



# Brucella Infection in Domestic Animals in Nigeria: A Review

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**Abstract**

Brucellosis of animal origin is currently in the increase, especially in the developing countries like Nigeria where animals and man share microenvironment together coupled with lack of proper control measures. The disease due to Brucella species has zoonotic implication and is responsible for high economic loss. Brucella spp. infects many animals' species and their prevalence is worldwide, mainly associated with the presence or absence of control programmes and also in some countries, with the vaccination of animals against the disease. It is eradicated through prevention, surveillance and test-and-slaughter programmes in animals by many developed countries. To control and eradicate brucellosis, it is pertinent to identify the risk factors of the disease in animals and/or the environment that maintain such infections. Several risks have been identified; the most important have been identified as animal management (age, sex, species or breed), herd management (herd/flock size, number of species, contact with wild animals or type of animal production), farm management (facilities, cleaning and disinfection or veterinary support) and farmers' knowledge about the disease. All these have been poorly studied and reported in Nigeria, leading to scanty of information for effective implementation of eradication, prevention and control programmes. The objective of this manuscript was to review the work of earlier workers on Brucellosis in domestic animals and to a certain extent its impact on humans. There is also the need to educate the populace on the dangers of the disease in both human and animals.

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## Introduction

Brucellosis has been reported to be a highly infectious, contagious, zoonotic, and economically important bacterial disease of animals, wildlife and humans worldwide [1]. It is also one of the most important infectious causes of reproductive disorders in domestic animals [1]. The disease has been called with a number of names that include contagious abortion, infectious abortion, and epizootic abortion. In horses it is also called “fistulous withers” and “poll evil” due to its involvement of the bursa [2,3]. In cattle, brucellosis has been called ‘Bang’s Disease’ in tribute to the Danish veterinarian who is regarded to be the pioneer in the study of the disease caused by this species [2,3]. The disease in humans is called “Malta fever”, “Mediterranean fever” and “Gibraltar fever” according to the region in which the disease was first described [2,3]. The disease in humans has also been called undulating fever due to the oscillating temperature usually seen in infected persons.

The disease brucellosis can be said to be in existence since the middle of 1850s with the report of assistant Surgeon, Jeffrey Alien Marston who gave a very good and accurate account on the disease among troops in Mala [4] even though Cleghorn [5] reported that Hippocrates described a similar disease more than 2,000 years earlier on. Since then, the disease has been reported in almost all continents of the world.

Clinical signs due to *Brucella* species infections in animals vary depending on the animal species involved [3]. In cattle and to a certain extent small ruminant, the main clinical signs are abortion and retained placenta [6,7]. Other signs could include weak offspring at birth and hygroma at the knee and hock, especially in cattle [6,8]. It has been reported that abortion in ruminants usually occurs once with the animal returning to normal subsequently [9] abortion usually takes place during the third trimester of gestation. There may be involvement of the udder, especially in ewes and does following the infection and this is usually seen in infections due to *Brucella melitensis*.

## Material and methods

Systematic methodology was adopted where peer-reviewed, scholarly journals in Scopus, PubMed, Google search engine were used. Searched terms such as brucellosis, animals, human and zoonosis were used to search for the articles used in this review. The following criteria were also used when searching for the articles: journals published in English, exposure interest and case reports.

A number of articles, which are unique in the subject matter, were retrieved as part of the inclusion criteria. The articles used were on studies in Nigeria and elsewhere and that were published in Nigeria and other parts of the world. Some unpublished MSc and PhD theses were also retrieved and used.

