Serological Survey of Pathogenic *Leptospira* in Reservoir Household Rats (*Rattus rattus*) and Community Risk Perception in Sokoto Metropolis, Sokoto State, Nigeria

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ABSTRACT

Leptospirosis, a neglected zoonosis caused by pathogenic Leptospira species, poses significant public health risks in urbanizing areas of sub-Saharan Africa, where rodents like Rattus rattus serve as key reservoirs. Sokoto Metropolis, Nigeria, exemplifies such vulnerability due to rapid urbanization, poor sanitation, and high rodent infestation in informal settlements. This cross-sectional study determined the seroprevalence of pathogenic Leptospira IgG in household rats and evaluated community knowledge, attitudes, and practices (KAP) toward rodent-borne diseases. Rodents were systematically trapped across Sokoto North, Sokoto South, Wamakko, Dange-Shuni, and Kware local government areas using baited wire-mesh live traps over two consecutive nights per site, yielding 212 Rattus rattus samples. Serum was harvested from cardiac puncture blood and tested via indirect ELISA (Rat Leptospira IgG ELISA Kit, AFG Scientific, USA) at 450 nm, with positivity defined by manufacturer cut-offs (≥0.5 OD). Concurrently, structured questionnaires were administered to one adult per household (n=212) via face-to-face interviews in Hausa/English on Google Forms, assessing socio-demographics, housing, livestock ownership, sanitation, and KAP (Cronbach's α=0.78). Data were analyzed descriptively and via chi-square/logistic regression (p<0.05). Overall Leptospira seroprevalence was 33% (70/212), with district variations: Wamakko (27.1%), Sokoto South (25.7%), Sokoto North (24.3%), Dange-Shuni (15.7%), Kware (7.1%; χ²=8.49, p=0.075). No significant associations emerged with age (e.g., >50 years: 61.4% positive, p=0.254), gender (males 91.4% of positives, p=0.162), education (Quran/Madrassa 35.7% positive, p=0.104), occupation (p=0.906), marital status (p=0.720), household role (p=0.481), house type (mud 32.9% positive, p=0.213), animals owned (6-10: 54.3% positive, p=0.107), or toilet type (water closet 52.9% positive, p=0.394). Household size trended higher in larger groups (6-10: 51.4%, p=0.056), suggesting crowding risks. Community KAP revealed moderate rodent disease awareness but poor leptospirosis-specific knowledge and inconsistent prevention (e.g., traps, rodenticides). Larger households and substandard housing amplified exposure. These findings confirm active Leptospira circulation in urban rats, with ubiquitous risk across demographics, underscoring gaps in awareness and sanitation. Integrated One Health strategies rodent control, sanitation upgrades, and targeted education are essential to curb transmission in similar Nigerian settings.

Keywords: *ELISA, Leptospira, Nigeria, Seroprevalence, Sokoto Metropolis, Rattus rattus, Risk Perception*

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INTRODUCTION

Leptospirosis is a globally important zoonotic disease caused by pathogenic bacteria of the genus *Leptospira*, encompassing both harmful and harmless species. This disease affects a wide range of hosts, including domestic and wild animals, but rodents especially species like *Rattus rattus* are key reservoirs that facilitate the transmission of the bacteria to humans. Humans typically become infected through direct or indirect contact with the urine of infected animals or by exposure to contaminated environments such as soil and water. These environmental reservoirs are particularly significant in areas suffering from poor sanitation, frequent flooding, and inadequate waste disposal systems (Levett, 2024; Haake and Levett, 2021).

The transmission dynamics of leptospirosis highlight its epidemiological relevance in tropical and subtropical regions where climatic conditions, environmental factors, and socio-economic challenges combine to sustain zoonotic spill over. Factors such as heavy rainfall, contaminated surface water, and overcrowded living conditions intensify the risk of infection, notably in low-income urban and peri-urban areas (Costa *et al*., 2023). In these settings, leptospirosis can lead to severe outbreaks, causing considerable illness and death. Its symptoms often include fever with nonspecific signs, which complicates diagnosis and delays treatment, making the disease under-recognized in many endemic locations.

