ORIGINAL ARTICLE

Prevalence and predictors of risk factors for Brucellosis transmission by meat handlers and traditional healers' risk practices in Ibadan, Nigeria

H.K. ADESOKAN[1], P.I. ALABI[2], M.A. OGUNDIPE[1]
[1]Department of Veterinary Public Health and Preventive Medicine, University of Ibadan, Nigeria; [2]Department of Epidemiology and Medical Statistics, University College Hospital Ibadan, Nigeria

Keywords

Brucellosis • Public health • Risk factors

Summary

Introduction. *Brucellosis is endemic in Nigeria and risk factors enhancing its transmission are prevalent.*
Methods. *Following serological evidence of brucellosis and isolation of B. abortus from slaughtered cattle in Ibadan, Nigeria, we administered a semi-structured questionnaire to determine the prevalence and predictors of eating and selling bovine gravid uterus among 350 meat handlers from five major meat processing facilities. We conducted key informant interview for five leading traditional healers to document its use. Data were analyzed using Stata 12.*
Results. *The prevalence of eating and selling gravid uterus were 29.7% and 40.3% respectively. Being meat/offal processor (OR=1.9, 95%CI: 1.11-3.3, P = 0.008) and not knowing that eating undercooked contaminated gravid uterus could expose humans to brucellosis (OR=19.5; 95%CI: 5.73-66.03; P = 0.000) were strong predictors of eating gravid uterus. Similarly, being adult (OR = 1.7, 95%CI: 1.08-2.57, P = 0.02) and inadequate knowledge of brucellosis as a preventable disease (OR = 0.03; 95%CI: 0.004-0.27, P = 0.001) predicted selling gravid uterus. Qualitative data from the traditional healers revealed using gravid uterus as special medicinal preparations to hasten parturition in overdue pregnancies, treat infertility and old age diseases in humans.*
Conclusions. *We demonstrated a high prevalence of risk factors for brucellosis transmission, and some meat handlers' socio-demographic characteristics and brucellosis knowledge-based markers as predictors of these factors. The traditional healers' practices portend a challenge to the current brucellosis control strategy. These findings provide insights into designing all-inclusive health programmes aimed at controlling brucellosis spread in Nigeria and other similar settings in developing countries.*

Introduction

Brucellosis is one of the most important zoonoses in the world [1]. The disease is endemic in many regions of the world, including Latin America, the Middle East, Africa, Asia and the Mediterranean basin [2]. The global burden of the disease in humans remains enormous with more than 500,000 infections per year worldwide [2-4]. It has been reported as an important cause of Fever of Unknown Origin [5] and particularly among the occupationally exposed groups, [6] as it is often easily misdiagnosed as other febrile syndromes such as malaria and typhoid fever, thereby resulting in mistreatments and underreporting [7]. Meanwhile, all brucellosis infections in humans are due to direct or indirect contact with infected animals or animal materials [8] and the incidence is directly related to the prevalence of the disease in animals, socioeconomic level, eating habits, poor hygiene and practices that expose humans to infected animals or their products [9]. It is acquired in people through breaks in the skin following direct contact with infected animals' tissues or blood or their secretions. Infection may also result from consumption of contaminated unpasteurised milk and milk products [10] as well as undercooked contaminated meat [11, 12].

Human brucellosis is widespread in Nigeria, particularly among the occupationally exposed groups. In the North-Eastern part of the country, Baba et al. [13] reported a 5.2% prevalence of brucellosis among 500 occupationally exposed patients. In another study in North-Central part of the country, 43.8% of the 7.8% brucellosis infected hospital patients were abattoir workers [14]. In addition, Aworh et al. [15] documented a 24.1% seroprevalence of brucellosis among abattoir workers at the Federal Capital Territory, Abuja, Nigeria. Over 55% of 7161 people examined in different parts of western Nigeria had positive *Brucella abortus* antibodies in their sera, with higher incidences of titres found among dairy farmers and slaughter men than the general population [16].

Specifically, continuous evidences of serological prevalence of brucellosis among the slaughtered cattle in Ibadan, South-Western Nigeria abound ranging between 5.31 and 8.6% [17-20]. In humans, Cadmus et al. [18] reported a high seroprevalence of 66.3% of brucellosis among apparently healthy abattoir workers while recent unpublished data confirmed isolation of *B. abortus* from slaughtered cattle in the same area. Despite these, the

practice of eating and selling gravid uterus is common among meat handlers. In addition, traditional healers reportedly make use of gravid uterus locally called *abodi alaka* for some concoctions; whereas, a gravid uterus sustains the growth of *Brucella* organism [21, 22]. The risk is potentiated by the habit of eating uncooked or undercooked meat as well as poor handling during food preparation [11, 23]. This study was aimed at determining the prevalence and predictors of the risk behaviours of eating and selling gravid uterus by meat handlers and also documenting usage of this organ by leading traditionalists in Ibadan, Nigeria.

