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An overview of Animal and Human Brucellosis in Nigeria

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ABSTRACT

Brucellosis is a bacterial disease in humans and animals caused by a group of organisms in the genus *Brucella*. It is highly contagious and one of the most important zoonosis in the world. The disease remains endemic in Nigeria and its actual incidence and prevalence are unknown due to poor surveillance and inadequate disease reporting system. A comprehensive review of the literature published online was carried out on manuscripts published as far back as 1976 to 2021, A computerized search of existing literature was conducted using the Google search engine, PubMed electronic database and Commonwealth Agricultural Bureaux (CAB) abstracts to identify and review relevant publications on brucellosis in animals and humans in Nigeria using the following search terms: brucellosis, malta fever, undulant fever, febrile fever, Gibraltar fever, gastric fever, remittent fever, Mediterranean fever, bangs disease and contagious bovine/ovine abortion. Our review showed that brucellosis is widely distributed in Nigeria amongst human and animal hosts. Undulant fever is the most commonly reported syndrome in humans, while abortion is the most prevalent symptom documented in animals. Serological techniques like rose-Bengal/card test (RBT), standard agglutination tests (SAT), complement fixation test (CFT), indirect enzyme immunoassays (ELISA) and polymerase chain reaction (PCR) are often used to determine the prevalence of brucellosis in human and animal hosts. Losses enumerated in the literature include those due to abortions, diminished milk production and contamination of milk, mastitis, animal culls and condemnation of infected animals due to breeding failure and inability to participate in the international animal export trade. In humans, brucellosis reduced work capacity through the sickness of the affected people and can be acquired from animals. There is need for a drastic public health interventions and control measures on brucellosis in the livestock industry in Nigeria.

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INTRODUCTION

Brucellosis (Malta fever, undulant fever, febrile fever, Gibraltar fever, gastric fever, remittent fever and Mediterranean fever in humans, bangs disease and contagious bovine/ovine abortion in cattle and sheep) was first described by Hippocrates in 450 A.D. The first published accurate description of brucellosis as "Mediterranean gastric remittent fever" was done by Martson, a British Army physician in Malta in 1861 **(Martson, 1861).** David Bruce isolated a microorganism he named *Micrococcus melitensis* from the post-mortem spleen of a British Soldier with Malta fever and *Bacillus abortus* from aborted bovine foetus and foetal membranes **(Bang and Stribolt, 1897).** The organisms were named *Brucella* by Meyer and Shaw in 1920 in honour of Bruce **(Meyer and Shaw, 1920).**

Brucellosis, caused by *Brucella* species, is considered a neglected zoonosis by the World Health Organization largely due to lack of public awareness and yet it is one of the most important endemic zoonotic infections, especially in pastoral and mixed crop-livestock farming systems in Africa **(Abdulssalam and Fein, 1976; Palmer *et al*., 1998; McDermott and Arimi, 2002; Ariza *et al*., 2007; Karimuribo *et al.*, 2007; Seleem *et al*., 2010).**

The first phase of brucellosis investigation in Nigeria was between 1966 to 1981 **(Adams and McKay, 1966; Banerjee and Bhatty, 1970; Esuruoso, 1974a&b; Nuru, 1974; Nuru and Schnurrenberger, 1975; Eze, 1978a&b; Nuru, 1982).** As a result of the awareness created by the first phase, several investigators took interest in various aspects of brucellosis in Nigeria from 1981 **(Bale and Kumi-Diaka, 1981; Chukwu, 1985a&b; Chukwu, 1987; Ocholi, 1990; Asanda and Agbede, 2001; Bale and Nuru, 2001; Shola and Ogundipe, 2001; Ocholi *et al*., 2004; Cadmus *et al*., 2006; Adamu, 2009; Cadmus *et al*., 2009; Gusi *et al*., 2010; Farouk *et al*., 2011; Hamza, 2011; Junaidu *et al*., 2011; Mbuk *et al*., 2011; Mai, 2012; Olabode *et al*., 2012).**