Nigeria illustrates the challenges associated with controlling leptospirosis in sub-Saharan Africa. Although evidence suggests the disease is endemic, it remains underreported and understudied due to limited diagnostic resources, frequent misdiagnosis as other febrile illnesses like malaria or typhoid, and low awareness in healthcare and community settings (Akinbo *et al*., 2022). Rodents, particularly *Rattus rattus*, thrive in Nigerian urban and peri-urban environments where rapid expansion of informal settlements and poor sanitation provide ideal conditions for their proliferation (Oladele *et al*., 2024). These rodents commonly inhabit homes, food storage areas, and refuse sites, increasing contact with humans and domestic animals, thus serving as active reservoirs that sustain *Leptospira* transmission in human-dominated settings.

Sokoto Metropolis, the capital of Sokoto State in Northwestern Nigeria, exhibits unique ecological and socio-cultural factors that heighten the risk of *Leptospira* transmission. Situated in the Sudan-Sahel ecological zone, Sokoto experiences a semi-arid climate with seasonal rivers and sparse vegetation, alongside pastoral livestock farming, all critical to its economy. Rapid urban growth, characterized by overcrowding, substandard housing (such as mud and thatched homes), and poor waste management and drainage, fosters conditions conducive to rodent infestation and environmental contamination (Oladele *et al*., 2024). These combined factors enable the persistence of *Leptospira* in the environment and increase the likelihood of zoonotic transmission to the population. Local practices and socio-economic realities also influence the community's vulnerability to leptospirosis. Many households rely on untreated surface water, enhancing exposure to contaminated sources (Udechukwu *et al*., 2024). Additionally, livestock kept near homes provide further contact points among animals, rodents, and humans, complicating transmission cycles. These complexities point to a need to look beyond the mere presence of the pathogen and incorporate assessments of community knowledge, attitudes, and practices (KAP) regarding rodents and related diseases.

Community risk perception critically affects the effectiveness of disease prevention in leptospirosis-endemic regions. Knowledge about rodents as disease carriers, understanding transmission modes, and beliefs concerning the severity of leptospirosis influence behaviors and uptake of preventive methods like sanitation improvement, rodent control, and safe water use. Nevertheless, evidence shows that knowledge is often incomplete, risks are underestimated, and preventive behaviors are inconsistently practiced in resource-limited endemic areas (Udechukwu *et al*., 2024). Thus, evaluating KAP offers essential insights to identify gaps and opportunities for culturally appropriate health education and public health initiatives. This study seeks to conduct a serological survey of pathogenic *Leptospira* in peridomestic *Rattus rattus* populations within Sokoto Metropolis and examine community perceptions about rodent-borne diseases. By combining biological evidence with socio-behavioral data, the research aims to provide a comprehensive understanding of leptospirosis epidemiology in this Nigerian urban setting. The outcomes are expected to guide integrated One Health approaches, including rodent management, environmental sanitation, and community engagement, to effectively reduce leptospirosis risks in Sokoto and similar contexts.

MATERIALS AND METHODS

Study Area

Sokoto State, located in the northwestern region of Nigeria, shares an international border with the Niger Republic to the north, making it a strategic hub for trans-border livestock trade and cultural exchange (Figure 1). The state lies within the Sudan-Sahel ecological zone, characterized by semi-arid savannah grassland, seasonal rivers, and sparse vegetation, ideal for pastoralism and extensive livestock rearing, especially of cattle, goats, sheep, and camels (Oladele *et al.,* 2024). These livestock activities form the backbone of the local economy and are vital for both domestic consumption and cross-border trade (Mamman, 2005). Sokoto city, the state capital, serves as the administrative and economic centre.

