

## BRUCELLA EXPOSURE IN DOGS AND ASSOCIATED HUMAN RISK FACTORS IN PLATEAU AND NASARAWA STATES, NIGERIA

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### ABSTRACT

Brucellosis is a zoonotic disease of significant public health and economic concern caused by gram-negative bacteria of the genus *Brucella*. Human infection typically results from contact with infected animals or consumption of contaminated animal products. This study investigated *Brucella* exposure in dogs and assessed the knowledge, attitudes, and practices (KAP) of dog handlers in Plateau and Nasarawa States, Nigeria. A cross-sectional survey was conducted in which 200 blood samples were systematically collected from dogs attending veterinary clinics, kennels, and breeder facilities. Sera were tested using the Rose Bengal Plate Test (RBPT). Additionally, 100 dog handlers were interviewed with a structured, pre-tested questionnaire to assess risk factors and KAP related to brucellosis. Overall, *Brucella* seroprevalence in dogs was 48.5%, 95%CI: 41.6 - 55.5 (97/200). Seroprevalence was higher in Plateau State (59%, 95%CI: 49.3% – 68.7%) compared to Nasarawa State (38%, 95%CI: 28.5% – 47.5%). Higher seropositivity was observed among dogs older than 12 months (60%), females (54.3%), local breeds (55.4%), and those under extensive management (50%). Major risk factors included lack of protective hygiene practices (59%) and consumption of undercooked dog meat (54%). Notably, 76% of respondents had never heard of brucellosis, and 89% did not screen dogs prior to breeding. These findings indicate a high level of exposure to *Brucella* among dogs and highlight critical gaps in awareness and biosecurity practices among handlers. Targeted public health education, routine dog screening, and a coordinated national brucellosis control strategy are urgently needed to reduce the risks of transmission to humans and other animals.

**Keywords:** Brucellosis, Dogs, Risk factors, Seroprevalence, Zoonosis

### INTRODUCTION

Brucellosis is a highly contagious zoonotic disease caused by bacteria of the genus *Brucella*, which primarily affects domestic animals and occasionally humans (Wilkinson, 1993). Globally, it ranks as the second most significant zoonotic disease after rabies (OIE, 2012), with serious public health and economic consequences (Cadmus *et al.*, 2006). *Brucella* species are facultative intracellular, Gram-negative coccobacilli with host specificity. Six classical species are

recognized: *B. melitensis* (goats and sheep), *B. abortus* (cattle), *B. suis* (pigs), *B. ovis* (sheep), *B. canis* (dogs), and *B. neotomae* (wild rodents) (Pappas, 2006). Dogs are susceptible to *B. canis*, *B. abortus*, *B. suis*, and *B. melitensis* (Planz & Huddleson, 1931; Carmichael & Bruner, 1968), with *B. canis* being the most common cause of canine brucellosis.

Canine brucellosis affects the reproductive and reticuloendothelial systems and is characterized by abortion,

epididymitis, orchitis, infertility, and uveitis (Carmichael *et al.*, 1998; Lucero *et al.*, 2010). Transmission occurs through venereal routes, ingestion of contaminated materials, or direct contact with infected discharges (Mantur & Amarnath, 2008; Wallach *et al.*, 2009). The disease can be transmitted horizontally between dogs or vertically through contact with foetal tissues and reproductive secretions. The incubation period ranges from two weeks to three months, and most dogs can be serologically diagnosed within 8–12 weeks post-infection (CFS & PH, 2012).

Infected female dogs may present with late-term abortions, stillbirths, and persistent vaginal discharge (Wanke, 2004; Lucero *et al.*, 2005), while males may exhibit infertility, epididymitis, scrotal dermatitis, and prostatitis (Gyuranecz *et al.*, 2011; Khan *et al.*, 2011). Lymphadenopathy and bacteraemia also occur as the organisms disseminate through lymphatic and hematogenous routes (Enright, 1990).