Brucella infections

Brucella infections in humans are derived directly or indirectly from exposure to infected animals and animal by-products or consumption of unpasteurized dairy products **(Chomel *et al*., 1994; Pappas *et al*., 2006).** Brucellae are shed in large numbers in the milk, urine, blood, and cystic products of infected animals **(Cooper, 1992).** Direct contact with animals or their secretions through cuts and abrasions in the skin, by way of infected aerosols inhaled or inoculated into the conjunctival sac of the eyes or through the ingestion of unpasteurized infected milk and dairy products **(Georgious *et al*., 2005; Young, 1995; WHO, 2006).**

Other factors associated with the prevalence of brucellosis in various species of livestock and wildlife include; climatic conditions, geography, species, sex, age and diagnostic tests applied **(Crump *et al*., 2003; Jennings *et al*., 2007).** Consequently, brucellosis has been an occupational risk for farmers, animal handlers, nomads, veterinarians, butchers, abattoir workers, hunters, animal product consumers and laboratory personnel **(Collard, 1967; Alausa and Osoba, 1975; Alausa and Awoseyi, 1976; Alausa, 1979; Alausa, 1983; Adekolu-John, 1989; Adamu, 2009; Baba *et al*., 2001; Karimi *et al*., 2003; Agasthya *et al*., 2007; Ofukwu, 2007; Claeys *et al*., 2012; Olabode *et al*., 2012; Aworh *et al*., 2013).**

Host preference

Epidemiological evidence shows that *Brucella* usually has definitive host preferences **(Bercovich, 1998).** Even though the *Brucella* species are relatively host specific, interspecies transmission does occur. *B. abortus* is recognized as the main cause of contagious abortion in cattle, but sheep, goats, dogs, horses, camels, buffalos as well as field animals that have been in contact with infected cattle may also contract infection **(FAO, 2017)** *Brucella melitensis* is highly contagious and infectious to sheep and goats, however, cattle, dogs, camels and pigs may also become infected with *B. melitensis* **(Zowghi and Ebadi, 1988).** *Brucella suis* which usually infects swine may also infect cattle, horses, dogs and wild animals **(Bale and Nuru, 1985)**. *Brucella ovis* infect mainly sheep while *B. canis* infect dogs **(Marin *et al*., 1996b)**.

Bovine brucellosis

Brucellosis was first reported in Nigeria in 1927, since then, several epidemiological surveys have revealed the presence of the disease in livestock population in Nigeria **(Ocholi *et al.*, 1993).** Bovine brucellosis due to *Brucella abortus* is the most prevalent *Brucella* infection in Nigeria (**Akinyemi *et al*., 2022**). There had been isolation of *Brucella* from cattle, goats, sheep, horses, pigs and dogs all of which were associated mainly with *B. abortus* biotype 1. There is no known published report of the isolation of *B. melitensis, B. canis, B. ovis, B. neotomae* from livestock in Nigeria **(Bale and Kwanashie, 1984, Ocholi *et al.*, 1993).**

Bovine brucellosis is an endemic disease in Nigeria **(Agunloye, *et al*, 1999).** The disease has been diagnosed wherever there are cattle in Nigeria and all breeds of cattle have been reported to be susceptible. Studies in various parts of the country indicate that the disease is widespread particularly in ranches, livestock breeding centers and dairy farms where prevalence ranged between 3.7% and 48.8% **(Esuruoso, 1974a; Agunloye, *et al*, 1999)** and between 0.4 and 26% in the traditional nomadic Fulani herds, and in slaughtered cattle through abattoir surveys **(Nuru and Dennis, 1975; Eze, 1978a; Falade and Shonekan, 1981; Chukwu, 1987; Ocholi *et al*, 1996).** All these investigations were based on serological surveys using rose-bengal test (RBT), buffered antigen plate agglutination test, standard tube agglutination test, Wright sero-agglutination test, complement fixation test (CFT) and indirect enzyme-linked immunosorbent assay (ELISA), very few studies have been dedicated to the investigation of the different biovars of brucellae among bovines in Nigeria **(Ducrotoy *et al*., 2014)**.

