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DISTRIBUTION OF DOMESTIC RAT INFESTATION IN HOMES OF SELECTED LOCAL GOVERNMENT AREAS IN OGUN STATE, NIGERIA AND ITS PUBLIC HEALTH IMPLICATIONS: A RESPONDENT-BASED APPROACH

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ABSTRACT

This study aims to investigate the distribution of domestic rat (black and brown rat) infestation in selected local government areas (Abeokuta South, Abeokuta North and Odeda LGAs) in Ogun State, Nigeria based on respondent's information. One hundred and eighty (180) well-structured questionnaires were strategically administered to one hundred and eighty homes (odd number) which were represented by a respondent. The survey revealed that a large percentage of the respondents fall under the middle class (65.0%) and upper class (29.4%) socio-economic status while the majority of the respondents live in a bungalow (58.9%). Generally, 74% of the respondents have domestic rats in their homes, while based on the LGAs, Abeokuta North (77%) has the highest form of rat infestation seconded by Odeda (75%) while the lowest was recorded in Abeokuta South (73%), three time higher than the CDC baseline. The control measures for rat elimination appear in the order of poison only (36%) > poison and trap (33%) > trap only (23%). Chi-square test revealed a significant relationship between demographics, home hygiene practices with the rat infestation (P<0.05), while Pearson correlation revealed a moderate relationship between control measures and rat infestation (r=0.55; p<0.01). Conclusively, our investigation has revealed a high level of rat infestation across the study areas with Abeokuta North as a hotspot, significantly correlated with the studied parameters. Therefore, a combinatory use of control measures, control of population density and proper home hygiene practices need to be implemented to avoid potential economic loss and disease outbreaks.

Keywords: Domestic Rat**,** Homes, Infestation, Local governments, Ogun State, Public Health

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INTRODUCTION

Domestic rats are small omnivores with a wide range of dietary preferences, highly adaptable in behaviour and mobility. They are considered as one of the world's most notorious and prolific urban pest species (Buckle and Eason, 2015). Domestic rats have serious and potentially life-threatening effects on human health, food production, agricultural production, property, and the natural environment (Lambert *et al*. 2017). Rats have also been reported to have a detrimental effect on urban economies through a variety of sources, such as damage to infrastructure, and buildings, the direct cost of rodent control measures, destruction of personal belongings, and contamination of food (Lambert *et al*., 2017). Researchers have reported that infestation of rodents could also cause psychological trauma mostly in affected

communities (Lam *et al.,* 2018). Rat infestation is a common public health problem mostly in poor urban communities in Nigeria including agricultural and economic losses. An upsurge in interest in the various factors that may be associated with city rat infestations (Tamayo-Uria *et al.*, 2013), including those affecting techniques for controlling them (Patergnani *et al.*, 2010; Mughini Gras *et al.*, 2012), is the result of recent advancements in the investigation of rat-borne diseases and potential threats (such as injuries, allergies, and mental trauma) caused by exposure to rats and their droppings (Tamayo-Uria *et al.*, 2014). Domestic rats are ubiquitous and widely spread across east, central, and west Africa, where it is more prevalent and associated with risk of diseases such as haemorrhagic fever epidemics (Bonner *et al*., 2007). It is noteworthy that there are more than thirty (30) transmittable bacterial and viral diseases transmittable by rats, diseases such as leptospirosis, salmonellosis, listeriosis, plaque, pulmonary syndrome, Lassa fever, and haunta virus etc. (Bonner *et al*., 2007). Recent studies in Nigeria revealed that 47.2% (17 of 36) states in Nigeria are more endemic to haemorrhagic fever e.g. Lassa fever a result of the infestation of rodents especially rats which endangers human health through cuts, scratches, and wounds, including eyes and mouth via ingestion of food and water contaminated through rat fur and faecal matters (Orji *et al.,* 2020). Rat has been reported to transmit leptospires through the shedding of fur in water and soil (Costa *et al.*, 2015). According to Ilori *et al.* (2018), high rat infestation-associated fatalities in Nigerian states (Edo, Ondo and Ebonyi), with a record of over 75% cases and 14.6%, 24.2%, and 23.4% mortality respectively have been recently reported. However, in urban settings, the prevalence of rats and the associated risk of damage to property and transmission of disease are likely to vary from neighborhood to neighborhood due to socioeconomic status (Johnson, 2016). Lower socioeconomic status has always been reported with high levels of rat infestation (Johnson, 2016; Reland, 2016).