### Livestock owner’ knowledge on brucellosis

The livestock owners’ knowledge on brucellosis has been studied by a number of researchers in Nigeria. For example, Kaltungo [6,8] reported that 41.0% of the pastoralists during a study in Kaduna State, Nigeria was fully aware of the existence of brucellosis in cattle and that 41.0% others were not aware of the disease being in small ruminants. Those that indicated awareness of the disease in cattle indicated their sources of knowledge as veterinary professionals (7.0%), the national radio agricultural programmes (32.0%), and other pastoralists (68.0%). Furthermore, Buhari [7] reported sources of knowl-

edge on brucellosis by pastoralists in a study to be extension workers, parents in addition to those indicated by pastoralists in Kaltungo’s study [6]. In another study to determine the infection rate of dogs in some selected Local Government Areas of Plateau State, Nigeria, Abdullateef [10], reported that 76.9% of the dog owners interviewed were not aware of brucellosis in dogs. With regard to horse grooms’ knowledge of brucellosis, up to 37.5% of the grooms in Kaduna State indicated being aware of brucellosis and mentioned their sources of knowledge as media (22.5%), other experienced grooms (10.0%) and veterinary professionals (5.0%) [11]. Furthermore, the some of the horse grooms considered the disease to affect the reproductive system as 5.0% of the respondents regarded the disease to cause abortion in mares while 15.0% of the grooms considered the disease to cause testicular inflammation in stallions [11]. In a study to determine the level of knowledge small ruminants’ owners, livestock traders and abattoir workers on brucellosis indicated that 22.7% of the small ruminants’ owners were aware of the disease while 25.76% and 51.52% of the livestock traders and abattoir workers respectively were also aware of the disease [12]. Similarly, in the same study, Yakubu [12] reported that all the medical personnel knew how to diagnose brucellosis and agreed that *B. abortus*, *B. melitensis* and *B. suis* could cause disease in humans. Furthermore, 3.7% of the medical personnel interviewed agreed that blood (3.7%) and aborted materials (74.07%) are the samples for the confirmation of brucellosis in humans.

Livestock owners’ knowledge of signs of brucellosis in animals was more in cattle with the signs being abortion (59.5%), hygroma (42.9%) and retained placenta (21.4%) [7]. These respondents further indicated that sources of infection with *Brucella* organisms in animals to be natural infection among cattle through the pasture (33.3%) and contaminated water (26.2%). As a further record of the disease in cattle herds, Buhari [7] found that pastoralists recorded 69.0% abortions in their herds and that 23.8% of the respondents reported abortion in less than 6 months to the time of the study while 16.7% and 31.0% of the respondents reported abortion one year and more than one year prior to the period of the study. In addition, 60.0% of the respondents reported that the abortions were taking place during the third trimester while 11.9% others indicated the abortion occurring during the second trimester of gestation. In addition, Kaltungo et al., [13] reported that pastoralists also gave other signs of brucellosis in ruminants to include weak young and stillbirth. With regard to the knowledge of brucellosis in horses [11], reported that grooms in Kaduna State, Nigeria identified its signs as abortion (15.0%), wounds at the poll (12.5%) and withers (20.0%). In a similar study at Kano metropolis, Kano State, Nigeria, reported grooms’ awareness of the disease and even used other veterinary methods to treat it. In a transect walk, reported siting some horses with swollen olecranon bursa and the grooms claimed it to be brucellosis.

With regard to the means of infection for humans, respondents indicated source with meat having 0.0% contribution [7]. Similarly, Kaltungo et al., [13] reported pastoralists mentioning sources of infection for humans to be fresh milk (93.75%) from cattle, sheep and goats, eating ‘suya’ (25.0%), ‘Balangu’ (34.38%), and ‘Kilishi’ (12.5%), Buhari (2014)[7] also reported that sources of infection for animals as reported by pastoralists include mating (19.1%, pasture (33.3% and contaminated water (26.2%) (Buhari, 2014)[7]. However, their taking milk directly from the udder of cattle and even sheep and goats does not portray this knowledge as if the animals are infected with

Brucella species, they can easily come down with the disease.