However, some studies have reported the isolation of biovars 1, 2, 3 and 4 of *B. abortus* **(Ocholi *et al*, 1993).** Twenty strains of *B. abortus* were isolated from cattle in Northern States Nigeria. Out of which 19 (95%) were of biotype 1, while 1 (5%) was of biotype 2 (**Eze, 1978b)**. Similarly, out of 8 strains of *B. abortus* from semen and aborted fetuses of cattle in livestock investigation of breeding centers in Nigeria, 5 (62.5%) were of biotype 1, 2 (25%) were of biotype 3 and 1 (12.5%) was of biotype 4 **(Bale and Kumi-Diaka, 1981, Ocholi *et al*., 2004; Ocholi, 2005).**

Ovine and Caprine Brucellosis

Brucellosis in small ruminants, sheep and goats is considered a disease of high importance in Nigeria from the social and economic point of view (**Bale *et al.*, 1982)**. The first report of brucellosis in goats was based on serological evidence presented by **Adams and Mckay (1966)** and later by **Kramer *et al*. in 1967**). Subsequent reports based on serological surveys from various parts of the country have confirmed the presence of the disease among sheep and goats **(Falade *et al,* 1975; Falade *et al*., 1981; Falade and Shonekan, 1981; Okewole *et al.*, 1988).** These studies revealed that prevalence of brucellosis in sheep and goats vary between 2.15% and 14.5%. Some reports are available on the isolation of brucellae from sheep and goats **(Kramer *et al*., 1967; Okoh, 1980; Falade, 1981; Falade and Shonekan, 1981; Bale *et al*., 1982; Brisbie *et al*., 1993).**

Field experiences indicate that abortion occurs frequently in sheep and goats but the causes were not subjected to detailed laboratory investigation (**Okoh, 1980)**. However, the isolation of *B. abortus* biotype 1 was reported by **Falade (1981)** and isolation of an untyped *B. abortus* from sheep milk by **Bale *et al*. (1982) and Okoh (1980)** isolated *B. abortus* from a case of sporadic natural infection of sheep.

Canine brucellosis

The social and economic importance of the disease has not been properly assessed despite the fact that increase in the number of commercial breeding kennels may aid/increase the risk factors for the transmission of the disease among dogs **(Osinubi *et al*., 2004)**. Although **Ayivor *et al,* (1987).** did not detect the presence of antibodies to *Brucella* in dogs in Nigeria in their serological survey of canine brucellosis however, *B. canis* had been detected through serology with a prevalence rate of 28.6% **(Adesiyun *et al,* 1986)** and through cultural recovery from a case of abortion in an imported boxer breed of dog **(Okoh *et al.*, 1979). Agunloye *et al*. (1999)** obtained serological evidence of *Brucella abortus* infection in dogs in Ibadan with a prevalence of 4.35% out of 92 dogs sampled. **Osinubi *et al*. (2004)** found that 21.5% of 200 dogs studied in Zaria were positive for *B. abortus* agglutinins by Rose Bengal Plate Tests (RBPT).

Swine brucellosis

Swine brucellosis has been studied since the 1940s. Early evidence of swine brucellosis in Nigeria are reported by **Adams and McKay (1966)** in Eastern Nigeria. Although the disease may exist, there is not enough information to indicate the prevalence of brucellosis in pigs in Nigeria. Twelve (2.7%) out of 443 pigs sampled from 6 pig farms in the Northern states of Nigeria had *Brucella* antibodies and untyped *B. suis* was isolated from 2 of the pigs **(Bale and Nuru, 1985).**

