Community perceptions of factors associated with risk of transmission of brucellosis and prevention

A total of five factors were identified by the six groups (Table 5) that were perceived to contribute to brucellosis transmission. Handling of aborted fetuses, living close with animals especially goats and sheep, and drinking raw milk were the most frequently identified. Handling of abortus was the top ranked factor and perceived as most important in all the six focus groups. Overall, there was a moderate statistical agreement in the ranking of all 5 factors across the six focus groups (W^c 0.48, $p < 0.01$; $n = 6$).

Discussion

Brucellosis is primarily an animal disease, but humans can contract it by handling diseased animals or by eating contaminated animal products [36]. Therefore, the prevalence of brucellosis in animals is generally reflected in the incidence of the disease in people [37]. In this study, overall self-reported prevalence of brucellosis was high (55%), which was higher as compared to a study that estimated a prevalence of 23.3% (97/416) among febrile patients attending Wau hospital in South Sudan [38] and 7.5% among only febrile non-malaria cases in Uganda [39]. In concurrence with this study, previous studies in Nigeria [40] reported a relatively high prevalence of 44% among butcher workers. A previous study found the highest brucellosis prevalence in the age-group between 15 and 30 years among patients with pyrexia of unknown origin (PUO) [41], which resonates with our study that found high prevalence among the same age group. However, the difference in their proportions compared to the study could be due to the fact that we employed a cross sectional design and data from self-reporting which make participants more willing to reveal relevant information necessary in research. Also, the fact that some studies are taken from participants in the hospital setting allowing capture of data and the burden of the diseases that is limited to the hospital settings rather than in the general population. Also, the findings in the study show that the participants had a poor total perception having 27 higher odds more for experience of brucellosis, this could possibly explain the high prevalence within the region. Interestingly, the high prevalence of brucellosis in our study could further be attributed to the fact that our research was predominantly in a district in the cattle corridor which is characterised with a high level of contact (consumption) with animals and animal products such as milk. The direction of the link may go either way. Cattle corridor is home to the majority of the Uganda's cattle and small ruminant populations, making up approximately 60% of the country's total livestock [12]. The area is marked by intricate patterns of movement among cattle, small ruminants, and close interaction [42]. These patterns can have significant implications, potentially facilitating the transmission of brucellosis thus increasing prevalence. The movement of animals, whether for trade, grazing, or other purposes, can spread diseases from infected to healthy animals, and to humans exacerbating disease outbreaks.

The majority of the participants (99.2%) demonstrated a high level of knowledge about brucellosis, which aligns well with observations from another study [43] that reported that 96% of the respondents had heard about brucellosis, 70% knew how it is spread, and 60% perceived it as a health problem. The high level of knowledge could be attributed to the fact that the area is hotspot for brucellosis implying that outbreaks are likely to have increased their vigilance and understanding of the disease. Owing to the high literacy level among the participants, the high knowledge could also be as a result of their level of education. Though, data shows high level of knowledge, there is need to translating this knowledge into consistent practices hence reduction in the prevalence of brucellosis. Furthermore, a study among cattle farmers, meat handlers, and medical professionals in Namibia found that overall awareness of brucellosis was 43.50% [20]. This however is different with a study among agro-pastoral community in Kilombero district, Tanzania [21] that found that the community was lacking the understanding of the biomedical concept of brucellosis and attributed symptoms to mystical reasons instead. The differences in the level of knowledge may be attributed to lack of a consistent measure tool which is implying a need for globally recognized research institutions to develop a scale for assessing knowledge [44]. This would facilitate accurate comparisons of knowledge levels across various studies, populations and environments.

A significant proportion of the participants demonstrated a positive perception concerning the transmission routes of brucellosis mentioning handling of aborted fetuses and living close with the animals having more impact. Although, the participants showed awareness of the transmission routes, the self-reported prevalence was high because often times, when brucellosis is endemic in the region, the baseline prevalence may be high, making it difficult to reduce incidence even with good awareness and practices. Continuous exposure to infected animals can perpetuate the cycle of infection. Also, a difference or gap between knowledge and practice could perpetuate continuous infection. It implies a need for more community engagement and strengthened health education. However, this is in contrast to a study in Kenya [45] which reported that 55 (82%) mentioned drinking of raw milk as the main route of transmission. The perception towards milk differs among cultures, being shaped by elements such as socioeconomic status, religious convictions, and cultural significance [46] that often impacts its consumption. This then influences perception of it as a major cause of brucellosis. For instance, in many cultures, milk and dairy products hold a significant place in traditional diets and rituals [47], which influence the perception and consumption of milk, and changing these habits can be challenging. If milk is consumed raw or not properly pasteurized, and if the animals providing the milk are infected with *Brucella* bacteria, the risk of brucellosis increases. Therefore, understanding these cultural perceptions towards milk is crucial for public health efforts to control and prevent brucellosis. Health education campaigns, for example, need to consider these cultural factors to effectively communicate the risks associated with consuming contaminated milk and to promote safe milk handling and consumption practices [12].