In a similar study by Kaltungo (2013)[6] only 10.0% of the respondent pastoralists indicated knowing brucellosis to be zoonotic with the source of infection for humans being ingestion (2.9%). Furthermore, the respondents could not appreciably relate the signs of brucellosis in humans. Similarly, Buhari (2014)[7] reported that only 16.7% of the pastoralists in a study considered brucellosis being zoonotic and they indicated means of transmission of the disease in humans as being milk consumption (2.4%), with meat having no role in its transmission. All these indicated that the pastoralists, who own greater than 80% of the national cattle herd, have no clear-cut knowledge of brucellosis. This can account for their actions with regard to husbandry and movement practices as will be seen later. As to the signs of the disease in humans Kaltungo (2013)[6] reported that pastoralists gave signs and symptoms of the disease as night sweats (4.3%), intermittent fever (4.3%) and others (2.9%). Similarly, pastoralists in a study by Buhari (2014)[7] indicated signs of brucellosis in humans to be fever (2.4%), night sweats (2.4%), weakness (2.4%) and sleeplessness (12.4%). In a study to determine horse grooms' knowledge on brucellosis, and being zoonotic in Kano metropolis, only 15.0% of the respondents considered the disease being zoonotic and gave sources of infection for humans as meat consumption (2.5%) and milk consumption (15.0%) and the signs of the disease in humans to be fever (7.5%), night sweats (7.5%) [11]. In another study to determine the level of knowledge of medical personnel on brucellosis, Yakubu [12] reported that all (100.0%) the respondents agreed that the disease could be transmitted from animals to humans with cattle (59.26%) being the most common source of infection followed by goats (27.78%), sheep (24.07%), dogs (11.11%) and least by pigs (9.26%).

The habit of eating 'balangu', 'kilishi' and 'tsire' which are meat products derived from low heat in the Northern part of the country and to a certain extent other parts of Nigeria can be said to predispose the traders and consumers to brucellosis should the meat used for the preparation of these beef products be from Brucella infected animals. This is because the beef products are roasted and hardly become exposed to severe heat as to kill any bacteria that may be contained in them. In a study in Kaduna State reported that people in the State were in a habit of eating these beef products almost on daily basis. Similarly, 'Nono' and other dairy products are delicacies to people in Northern parts of Nigeria. Not only that reported that it was common place for pastoralists' children to drink milk directly from the udder of cattle. The demonstration of Brucella antibodies in the milk of sheep and goats by Kaltungo [6,8] in Kaduna, Katsina and Sokoto State and Buhari [7] in cows in Kaduna State would throw a pointer to the risks that milk consumers can be exposed in the drinking of milk from animals not screened for Brucella species. Furthermore, Buhari [14] identified B abortus and B suis from milk of sheep and goats in Zaria, Kaduna State, Nigeria using PCR. has also reported pastoralists consuming milk that could expose them to tuberculosis. Another habit of people collecting blood from slaughtered animals and cooking it for consumption could result in such people being exposed to brucellosis, should the blood be from Brucella infected animals. This is because and Buhari [14] have demonstrated the presence of B abortus and B suis in the blood of horses' and small ruminants respectively.

### Husbandry and management practices

Pastoralists in Nigeria have been reported to keep cattle,

sheep, goats, poultry, horses, donkeys, poultry and dogs for herding [7,13]. It is not even impossible to see polo and racing horse owners and grooms keeping other domestic animals like small ruminants, poultry and dogs along with their horses. To them, the horsed owners and grooms observed that they were keeping these other livestock for economic gains. In addition, the animals are raised mostly under extensive management system [13,15-17]. Musa et al., [18] further reported that the respondents in their study indicated that chickens used to peck on placenta and aborted fetuses. Similarly, Kaltungo et al., [13] reported that various animal species could be seen grazing on the same grazing field together.