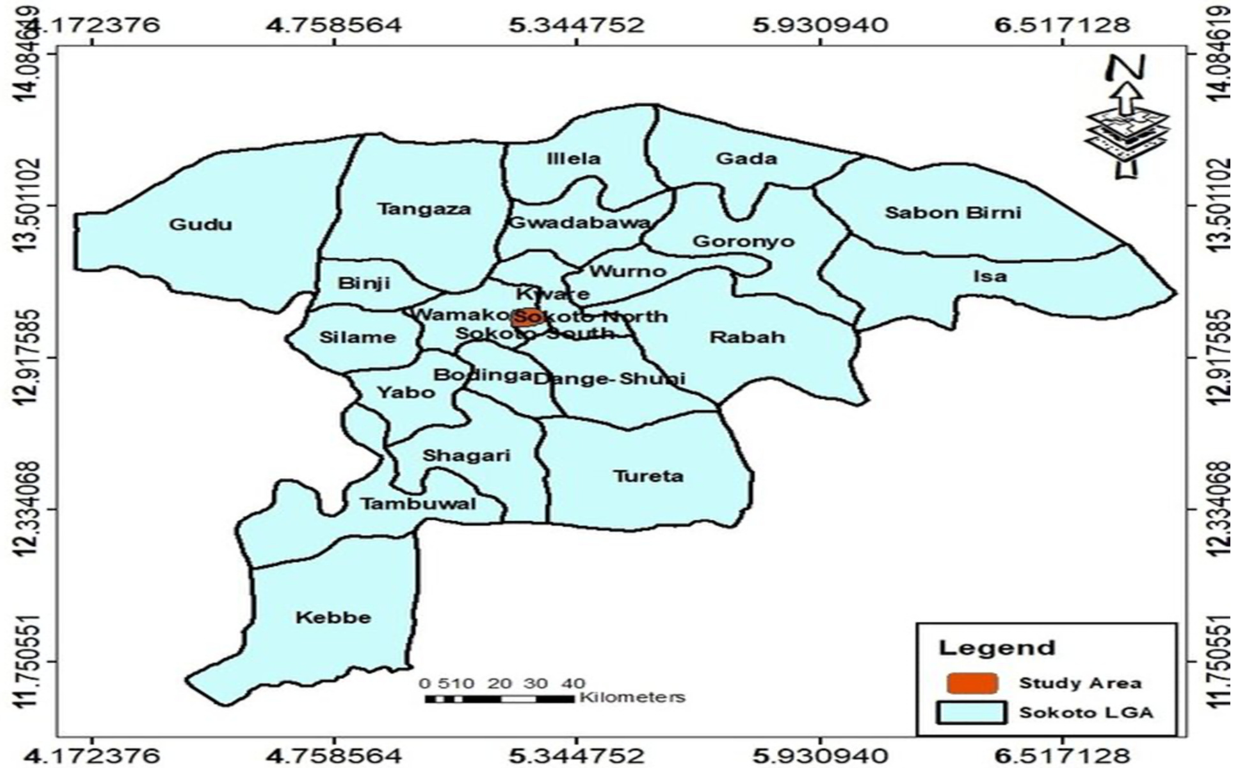

Figure 1: Map of Sokoto State showing the 23 Local Government Areas and the Study Area (Fouad *et al.,* 2024).

It is more densely populated compared to rural parts of the state, with an estimated population exceeding 600,000 (Mamman, 2000). The city is marked by rapid urbanization, growing informal settlements, and a dense network of markets, abattoirs, and food handling areas, all of which contribute to complex interactions between humans, animals, and the environment. These conditions make Sokoto metropolis both a centre of livestock trade and a potential hotspot for zoonotic disease transmission, including Leptospirosis, especially due to poor sanitation and high rodent activity in densely populated neighbourhoods.

The study was conducted in Sokoto metropolis, which comprises Sokoto North and Sokoto South local governments, as well as parts of Wamakko, Dange-Shuni and Kware Local Government Areas. These areas are characterized by high-density residential settlements, informal waste disposal practices, and abundant rodent populations, factors conducive to the transmission of rodent-borne zoonoses such as Leptospirosis (Figure 1).

Study Design and Population

This study employed a cross-sectional design to assess community risk perception and the molecular evidence of pathogenic *Leptospira* circulation among domestic rats in Sokoto Metropolis, North western Nigeria. The research used a structured questionnaire survey targeting human populations and laboratory-based diagnostics on captured rodents to establish both behavioral and biological evidence of Leptospirosis risk. The population of Sokoto metropolis is large, youthful, and predominantly urban poor, with a mix of civil servants, traders, artisans, and students, alongside peri-urban communities that depend on farming and livestock keeping (Dankani, 2018). The residents of Sokoto are predominantly Hausa-Fulani, and the city has densely populated neighbourhoods with limited sanitation infrastructure, irregular waste disposal, and poor drainage systems, conditions that increase contact with rodent populations and contaminated water (Nahuce *et al.,* 2022). These demographic and environmental features in addition to the high population density, informal settlements, and frequent human-rodent interactions (through food storage, open refuse dumps, and livestock markets) create an environment conducive to *Leptospira* l transmission (Neiderud 2015). Moreover, limited awareness about zoonotic diseases, combined with reliance on untreated surface water in some areas, shapes the community's risk perception and influences exposure pathways.