It has been projected that by 2030, the world's urban population will drastically increase, by an estimated 1.2 million individual and hence the current habitation will be overcrowded thereby generating a befitting breeding site for domestic rats (Taylor *et al*., 2008). A densely populated area is suitable for symbiotic rodents, especially in those minutest areas where they can cope, such as unconventional communities without adequate sewage disposal, hygiene, housing, or infrastructure. (Onyido *et al*., 2009; Majekodunmi *et al*., 2022;). It is essential to identify the factors that facilitate rat infestations at various spatial levels, as higher rat populations are thought to increase the likelihood of transmission of disease and destruction of property (Rael *et al.,* 2016). Due to continued global urbanization cities must have effective strategies in place to prevent, eradicate, and monitor the rat population and its effects – a process that is now commonly referred to as management (United Nation, 2019). Thus, this study aimed to investigate the distribution and rate of domestic rat (black and brown rat), infestation in three local government areas in Ogun State, South West Nigeria and its economic and health implications.

MATERIALS AND METHODS

Study Area

A cross-sectional respondent-based study was conducted in selected local government areas in Ogun State, Southwestern, Nigeria between May and June 2023. Ogun State borders Lagos, Oyo, Ondo State and Benue Republic to the south, north, east and west respectively. Abeokuta is the capital and largest of all the cities in the state. Three (3) local government areas (Abeokuta South, Abeokuta North and Odeda) were used for the study and are shown in Figure 1.

Figure 1. The map of Ogun State showing its Local Government Areas (blue arrow indicating the study areas)

Research Design & Data Collection

The study used a survey research approach, in which the researchers collected data from a sample of the selected local government areas using interviewer-administered standardized questionnaires to draw generalizations for the study's objectives. To support the research's conclusions, the source of data needs to administer a set of questions to the respondents. A total of one hundred and eighty (180) questionnaires, sixty (60) each were administered to homes (odd number) represented by a prior interviewed respondent. The questionnaire was made up of four components (demographic data, presence of rats in homes, rat control techniques and individual home practices). The socio-economic classification of respondents was determined using the classification of Orji *et al.* (2020) which classified respondents into five groups namely 1–5 using the mean sum of maternal and paternal education and occupation. These groups were then classified into upper social economic status if the mean sum falls between 1–2, middle if 3 and lower social economic status if 4–5.

Data Management and Analysis

Collected data were entered into Statistical Package for the Social Sciences (version 21, IBM SPSS, Chicago, USA). Parameters were presented as frequency tables and charts. Multivariate analysis (Chi-square (χ^2) test and Pearson correlation) was adopted to determine the relationships between socio-demographics, control measures, home practices and the presence of rats in homes. The level of statistical significance was set at $p<0.05$ at a 95% confidence level.

RESULTS

Demographic data

The demographic data for the respondents are presented in Table 1, the findings indicate that women 56.7% made up the bulk of respondents while men were 43.3%. The respondents' average age was 20 - 35 years (60.6%) followed by 36 - 45 years (19.4%), less than 20 years (12.2%) and the lowest were those above 45 years (7.8%). The majority of the respondents (51.7%) had secondary education followed by 25.6% who had tertiary education, 17.2% with primary education and the lowest (5.6%) had no formal education. 63.9% of the respondents live in a nuclear family, while 36.1% as an extended family. Most of the respondents (65.0%) are from the medium socioeconomic class, 29.4% are from the upper socioeconomic class and 5.6% are from lower socioeconomic rank. The majority of the respondents (58.9%) live in a bungalow, while 41.1% in buildings with stories. The respondents' living arrangements were majorly 2-4 bedroom flats (43.3%) followed by face-to-face (29.4%) while those in one/room and parlour self-contained account for 27.2%.