The practice of pastoralists by grazing their animals in the country side facilitates the transmission and even spread of the disease as infected animals interact with susceptible ones almost on daily basis. It is possible to see cows aborting during grazing just as it is also possible to see them calving on the grazing ground. This results in the spread of the Brucella organisms in the grazing field with high risks for any animal that comes along in such areas for grazing. The practice of nomads to go on transhumance in Africa, especially in West Africa, where transhumance cattle are almost always on the move can facilitate the spread of the disease once some of the herds are infected. The relatively high seroprevalences in many cattle, sheep and goats and even horses can allow one to predict wide spread of the disease in Nigerian livestock and the uncontrolled grazing areas could be considered as predisposing factors for these seroprevalences. Furthermore, the uncontrolled livestock markets along with lack of routine purposeful surveillance against livestock diseases could make diseases, especially zoonotic ones, to spread in the communities without hindrance. The way polo and horse racing are conducted in Nigeria where grooms meet other grooms and exchange grooming tools can easily facilitate transfer of diseases, particularly brucellosis if some of the horses are infected with poll evil and fistulous wither [11].

Like for grazing facilities for the national cattle herds, Kaltungo [8] reported small ruminants in Katsina and Sokoto states of Nigeria using communal watering points in communities. In a situation whereby an animal just aborted or even calved and is shedding Brucella organisms, such shedding can result in some of the organisms being dropped into the community watering facility for others to pick and subsequently develop the infection. Since pastoralists graze their cattle along with their sheep, the demonstration of seropositivity in their sheep and even goats are not impossible. Thus, Kaltungo [6] and Buhari [7], in separate studies in Kaduna State opined that the spread of brucellosis among pastoralists' herds was easy due to the extensive management system that allows extensive grazing pattern and the fact that they move in groups using the same grazing and watering points.

Another possible area where brucellosis can be introduced into herds or flocks is the way livestock owners add new animals into their herds or flock. Kaltungo [6] reported 70.0% of the livestock owners sourcing new animals for their flocks from open markets with only 6.0% of the respondents sourcing their new animals from established farms. Not only that quarantine following purchase of animals is not practiced as Kaltungo [6] further reported that 64.0% of the respondents were not practicing any quarantine when they purchased new animals. In another study, Kaltungo et al., [13] reported 32.81 % of the respondents adding new animals from markets immediately they brought them to the homestead while only 14.06% practiced

quarantine before adding new animals.

The breeding system being employed by livestock owners in Nigeria can be said to facilitate the spread of brucellosis. For example, Kaltungo [6] and Yakubu [12] all reported farmers borrowing breeding sires for their female animals on heat. In a study on brucellosis in small ruminants, Kaltungo [6] reported that 56.0% of the respondents indicated borrowing breeding rams and bucks from their neighbours while 71.0% others indicated lending out their sires to pothers for breeding. In another study, Buhari [7], reported that up to 71.4% of the respondents were in a habit of borrowing bulls for breeding their cow and that 42.8% of the respondents agreed that such borrowing had adverse effects on the animals as it could lead to disease transmission. Similarly, Abdullateef [10] reported that only few dog breeders (20.0%) were in a habit of screening the bitches before breeding.

Another area that brucellosis can be spread is the management of abortion and aborted fetuses. For example, Buhari [7] reported 69.1% of the respondents in a study indicating the occurrence of abortion in their cattle herds and that 60.0% of such abortions were occurring during the third trimester of gestation. Kaltungo [6] reported up to 81.0% of the respondents having abortion in their small ruminants and that 68.0% of the abortion was occurring during the third trimester of pregnancy. Furthermore, Kaltungo [6] reported that only 9.0% of the respondents were in a habit of burying aborted fetuses while another 1.0% was burning aborted fetuses. This means that most of aborted fetuses are left in the environment with subsequent contamination of such environment, should the abortion be due to infection with any organism like *Brucella*. This is in a situation whereby Kaltungo [6] reported up to 59.0% retained placenta in a study in small ruminants. In a separate study, Buhari [7] reported 45.0% of pastoralists throwing away aborted fetuses from cattle while only 7.1% of them were in a habit of burying such aborted fetuses. The researcher further reported that another 16.7% of the respondents indicated hanging fetuses on trees while 2.4% others indicated giving such aborted fetuses to their dogs. With regard to retained placenta, Kaltungo [6] reported farmers having up to 24.0% retained placenta in their flocks while Buhari [7] reported 21.4% of the respondents having retained placenta in their herds.