Materials and methods

Study Design, Site and Population

This cross-sectional study was conducted in Ibadan, Nigeria. Nigeria is the most populous country in Africa (over 170 million in 2012; http://esa.un.org/wpp/ASCII-Data/DISK_ NAVIGATION_ASCII.htm) with an estimated livestock population of 20.49 million cattle, 23.07 million sheep, 28.07 million goats, 6.54 million pigs (http://www.fao.org/ag/againfo/ resources/en/glw/GLW_dens.html),18,200-90,000 camels, and 210,000 horses (http://faostat.fao.org/site/573/default.aspx#ancor) [24]. It ranks second of the four countries (Nigeria, India, Ethiopia, and Bangladesh) that account for 44% of poor livestock keepers globally [25]. Ibadan is located in South-Western Nigeria and lies between latitude $7^{0}32^{1}$N and longitude $3^{0}54^{1}$E. It is the third largest metropolitan area, by population, as well as the largest metropolitan geographical area in the country. Previous and on-going reports showing serological evidence of brucellosis [17-20] as well as isolation of *B. abortus* (unpublished data) in slaughtered cattle in this study area abound. The study was carried out using the five major government-owned meat processing facilities which supply meat to the teeming population of over 2 893 137 people [26] in the area, including its surrounding environments. These meat processing facilities were chosen on the basis of the populations of their workers (Oyo State Department of Agriculture and Rural Development, personal communication) while the food animals slaughtered represent more than 65% of the slaughtered animals in the area.

The study spanned a period of two months. The population at the meat processing facilities from which the respondents were selected consisted of meat butchers, meat/offal processors, meat buyers and children. The inclusion criteria for selection of potential participants were being meat handlers actively participating in meat processing operations and being at least 18 years of age. A meeting was held with all the potential participants on the objectives and benefits of the study and were informed that they could choose either to participate or not in the study. They were then grouped based on the slaughter halls where each of them worked. A pretest was conducted among ten randomly selected meat handlers, after which some of the questions were modified to improve clarity. Thereafter, visits were made based on the groupings and all consenting participants who met the inclusion criteria, excluding those who participated in the pretest, were interviewed. Each of them was allotted a code on the questionnaire. The researchers made provisions for interpreters for those who did not understand English, but only their local language. In all, only 17 people among those who met the inclusion criteria and were asked to be interviewed declined participation. In addition, the researchers identified a key leader who was knowledgeable about the traditional settings in each of the areas where the meat processing facilities used were located. These key leaders assisted the researchers in identifying the leading traditional healers in the areas for interview.

Data collection and analysis

Data for this study on the participating meat handlers were collected using a semi-structured interviewer-administered questionnaire by well-trained personnel. The questionnaire included three parts. In the first part, we attempted to determine the socio-demographic profiles of the respondents including the age groups (18-40 years as young adult and > 40 years as adult), sex, highest education received, nature of occupation and length of years already spent as workers in meat processing. The second part had five questions to determine their knowledge on bovine brucellosis as it relates to its transmission to humans with response options of 'yes', 'no' or 'I don't know'. The third part contained five questions inquiring about their risk behaviours including whether or not they eat, or sell gravid uterus with response options of either 'yes' or 'no'. Using a key informant interview, the identified leading traditional healers were asked questions on their uses of gravid uterus as well as on issues related to their awareness and knowledge of brucellosis transmission with respect to their practices. Their responses were documented, collated and summarized.

The central study outcome variables from the questionnaires on the meat handlers were whether the respondents did or did not eat or sell gravid uterus and those who indicated eating or selling it were classified as high risk and those who did not as low risk. The independent variables were demographic variables and knowledge-based markers related to brucellosis. Data were analyzed using Stata 12.0 (StataCorp LP, Texas, USA) and were tabulated based on the risk category. The values in each category were presented together with their respective percentages. Univariate analysis was first done on all variables using chi-squared statistic with Fisher's exact test when necessary to determine potential variables for the logistic regression model. A multivariate unconditional logistic regression analysis was done using the variables that were statistically significant at 10% level. Backwards stepwise regression was used with the least significant variable removed at each stage until the model contained only those factors which were significant at the 5% level. All tests were two-tailed and p-values of less than or equal to 5% were considered significant.

The odds ratios were reported with their 95% confidence intervals (CI).

Results

A total of 350 meat handlers and five leading traditional healers participated in this study. Out of these meat handlers, 104 (29.7%) and 141 (40.3%), respectively affirmed eating and selling gravid uterus, thereby constituting the high risk groups (Tab. I). Based on socio-demographic characteristics, 50.9% were young adults, 62.9% were male respondents, 52.3% had primary education, 57.1% were meat/offal processors and 64.0% had been in meat processing facilities as workers for more than ten years (Tab. II).