Table 1: The demographic data for the respondents

Parameters	Frequency (n=180)	Percentage	Cumulative Percentage
Gender			
Male	78	43.3	43.3
Female	102	56.7	100
Total	180	100	
Age Group			
<20 years	22	12.2	12.2
20 -35 years	109	60.6	72.8
63-45 years	35	19.4	92.2
>46 years	14	7.8	100
Total	180	100	
Literacy Level			
No formal Education	10	5.6	5.6
Primary	31	17.2	22.8
Secondary	93	51.7	74.4
Tertiary	46	25.6	100
Total	180	100	
Family Type			
Extended	65	36.1	36.1
Nuclear	115	63.9	100
Total	180	100	
Economic Status			
Lower	10	5.6	5.6
Middle	117	65.0	70.6
Upper	53	29.4	100
Total	180	100	
Housing Type			
Bungalow	106	58.9	58.9
Story Building	74	41.1	100
Total	180	100	
Accommodation Type			
2-4 Bedroom flat	78	43.3	43.3
Face to Face	53	29.4	72.8
One/Room & Parlour Self	49	27.2	100
Total	180	100	

Presence of Domestic rat in Homes and their Control Measures

The prevalence of domestic rats in homes is presented in Figures 2 and 3. Generally, domestic rats are present in the homes of a significant portion of the respondents (74%) while others (26%) have no rats. Based on the local government, the highest rat infestation was recorded in Abeokuta North (77%) seconded by Odeda (75%) while the lowest was in Abeokuta South (73%). The highest control measure for rat elimination was poison only (36%), followed by poison and trap (33%), and trap only (23%) while the lowest was others measure (8%) (Figure 4).

Home hygiene practices

Table 2: displays the respondents' adopted domestic hygiene practices. The majority of respondents (58.9%) occasionally open windows or doors at night, followed by 29.4% who usually do so and 11.7% who don't. 84.4% of respondents don't spread food outside, whereas 15.6% do. 86.7% of respondents never use rats for food, whereas 13.3% occasionally do. The majority of respondents (66.1%) always kept their food in airtight containers, followed by 31.1% who do occasionally and 2.8% who don't.