Dogs may also acquire *B. abortus* through contact with infected cattle or ingestion of contaminated foetal materials (Forbes, 1990; Bricker *et al.*, 1994). Cross-species transmission, including dog-to-cattle and dog-to-human, has been demonstrated (Forbes, 1990). Diagnosis relies on serological tests such as Rose Bengal Plate Test (RBPT), Rapid Slide Agglutination Test (RSAT), Enzyme Linked Immuno Sorbent Assay (ELISA), and molecular techniques, including Polymerase Chain Reaction (PCR) (Romero *et al.*, 1995; Matar *et al.*, 1996). Although some antibiotic regimens (e.g., tetracyclines with dihydrostreptomycin) have been recommended for one to two months, treatment is however, difficult because the bacterium is embedded within the mucosa cells of the animal and has a high relapse rate (Wanke *et al.*, 2006). There is currently no vaccine available for canine brucellosis (Khan *et al.*, 2011).

Environmental persistence of *Brucella* species is notable, especially under conditions of low temperature and high humidity. The bacteria can survive in aborted fetuses, soil, and fomites for extended periods and are resistant to desiccation, though they are inactivated by standard disinfectants and autoclaving (Aune *et al.*, 2012; CFS & PH, 2012).

In Nigeria, canine brucellosis has been reported with varying prevalence rates. Serological surveys have recorded prevalence rates of 21.5% in Zaria (Osinubi *et al.*, 2004), 28.6% (Adesiyun, 1986), 5.46% in Lagos and Ibadan (Cadmus, 2006), and 29.2% in Jos (Momoh-Abdullateef *et al.*, 2014). Other prevalence rates include 21.9% in Gombe (Audu *et al.*, 2018), 1.96% in Benue (Ndumari *et al.*, 2020), and 27.7% in Enugu and Anambra States (Anyoaha *et al.*, 2020). A similar report from South Korea also confirmed *B. abortus* infection in dogs due to cattle-to-dog transmission (Baek *et al.*, 2003). In Nigeria, *B. abortus* biovar 3a was

reported in cattle (Bertu *et al.*, 2015), highlighting the possibility of cross-species spillover.

Despite being a notifiable disease, brucellosis remains underreported in Nigeria due to limited surveillance, poor laboratory capacity, and lack of molecular diagnostics (Ocholi *et al.*, 1993b). The rise in dog ownership, breeding activities, and dog meat consumption, especially in the North Central region, raises concern over potential zoonotic transmission. Many imported exotic dogs are not screened before entry, and dogs are often fed raw foetal materials from abattoirs (Cadmus, 2010). These factors increase the risk of *Brucella* infection among dogs and exposure to handlers.

Human infection with canine brucellosis is rare but significant. Transmission occurs via direct contact with infected animals or exposure to secretions, with symptoms including fever, malaise, arthralgia, hepato-splenomegaly, and reproductive complications (Bossi *et al.*, 2004; Godfroid *et al.*, 2011; Dean *et al.*, 2012a). A prevalence of 7.6% was reported among humans exposed to infected dogs in Makurdi, Nigeria (Ofukwu *et al.*, 2004). Veterinarians, breeders, and butchers are particularly at risk, often due to low awareness and poor biosecurity practices (Momoh-Abdullateef *et al.*, 2014).

The disease has major veterinary, public health and economic implications (Franco, 2007). While *B. melitensis* poses the highest zoonotic risk, *B. abortus* and *B. suis* also contribute significantly, whereas *B. canis* is considered to have lower zoonotic potential (Pappas, 2010). The paucity of information on canine brucellosis in Nigeria, particularly in terms of molecular epidemiology, hinders efforts to control the disease.

This study was therefore designed to determine the *Brucella* exposure in dogs and associated human risk factors in Plateau and Nasarawa States, Nigeria. The findings will contribute to baseline data for surveillance and control strategies, inform public health interventions, and clarify the zoonotic potential of canine brucellosis in the region.

## MATERIALS AND METHODS

### STUDY AREA

This study was conducted in Plateau and Nasarawa States, both located in North Central Nigeria.

### PLATEAU STATE

Plateau State covers approximately 30,913 km<sup>2</sup> and has a population of over 3 million (NPC, 2006). It is situated between latitudes 8°24'N and 10°38'E, and is characterized by a temperate climate due to its high altitude, ranging from 1,200 to 1,829 meters above sea level. The state experiences annual rainfall between 132–146 cm and temperatures ranging from 13°C to 22°C. Agriculture and tourism are the major economic activities.