Assessment of predictors of eating gravid uterus by meat handlers

Of all the socio-demographic variables, only being meat/offal processors (P = 0.008) was the significant factor associated with eating gravid uterus. The meat/offal processors (OR: 1.9, 95% CI: 1.11-3.30) respondents were about two times more likely to eat gravid uterus than the butchers (Table II). Furthermore, the low risk group (those who did not eat gravid uterus) demonstrated significantly better knowledge than those who ate gravid uterus. For instance, 18.3% of the low risk group and only 1% of the high risk group knew that *Brucella*-contaminated gravid uterus could contaminate other raw meat or food materials by contact (P = 0.000). Again, 38.2% of the low risk group and only 2.9% of the high risk group knew that consumption of under-cooked or raw contaminated gravid uterus could expose humans to infection with brucellosis (P = 0.000). However, the two groups did not differ significantly (though the low risk group demonstrated higher knowledge level) in whether or not brucellosis was a preventable disease (P = 0.322) (Table III). Overall, not knowing that consumption of undercooked or raw contaminated gravid uterus could expose humans to brucellosis (OR = 19.5, 95%CI: 5.73-66.03, P =0.000) and that it could contaminate other food materials or raw meat (OR = 15.6, 2.05-118.92, P =0.008) were the strong predictors of eating gravid uterus by the meat handlers. Lower risks of eating gravid uterus were predicted by having heard of brucellosis and knowing brucellosis as a zoonosis (Tab. III).

Assessment of predictors of selling gravid uterus by meat handlers

Only being adult (OR: 1.7, 95% CI: 1.08-2.57, P = 0.02) of all the socio-demographic variables examined was the strong predictor of selling gravid uterus by meat handlers,

Tab. I. Prevalence of risk factors for brucellosis transmission to humans among meat handlers in Ibadan, Nigeria (n = 350).

Variable	N (%; 95% CI)
Eat gravid uterus	104 (29.7; CI: 24.9 - 34.5)
Sell gravid uterus to unsuspecting buyers as some other meat parts	141 (40.3; CI: 35.2 - 45.4)
Do not wear protective coverings when handling gravid uterus	289 (82.6; CI: 78.6 - 86.6)
Do not separate gravid uterus from other raw meat	131 (37.4; CI: 32.3 - 42.5)
Do not wash hands after handling gravid uterus	215 (61.4; CI: 56.3 - 66.5)

Tab. II. Socio-demographic characteristics of meat handlers in relation to the risk factor of eating gravid uterus in Ibadan, Nigeria (n = 350).

Variable	Category	Total n (%)	Do not eat gravid uterus (n = 246) %	Eat gravid uterus (n = 104) %	Univariate *P*-value	Logistic regression OR, 95% CI, *P*-value
Age	Young adult	178 (50.9)	50.4	51.9	0.80	NA*
	Adult	172 (49.1)	49.6	48.1		
Gender	Male	220 (62.9)	61.4	66.3	0.38	NA*
	Female	130 (37.1)	38.6	33.7		
Education	None	60 (17.1)	15.4	21.2	0.39	NA*
	Primary	183 (52.3)	54.1	48.1		
	Post-primary	107 (30.6)	30.5	30.8		
Duration in meat processing facilities (in years)	≤ 10	126 (36.0)	35.4	37.5	0.70	NA*
	> 10	224 (64.0)	64.6	62.5		
Occupation	Butchering	150 (42.9)	45.5	36.5	0.02	
	Meat/offal processing	200 (57.1)	54.5	63.5		1.9, 1.11-3.30, 0.008

*NA: Variables not significant at univariate analysis and were not included for logistic regression.

Tab. III. Knowledge levels of brucellosis by meat handlers in Ibadan, Nigeria with respect to risk category (n = 350).

Variable	Total n (%)	Do not eat gravid uterus (n = 246) %	Eat gravid uterus (n = 104) %	Univariate *P*-value	Logistic regression OR, 95% CI, *P*-value
Have you heard of brucellosis?					
Yes	14 (4.0)	4.1	3.8		
No	336 (96.0)	95.9	96.2	0.015	0.2, 0.04-0.71, 0.016
Does brucellosis spread from animals to man?					
Yes	9 (2.6)	3.7	0.0		
No	111 (31.7)	23.2	51.9		7.3; 0.89-60.42; 0.065
I don't know	230 (65.7)	73.1	48.1	0.000	2.2; 0.27-18.19; 0.457
Does *Brucella*-contaminated gravid uterus contaminate other food material/raw meat by contact?					
Yes	46 (13.1)	18.3	1.0		
No	101 (28.9)	30.5	25.0		15.6; 2.05-118.92; 0.008
I don't know	203 (58.0)	51.2	74.0	0.000	27.5; 3.72-203-57; 0.001
Does consumption of under-cooked or raw contaminated gravid uterus expose humans to brucellosis infection?					
Yes	97 (27.7)	38.2	2.9		
No	94 (26.9)	23.6	34.6		19.5; 5.73-66.03; 0.000
I don't know	159 (45.4)	38.2	62.5	0.000	21.7; 6.58-71.38; 0.000
Is brucellosis a preventable disease?					
Yes	14 (4.0)	4.9	1.9		
No	76 (21.7)	20.3	25.0		
I don't know	260 (74.3)	74.8	73.1	0.322	NA*