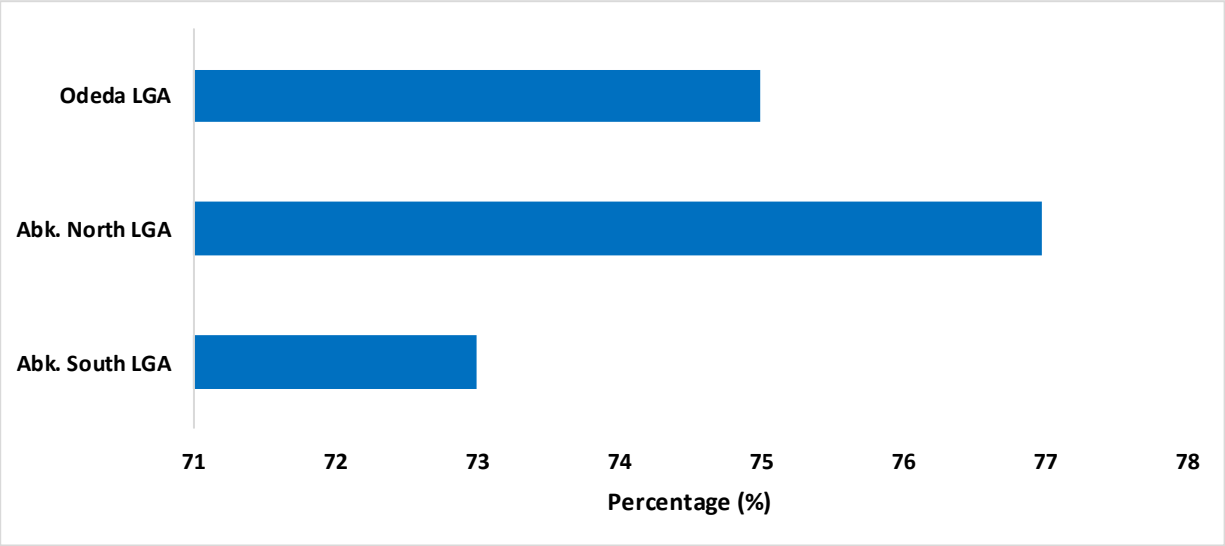

Figure 2: Percentage distribution of domestic rats in the homes by LGA

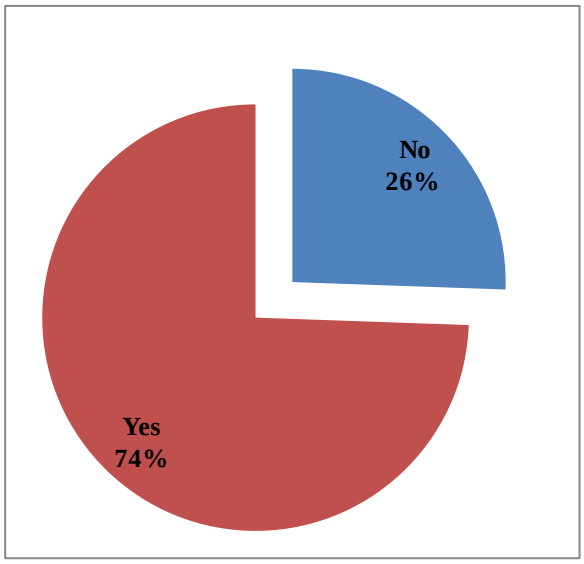

Figure 3: Overall presence of rats in homes

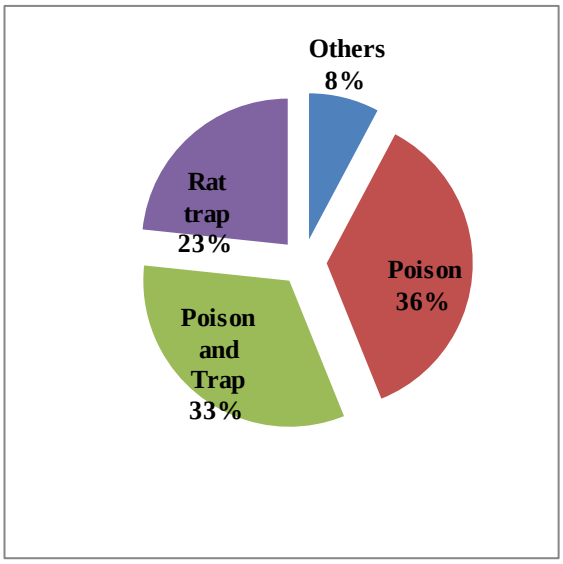

Figure 4: Control methods

Association between socio-demographic data, home hygiene practices and rat infestation

The relationship between parameters is presented in Tables 3 and 4. The chi-square (χ^2) test revealed a statistically significant relationship between the sociodemographic status of the respondents with the presence of domestic rats in homes ($P<0.001$). It also revealed a statistically significant relationship between control measures, and home hygiene practices with the presence of domestic rats in homes ($P\leq0.05$). Pearson correlation between demographic data, presence of rats in homes, control measures and home practices (table 5) showed a strong correlation between LL and FT (r=0.706), ES (r=0.856), HT (r=0.673), AT (r=0.805), OWD (r=0.761) and FS (r=0.712). FT and HT (r=0.628), AT (r=0.765) and OWD (r=0.935). ES and HT (r=0.737), AT (r=0.821), FSO (r=0.604) and FS (r=0.869). AT and OWD (r=0.804), FSO (r=0.605) and FS (r=0.854). FSO and FS (r=0.629). A moderate correlation was observed between LL and FSO (r=0.547). FT and ES (r=0.546), FS (r=0.530). ES and OWD (r=0.579). HS and FSO (r=0.514). RIH and CM (r=0.552). OWD and FS (r=0.557).

Table 2: Respondents home practices

Parameters	Frequency (n=180)	Percentage	Cumulative Percentage
Open Windows			
Always	53	29.4	29.4
Never	21	11.7	41.1
Sometimes	106	58.9	100.0
Total	**180**	**100**	
Spread Food Outside			
No	152	84.4	84.4
Yes	28	15.6	100.0
Total	**180**	**100**	
Rat for Food			
Never	156	86.7	86.7
Sometimes	24	13.3	100.0
Total	**180**	**100**	
Food in Airtight Containers			
Always	119	66.1	66.1
Never	05	2.8	68.9
Sometimes	56	31.1	100.0
Total	**180**	**100**	

Table 3: Relationship between sociodemographic data and the presence of rats in homes