Sample Size and Sampling Technique

A minimum of 53 samples was calculated using Conchran's formula for estimating a single population proportion and a prevalence of 3.6% (Krairojananan *et al.,* 2020). This was multiplied by 4, representing Sokoto North, Sokoto South, and Wamakko Local Government Areas (LGA). At the same time, Kware and Dange-Shuni, which had the least settlements as part of the Sokoto metropolis, were merged as one. Hence, the total sample was 212. A multistage sampling technique was utilized. Initially, within each LGA, enumeration areas (districts) were randomly chosen, followed by systematic selection of households. Based on assumed population density, 46 samples, 77 samples, 24 samples, 57 samples, and 8 samples were arbitrarily allocated to Sokoto North, Sokoto South, Dange Shuni, Wamakko and Kware LGAs, respectively.

Questionnaire Data Collection

To assess community risk perception and behavioral responses to rodent-borne diseases in Sokoto Metropolis, a structured questionnaire survey was employed to collect data across the selected local government areas using a systematic random sampling technique to ensure representativeness. Following a mapping of residential areas, trained data collectors conveniently selected the first consenting household and subsequently visited every tenth household to administer the questionnaire. Where a household refused consent or residents were absent at the time of our visit, the preceding household was chosen. Within each selected household, one adult respondent (preferably the head of household or an informed representative) was recruited to participate in the study. Data were collected through face-to-face interviews conducted by trained field staff using a structured and pre-validated questionnaire. The tool was developed based on existing literature on rodent-borne diseases and was further refined through expert review for contextual relevance (Udechukwu *et al.,* 2024). The questionnaire was pre-tested through a pilot study involving 30 participants drawn from districts within the Sokoto metropolis that were not included in the main study. Internal consistency of the instrument was assessed using Cronbach's alpha, which yielded a value of 0.78, indicating acceptable reliability. Prior to deployment, the questionnaire was translated into Hausa and back-translated to ensure consistency and avoid loss of meaning. It was uploaded into a Google Form and administered using mobile tablets to ensure accuracy and ease of data capture.

The questionnaire consisted of four major sections, including participants' demographic and household characteristics (age, sex, education level, occupation, marital status, household size, and role within the household). Section one of the questionnaire also included structural and environmental factors, including type of housing (e.g., mud, thatched, modern), ownership of livestock or domestic animals (cattle, sheep, goats, dogs, cats, etc.), type of toilet facilities, and general household hygiene. Section two of the questionnaire assessed knowledge and perception of rodents and rodent-borne diseases to understand the level of awareness of rodents as disease vectors, understanding of Leptospirosis and other rodent-associated diseases, knowledge of disease transmission routes, and previous exposure to health education on rodents.

Similarly, attitudes of the participants toward prevention of rodent-borne diseases were measured using a series of Likert-scale statements to evaluate beliefs about rodent-related health risks, the importance of rodent control, individual responsibility in preventing infestations, and the perceived effectiveness of public health education. Finally, section four assessed the practices and control measures commonly adopted and practised, such as the use of traps, rodenticides, keeping cats, storing food in sealed containers, and regular cleaning practices. Respondents were asked to identify all applicable methods they used to mitigate rodent infestations. Each interview lasted approximately 20-30 minutes. The questionnaire responses were reviewed daily by supervisors for completeness and consistency.

Rodent Trapping Procedure and Sample collection

The procedure for trapping domestic rats followed established protocols adapted from Machtinger and Williams (Machtinger and Williams 2020). Rodent trapping was carried out in selected locations across Sokoto Metropolis. A total of 10 wire-mesh live traps were used for capturing rats in both residential and peri-domestic environments. Traps were strategically placed in areas with high signs of rodent activity, such as kitchens, food storage rooms, and compound peripheries.

Traps were set in the evening between 5:30 pm and 7:30 pm, baited with a fish and groundnut cake. Each trap was checked the following morning between 6:30 am and 7:30 am. Traps were kept closed during the day to avoid unintended trapping and to preserve bait integrity and then reset each evening at the same locations. Trapping at each site was conducted over two consecutive trap nights. In open compounds, traps were spaced approximately 10 meters apart where feasible, while in more irregularly structured households, placement was adapted to the local context.