*NA: Variables not significant at univariate analysis and were not included for logistic regression.

with the adult respondents being almost two times more likely to sell gravid uterus than the young adult group (Tab. IV). With respect to knowledge-based markers for brucellosis transmission, the low risk group demonstrated significantly better knowledge than the high risk group, except on the questions that related to whether or not consumption of contaminated gravid uterus could expose humans to brucellosis as well as whether brucellosis was a preventable disease or not (Table V). In all, lower risks of selling gravid uterus were predicted by knowing that consumption of contaminated gravid uterus could expose humans to brucellosis infection (OR = 0.2, 95%CI: 0.13-0.44, $P = 0.000$) and that brucellosis was a preventable disease (OR = 00.3, 95%CI: 0.004-0.27, $P = 0.001$) (Tab. V).

Qualitative data from traditional healers on the usage of gravid uterus

Qualitative data from the leading traditional healers' key informant interview revealed high risk behaviour for brucellosis transmission. Responding to the question on what they used gravid uterus for, they said "*We usually use it to treat some health conditions associated with old age, to hasten parturition in overdue pregnancies as well as to treat infertility in women*". According to them, gravid uterus was made into special medicinal preparations for the affected individuals to eat. However, none of the traditional healers knew any animal disease that could be associated with gravid uterus neither were they aware of the possibility of brucellosis transmission from eating contaminated gravid uterus.

Discussion

The global burden of human brucellosis remains enormous [2, 4]. Though eradicated in many developed countries after years of effort, the disease is still a major neglected zoonosis of developing countries, including Nigeria [1]. The incidence is directly related to the prevalence of the disease in animals, eating habits, poor hygiene and practices that expose humans to infected animals or their products [9]. As such, livestock workers, including meat handlers, have been incriminated in the spread of human brucellosis in Nigeria [15, 27-28]. Poor hygiene and eating of raw or improperly cooked contaminated meat, the practices characteristic of meat handlers in Nigeria are known to favour the spread of brucellosis [11-12]. In order to reduce the spread of human brucellosis in the country, knowledge about the predictors of the risk factors of eating and selling gravid uterus known to sustain *Brucella* organisms is essentially required. This current study presents the socio-demo-

Tab. IV. Socio-demographic characteristics of meat handlers in relation to the risk factor of selling gravid uterus in Ibadan, Nigeria (n = 350).

Variable	Category	Total n (%)	Do not sell gravid uterus (n=209) %	Sell gravid uterus (n=141) %	Univariate *P*-value	Logistic regression OR, 95% CI, *P*-value
Age	Young adult	178 (50.9)	56.0	43.3	0.02	
	Adult	172 (49.1)	44.0	56.7		1.7; 1.08-2.57; 0.02
Gender	Male	220 (62.9)	66.5	57.5	0.085	1.5; 0.95-2.29, 0.086
	Female	130 (37.1)	33.5	42.6		
Education	None	60 (17.1)	17.2	17.0		
	Primary	183 (52.3)	50.7	54.6	0.733	NA*
	Post-primary	107 (30.6)	32.1	28.4		
Duration in meat processing facilities (in years)	≤ 10	126 (36.0)	38.8	31.9	0.191	NA*
	>10	224 (64.0)	61.2	68.1		
Occupation	Butchering	150 (42.9)	44.5	40.4	0.45	NA*
	Meat/offal processing	200 (57.1)	55.5	59.6		

*NA: Variables not significant at univariate analysis and were not included for logistic regression.

Tab. V. Knowledge levels of bovine brucellosis by meat handlers in Ibadan, Nigeria with respect to risk category of selling gravid uterus (n = 350).