Demographics data	Presence of rats in homes (%)		Chi-square (χ^2) test	
	Yes	No	value	P
Literacy Level				
No Education	-	10 (100%)	155.13	<0.001*
Primary	-	31 (100%)		
Secondary	88 (94.6%)	05 (5.4%)		
Tertiary	46 (100%)			
Family Type				
Extended	19 (29.2%)	46 (70.8%)	109.32	<0.001*
Nuclear	115(100%)	-		
Economic Status				
Lower	-	10 (100%)	48.99	<0.001*
Middle	81 (69.2%)	36 (30.8%)		
Upper	53 (100%)	-		
Housing Type				
Bungalow	60 (56.6%)	46 (43.4%)	43.14	<0.001*
Story Building	74 (100%)	-		
Accommodation Type				
2-4 Bedroom flat	32 (41.0%)	46 (59.0%)	80.80	<0.001*
Face to Face	53 (100%)			
One/Room & Parlour Self	49 (100%)			

**Significant at $p \leq 0.001$*

Table 4: Relationship between control measure, home practices and presence of rats in homes

Parameters	Presence of rats in homes (%)		Chi-square ($\chi 2$) test	
	Yes	No	Value	P
Control Measure				
Rat Trap Only	42 (100%)	-	94.61	<0.001*
Poison & Trap	59 (100%)	-		
Others	-	14(100%)		
Poison Only	33(50.8%)	32(49.2%)		
Open Window at Night				
Always	07 (13.2%)	46 (86.8%)	148.07	<0.001*
Never	21 (100%)	-		
Sometimes	106 (100%)	-		
Spread Food Outside				
No	106 (69.7%)	46 (30.3%)	11.38	0.001*
Yes	28 (100%)	-		
Rat as Food				
Never	110 (70.5%)	46 (29.5%)	9.51	0.002*
Sometimes	24 (100%)	-		
Food in Airtight Containers				
Always	73 (61.3%)	46 (38.7%)	31.674	<0.001*
Never	05 (100%)	-		
Sometimes	56 (100%)	-		

**Significant at p≤0.05*

Table 5: Correlation between some demographic data, presence of rats in homes, control measures and home practices

Parameters	LL	FT	ES	HT	AT	RIH	CM	OWD	FSO	FS
LL	1									
FT	**0.706****	1								
ES	**0.856****	*0.546***	1							
HT	**0.673****	**0.628****	**0.737****	1						
AT	**0.805****	**0.765****	**0.821****	**0.834****	1					
RIH	-0.786**	-0.779**	-0.494**	-0.490**	-0.596**	1				
CM	-0.675**	-0.765**	-0.654**	-0.791**	-0.943**	*0.552***	1			
OWD	**0.761****	**0.935****	*0.579***	**0.660****	**0.804****	-0.850**	-0.801**	1		
FSO	*0.547***	0.323**	**0.604****	*0.514***	**0.605****	-0.251**	-0.561**	0.339**	1	
FS	**0.712****	*0.530***	**0.869****	**0.844****	**0.854****	-0.413**	-0.756**	*0.557***	**0.629****	1

***Correlations are significant at p<0.01*

Values in bold and italicised are positively strong & moderate correlation respectively.

Key: LL=Literacy level, FT=Family Type, ES=Economic Status, HT=Housing Type, AT=Accommodation Type, OWD=Open Windows/Doors, RIH=Rat in Homes, CM=Control Measures, FSO=Food spread Outside and FS=Food Storage

DISCUSSION

The observed high percentage of respondents being female could be linked to the usual availability of women and children in the home compared to fathers. A high level of literacy was recorded in this study which could positively influence the credibility of the response provided by the respondents. High domestic rat infestation (>70) was observed across the studied local government areas with the hotspots being Abeokuta North. The Centers for Disease Control and Prevention (CDC), (2006) in an urban rodent survey reported that areas with rat infestation rates above 25% are considered to be at high risk of rodent-borne diseases. Rodents are important reservoirs and vectors of at least seventy (70) zoonotic illnesses, of which sixteen (16) are helminthic parasites, which are significant causes of parasitic zoonosis in humans (Rabiee *et al.*, 2018). Aside from being mechanical vectors for many infectious diseases, rats can