Equine brucellosis

Horses have gained more attention in Nigeria due to increasing interest in polo games and horse racing **(Ameen *et al*., 2019).** The role played by horses in the transmission of brucellosis in Nigeria is poorly understood. There are very few reports available on the presence of the disease in horses. However, **Bale and Kwanashie (1984)** demonstrated *Brucella* antibodies in horses in Northern Nigeria where 14 (8%) out of 166 horses were reactors. The isolation of *B. abortus* biotype 1 from an aborted equine fetus in Toro, Bauchi State of Nigeria **(Oladosu *et al*., 1986)** confirmed the presence of the disease in horses in the country. **Baba, (2016)** from his study in horses in Kaduna State, Nigeria obtained an overall seroprevalence of 5.59% and 20.07% using RBPT and SAT-EDTA respectively.

The seroprevalence by breed were 11.9% and 12.70% by RBPT and SAT-EDTA respectively for Arewa breed, 1.69% and 28.81% by RBPT and SAT-EDTA respectively for Argentine breed, 0.00% and 21.74% by RBPT and SAT-EDTA respectively for Sudanese breed and 0.00% and 16.21% by RBPT and SAT-EDTA respectively for Talon breed of horses (**Baba, 2016)**. The corresponding seroprevalence by sex were 0.84% and 29.41% for females and 8.65% and 14.05% for males (**Baba, 2016)**. The seroprevalence by age-group were 8.33%, 8.97%, 0.99% and 2.94% for 1 to 5 years old, 6 to 10 years old, 11 to 15 years old and above 15 years old respectively using the RBPT. Respective seroprevalence by purpose were 11.82%, 1.34%, and 2.22% for ceremonial, polo and racing horses using the RBPT (**Baba, 2016)**. From the structured questionnaire, 37.50% of the respondents were aware of brucellosis and 22.50% ascribed their sources of information on the disease to be the media, 10.00% of the experienced groomers among the respondents and 5.00% professionals who attended to the veterinary care of their horses **(Ameen *et al*., 2019).**

Camel brucellosis

The available evidence on the presence of brucellosis in camels in Nigeria is based on serological survey of camels in Kano State, Nigeria by **Okoh (1978)** and in Nigerian three Northern states of Kaduna, Katsina and Kano by **Adamu *et al*., (1997)** where prevalence of *Brucella* antibodies were 1.0% and 27.8% respectively. Salisu *et al.* also reported 110 (11.22%) RBPT positive and 103 (10.50%) SAT positive samples from camels in Katsina State, Nigeria. Out of 472 and 508 serum samples tested from the field and abattoir respectively, 63 (13.3%) and 47 (9.3%) were positive by RBPT while 62 (13.1%) and 41

(8.1%) were positive by SAT respectively **(Salisu *et al*., 2018)**.

Chicken brucellosis

Brucellosis had been reported in Nigeria chickens from Kaduna and Sokoto States, Nigeria **(Bale and Nuru, 1982; Junaidu *et al*., 1986).**

Human brucellosis

The first case of brucellosis in humans from different parts of Nigeria was reported in 1962 **(Collard, 1967)** when *Brucella* antibodies were demonstrated in the sera obtained from healthy persons in various parts of Nigeria. Between 1962 and 1967 records obtained from University College Hospital, Ibadan, Oyo State, Nigeria indicated 9 cases of human brucellosis and *Brucella* species were isolated from 4 blood and 1 bone marrow culture **(Falade, 1974).** Most cases of human brucellosis were essentially due to occupational hazard, occurring amongst workers in the livestock industry (**Alausa, 1979)**. Epidemiological studies revealed a significantly higher prevalence of infections among occupationally exposed persons including herdsmen, abattoir workers and veterinarians than in occupationally non-exposed population including blood donors and normal pregnant women **(Falade, 1974; Alausa, 1979; Alausa and Osoba, 1975; Alausa and Awoseyi, 1976).** The source of infection for humans is primarily from livestock reservoirs of brucellosis. Thus, the risk to humans is a function of the risk in livestock and the livestock-human infection rate **(Baba *et al*., 2001; Brisbie *et a*l., 1993; Asanda and Agbede, 2001; Ofukwu *et al*., 2007).**