Variable	Total n (%)	Do not sell gravid uterus (n = 209) %	Sell gravid uterus (n = 141) %	Univariate *P*-value	Logistic regression OR, 95% CI, *P*-value
Have you heard of brucellosis?					
Yes	14 (4.0)	4.8	2.8		
No	336 (96.0)	95.2	97.2	0.362	NA*
Does brucellosis spread from animals to man?					
Yes	9 (2.6)	4.3	0.7		
No	111 (31.7)	39.2	19.9		2.7; 0.32-22.54; 0.359
I don't know	230 (65.7)	56.5	79.4	0.000	7.6; 0.94-61.69; 0.058
Does *Brucella*-contaminated gravid uterus contaminate other food material/raw meat by contact?					
Yes	46 (13.1)	13.9	12.1		
No	101 (28.9)	22.5	38.3		2.0; 0.96-4.01; 0.065
I don't know	203 (58.0)	63.6	49.7	0.006	0.9; 0.46-1.75; 0.751
Does consumption of under-cooked or raw contaminated gravid uterus expose humans to brucellosis infection?					
Yes	97 (27.7)	15.8	45.4		
No	94 (26.9)	30.6	21.3		0.2; 0.13-0.44; 0.000
I don't know	159 (45.4)	53.6	33.3	0.000	0.2; 0.13-0.37; 0.000
Is brucellosis a preventable disease?					
Yes	14 (4.0)	0.5	9.2		0.03; 0.004-0.27;
No	76 (21.7)	25.4	16.3		0.001
I don't know	260 (74.3)	74.2	74.5	0.000	0.1; 0.01-0.40; 0.005

*NA: Variables not significant at univariate analysis and were not included for logistic regression.

graphic factors of meat handlers and brucellosis knowledge-based markers which influence the occurrence of the risky practices of eating and selling gravid uterus in Nigeria. It also reports the implications of traditional healers' usage of gravid uterus on the epidemiology and control of human brucellosis in the country.

To our knowledge, this study appears to be the first to investigate the predictors of the risk factors of eating and selling gravid uterus by meat handlers in Nigeria as well as traditional healers' practices in relation to brucellosis transmission. This study has established a high prevalence of risk factors for human brucellosis infection including the primary outcomes of interest, namely eating and sell-

ing gravid uterus by meat handlers. These include: eating gravid uterus (29.7%); selling gravid uterus to unsuspecting buyers (40.3%); not wearing protective coverings when handling gravid uterus (82.6%), not washing hands after handling gravid uterus (61.4%) and not separating gravid uterus from other meat parts (37.4%).

Our findings showed that almost one-thirds and above two-fifths of the meat handlers, respectively engaged in eating and selling gravid uterus. These practices by this high risk occupational group are a matter of public health concern considering the prevailing serological evidences of brucellosis and reported isolation of *B. abortus* from the same population of slaughtered cattle (unpublished data) in the study area. The ingestion of tissues, foodstuff or fluid containing *Brucella* organism is a route of brucellosis transmission [11]. As such, there is a high risk for human infection with brucellosis among these meat handlers and other potential consumers who are exposed, given the habit of eating raw or improperly cooked meat which is common amongst livestock keepers and meat handlers in Nigeria [28, 29] and amongst Africans in general [11, 12]. In addition, poor hygienic practices characteristic of meat handlers and most households in developing countries, including Nigeria [30, 31], could as well enhance the transmission of the organism. As reported, handling and preparation of infected meat and offal without proper hygienic precautions may lead to contamination of other foods [32]. Similarly, while brucellosis is a worldwide known abortifacient disease [33] and an important cause of infertility in infected animals [34], routine use of gravid uterus from brucellosis endemic cattle population by the traditional healers in treating health conditions associated with old age, overdue pregnancies and infertility is startling. The need to investigate indigenous or traditional handling of animals and animal products in the epidemiology of human diseases, including brucellosis in Nigeria and other developing countries, becomes apparent.

Evaluation of demographic variables showed that at least one or more of being adult respondents and meat/offal processors were significantly associated with the high risk factors of eating and selling gravid uterus by the meat handlers. In this study, although not statistically significant, the male respondents were about two times more likely to sell gravid uterus than the female respondents. This finding is in agreement with the reports of some other workers with respect to risk taking by the male respondents. Hambolu et al. [29] observed that being male respondents was an important predictor of the high risk behaviour of consumption of *fuku elegusi* (tuberculosis-infected lungs) amongst abattoir workers in Nigeria. According to Courtenay [35] and Davidson et al. [36], predominance of risk-taking amongst male humans is inherently related to the social construction of masculinity. In addition, male subjects are more involved in the care and management of animals as well as processing of meat than the female subjects; hence, they are likely to be more involved in risk practices associated with the occupation. Again, the report of European Commission [37] on risk taking in food handling indicated that women seem to be somewhat more susceptible to worry when it comes to the risk perceptions. This explains whythey have a lower tendency to be involved in taking risks. Other studies [38-39] have also consistently shown men to have less than ideal food hygiene practices and a significantly lower knowledge of food safety issues.

Furthermore, the adult meat handlers were about twice more likely to be involved in the sale of gravid uterus than the younger age group. Adult meat handlers have been reported to exhibit lower food safety practices [31]. Likewise, Altekruse et al. [40] reported that unsafe practices were reported more often by men and adults. This occurrence among the adult meat handlers might be associated with the observation that they often feel unconcerned with any possible consequences that could be associated with such risky practices for lack of evidence-based immediate effects on them. And since brucellosis mimics other febrile conditions and could be latent for years [41], they always tend to equate any feverish conditions they experience to either malaria or typhoid fever.