contaminate edibles and the environment with faecal matter (CDC, 2004). They can also be destructive such as the eating of electric cables, and wires from home appliances and exposing the interior wires to potential fire hazards (Orji *et al.*, 2020). The study showed an infestation rate thrice (3x) the proposed 20% guideline by the CDC. The study indicates a higher risk which could be linked to the demographic, rat control methods and home hygiene practices of the respondents. The majority of the respondents (94%) are classified under the middle-upper socioeconomic strata and are more likely to live in homes surrounded by bushes, unmanaged housing conditions, unplanned urbanization, poor waste management serving as shelter for rats, leading to the establishment of rat breeding habitats. Rat infestations are also known to be much more prevalent in older homes, which is another factor that influences rat infestations in the settings (Tamayo-Uria *et al.*, 2014). The report from the study is similar to the finding observed in Benin City, Edo State (70.6%) (Odigie *et al.*, 2007), higher than observation from Johannesburg, South Africa (54%) (Jassat *et al.*, 2013) and Salvador, Brazil (45.9%) (Santos *et al.*, 2017). Contrary to our result, other researchers observed higher infestation in Osogbo, Osun state (90.9%) (Olalekan, 2015), Southeast Nigeria (82.3%) (Orji *et al.*, 2020) and Esan, Edo state (96.1%) (Tobin *et al.*, 2014).

The study found that nuclear families, those living in face-to-face rooms/parlour self-contained apartments had 100% domestic rat infestations. This demonstrates that the likelihood of a rat infestation increases with population density. High human population densities are typically correlated with high dwelling densities, and the higher the density of dwellings, the more likely it will operate as a source of rat infestation (Tamayo-Uria *et al.*, 2014). Rats are made accessible by substandard housing (Olalekan, 2015; Orji et al., 2020). Similar to this study, a Taiwanese study (Pai *et al.*, 2003) revealed that the number of homes in a community was a significant environmental and demographic component linked to a rat infestation. Good housing standards and a clean environment are efficient ways to combat the management of rodents, according to a South-Western Nigerian study (Olayinka *et al.*, 2015). Rat control is exceedingly difficult because of their nocturnal habits, which keep them hidden and make them difficult to spot. Rat poisons are one of the main approaches for rat control in this study, compared to other control methods, rat poisons are easily prepared, readily available, and inexpensively priced. As a result, it might help to understand why respondents chose it over alternative control measures. Rat poisoning with baits might not be the best option for indoor application because it could result in rat deaths inside the apartment generating a terrible odour and a housefly infestation (Orji *et al.*, 2020) that could cause a new ailment since they are mechanical vectors of pathogens. If rat poisons are not properly handled in homes, it could result in children accidentally poisoning themselves. This was consistent with research conducted in the Nigerian states of Eboyi (Orji *et al.*, 2020), Edo (Odigie *et al.*, 2007) and Osun (Olalekan, 2015). Although the ingredients in these rat poisons are unreliable, their usage needs to be regulated to prevent environmental damage and potential risks from chemical poisoning. As seen in other studies such as Esan Nigeria (Odigie *et al.*, 2007) and Los Rios, Chile (Muoz-Zanzi *et al.*, 2014), alternative means of controlling rats should be promoted such as rat traps and biological means (e.g. Cats) (Adegoke *et al.*, 2017). This is because rats have been discovered to possess highly developed learning behaviours allowing them to avoid traps, baits and chemical rodenticides. Studies have also unequivocally shown that environmental modification is a better rat control method than the use of poisons (Karija *et al.*, 2013). Therefore, to reduce the burden of domestic rat infestation, integrated rodent management based on good ecological and biological methods and species ethnology should be used. This study discovered a substantial correlation between domestic rat infestation and home practices such as windows or doors opening at night and spreading food on the ground outside of homes. The eradication of this practice is pivotal since rats are omnivores capable of consuming similar foods as humans, which is relevant to the spreading of food on the floor. The urine, saliva, and droppings deposited by rats on the food serve as a reservoir for pathogens (disease-causing organisms), which

have been identified as the main cause of the illness (CDC, 2004). The percentage of rats consumed (13.3%) in this study is of minimal concern. However, viral hemorrhagic fevers like Lassa and Ebola have been noted to be widespread in areas where bush meat consumption is significant (Orji *et al.*, 2020). It has also been noted that the killing, dressing, and preparation procedures for these meals provide a risk for the spread of this or a similar disease. The consumption rate was 4.4% in Benin City, Edo state, according to a study (Tobin *et al.*, 2014), but the rate in Osun State (20.2%) was higher (Olalekan, 2015). However, haemorrhagic fever (Lassa fever illness) epidemics have been reported in these areas (Tobin *et al.*, 2014; Ossai *et al.*, 2020). The prevalence rates observed in the study were significantly influenced by variations in socioeconomic status, family type, house quality, home and environmental hygiene, and the respondents' active participation in rat control.