Captured rodents were transported in covered containers to the Epidemiology Laboratory at the Faculty of Veterinary Medicine, Usmanu Danfodiyo University, Sokoto, for humane handling and sample collection. Prior to blood and kidney tissue samples collection, Captured rats were anaesthetised using a combination of Ketamine and Xylazine intraperitoneal at 50 mg kg^{-1} and 4 mg kg^{-1} xylazine, respectively. Blood samples were collected via cardiac puncture, and kidney tissues were aseptically excised post-mortem. Samples were stored in appropriately labelled vials and preserved at -20°C for downstream laboratory analysis.

Enzyme Linked Immunsorbent Assay for *Lepstospira* IgG

Harvesting Serum Samples

Whole blood samples were collected from captured domestic rats via cardiac puncture under anaesthesia, using sterile 5 mL syringes and plain vacoutainers tubes without anticoagulants (Rodríguez-Rodriguez *et al.,* 2024). The collected blood was allowed to clot at room temperature and subsequently centrifuged at 3,000 rpm for 10 minutes to separate the serum. Serum samples were carefully aspirated using sterile pipettes, aliquoted into cryovials, and stored at -20 °C until testing. All sample collection was conducted under sterile conditions at the Epidemiology Laboratory, Faculty of Veterinary Medicine, Usmanu Danfodiyo University Sokoto, Nigeria.

Serological Screening

Serological screening for exposure to *Leptospira* spp. was performed using the Rat *Leptospira* IgG ELISA Kit (AFG Scientific, USA), a commercial indirect ELISA kit designed to quantitatively detect IgG antibodies against *Leptospira* in rat serum. The assay was conducted according to the manufacturer's instructions. The kit was preserved at -20°C as recommended by the manufacturers and the test was done as contained in the ELISA Protocol. Negative control was taken at 0.0 to 0.3 OD, and 0.5 OD and above for positive as contained in the protocol with a recommended wavelength of 450nm. Briefly, rat serum samples were diluted with 40µL of sample diluent and testing sample 10µL. A total of 50 µL of each diluted sample, along with positive and negative controls provided in the kit, was pipetted into the microplate wells pre-coated with *Leptospira* antigens, covered with the adhesive strip, and then incubated at 37°C for 40 minutes to allow antigen-antibody binding. After incubation, wells were washed five times with the provided wash buffer to remove unbound components. Then, 50 µL of horseradish peroxidase (HRP)-conjugated anti-rat IgG secondary antibody was added to each well and incubated again at 37 °C for 40 minutes. A second wash was performed, followed by the addition of 50 µL of TMB substrate (3, 3', 5, 5'-Tetramethylbenzidine) to initiate colour development. Plates were incubated in the dark at room temperature for 15 minutes, and the enzymatic reaction was stopped by adding 50 µL of stop solution.

Optical density (OD) was measured at 450 nm using a microplate reader (Optic System IVYMEN® 2001C, USA). The intensity of the colour developed was proportional to the concentration of anti-*Leptospira* IgG in the samples.

Results were interpreted by calculating the OD ratio in comparison with the cut-off value, depending on the kit's instructions. Samples with OD values equal to or greater than the manufacturer-defined cut-off were considered positive for *Leptospira* IgG, indicating past or current exposure. Samples with OD values below the cut-off were considered negative.

Statistical Analysis

Descriptive statistics were used to summarise the data. Categorical data are presented as frequencies and percentages, whereas continuous data are presented as median and interquartile range. There were no missing data points in the final dataset. The participants' knowledge and attitudes were evaluated based on their responses to the structured questionnaire. Knowledge assessment consisted of multiple true/false statements, where correct answers were scored as two and incorrect answers as 1. Using Bloom's original cut-off point, knowledge scores were dichotomised into two categories: poor knowledge (≤ 60% of the total score, corresponding to 0–6 points) and good knowledge (> 60% of the total score, corresponding to 7–11 points) (Mohamud *et al.*, 2023). Attitude statements were evaluated using a 5-point Likert scale ranging from "strongly agree" (5 points) to "strongly disagree" (1 point). For reverse-coded statements, the scoring was inverted, with "strongly disagree" receiving 5 points and "strongly agree" receiving 1 point. The total attitude scores were categorised as negative (≤60% of the total score, corresponding to 11–33 points) and positive (> 60% of the total score, corresponding to 34–55 points). The relationships between the knowledge and attitude scores were analysed using Pearson correlation analysis. Variables with P-value < 0.25 in bivariate logistic regression were moved to multivariate analysis to adjust for confounders to find out the potential predictors of good knowledge and positive RT-PCR results (Hosmer, 2000). Statistical significance was set at $p < 0.05$.