The study also showed that meat/offal processors were twice more likely to eat gravid uterus than the butchers. The reason for this might be because the meat/offal processors generally have more direct contact with gravid uterus considering the nature of their work. Generally, offal processors have a more constant contact with viscera, gravid uterus and fetal membranes of infected animals (the preferred sites of localization of the bacteria) and are generally more prone to contract brucellosis [42, 43]. Hence, there is a higher likelihood of eating the products they often deal in than the butchers who only have occasional contact since the offal processors end up processing all the viscera/offals from various slaughtered animals.

Although the low risk group exhibited better knowledge levels than the high risk group, it is disheartening that the knowledge levels of the entire population on issues related to brucellosis, its transmission and prevention were far below average. Ordinarily, one would expect people drawn from such a high risk occupation to be prioritized with messages regarding brucellosis. This poor knowledge as well as the risky practices coupled with the endemicity of bovine brucellosis in cattle population [44, 45] in Nigeria is a matter of public health concern. This is evident by the high seroprevalence of human brucellosis reported amongst livestock workers in Ibadan, South-Western Nigeria [18]. Reports from Tanzania also showed highest seroprevalence of brucellosis amongst abattoir workers, particularly those involved in the slaughtering and cleaning of slaughtered animal parts [46] and a 48% seroprevalence amongst families associated with livestock keeping [12]. Alavi et al. [47] also reported an association between work practices and *Brucella* infections amongst nomads in Khuzestan, Iran.

Our findings notwithstanding; one limitation of this study is the use of only government-owned meat processing facilities. Inclusion of private meat facilities could have

given more comprehensive insights. However, the findings of this study are generalizable to meat handlers in Nigeria as the chosen facilities are typical of other meat processing facilities in terms of conditions of the facilities and the ways by which meat handlers are regulated. Despite this limitation, the study has demonstrated a high prevalence of risk factors for human brucellosis transmission as well as some socio-demographic characteristics of meat handlers and knowledge-based markers as predictors of risk factors of eating and selling gravid uterus in Ibadan, Nigeria. It has also reported risk practices by traditional healers that could serve as a limiting factor to brucellosis control in the area. The information provided are very important insights in understanding the epidemiology of human brucellosis in Nigeria and thus serve as critical baseline data for informed control and prevention of the disease in the country. Overall, we recommend the need for all-inclusive brucellosis control programmes, taking into consideration the roles of meat handlers and traditional lifestyles in the epidemiology of human brucellosis in Nigeria. Such risk factors might not be limited to Nigeria alone, but also common among other developing countries particularly in sub-Saharan Africa. As such, there is a need for both national and international relevant stakeholders to synergistically formulate policies towards raising awareness campaigns about zoonoses in general among the high risk occupational groups in developing nations of the world.

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The authors declare that there is no conflict of interest whatsoever.

Authors' contributions

HKA initiated the concept and design of the study and wrote the manuscript; PIA did the statistical analysis and was involved in the writing of the manuscript; and MAO did the data collection and wrote the first draft of the manuscript. All authors read and approved the final version of the manuscript.

References

[1] World Health Organization, Food and Agriculture Organization of the United Nations & World Organization for Animal Health. *Report of the WHO/FAO/OIE joint consultation on emerging zoonotic diseases*, World Health Organization, Geneva 2004.

[2] Pappas G, Papadimitriou P, Akritidis N, Christov L, Tsianos EV. *The new global map of human brucellosis*. Lancet Infect Dis 2006;6:91-9.

[3] Dean AS, Crump L, Greter H, Schelling E, Zinsstag J. *Global burden of human brucellosis: a systematic review of disease frequency*. PLoS Negl Trop Dis 2012;6:e1865.

[4] Minas M, Minas A, Gourgulianis K, Stournara A. *Epidemiological and clinical aspects of human brucellosis in Central Greece.* Jpn J Infect Dis 2007;60:362-6.

[5] Ciftçi E, Ince E, Doğru U. *Pyrexia of unknown origin in children: a review of 102 patients from Turkey.* Ann Trop Paediatr 2003;23:259-63.

[6] Pathak AD, Dubal ZB, Doijad S, Raorane A, Rodrigues S, Naik R, Naik-Gaonkar S, Kalorey DR, Kurkure NV, Naik R, Barbuddhe SB. *Human brucellosis among pyrexia of unknown origin cases and occupationally exposed individuals in Goa Region, India.* Emerg Hlth Threats J 2014;7:238-46.

[7] Bax HI, Van Veelen ML, Gyssen IC. *Brucellosis, an uncommon and frequently delayed diagnosis.* Netherlands J Med 2007:2:352-5.