CONCLUSION

In a survey on the domestic rat infestation in selected Local Government Areas of Ogun State, Nigeria. The research revealed that domestic rat infestation occurs in over 70% of homes, with the most preferred method of domestic rat control being rat poison. Domestic rat infestations had a significant association with sociodemographic status, control method preference, and home hygiene routines.

Recommendations

Instead of utilizing rat poison as the sole technique of rat control, homes should seek out combined approaches that include rat poison, traps, use of cats and good environmental sanitation. To prevent rat infestations, home members are advised to practice good hygiene such as storing food in airtight containers and keeping their doors and windows closed, especially in the nighttime. Domestic rat infestation in homes might be decreased by government intervention plans such as initiatives to sensitize the populace about the economic and health implications and potential decent housing programs.

REFERENCES

Adegoke, O.O., Ajibola, O.F., Ogundairo, J.A. (2017). Knowledge, attitude and practices of foodstuff sellers on Lassa fever in major markets in Ibadan. *African J Psychol Study Soc*; 20:165-76.

Buckle, A. P. and Eason, C. T. (2015). Control methods: chemical. *Rodent pests and their control*, *2*, 123-154.

Centers for Disease Control and Prevention (2004). *Imported Lassa fever-new Jersey, 2004*. MMWR Morb Mortal Wkly Rep;53:894-7(Accessed August, 2023).

Centers for Disease Control and Prevention. *Integrated Pest Management: Conducting Urban Rodent Surveys*. Atlanta: Centers for Disease Control and Prevention; 2006. Available from: https://www.cdc.gov/nceh/ehs/ Docs/IPM_Manual.pdf. [Accessed on August, 2023].

Costa, F., Wunder, E.A., Jr, De Oliveira, D., Bisht, V., Rodrigues, G., Reis, M.G., Ko, A.I., Begon, M., & Childs, J.E. (2015). Patterns in *Leptospira* Shedding in Norway Rats (*Rattus norvegicus*) from Brazilian Slum Communities at High Risk of Disease Transmission. *PLoS neglected tropical diseases*, *9*(6), e0003819. https://doi.org/10.1371/journal.pntd.0003819

Ilori, E.A., Furuse, Y., Ipadeola, O.B., Dan-Nwafor, C.C., Abubakar, A., Womi-Eteng, O.E, *et al.* (2019). Epidemiologic and clinical features of Lassa fever outbreak in Nigeria, *Emergence Infectious Diseases*; 25:1066-74

Jassat, W., Naicker, N., Naidoo, S. and Mathee, A. (2013). Rodent control in urban communities in Johannesburg, South Africa: From research to action. *Int J Environ Health Res*; 23:474-83.

Johnson, S., Bragdon, C., Olson, C., Merlino, M., and Bonaparte, S. (2016). Characteristics of the built environment and the presence of the Norway rat in New York City: results from a neighborhood rat surveillance program, 2008 – 2010. *Journal*

Environmental Health Research 78, 22–29.

Karija, M., Shihua, Q. and Lukaw, Y. (2013). The impact of poor municipal solid waste management practices and sanitation status on water quality and public health in cities of the least developed countries: The case of Juba, South Sudan. *International Journal of Applied Science and Technology*.3:87-99.

Lam, R., Byers, K. A. and Himsworth, C. G. (2018). SPECIAL REPORT: Beyond Zoonosis: The Mental Health Impacts of Rat Exposure on Impoverished Urban Neighborhoods. *Journal of Environmental Health*, *81*(4), 8-13.

Lambert, M., Vial, F., Pietravalle, S., and Cowan, D. *(*2017*).* Results of a 15-year systematic survey of commensal rodents in English dwellings. *Scientific Reports* **7**, 15882.