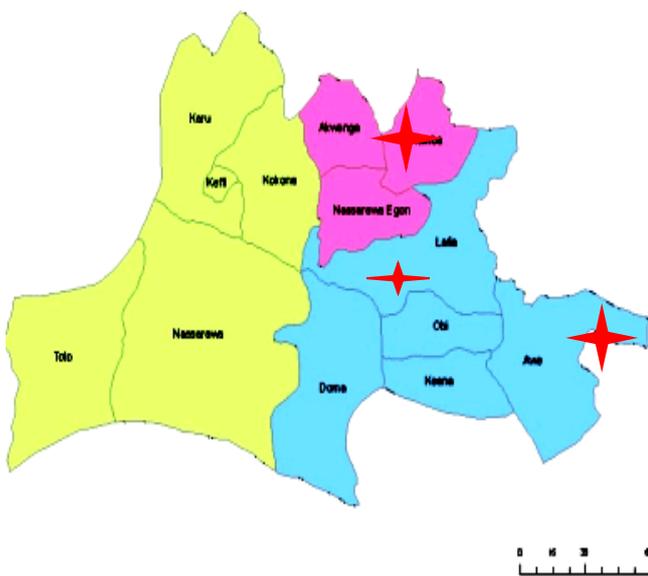


**Figure I: Map of Plateau State showing the Local Government Areas (LGA)**

Note: The Red star shows LGA sampled

**NASARAWA STATE**

Nasarawa State spans 27,217 km<sup>2</sup>, with a population of about 1.87 million (NPC, 2006). It lies between latitudes 7°45'N and 9°25'N and experiences a tropical climate with distinct wet (April to October) and dry (November to March) seasons. The average annual rainfall ranges from 1,200 to 2,000 mm. The state's economy is driven by agriculture and mineral resources.



**Figure II: Map of Nasarawa State showing the Local Government Areas (LGA):** Note: The Red star shows LGA sampled

**STUDY DESIGN AND POPULATION**

A cross-sectional study design was employed to assess the Brucella exposure in dogs and associated risk factors among

their handlers. The target population included domestic dogs presented at veterinary clinics, dogs kept in kennels and breeder facilities, and their respective handlers, including veterinarians and breeders.

Local Government Areas (LGA) and districts were selected using simple random sampling by balloting, while veterinary clinics, kennels, and breeder houses were chosen purposively. Dogs at clinics were sampled systematically. Structured questionnaires were administered during biweekly visits to selected sites over the study period.

**SAMPLE SIZE DETERMINATION**

The required sample size was determined using the formula of Mugo (2008) at 95% confidence level, and prevalence rate of 10.26% as reported by Momoh *et al.*, (2022) was used.

$$N = \frac{Z^2 pq}{L^2}$$

Where N= Sample size

Z<sup>2</sup>=Appropriate value for the standard normal deviate for the desired confidence= 1.962

P=Prevalence

q=1-p

L<sup>2</sup>= Allowable error of 5% ([www.wallstreetmojo.com](http://www.wallstreetmojo.com))

$$N = \frac{1.96^2 \times 0.1026 (1-0.1026)}{0.05^2} = 141.48$$

141 samples were to be collected, but to enhance accuracy and minimize error, a total of 200 samples were ultimately collected.

**QUESTIONNAIRE SURVEY**

A pre-tested, structured questionnaire was administered to collect data on dog-related variables (age, sex, breed, management system, location, and obstetric history) and handler-related variables (occupation, education level, and awareness of brucellosis). Participation was voluntary, and informed consent was obtained before administration.

**SAMPLE COLLECTION AND HANDLING**

Venous blood (5 ml) was aseptically collected from the cephalic vein of each dog using sterile 5 ml syringes and plain vacutainer tubes. Samples were allowed to clot at room temperature or centrifuged at 3,000 rpm for 20 minutes to obtain sera. The sera were transferred into labelled tubes corresponding to the questionnaire ID and stored at -20°C at the Bacterial Zoonoses Laboratory, National Veterinary Research Institute (NVRI), Vom, until analysis.

**LABORATORY PROCEDURES  
SEROLOGY**

Serological testing for *Brucella* antibodies was performed using the Rose Bengal Plate Test (RBPT) following the standard procedure described by Alton *et al.* (1988). Equal volumes (30 µl) of antigen (Zoetis, Belgium-UK) and serum were mixed on a test plate, rocked for 4 minutes, and observed for agglutination. The appearance of pink-red clumps indicated a positive result, while the absence of agglutination was recorded as negative.