#### **Attitude and practices with regard to brucellosis**

In a study of canine brucellosis in Plateau State, Nigeria, Abdullateef [10] reported that up to 75.0% of the respondents were in a habit of consuming roasted dog meat while 21.0% and 4.0% of the remaining respondents were eating dog meat as boiled and fried respectively.

The farmers' practices through disposal of aborted fetuses and placenta can lead to the spread of *Brucella* organisms should the abortion be due to *Brucella* organisms. Thus, there could be spread of the organisms in the environment as Kaltungo [6] and Buhari in [7] reported dogs carrying such aborted fetuses and placenta around the pastoralists' homestead. In the rainy season, the aborted fetuses that have been disposed could lead to rain water taking the discharges from these fetuses and placenta to nearby streams and even beyond should there be strong rain. The cool weather commonly seen during the harmattan season in Nigeria could also prolong the presence and therefore spread of the *Brucella* organism if abortion due to *Brucella* organism occurs during this season. have reported that the organisms can stay in the pasture and survive

on grass for variable periods of time depending on environmental conditions. They further reported that infection can result in susceptible animals if they come in contact with uterine discharges due to *Brucella* organisms from an infected animal.

The presence of an infected animal, especially chronically infected ones can result in the continuous release of the organisms in the urine and other body discharges with consequent spread of the organisms in the environment.

has reported that the *Brucella* organisms can survive in the urine in the environment for up to 37 days and in manure for an extended period of time. Kaltungo [8], Buhari [14] have variously demonstrated that small ruminants and horses can develop acute and chronic infections with *Brucella abortus*, *B. melitensis* and *B. suis*. They also demonstrated mild and severe infections with these organisms in these animals. The migration of pastoralists from the North to the South of Nigeria during the dry season can also help in the spread of *Brucella* organisms, especially that they interact with resident animals in the areas they go Saidu et al., [15] reported the transhumant and husbandry practices of pastoralists in Nigeria.

In Nigeria, the most common source of additions for new animals in herds and flock are the open markets [6,7,12]. Thus, in a situation whereby a farmer has experienced abortions in his herd or flock, the only way out for him is to dispose them through these open markets. Thus, another farmer desirous of increasing his herd or flock size could get his new animals from these markets. Thus, there is a high potential for him to introduce brucellosis into his herd or flock, should any animal with brucellosis be sent to the, market for sale. The transhumance nature of most of the pastoralists in Nigeria and those in the neighbouring countries with Nigeria can be said to be predisposing factors for spread of brucellosis in these countries. The migration for feeding on crop residues purposely kept by crop farmers for transhumance herds in return for manuring crop farmers farms in many states of Northern Nigeria can also be said to predispose the spread of brucellosis as such transhumance herds may have some of the animals with brucellosis and in such cases may be shedding the organisms in their urine and possibly uterine discharges should abortion take place in the process. Saidu et al., [15] reported that pastoralists move from the North to the South of Nigeria during the dry season and come back at the beginning of the rainy season. Thus, there is the presence of pastoralists' herds from the Niger Republic during such seasons. It is therefore possible for them to bring in *Brucella* infections or take up the infection to other animals in the neighbouring countries. Similarly, Ocholi et al., [19,20] reported that free movement of animals as occasioned in Nigeria is capable of spreading Brucellosis among animals. Atsanda and Agbede [21] also reported that herding of different animal species in the same area could facilitate in the introduction and spread of brucellosis. Furthermore, Junaidu et al., [22] and Bertu et al., [23] reported that grazing of animals on the same pastures and use of same watering points were capable of spreading brucellosis. In their separate research, Kaltungo [8] and reported pastoralists and ceremonial horses being grazed together and that the small ruminants and horses were found to high seroprevalences of *Brucella* species. They were also able to demonstrate *B. abortus* and *B. melitensis* in the animals they studied. The current situation whereby cattle rustling is gradually gaining ground in Nigeria will result in the spread of the disease in all nooks and corners of Nigeria. There is the fear that uncontrolled slaughter of could take place with the result that