Mughini Gras, L., Patergnani, M, Farina, M. (2012) Poison-based commensal rodent control strategies in urban ecosystems: some evidence against sewer-baiting. *EcoHealth* 9:75–79

Muñoz-Zanzi, C., Mason, M., Encina, C., Gonzalez, M. and Berg, S. (2014) Household characteristics associated with rodent presence and Leptospira infection in rural and urban communities from Southern Chile. *Am J Trop Med Hyg*; 90:497-506

Odigie, E., Ighedosa, S., Vincent, O.G., Usifoh, S., Asemota, D., Faboya, T., *et al.* (2007) Risk perception of lassa fever and rodent control practices in a university campus in South-South Zone of Nigeria. *Soc Exp Biol Niger*; 17:14-22

Olalekan, A.W. (2015) Community awareness and perception towards rodent control: Implications for prevention and control of Lassa fever in urban slums of southwestern Nigeria. *Malta J Heal Sci.*; 2:26-32.

Olayinka, S., Omotoso, B., Osaretin, A. and Adewunmi, E. (2015). Awareness of Lassa fever in a rural community in South West Nigeria. *Sch J Appl Med Sci.*; 3:1137-42.

Onyido, A.E., Okolo, P.O., Obiukwu, M.O., Amadi, E.S. (2009). Survey of vectors of public health diseases in undisposed refuse dumps in Awka town, Anambra State, Nigeria. Res. *Journal Parasitology*. 4(1):22-27

Orji, M.L.C., Nwaneri, D.U., Obu, D.C. and Anyanwu, O.U. (2020). Household rat infestation and methods of its control in a lassa fever endemic community in Southeast Nigeria. *Niger J Med*; 29:601-6.

Ossai, E.N, Onwe, O.E., Okeagu, N.P., Ugwuoru, A.L., Eze, T.K. and Nwede, A.S. (2020). Knowledge and preventive practices against Lassa fever among heads of households in Abakaliki metropolis, Southeast Nigeria: A cross-sectional study. *Proc Singapore Healthc*.29:73-80

Pai, H.H., Hong, Y.J. and Wang, C.H. (2003). A community-based surveillance on determinants of rodent infestation. *Kaohsiung J Med Sci;* 19:13-8.

Patergnani, M., Mughini Gras, L., Poglayen, G., Gelli A., Pasqualucci, F., Farina, M., and Stancampiano, L. (2010) Environmental influence on urban rodent bait consumption. *J Pest Sci.* 83:347–359

Rabiee, M.H., Mahmoudi, A., Siahsarvie, R., Krystufek, B. and Mostafavi, E. (2018). Rodent-borne diseases and their public health importance in Iran. *PloS Negl. Trop. Dis.* 12.

Rael, R.C., Peterson, A.C., Ghersi, B.M., Childs, J. and Blum, M.J. (2016). Disturbance, reassembly, and disease risk in socioecological systems. *Ecosystem health* 13, 450–455. doi: 10.1007/s10393-016-1157-1

Santos, N.J., Sousa, E., Reis, M.G., Ko, A.I. and Costa, F. (2017). Rat infestation associated with environmental deficiencies in an urban slum community with high risk of leptospirosis transmission. *Cad Saude Publica*;33:e00132115.

Tamayo-Uria.I., Mateu, M.J. and Mughini-Gras, L. (2013) Temporal distribution and weather correlates of Norway rat (*Rattus norvegicus*) infestations in the city of Madrid, Spain. *EcoHealth* 10:137–144

Tamayo-Uria, I., Mateu, J., Escobar, F. and Mughini-Gras, L. (2014). Risk factors and spatial distribution of urban rat

infestations. *Journal of Pest Science*, *87*, 107-115.

Taylor, P.J., Arntzen, L., Hayter, M., Iles, M., Frean, J. and Belmain, S. (2008). Understanding and managing sanitary risks due to rodent zoonoses in an African city: Beyond the Boston Model. *Integrated Zoology*, 3, 38–50.

Tobin, E., Asogun, D., Happi, C., Ogbaini, E., Gunther, S. (2014) Risk factors for Lassa fever in endemic communities of Edo State, Nigeria. *Int J Infect Dis*; 21:258-9.

United Nations (2019). *World urbanization Prospects: The 2018 Revision*. Publications/Files/WUP2018-Report.pdf. (Accessed September 11, 2023)