[8] Corbel MJ, Nicoletti PL, Young EJ. *Brucellosis: epidemiology and prevalence worldwide*. In: Young EJ, Corbel MJ, eds. *Brucellosis: Clinical and laboratory aspects.* Boca Raton: CRC Press 1989.

[9] Swai ES, Schoonman L. *Human brucellosis: seroprevalence and risk factors related to high risk occupational groups in Tanga Municipality, Tanzania*. Zoonoses Public Hlth 2009;56:183-7.

[10] Georgiou P, Nicholas A, Mile B, Epameinondas T. *Brucellosis*. New Eng J Med 2005;352:2325-36.

[11] John K, Fitzpatrick J, French N, Kazwala R, Kambarage D, Mfinanga GS, MacMillan A, Cleaveland S. *Quantifying risk factors for human brucellosis in rural northern Tanzania*. PLoS ONE 2010;5:e9968.

[12] Shirima GM, Fitzpatrick J, Kunda JS, Mfinanga GS, Kazwala RR, Kambarage DM, Cleaveland SC. *The role of livestock keeping in human brucellosis trends in livestock keeping communities in Tanzania*. Tanzanian J Hlth Res 2010;12:203-7.

[13] Baba MM, Sarkindared SE, Brisibe F. *Serological evidence of brucellosis among predisposed patients with pyrexia of unknown origin in the north eastern Nigeria.* Central European J Public Hlth 2001;3:158-61.

[14] Ofukwu AR, Yohanna CA, Abuh HA. *Brucella infection among hospital patients in Makurdi, North central Nigeria*. Niger J Parasitol 2006;16:73-78.

[15] Aworh MK, Okolocha E, Kwaga J, Fasina F, Lazarus D, Suleman I, Poggensee G, Nguku P, Nsubuga P. *Human brucellosis: seroprevalence and associated exposure factors among abattoir workers in Abuja, Nigeria - 2011*. Pan Afr Med J 2013;16:103.

[16] Alausa O, Awoseyi A. *Brucellosis: the situation in Western Nigeria*. Trop Geogr Med 1976;28:54-9.

[17] Ishola OO, Ogundipe GAT. *Sero-prevalence of brucellosis in trade cattle slaughtered in Ibadan, Nigeria*. Trop Vet 2001;19:17-20.

[18] Cadmus SIB, Ijagbone IF, Oputa HE, Adesokan HK, Stack JA. *Serological survey of brucellosis in livestock animals and workers in Ibadan, Nigeria*. Afr J Biomed Res 2006;9:163-8.

[19] Cadmus SIB, Osikoya IE, Adesokan HK. *Brucellosis in trade cattle in Lagos State: an investigation of two Abattoirs*. Nig Vet J 2009;29:43-46.

[20] Bwala DG, McCrindle C, Fasina FO, Ijagbone I. *Abattoir characteristics and seroprevalence of bovine brucellosis in cattle slaughtered at Bodija Municipal Abattoir, Ibadan, Nigeria*. J Vet. Med Animl Hlth 2015;7:164-8.

[21] Crawford RP, Huber JD, Adams LG. *Epidemiology and surveillance.* In: Nielsen K, Duncan BO, eds. *Animal brucellosis.* CRC Press 1990, pp. 131-151.

[22] McEntee M. *The uterus: degenerative and inflammatory lesions*. In: *Reproductive pathology of domestic mammals.* San Diego, California: Academic Press, Inc. 2012.

[23] Momoh HA, Ijale GO, Ajogi I, Okolocha EC. *Risk factors and level of awareness of canine brucellosis in Jos, Plateau State, Nigeria*. J Vet Med Animl Hlth 2015;7:39-44.

[24] Adamu NN, Ajogi I. *Serological investigations of camels*

(Camelus dromedarius) slaughtered at Kano municipal abattoir for evidence of brucellosis. Trop Vet 1999;18:45-8.

[25] International Livestock Research Institute. *Mapping of poverty and likely zoonoses hotspots.* Nairobi, Kenya: ILRI, 2012. http://cgspace.cgiar.org/handle/10568/21161. (Accessed June 24, 2014).

[26] Wahab B. *Ibadan: a rapidly growing city in need of a master plan*. Paper read at the Architects' Congress/Annual General Meeting organized by the Nigerian Institute of Architects, Oyo State Chapter, held at Penrose Event Centre, Obafemi Awolowo Avenue, Old Bodija Estate, Ibadan 2011. Available at: http://socsc.ui.edu.ng/WBWahab. (Accessed August 15, 2015).

[27] Adamu NB, Adeniyi SO, Adamu SG, Bale JOO, Okoh AEJ, Umaru GA, Umar YA. *Seroprevalence of brucellosis among livestock workers at Maiduguri cattle market, Borno State, North Eastern, Nigeria*. J. Public Hlth Epidemiol 2015;7:253-7.