Diagnosis of Brucellosis

The diagnosis of brucellosis is confirmed by isolation and identification of the causative organism (**Bricker *et al*., 2002)**. These tests are Acidified antigen agglutination tests such as the Rose-Bengal test (RBT) and the buffered antigen plate agglutination test. These serological tests are simple to perform, inexpensive and suitable for screening individual animals **(Nielsen, 2002).** However, false negative reactions occur. These tests are referred to as the RBT tests. Standard agglutination tests (SAT) such as the standard tube agglutination test and the sero-agglutination test of Wright constitutes another group of tests that are comparable with each other, they are referred to as the SAT-tests. According to **Nielsen (2002),** SAT tests are susceptible to producing false positive reactions. The Complement fixation test (CFT) is another test. The CFT is recommended by the OIE as the test prescribed for international trade **(Nielsen, 2002)** CFT is often used as a second test for confirmation of RBT-positive sera.

Indirect enzyme-linked immunosorbent assay (ELISA) is the fourth serological test group that is often used to determine the prevalence of brucellosis in surveys. Other ELISA tests are highly sensitive, and simple to use but expensive **(Nielsen *et al*., 1988).** Indirect ELISA is more sensitive than RBT tests and has a sensitivity of 100% and a specificity of 84.5% **(Roop *et al*., 1987).** Milk ring test (MRT) is an adaptation of the agglutination test. This test is used to show if antibodies are present in the milk. Molecular characterization of isolates by conventional Polymerase chain reaction (PCR) and Bruce-ladder multiplex (PCR) are other methods that have been used to identify *Brucella* organisms in man and animals **(Bertu *et al*., 2021)**.

Diagnostic test for brucellosis: two categories

There are diagnostic tests that demonstrate the presence of the organism and those that detect immune response to the antigen **(OIE, 2009).** Unequivocal diagnosis of *Brucella* infections can be made by isolation and identification of *Brucella*, but in situations where bacteriological examination is not practicable, diagnosis must be based on serological methods. There is no single test by which a bacterium can be identified as *Brucella*. A combination of growth characteristics, serological, bacteriological and/or molecular methods is usually needed **(OIE, 2009)**.

Direct Smear

The microscopic examination of *Brucella* spp. present as coccobacilli or short rod measuring 0.6-1.5 µm long and 0.5-0.7 µm wide. They are usually arranged singly and less frequently in pairs or small groups. The morphology of *Brucella* is fairly constant, except in old cultures where pleomorphic forms may be evident. *Brucella* is non-motile. They do not form spores, and flagella, pilli, or true capsules are not produced. *Brucella* are Gram-negative and usually does not show bipolar staining. They are not truly acid-fast, but are resistant to decolorization by weak acids and thus stain red by the Stamps modification of the Ziehl-Neelsen method (**OIE, 2009)**. This is the usual procedure for the examination of smears of organs or biological fluids that have been previously fixed with heat or ethanol and by this method, *Brucella* organisms stain red against a blue background **(Roop *et al*., 1987).**

Microscopic demonstration of characteristic clumps of *Brucella*, organisms in stained smears of fetal membranes, vaginal swabs, milk and semen by modified Köster staining, Stamp's modified Ziehl-Neelsen staining and Fluorescent Antibody Techniques may provide tentative diagnosis **(Alton, 1990; Bercovich, 1998).** However, morphologically related micro-organisms such as *Chlamydia psittaci* and *Coxiella burnetti* (Q-fever) can lead to false diagnosis **(Radostitis *et al*., 2000).**