**DATA ANALYSIS**

Data were analysed using SPSS version 21. Descriptive statistics were used to calculate the seroprevalence, while Chi-square tests assessed associations between seropositivity and independent variables. Fisher’s exact test was applied where expected frequencies were low. Statistical significance was set at  $p \leq 0.001$ .

**RESULTS**

**SEROLOGY RESULTS**

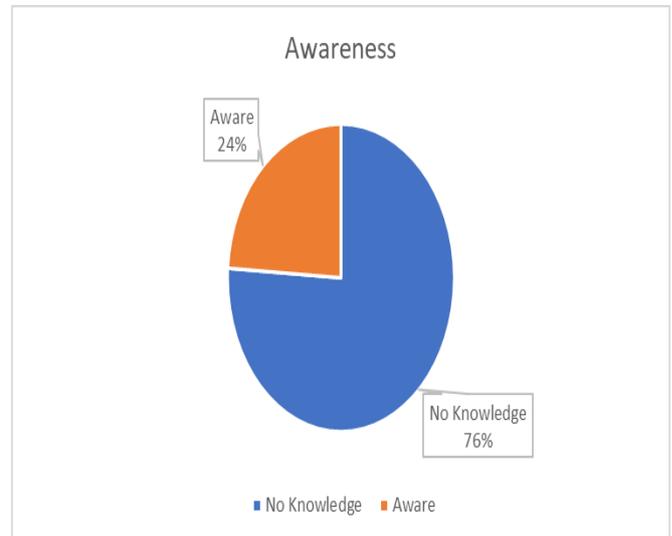
Out of the 200 dog serum samples tested using the Rose Bengal Plate Test (RBPT), 97 (48.5%) tested positive for *Brucella* antibodies. Geographic distribution showed a significantly higher seroprevalence in Plateau State (59.00%,  $n=59/100$ ) than in Nasarawa State (38.00%,  $n=38/100$ ), indicating a strong association ( $\chi^2 = 9.90, p= 0.0017, df = 1$ ) between location and infection (Table I).

Similarly, dogs aged  $\geq 12$  months showed the highest seroprevalence (60.0%,  $n=72/120$ ), followed by those aged 6 to <12 months (33.33%,  $n=19/57$ ), and those under 6 months (26.09%,  $n=6/23$ ). The association between age and seropositivity ( $\chi^2 = 16.56, p<0.001, df = 2$ ) was statistically significant (Table 2). In Table 3, female dogs exhibited a higher seroprevalence (54.33%,  $n=69/127$ ) compared to males (38.36%,  $n=28/73$ ). The difference was statistically significant ( $\chi^2 = 4.34, p = 0.037, OR = 1.91, df = 1$ ). Furthermore, local breeds showed the highest seroprevalence at 55.43%, ( $n=51/92$ ), followed by mixed breeds at 43.66% ( $n=31/71$ ), and exotic breeds at 40.54% ( $n=15/37$ ). The association between breed and infection was statistically significant ( $\chi^2 = 3.46, p = 0.177, df = 2$ ) (Table IV).

Table V shows that dogs raised under extensive management systems had slightly higher seroprevalence (50.00%,  $n=46/92$ ) compared to those under intensive systems (47.22%,  $n=51/108$ ). The association between management system and infection was not statistically significant ( $\chi^2 = 1.54, p = 0.215, OR = 0.90, df = 1$ ).