Being a livestock farmer was associated with greater odds (aOR = 14.4) of self-reported prevalence; a study in Malaysia [48]also found the odds of having brucellosis are 7.19 times higher in farmers compared to non-farmers. Brucellosis is a disease often linked to occupation, and livestock farmers have been identified as one of the groups most at risk for contracting this disease. However, a study among small ruminant dairy farmers [49] found the odds ratio for the occurrence of brucellosis in goat farmers was 1.8 times compared to sheep farmers. The participants identified symptoms of brucellosis and "all the above" (fever, pain, malaise) as the main symptoms of brucellosis (95% CI: 2.63–18.25, P = ≤0.001). This highlights the importance of recognizing symptoms and having a comprehensive understanding of the disease for early detection and prevention among livestock farmers. A strong association with perception (aOR = 26.8, 95% CI: 2.4,58.3, P = <0.001) was also observed. Understanding the causes and modes of transmission of brucellosis plays a pivotal role in facilitating comprehension and acceptance of preventive interventions, which are imperative for mitigating disease spreading within agro-pastoral populations. Further still, this study found a strong and significant association between self-reported prevalence and living close with animal (aOR = 0.4, $p = 0.019$) and handling aborted fetuses (aOR = 0.2, p = <0.001). Also, in the FGDs, during risk factor rankings, handling of aborted fetuses and materials and living close with animals were ranked highest. This finding is in alignment with a study in Pakistan on assessing knowledge, perceptions and one-health [50] who identified perception of avoiding living close to animals or handling abortus decreased self-reported prevalence. As results from the FGD denote awareness of the risk, individuals handling aborted fetuses might follow strict health and safety protocols, reducing their risk of adverse health outcomes. Such insights can help shape public health recommendations and occupational health guidelines. However, despite being aware of the risks, the consumption of raw milk was ranked low in terms of riskiness during the FGDs. This could be due to the significant cultural importance attached to milk, which compels individuals to continue engaging in potentially risky behaviours related to livestock interactions, such as drinking raw milk. The cultural importance of milk consumption denotes disease management strategies that need to consider more than just health risks - they also need to address the complex interplay of culture, behaviours, and health education that goes beyond simply raising awareness about the risk of consuming raw milk.

Conclusions

This study assessed self-reported prevalence, the knowledge, and perceptions of agro-pastoralists in Nakasongola district. A high number of participants self- reported a history of brucellosis. Although the data may need to be interpreted with caution because it was based on self-reports; such data provides valuable insights into the burden of brucellosis as perceived by affected individuals hence offering details on the frequency of symptoms experienced, healthcare-seeking behaviour, and the perceived impact on livelihoods and well-being. Additionally, self-reported data can aid in detecting under-reporting or misdiagnosis of brucellosis cases, thus illuminating the true scope of the disease within populations. The perceptions of communities regarding brucellosis are pivotal in influencing health-seeking behaviours and preventative measures among agro-pastoralists in Nakasongola. Cultural beliefs and perceptions of the disease's severity and mode of transmission shape individuals' attitudes towards brucellosis prevention and control. Understanding these community perceptions is crucial for developing interventions that are culturally appropriate and for addressing obstacles to accessing healthcare. Agro-pastoralists in Nakasongola display varying levels of knowledge about brucellosis. While some individuals demonstrate a deep understanding of the disease, its transmission methods, and preventive measures, others may have limited awareness or hold misconceptions. Therefore, raising awareness in a manner that translates knowledge into actionable steps is significant. The presence of knowledge gaps concerning brucellosis symptoms, diagnosis, and treatment highlights the necessity for tailored health education programs in these communities.

Limitations

While the study identified causal association between self-reported prevalence, knowledge, and perception, it's important to note that these are not necessarily causal relationships as discrepancies in habits and customs cannot be obtained, given the cross-sectional design of the study. In future investigations, there may be a need to employ in-depth qualitative study to render it more credible and could provide further insights into the dynamics of these relationships. Also, reliance on self-reported prevalence may raise questions about the reliability of the findings, however this was validated using follow up questions of the symptoms and treatment of the disease during the survey. Whilst, we also acknowledge that the high self-reported prevalence in this region presents a significant diagnostic challenge for clinicians. To address this, there is an urgent need for enhanced diagnostic services with precise diagnostic specificity. This includes the development and validation of point-of-care tests and testing strategies, including future research to take samples for patients with febrile illnesses in this area using more precise diagnostic specificity tests for better understanding of the prevalence.

Supplementary Information

The online version contains supplementary material available at https://doi.org/10.1186/s12879-024-09717-y.

Supplementary Material 1

Acknowledgements

We acknowledge funding obtained from Norwegian Agency for Development Cooperation (NORAD) through the NORHED-II Program and the project Climate Change and Infectious Diseases - A One Health Approach (CIDIMOH), grant number 68802. Further, great thanks to Makerere University Research and Innovation Fund (MakRif-PhD) for part of data collection.

Author contributions

Conceptualization: CTK, SN, PA. Methodology: CTK, LRN, JO, CA, DOKSupervision: PA, SN, MT. Writing – original draft: CTK. Writing – review & editing: CTK, LRN, DOK, CA, PA, SN and MT. All authors contributed to the article and approved the submitted version.

Funding

Data collection for this paper was supported with funding from the project-Climate Change and Infectious Diseases - A One Health Approach (CIDIMOH) under NORAD.

Data availability

All data supporting the results and conclusion of this paper are included in the article.

Declarations

Ethics approval and consent to participate

Ethical approval was sought from Makerere Social Sciences Research Ethics Committee (MAKSSREC 0823698). Scientific and ethical clearance to conduct this study was obtained from the Uganda National Council for Science and Technology (UNCST) with reference number of SS2223ES. In addition, permission and clearance was obtained to conduct the study from the Chief Administrative Office (CAO) of Nakasongola District. Participants gave written informed consent using a consent form that was signed during data collection. Participation was voluntary, anonymous thus confidentiality was maintained as only the identifier numbers were used for the participants.

Consent for publication
Not applicable.

Competing interests
The authors declare no competing interests.

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Received: 20 May 2024 / Accepted: 5 August 2024
Published online: 08 August 2024

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