Cultural Isolation and Identification

The confirmatory and unequivocal method for the diagnosis of brucellosis is based on the isolation of *Brucella* from clinical specimens **(Alton, 1990).** *Brucella* can be isolated on ordinary solid media, the use of non-selective media is not usually recommended because of overgrowing contaminants usually present in field samples. Selective media are needed for isolation purposes **(Corbel, 2006).** The Farrell's selective medium, developed for the isolation of *B. abortus* from milk **(Farrell, 1974),** is recommended for the isolation of *Brucella* species **(Alton, 1990).** However, nalidixic acid and bacitracin, at the concentration used in this medium, may have inhibitory effects on some strains of *B. abortus, B. melitensis* and *B. ovis* **(Marin *et al*., 1996b).** Thus, its sensitivity for the isolation of *Brucella* spp. from naturally infected sheep is sometimes lower than that obtained with less selective Thayer-Martin's medium **(Marin *et al*., 1996a).** The sensitivity of bacteriological diagnosis is significantly increased by the simultaneous use of both the Farrell's and the modified Thayer-Martin's media **(Marin *et al*., 1996b).**

The identification of *Brucella* involves colonial and cellular morphology, Gram's reaction, agglutination with monospecific antisera (A, M or R antigens, and results from routine biochemical tests **(Corbel, 2006).** Typing of isolates of *Brucella* into biovars involves conventional procedures for cultural characteristics that include CO_2 requirement, H_2S/urease production, sensitivity to erythritol/dyes (Thionin, basic Fuchsin) and susceptibility to antibiotics **(Alton, 1990).**

The full-proof method for the diagnosis of brucellosis is based on the isolation of *Brucella* organism; the procedure is laborious, time-consuming, costly, and hazardous. Furthermore, the probability of successful recovery of *Brucella* is strongly reduced when the material is heavily contaminated or when only a few organisms are present. The sensitivity of the isolation method also depends on the viability of *Brucella* within the sample, the nature of sample and the number of specimens tested from the sampled animal **(Yagupsky *et al*., 2019).** Moreover, negative culture results do not exclude infection **(Bercovich, 1998).**

Public health importance of brucellosis

According to the FAO and OIE, brucellosis is still one of the most important and widespread zoonosis in the world especially in developing countries **(Ocholi *et al,* 2013).** Animal and human brucellosis are closely related due to dependence on animals for nutrition, social and economic development and companionship. **(WHO, 2006, Aiyedun *et al,* 2019).** The occurrence of the disease in humans depends to a large extent on the animal reservoir. The presence of the disease in sheep and goats causes a high rate of human infection. In many developed countries, brucellosis has been controlled in animals, which led to a decrease in the number of human infections. In industrialized countries, the disease The disease occurs sporadically in individuals who become infected abroad or by ingesting unsafe animal products and exposed occupational groups (WHO, 2006)**.** Out of the ten species of *Brucella* currently known, *B. melitensis, B. suis* and *B. abortus* have public health implications.

Brucellosis in humans is either a foodborne or occupational disease (**WHO, 2006)**. Humans usually acquire brucellosis by consumption of raw or unpasteurized milk or milk products. Soft cheeses made from unpasteurized milk are common. Brucellosis is recognized as an occupational hazard for farmers, veterinarians, workers of the meat industry especially abattoir workers, hunters, and laboratory workers **(McDermott and Arimi, 2002).** Hunters and workers in abattoir or slaughter houses may become infected by contact with infected blood. Laboratory exposures usually result from aerosols generated by improper centrifugation or other careless behaviors (**WHO, 2006)**.

Economic Importance

Brucellosis in one of the most widespread and economically ravaging zoonoses recognized worldwide, not only because of the heavy economic losses and reduction in animal protein supplies to which it is responsible but of its direct impact on human health **(WHO, 2006).** Brucellosis like other abortion causing diseases of animals, causes economic losses through temporary infertility arising from chronic metritis, actual abortion and resulting in decreased milk production by dairy cows, birth of weak animals that die soon after birth, retention of the placenta, death from acute metritis, sterility, arthritis or bursitis (hygroma), and increased cost of animal replacement as well as lowered sale value of infected animals **(FAO, 2017).**