the *Brucella* organisms will be distributed in the environment with consequent transmission to animals and even humans, especially that there will be no meat inspection in the process. Even the routine meat inspection at slaughter slabs and abattoirs has uncovered a number of infected animals (cattle and small ruminants) in Nigeria as Nuru and Dennis [24] have demonstrated *Brucella* antibodies in slaughtered cattle in North Central State, Nigeria. Similarly, Ogundipe et al., [25] in Ibadan, south of Nigeria also reported demonstrating *Brucella* antibodies in slaughtered goats in Jos, Plateau State, Nigeria.

In Nigeria, particularly the pastoralists have the tradition of drinking milk in many forms like 'Nono', especially when combined with millet or sorghum paste. Particularly in Katsina, Sokoto, Zamfara and Kebbi States, it is the traditional afternoon meal. In a situation where the milk is contaminated with *Brucella* organisms, there is the potential for people to be infected with the organisms. For example, Bertu et al., [23] reported demonstrating *Brucella* antibodies in the milk of small ruminants in Jos, Plateau State, Nigeria. In other studies, Kaltungo [6], Buhari [7] and Buhari [14] variously demonstrated *Brucella* antibodies in milk of cattle and small ruminants in Kaduna, Katsina and Sokoto States. Thus, the risk for human exposure is, to say the least, great as many of the animal species have been shown to have significant *Brucella* infections to the level of acute or chronic and mild or severe [8,14].

#### **Economic and public health importance of brucellosis in Nigeria**

Food animal (cattle, sheep, goats, pigs and poultry) production and horse business in terms of polo and racing along with ceremonial activities can be said to be important areas through individuals and even Government derive economic benefits [8]. In Nigeria and to a great extent most African countries, most of the meat sourced for human consumption by the populace are from cattle, sheep, goats and pigs with poultry meat being mainly used in major urban areas [15]. Furthermore, milk and other dairy products like butter and to a certain extent cheese are also sourced mainly from cattle. At least as of now, pastoralists use goat milk for medicinal purposes. Thus, should there be substantial prevalence of brucellosis, one would expect high abortion rates that could lead to reduction in the population of these animals. Thus, if it happens, will result in deficiency in the supply of the much-needed animal protein required by the populace to meet the Food and Agriculture Organization minimum 35grams per caput per day. The springing up dairy industries in Nigeria will similarly suffer as the amount of milk will decline since indicated that brucellosis is associated with decreased milk yield. Similarly, it will reduce the number of rams and goats required yearly for the religious festivals of Eid-Kabir and Christmas. The Nigerian Government and in fact many States Government have recently introduced settlement programmes for the purpose of improving livestock production, especially cattle production. Thus, there is the serious and urgent need to examine the role of many diseases, especially brucellosis as such diseases can stand on the way to intensive livestock production. The fact that crop farmers in Northern Nigeria use, free from brucellosis as once infected with *Brucella* species their role can be said to be compromised.

Abortion is one of the signs associated with brucellosis as Matope et al., [26] in Zimbabwe showed association of seropositivity and abortions and suggested that about one fifth of cows with seropositivity of up to 30% may be involved with abortion. no matter the disease abortion will reduce the calf crop as well

as potentials for herd size increase in any farm. It will also reduce the possible economic returns through the sale of excess offspring that could arise from breeding in a particular gestation period. The disease is associated with still birth [6]. As such this can result in economic loss through the production of offspring that may not be effective for replacement in herds. Similarly, calf born from a *Brucella* infected female cow may be weak and have slow growth rate. Such will not be good materials for either replacement in the farm or be sold to anybody who may require replacement animals as they may be seropositive for *Brucella* and propagate the organism in the subsequent years when they come to breeding age.