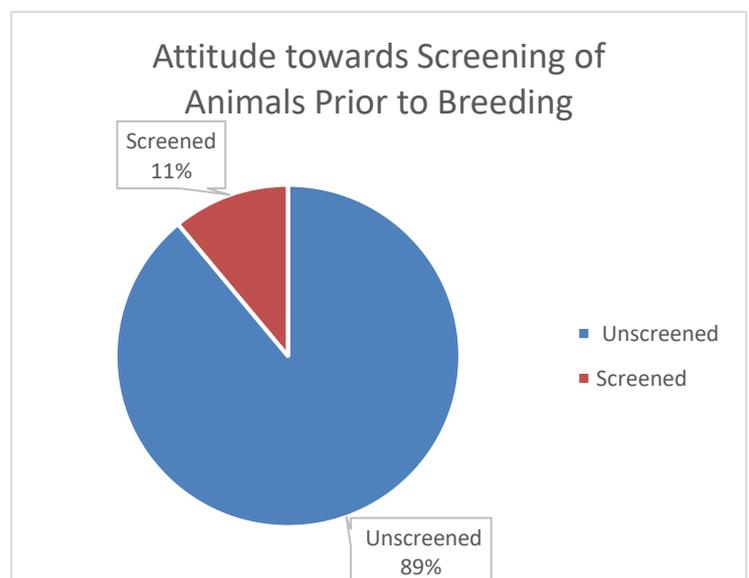
**KNOWLEDGE, ATTITUDES, AND PRACTICES OF  
DOG HANDLERS AND CONSUMERS**

Out of 100 respondents surveyed in Plateau and Nasarawa States, 76% reported no knowledge of brucellosis, while only 24% indicated some awareness of the disease (Fig.3).



**Figure III: Level of awareness of Respondents on Brucellosis by the respondents**

Most dog owners (89%) did not screen their animals for brucellosis before breeding, whereas just 11% conducted such screening (Fig 4).



**Figure IV: Attitude of Respondents towards screening of animals before breeding**

In terms of consumption behaviour, 54% of respondents preferred roasted dog meat, followed by 8% who consumed boiled meat, 3% who preferred fried, and 5% who consumed all three forms (Fig.5).

**TABLE I: BRUCELLA EXPOSURE IN DOGS BASED ON LOCATION IN PLATEAU AND NASARAWA STATES, NIGERIA**

Location (State)	Total Number of Dogs Examined	Total Number of Dogs Positive	Prevalence (%)	95% CI	$\chi^2$	p-value
Plateau	100	59	59.00	49.3 – 68.7		
Nasarawa	100	38	38.00	28.5 – 47.5	<b>9.90</b>	<b>0.0017</b>
Total	200	97	48.50	41.6 - 55.5		

**TABLE II: BRUCELLA EXPOSURE IN DOGS BASED ON AGE DISTRIBUTION IN PLATEAU AND NASARAWA STATES, NIGERIA**

Age groups (months)	Total Number of Dogs Examined	Number of Dogs Positive	Prevalence (%)	95% CI	$\chi^2$	p-value
0 < 6	23	6	26.09	10.2-47.2		
6 < 12	57	19	33.33	21.9 – 46.3		
≥12	120	72	60.00	50.9 – 68.6	<b>19.14</b>	<b>&lt;0.001</b>
Total	200	97	48.50	-		

**TABLE III: BRUCELLA EXPOSURE IN DOGS BASED ON SEX DISTRIBUTION IN PLATEAU AND NASARAWA STATES, NIGERIA**

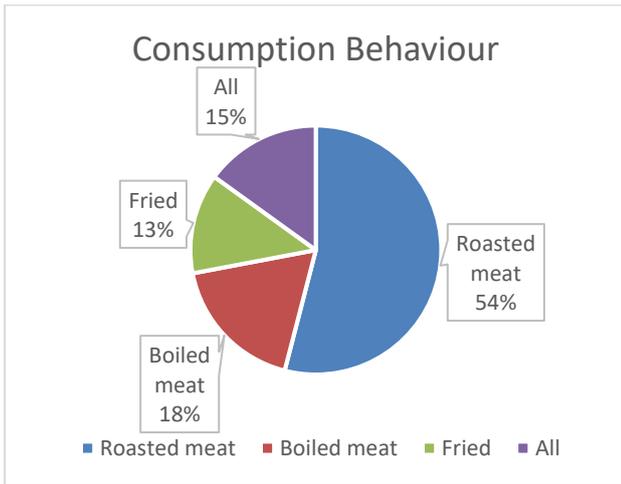
Sex	Total Number of Dogs Examined	Total Number of Dogs Positive	Prevalence (%)	95% CI	OR	$\chi^2$ p-Value
Male	73	28	38.36	27.3 – 50.3%		
Female	127	69	54.33	45.4 – 62.9%	<b>1.91</b>	<b>4.340.037</b>
Total	200	97	48.50			

**TABLE IV: BRUCELLA EXPOSURE IN DOGS BASED ON BREED DISTRIBUTION IN PLATEAU AND NASARAWA STATES, NIGERIA**

Breed	No. of Dogs Examined	No. of Dogs Positive	Prevalence (%)	95% CI	$\chi^2$	p-value
Local	92	51	55.43	44.8 – 65.6		
Mix	71	31	43.66	32.2 – 55.0		
Exotic	37	15	40.54	26.2 – 57.5		
Total	200	97	48.50	41.5 – 55.6	<b>3.46</b>	<b>0.177</b>