RESULTS

Analysis of Serology by ELISA and Demographics

The overall seroprevalence of pathogenic *Leptospira* detected by ELISA among domestic rats was 33% (70/212), representing a significant burden of exposure within the urban rodent population. Analysis of the associations between ELISA-detected *Leptospira* exposure and sociodemographic characteristics (Tables 1-11), revealed that no demographic variable showed a statistically significant relationship with ELISA status. However, positive rates were somewhat higher in Kware (7.1%) and among older respondents (61.4%). Occupation, gender, and educational level did not significantly influence ELISA results, suggesting that exposure is broadly distributed across population segments. Tables 1-11 compare ELISA results across different districts. The chi-square test suggests no statistically significant difference in test positivity between districts (P = 0.075). This indicates that in this dataset, the prevalence of *Leptospira* infection is relatively similar

Table 1: ELISA Test Status in various Sampled LGAs in Sokoto State, Nigeria.

District/Local Government	Negative (%)	Positive (%)
Dange-Shuni	13 (9.2)	11 (15.7)
Kware	3 (2.1)	5 (7.1)
Sokoto North	29 (20.4)	17 (24.3)
Sokoto South	59 (41.5)	18 (25.7)
Wamakko	38 (26.8)	19 (27.1)

χ^2: *8.49, P-value: 0.075*

Table 2: ELISA Test Status by Age of the Respondents.

Age Group	Negative n (%)	Positive n (%)
<20	2 (1.4)	1 (1.4)
21–30	23 (16.2)	7 (10.0)
31–40	15 (10.6)	3 (4.3)
41–50	35 (24.6)	16 (22.9)
>50	67 (47.2)	43 (61.4)

χ^2: *5.35, P-value: 0.254*

Table 3: ELISA Test Status by Gender of the Respondents.

Gender	Negative n (%)	Positive n (%)
Male	120 (84.5)	64 (91.4)
Female	22 (15.5)	6 (8.6)

χ^2: *1.96, P-value: 0.162*

Table 4: ELISA Test Status by Level of Education of the Respondents.

Level of Education	Negative n (%)	Positive n (%)
Quran/Madrassa	36 (25.4)	25 (35.7)
Primary School	10 (7.0)	3 (4.3)
Secondary School	22 (15.5)	17 (24.3)
College/University	67 (47.2)	21 (30.0)
No education	7 (4.9)	4 (5.7)

χ^2: *7.69, P-value: 0.104*

Table 5: ELISA Test Status by Occupation of the Respondents.

Occupation	Negative n (%)	Positive n (%)
Business/trading	60 (42.3)	33 (37.1)
Farmer	18 (12.7)	9 (12.9)
Government/private	49 (34.5)	21 (30.0)
Unemployed	15 (10.6)	7 (10.0)

χ^2: *0.56, P-value: 0.906*

across districts, though Dange-Shuni shows slightly higher positivity. No significant association was found between age group and ELISA results (P = 0.254). This suggests that age may not be a strong predictor for *Leptospira* exposure or infection in this population. The results do not show a significant difference between males and females in ELISA positivity (P = 0.162). Thus, gender does not appear to influence infection risk substantially in this sample.

There is no statistically significant association (P = 0.104), implying that education level may not be strongly linked to *Leptospira* exposure based on this data, although those with college/university education had a higher proportion of positives.

Occupation also does not significantly influence ELISA outcomes (P = 0.906). This suggests similar exposure levels across different occupational groups within this sample.

Marital status shows no significant association with ELISA results (P = 0.720), indicating marital status does not appear to affect *Leptospira* infection risk (Table 6). Household size has a near-significant result (P = 0.056), with larger households (>10 members) potentially showing higher positivity, possibly reflecting increased exposure risk due to crowded living conditions (Table 7). No significant association was observed (P = 0.481), indicating an individual’s role (child, father, mother, etc.) in the household does not significantly impact risk of infection in this study (Table 8). Different types of houses didn't significantly influence ELISA positivity (P = 0.213). However, there seems to be a trend where mud houses might be associated with higher positivity (Table 9).