The economic losses due to human brucellosis, even though difficult to estimate, result from physical and psychological suffering due to infection, hospitalization, the cost of drugs and the loss of work or income due to illness, physical incapacity and reduction in productivity **(FAO, 2017)**. Few studies have assessed the direct or indirect losses associated with brucellosis in livestock in Nigeria. Indirect losses, particularly those that require brucellosis-free status to access regional or international livestock markets, have not been estimated in sub-Saharan Africa but could be a considerable constraint to future trade **(McDermott and Arimi, 2002, Aiyedun *et al,* 2019).**

Prevention and Control of Brucellosis

The strategy for the control of brucellosis in animals is essential in endemic areas **(WHO, 2010).** It is important that the design and implementation of brucellosis control programs should be based on valid data from active and passive surveillance obtained from the field **(Nsubuga, 2006).** Once an active surveillance system is in existence with valid data collected from the field, the progress, impact, adequacy and efficacy of the control programs can be continuously assessed and evaluated. **(WHO, 2006).** Decisions as to the appropriate strategy for the control and/or elimination of brucellosis are usually a national responsibility **(WHO, 2006; Alton, 1990).**

The provision of information and education concerning the disease to farmers and local communities is essential. Also, professional training is essential for the implementation of the strategies by the appropriate national services. The training of the different groups in the society will ensure that the right actions are taken and necessary resources are mobilized **(McDermott and Arimi, 2002).** Conditions in different countries throughout the world vary so much that a single universal program for the control and/or eradication of brucellosis is not feasible.

Challenges of brucellosis control in Nigeria

Many factors have been identified to be militating against internationally laid down procedures for the control of brucellosis in Nigeria (**Akinyemi *et al*., 2022**). One of the major factors contributing to the spread of the disease is free movement of animals practiced by the nomadic Fulani herdsmen who are accustomed to the traditional extensive system of management and owns about majority of food animal population in Nigeria **(Ducrotoy, *et al*., 2016).** Herding together various animal species like cattle, sheep and goats help in the spread of the disease among animal population where infected species of animals spread the disease to other animals within the population **(Ocholi *et al*, 2013).** The Fulani cattle herd which constitutes 95% of the National animal population is migratory (**Ducrotoy *et al*., 2016)**. As nomads, they migrate from one part of the country to another in search of grazing lands and watering points. This makes disease investigation, protective vaccination of cattle in the herd, and identification and handling of cattle within the herd difficult **(Eze, 1978a).**

The incentives and disease control measures aimed at improving milk and beef yield and financial gains may not achieve much success with nomads as with commercial cattle producers. This is because the primary objective of the Fulanis for rearing cattle is for prestige and enhancement of social status, rather than for financial gains and provision of more animal protein for the ever-increasing human population. The system of animal disease surveillance and reporting in the country is not efficient. This makes epidemiological trace-back and enforcement of control measures very difficult. The importation of exotic high-production breeds of cattle without having the required veterinary infrastructure and support and the trend toward intensification of animal production favors the spread and transmission of the infection (**WHO, 2006)**. Porous international borders with free movement of infected animals across the borders into the country also allow easy transmission of infections. There is no known officially coordinated control programme for brucellosis in Nigeria (**Aiyedun *et al,* 2019)**.

CONCLUSION

A control program for brucellosis should be instituted if the unrealized potentials are to be derived from the livestock industry in the country. Control of brucellosis can be achieved by using vaccination to increase the population's resistance to the disease. Mass vaccination is indicated where the prevalence of infected animals is high. Test and slaughter of animals that are positive is another proven control program. The provision of information and education concerning the disease to farmers and local communities is essential. The farmer must be informed of all the advantages of the control campaign, such as the economic benefits and the elimination of risk to the health of his family and himself. A single universal program for the control of brucellosis is not feasible. The strategies to be adopted depending on individual countries' peculiarities, human and material resources and political commitment to brucellosis control and elimination.

Conflicting Interests

The authors declare that there is no conflict of interest.

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