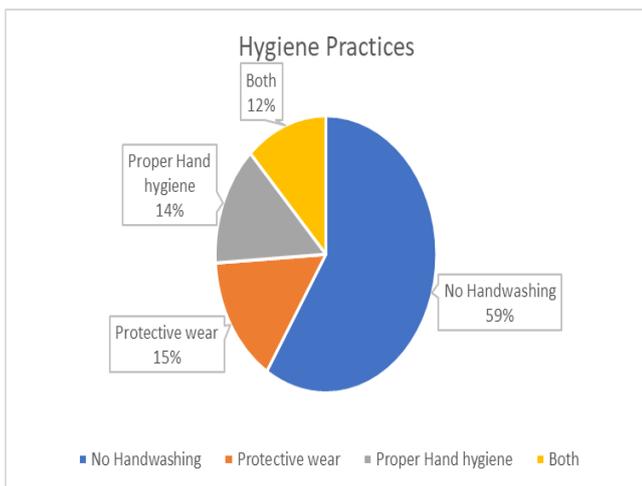
**TABLE V: BRUCELLA EXPOSURE IN DOGS BASED ON MANAGEMENT PRACTICES IN PLATEAU AND NASARAWA STATES NIGERIA**

Management system	No. of Dogs Examined	No. of dogs Positive	Prevalence (%)	95% CI	OR	$\chi^2$	p-Value
Intensive	108	51	47.22	38.10 -56.53			
Extensive	92	46	50.00	39.71 – 60.29	0.90 (0.51–1.56)	<b>1.54</b>	<b>0.215</b>
Total	200	97	48.50	41.53 – 55.50			



**Figure V: Consumption Behaviour of Respondents**

Hygiene practices revealed 59% of respondents neither practiced regular hand washing nor used protective wear during dog handling. Only 5% used protective wear, 4% practiced proper hand hygiene, and 2% reported doing both (Fig.6).



**Figure VI: Hygiene Practices of Respondents**

**DISCUSSION**

Brucellosis is a major zoonosis of public health and veterinary significance, particularly in developing countries where surveillance and control measures are limited or nonexistent (Pappas *et al.*, 2006; Godfroid *et al.*, 2005). The present study revealed a high seroprevalence of *Brucella* species (48.5%) in dogs in Plateau and Nasarawa States, indicating widespread exposure and potential endemicity in the study areas. This prevalence is considerably higher than that reported in other regions of Nigeria, such as Ibadan (Agunloye *et al.*, 1999; Ayoola *et al.*, 2016), Zaria (Adesiyun *et al.*, 1986; Osinubi *et al.*, 2004), and Enugu/Anambra (Anyaocha *et al.*, 2020). These variations could be attributed to regional differences in dog population densities, cultural practices, veterinary services, and diagnostic methods.

The high prevalence may also reflect the absence of a structured brucellosis control program in Nigeria, which contrasts with more regulated settings where vaccination and biosecurity are routinely practiced (Ducrottoy *et al.*, 2014). The lack of vaccination for dogs, alongside poor knowledge of the disease among breeders and handlers, creates a permissive environment for transmission. In this study, 76% of respondents lacked awareness of brucellosis, aligning with previous findings that low awareness is a key driver of disease persistence (Hollett, 2006; Momoh-Abdullateef *et al.*, 2015).

Geographical comparison indicated that dogs from Plateau State had a higher prevalence (59.00%) than those from Nasarawa State (38.00%). This may be linked to cultural practices, such as widespread dog meat consumption and higher density of breeding operations in Plateau (Bata, 2011; Elisha & Solomon, 2008). It is also possible that feeding practices, including the use of raw foetal materials from cattle or other animals, contributed to this disparity (Momoh-Abdullateef *et al.*, 2014).

Age was significantly associated with seropositivity, with dogs aged  $\geq 12$  months showing the highest prevalence (60%). This age-related trend is consistent with other studies (Ayoola *et al.*, 2016; Radostits *et al.*, 2007), which suggest that older dogs are more susceptible due to cumulative exposure and increased sexual activity. Similarly, it was noted that the risk of the disease increases with age due to greater environmental exposure and reproductive maturity (Kebede *et al.*, 2008).