[28] Adesokan HK, Alabi PI, Stack JA, Cadmus SIB. *Knowledge and practices related to bovine brucellosis transmission amongst livestock workers in Yewa, south-western Nigeria*. J South Afr Vet Asso 2013;84.

[29] Hambolu D, Freeman J, Taddese HB. *Predictors of Bovine TB risk behaviour amongst meat handlers in Nigeria: a cross-sectional study guided by the Health Belief Model.* PLoS ONE 2013;8:e56091.

[30] Bloomfield SF, Nath KJ. *Home Hygiene in Developing Countries: Prevention of infection in the home and the peri-domestic setting. Training resource for developing countries*. International Scientific Forum on Hygiene 2013. Available at: http://www.ifh-homehygiene.org/training-best-practice/home-hygiene-developing-countries-prevention-infection-home-and-peri-domest-0.

[31] Adesokan HK, Raji AO. *Safe meat-handling knowledge, attitudes and practices of private and government meat processing plants' workers: implications for future policy*. J Prev Med Hyg 2014;54:10-6.

[32] Ali FHM, Mahdey EA. *Incidence of Brucella species in slaughtered food animals and its edible offal at Beni-suef, Egypt*. Global Vet 2010;5:248-54.

[33] Ocholi RA, Kwaga JKP, Ajogi I. *Phenotypic characterization of Brucella strains isolated from livestock in Nigeria*. Vet Microbiol 2004;103:47-53.

[34] Adamu NB. *Epidemiology of Brucella infection in ruminants and humans and its public health implications in Borno state, Nigeria*. PhD thesis. Ahmadu Bello University, Zaria, Nigeria: Veterinary Public Health and Preventive Medicine Department. 2009.

[35] Courtenay WH. *Constructions of masculinity and their influence on men's well-being: a theory of gender and health*. Social Science Med 2000;50:1385-1401.

[36] Davidson KW, Trudeau KJ, van Roosmalen E, Stewart M, Kirkland S. *Perspective: gender as a health determinant and implications for health education*. Hlth Educ Behaviour 2006;33:731-743.

[37] European Commission. *Risk issues*. Special Eurobarometer 2006. Available at: http://ec.europa.eu/public_opinion/archives/ebs/ebs_238_en.pdf (Accessed September 04 2015). Nielsen K, Duncan B. Orlando, editors.

[38] McCarthy M, Brennan M, Kelly AL, Ritson C, de Boer M, Thompson N. *Who is at risk and what do they know? Segmenting a population on their food safety knowledge*. Food Quality and Preference 2007;18:205-17.

[39] Unusan N. *Consumer food safety knowledge and practices in the home in Turkey*. Food Control 2007;18:45-51.

[40] Altekruse SF, Street DA, Fein SB, Levy AS. *Consumer knowledge of foodborne microbial hazards and food-handling practices*. J Food Prot 1996;59:287-94.

[41] Akhvlediani T, Clark DV, Chubabria G, Zenaishvili O, Hepburn MJ. *The changing pattern of human brucellosis: clinical manifestations, epidemiology, and treatment outcomes over three decades in Georgia*. BMC Infect Dis 2010;10:346.

[42] Kumar P, Singh DK, Barbuddhe SB. *Sero-prevalence of brucellosis among abattoir personnel of Delhi*. J Commun Dis 1997;29:131-7.

[43] Ramos TRR, Junior JWP, Sobrinho PAM, Santana VLA, Guerra NR, Melo LEH, Mota RA. *Epidemiological aspects of an infection by Brucella abortus in risk occupational groups in the microregion of Araguaina, Tocantins*. Braz J Infect Dis 2008;12:133-8.

[44] Mai H, Irons P, Thompson P. *A large seroprevalence survey of brucellosis in cattle herds under diverse production systems in northern Nigeria*. BMC Vet Res 2012;8:144.

[45] Cadmus SIB, Alabi PI, Adesokan HK, Dale EJ, Stack JA. *Serological investigation of bovine brucellosis in three cattle production systems in Yewa Division, south-western Nigeria*. J South Afr Vet Asso 2013;84.

[46] Walshe MJ, Grindle J, Nell A, Bachmann M. *Dairy development in sub- Saharan Africa.* World Bank Technical Paper 135, Africa Technical Department Series, 1991; World Bank, Washington DC.

[47] Alavi SM, Rafiei A, Nikkhooi A. *The effect of lifestyle on brucellosis among nomads in Khuzestan Province of Iran*. Pakistan J Med Sci 2007;23:358-60.

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■ Correspondence: H.K. Adesokan, Department of Veterinary Public Health and Preventive Medicine, University of Ibadan, Nigeria- Tel. +2348027641242 - E-mail: latterglory70@yahoo.co.in