Another consideration of economic importance of brucellosis in the horse industry in Nigeria is their use in polo, racing, durbar and local sugar production from sugar cane [11]. Thus, infection of such bulls with *Brucella* species could mean their unavailability for this role. Bale and Kwanashie, [27], Baba [11], Ardo and Abubakar [28] and Njoga et al., [29] among others have demonstrated seroprevalence of *Brucella* species in horses (ceremonial, polo and racing) in many parts of Nigeria.

The public health importance of brucellosis in domestic animals and humans is high as Cadmus et al., [30] reported seropositivity in abattoir workers in Nigeria. Similarly, Haladu et al., [31] reported demonstrating seropositivity to *Brucella* in human patients that were having with febrile signs in Kano hospitals in 2010. The patients reported taking milk, had contacts with placenta from livestock with some of them being shepherds while others were butchers. Reports of seropositivity in persons have also been made by Falade [32] in Ibadan, Nigeria. Furthermore, Kaltungo [6,8], Farouk et al., [33] and Buhari [14], have demonstrated *Brucella* antibodies in the milk of small ruminants and cattle. Thus, *Brucella* infection in such persons could result in reduced to loss of man-hours with substance economic losses, considering the number of individuals that are involved in the livestock industry in Nigeria. Kaltungo [6,8], Buhari [7] and Baba [11] among others have reported the poor knowledge of brucellosis by animal owners in Nigeria. In a study on seroprevalence of brucellosis in dogs in Jos, Nigeria, Abdullateef [10] reported that 76.9% of the dog owners that participated in the study were not aware of brucellosis in dogs. Thus, should their dogs be infected with *Brucella* species they could easily contract the disease with consequent effects. Similarly, only 15.9% of the horse handlers in a study on seroprevalence of brucellosis in horses were aware of brucellosis [11]. The risk for human infection in horses is the nature of the disease in this animal species as lesions may not always be noticeable since Baba [14] even with demonstration of acute and chronic infection along with mild and severe infections could not demonstrate any lesions even though they were having high seropositivity.

The fear does not stop there as only 22.7%, 25.76% and 51.52% of small ruminants' owners, livestock traders and abattoir workers respectively in a study in Kaduna metropolis were aware of brucellosis [12]. Thus, these individuals that have contact with animals on regular basis could contract the disease should any of the animals be infected with *Brucella* species. Another fear is that Lawan et al., [34] reported that most of the Abattoir workers in North Western States of Nigeria do not have the prerequisite training for abattoir work and were not examined for medical fitness before engagement on the work. In addition, it was common practice to see butchers eating and smoking cigarettes as well as spitting in the slaughter hall while processing meat. They also reported that there were no formal

ante and post mortem inspection in most of the abattoirs under the study. They similarly reported that offals were washed with effluent and that organs with lesions suspected of being of tuberculosis were sold to the public. They further reported that meat from most of the States under their study was transported by old motor trucks, motor cycles and on wheelbarrows.

### Conclusion

The implementation of control and prevention measures of brucellosis in animals will help in eradicating human infections. Good hygiene and protective clothing/equipment are very important in preventing occupational exposure. In Nigeria, in addition to the epidemiological investigations, vaccine trial studies and effective control and prevention strategies as a national policy should be formulated and implemented. Even though brucellosis is eradicated in some developed countries, much work needs to be still done in Nigeria in order to eradicate this disease.

### Declarations

**Availability of data and material:** The authors declared that the review work data are available online. In addition, all data generated during this study are included in this manuscript

**Competing interest:** The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

**Author's contributions:** SI, BYK, and HBU analyzed and extracted relevant information from the various sources of the literature obtained. AYB, FUM, and HMD did the search for the various papers used in this research. SNA was the major contributor in writing the manuscript. All authors read and approved the final manuscript.

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