Sex-related differences were observed, with females showing higher seroprevalence (54.33%) compared to males (38.36%), although the association was not statistically significant. Several studies have reported similar findings (Cadmus *et al.*, 2006; Ayoola *et al.*, 2016), often attributing the increased risk in females to physiological factors such as higher erythritol concentrations in reproductive tissues, which promote bacterial growth (Enright, 1992; Radolf, 1994). Additionally, in communal and uncontrolled breeding settings, females are more likely to be repeatedly exposed to infected males.

Breed distribution also showed significant differences, with local breeds exhibiting the highest seroprevalence (55.43%). This contrasts with some studies where exotic breeds showed higher infection rates (Okoh *et al.*, 1978; Osinubi *et al.*, 2004), but supports findings that local breeds are often more exposed due to lower economic value, reduced care, and free-roaming behaviour (Cadmus *et al.*, 2011; Ayoola *et al.*, 2016). Despite these differences, all dog breeds are biologically susceptible to *Brucella* infection (OIE, 2007), highlighting that management and exposure factors may be more relevant than genetics.

Dogs under extensive management had a slightly higher seroprevalence (50.00%) compared to those under intensive care (47.22%). Extensive management often involves free roaming and increased exposure to contaminated materials such as aborted foetal tissues or infected carcasses (Nicoletti, 1989; Godfroid *et al.*, 2005). These findings are supported by FAO/WHO (1986), which identified ingestion of infected materials and sexual transmission as primary routes of *Brucella* transmission in dogs.

Behavioural risk factors were evident in this population. Notably, a majority of respondents (89%) did not screen their dogs before breeding. This is a major concern, as unregulated mating practices can facilitate widespread transmission of *Brucella*, particularly from infected studs to multiple females. As highlighted by Rhyan *et al.* (2000) and Cadmus *et al.* (2006), untested breeding dogs, especially imported ones, can serve as sources of infection in previously unaffected populations. The situation is worsened by the cultural preference for dog meat in parts of North Central Nigeria, where 54% of the population consumes roasted or inadequately cooked dog meat—a known risk factor for zoonotic transmission (Palmer *et al.*, 1998; Seleem *et al.*, 2010).

Hygiene practices among dog handlers were also poor, with 59% not practicing basic measures such as handwashing or wearing protective clothing. These practices are critical, as *Brucella* organisms can be transmitted through mucosal surfaces or skin abrasions, particularly during contact with reproductive secretions or aborted materials (Mantur & Amarnath, 2008). The occupational exposure of veterinarians, breeders, and butchers is especially concerning, as repeated contact without adequate protection increases the risk of infection (Momoh-Abdullateef *et al.*, 2015).

## CONCLUSION

The major risk factors identified were; low awareness, poor hygiene practices, unscreened breeding, extensive management systems, and the consumption of undercooked dog meat. Age, breed, management system, and location were all significantly associated with infection. Addressing these risk factors through education, policy, and improved veterinary services is critical for reducing both animal and human exposure to *Brucella* species. The findings of this study reinforce the endemicity of canine brucellosis in North Central Nigeria and underscore the importance of both veterinary and public health interventions. The high seroprevalence, coupled with poor awareness, inadequate screening, and high-risk behaviours, emphasizes the urgent need for a multisectoral response guided by One Health principles and the need for improved surveillance, education, and biosecurity to reduce the transmission of canine brucellosis and its zoonotic implications. To mitigate the

spread of brucellosis, public enlightenment programs targeting dog handlers and consumers should be prioritized. Breeders and veterinarians must adhere to proper screening protocols and hygiene practices. Free-roaming should be discouraged and intensive management systems encouraged. Thorough cooking of dog meat, regulation of dog imports, and the implementation of control policies at state and national levels are essential. Further epidemiological studies in other regions are recommended to guide effective intervention strategies.

## DECLARATIONS

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## DECLARATION OF COMPETING INTEREST

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest. All claims expressed in this article are solely those of the authors and do not necessarily represent those of their affiliated organizations or those of the publisher, the editors, or the reviewers.

## ETHICS APPROVAL

Ethical approval was obtained from National Veterinary Research Institute Animal Ethics Committee with NVRI AEC reference number: **AEC/03/195/25**

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