Table 6: ELISA Test Status by Marital Status of the Respondents.

Marital Status	Negative n (%)	Positive n (%)
Single	19 (13.4)	8 (11.4)
Married	113 (79.6)	55 (78.6)
Widowed/Divorced	10 (7.0)	7 (10.0)

χ^2: 0.66, P-value: 0.720

Table 7: ELISA Test Status by Size of Household of the Respondents.

Size of Household	Negative n (%)	Positive n (%)
1–5	39 (27.5)	9 (12.9)
6–10	50 (35.2)	36 (51.4)
11–15	39 (27.5)	19 (27.1)
>15	14 (9.9)	6 (8.6)

χ^2: 7.54, P-value: 0.056

Table 8: ELISA Test Status by Role of Household of the Respondents.

Role in Household	Negative n (%)	Positive n (%)
Child	16 (11.3)	6 (8.6)
Father	100 (70.4)	53 (75.7)
Mother	17 (12.0)	4 (5.7)
Uncle/Aunt	5 (3.5)	3 (4.3)
Grandparent	4 (2.8)	4 (5.7)

χ^2: 3.48, P-value: 0.481

Table 9: ELISA Test Status by Type of House of the Respondents.

Type of House	Negative n (%)	Positive n (%)
Mud house	31 (21.8)	23 (32.9)
Thatched house	6 (4.2)	2 (2.9)
Modern house	105 (73.9)	45 (64.3)

χ^2: 3.09, P-value: 0.213

Table 10: ELISA Test Status by Number of Animals Owned by the Respondents.

Number of Animals Owned	Negative n (%)	Positive n (%)
1–5	51 (35.9)	17 (24.3)
6–10	52 (36.6)	38 (54.3)
11–15	31 (21.8)	12 (17.1)
>15	8 (5.6)	3 (4.3)

χ^2: 6.10, P-value: 0.107

Table 11: ELISA Test Status by the Type of Toilet the Respondents Use.

Type of Toilet	Negative n (%)	Positive n (%)
Pit latrine	55 (38.7)	28 (40.0)
Water closet	68 (47.9)	37 (52.9)
Open defecation	19 (13.4)	5 (7.1)

χ^2: 1.86, P-value: 0.394

Although there is a trend towards higher positivity with owning more animals, this was not statistically significant (P = 0.107). This variable might influence exposure risk but needs further investigation (Table 10). The type of toilet used was not significantly associated with ELISA results (P = 0.394). The data suggests no clear link between sanitation facilities and *Leptospira* seropositivity in this sample (Table 11).

DISCUSSION

This investigation documented a 33% seroprevalence of pathogenic *Leptospira* IgG antibodies in *Rattus rattus* from Sokoto Metropolis, indicating substantial bacterial circulation in the city's rodent populations. Comparable rates of 30-40% have been recorded among peridomestic rats in African cities like Accra, Ghana (Adesokan *et al.*,

2020) and Nairobi, Kenya (Mutai *et al*., 2019), confirming rodents' role as primary reservoirs in urban Africa. However, lower figures such as 3.6% in Thai rodents (Krairojananan *et al*., 2020) highlight ecological variations affecting *Leptospira* persistence. Sokoto's elevated prevalence likely stems from suboptimal sanitation, sprawling informal housing, and climate conditions favoring bacterial survival (Haake *and* Levett, 2021). Frequent human-rodent encounters in homes with unmanaged waste further promote environmental contamination via infected urine. Worldwide, rodent *Leptospira* rates differ markedly; Brazilian urban slums frequently exceed 50% in Rattus norvegicus (Costa *et al*., 2023), positioning Sokoto's findings within moderate endemic levels and signalling urgent needs for pest management and sanitation upgrades.

No significant links emerged between *Leptospira* positivity and respondent characteristics like age, gender, occupation, marital status, or education, suggesting widespread exposure across Sokoto's communities. This pattern mirrors global urban leptospirosis dynamics, where ambient environmental factors outweigh personal demographics (Neiderud, 2015; Akinbo *et al*., 2022). Household crowding (>10 occupants) approached significance ($p=0.056$), implying heightened contamination risks in dense living spaces, akin to South Asian observations linking overcrowding to amplified exposure (Brennan *et al*., 2019). Mud dwellings, prevalent in Nigeria's peri-urban zones, exhibited elevated (non-significant) positivity, providing rodents with favourable harbourage (Oladele *et al*., 2024). Animal ownership trended toward higher seropositivity with greater livestock numbers, potentially creating extra transmission bridges by drawing rodents or sustaining reservoirs (Udechukwu *et al*., 2024). Although toilet types showed no effect contrary to broader literature emphasizing sanitation (Ko *et al*., 2021) this may reflect Sokoto's pervasive substandard conditions masking isolated influences.

Residents displayed fair general awareness of rodent-related illnesses but limited leptospirosis-specific understanding, mirroring sub-Saharan patterns where the disease is overshadowed by misdiagnoses like malaria (Akinbo *et al*., 2022). Sporadic use of controls like traps or sealed storage exacerbates vulnerability. Tailored education on transmission routes, clinical signs, and prophylaxis extended to all demographics and livestock handlers could bridge these deficits, incorporating local customs for better uptake. Within Nigeria, south-western rodent surveys reports 15% seroprevalence tied to wet-season flooding (Akinbo *et al*., 2022), while Sokoto's higher rates may arise from Sudan-Sahel aridity and distinct rodent behaviours. This study's dual serological-KAP methodology innovates local zoonotic research (Oladele *et al*., 2024). Globally, One Health frameworks succeed via rodent monitoring, sanitation, and education (Levett, 2024; Costa *et al*., 2023), as proven in India and Brazil (Brennan *et al*., 2019; Ko *et al*., 2021). Sokoto state should localize such strategies, bolstering diagnostics to counter underreporting from symptom overlap (Akinbo *et al*., 2022).

Conclusion

This study provides a comprehensive assessment of leptospirosis risk in Sokoto Metropolis through serological, demographic, behavioural, and environmental analyses. The detection of a 33% Leptospira seroprevalence among *Rattus rattus* underscores the significant public health threat posed by urban rodent populations, particularly within densely populated and sanitation-compromised communities. When contextualized within broader global evidence, the findings position Sokoto within the growing epidemiological pattern observed in tropical urban settings, where rodent-borne zoonoses thrive in environments marked by inadequate waste management, poor drainage systems, and limited disease awareness.

Although the study explored multiple socio-demographic variables including age, gender, education, marital status, occupation, household size, housing type, and animal ownership the absence of statistically significant associations between these factors and seropositivity (all p-values > 0.05) suggests that exposure risk is widespread and not restricted to specific population subgroups. The near-uniform distribution of seropositive cases across LGAs further reinforces the systemic nature of leptospirosis exposure in the metropolis. This pattern indicates that environmental determinants especially rodents, sanitation structures, and water contamination pathways may be stronger drivers of infection than individual socio-demographic characteristics.

The observed clustering of positive cases among respondents aged above 50 years and within larger households (6–10 occupants) aligns with known exposure dynamics in settings where increased contact with contaminated environments and shared living spaces enhance vulnerability. Similarly, the comparable positivity rates across occupational classes reflect the pervasive ecological overlap between human activity areas and rodent habitats in Sokoto. The substantial seroprevalence found in mud and modern houses alike also highlights that structural housing type alone does not shield residents from exposure, reinforcing the ubiquity of Leptospira contamination where rodents are endemic.

Taken together, the results reveal a deeply entrenched One Health challenge, where human, animal, and environmental interactions converge to sustain leptospirosis transmission. The significant rodent reservoir identified in this study, coupled with behavioural and infrastructural vulnerabilities, signals an urgent need for strengthened public health strategies. These strategies must transcend clinical responses and incorporate environmental sanitation, rodent ecology, cultural behavioural patterns, livestock human interfaces, and community engagement. The findings also highlight gaps in surveillance, diagnostic capacity, and awareness that presently contribute to underreporting and misdiagnosis of leptospirosis in Nigeria. Overall, this research advances understanding of leptospirosis epidemiology in northern Nigeria by integrating serological evidence with socio-behavioural and environmental data. It establishes baseline data essential for future interventions, risk modelling, and public health planning. Importantly, the study affirms that controlling leptospirosis in urban settings such as Sokoto requires sustained multisectoral collaboration rooted in the One Health paradigm. Only through coordinated efforts that address rodent reservoirs, improve sanitation systems, and empower communities can meaningful progress be achieved in mitigating the burden of this neglected zoonotic disease.

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