Knowledge, attitude, and preventive practices toward rodent-borne diseases in Ngorongoro district, Tanzania

Amina Issae,[1-3] Augustino Chengula,[4] Rose Kicheleri,[2] Christopher Kasanga,[4] Abdul Katakweba[1,3]

[1]African Centre of Excellence for Innovative Rodent Pest Management and Biosensor Technology Development, Sokoine University of Agriculture, Morogoro; [2]Department of Wildlife Management, Sokoine University of Agriculture, Morogoro; [3]Institute of Pest Management, Sokoine University of Agriculture, Morogoro; [4]Department of Microbiology, Parasitology and Biotechnology, Sokoine University of Agriculture, Morogoro, Tanzania

Correspondence: Amina Issae, African Centre of Excellence for Innovative Rodent Pest Management and Biosensor Technology Development, Sokoine University of Agriculture, P.O. Box 3110, Morogoro, Tanzania.
E-mail: amina.issae@sua.ac.tz

Key words: knowledge, attitude, practice, rodents, diseases, human-wildlife, Ngorongoro.

Acknowledgments: the African Centre of Excellence for Innovative Rodent Pest Management and Biosensor Technology Development (ACEII-IRPM and BTD), Sokoine University of Agriculture, Morogoro, Tanzania, is gratefully acknowledged by the authors for providing financial support for this study. The authors are also grateful to the community members, government officials, local authority leaders in the Ngorongoro district, and mathematic statisticians of the Sokoine University of Agriculture for their kind assistance and cooperation during this work.

Contributions: AI, AC, RK, CK, AA, SK, conceptualization, methodology, validation; AI, AC, RK, data curation; AI, formal analysis, original draft preparation; AI, AC, CK, AA, SK, investigation; AC, RK, CK, AA, SK, supervision; AI, RK, CK, AA, SK, writing, review and editing; AA, SK, project administration, resources. All the authors approved the final version to be published.

Conflict of interest: the authors declare no potential conflict of interest.

Ethical approval and consent to participate: the procedure to conduct this study was revised by the Ethical Review Committee of the Tanzania Medical Research Institute (NIMR) (Ref. No. NIMR/HQ/R.8a/Vol. IX/3676; 19th May 2021). Similarly, Sokoine University of Agriculture gave an approval letter for leading this study (Ref. No. SUA/ADM/R.1/8A/718; 3rd February 2021). Additionally, the local administrative authorities of Arusha region (Ref. No. FA.132/95/01/38; 12th February 2021) and Ngorongoro district (Ref. No. AB.114/354/01/134; 1st April 2021) provided permission too. Before the commencement of the face-to-face interview, the respondent gave written informed assent. In case the respondent can't write and read, verbal consent was obtained.

Funding: this work was supported by the Tanzania Center of Excellence Project (ACEII-Credit number 5799-TZ).

Availability of data and materials: the data used during the recent study are available from the corresponding author on reasonable request.

Received for publication: 17 November 2022.
Accepted for publication: 12 January 2023.

Journal of Public Health in Africa 2023; 14:2385
doi:10.4081/jphia.2023.2385

Abstract

In addition to their economic significance, rodents are hosts and transmit diseases. Most of rodent-borne diseases are endemic in rural Africa and sporadically lead to epidemics. Ngorongoro district is inhabited by humans, livestock, and wild animals. Therefore, a cross-sectional study was conducted to assess the level of knowledge, attitudes, and practices toward rodent-borne diseases among communities. The study used 3 focus groups, 20 key informant interviews, and the questionnaire (N=352) to collect data. The study found that 8.52% of respondents had good knowledge, 35.5% had a positive attitude and 94.3% had good practices toward rodent-borne diseases. The study revealed that only 28.13% of participants were aware of rodent-borne zoonoses. The majority of them (77.27%) believe that rodents are pests that destroy crops and do not transmit pathogens. Moreover, the results showed that the majority of them (82.9%) live in dilapidated huts that serve as rodent breeding places. Additionally, except for education and religion, the level of knowledge had no significant relationship with most of the participants' demographic variables. When compared to individuals who didn't attend school, those with secondary education (OR=7.96, CI=1.4-45.31, P=0.017) had greater knowledge of rodent-borne diseases and management. Similarly, to how attitude and practice were found to be considerably (r=0.3216, P=0.000) positively correlated, general knowledge and general practice scores were found to be significantly (r=0.1608, P=0.002) positively correlated. Despite showing good practices, the communities still lack knowledge of rodent-borne zoonosis. Rodent-borne disease education should be considered in Ngorongoro and other places.

Introduction

Rodents are mammals that are found worldwide except in Antarctica and are approximately divided into 2277 species globally.[1] These are the most abundant mammals that make up 42% of all mammals around the world. Rodents have the ability to survive in various habitats such as semi-arid, semi-aquatic, and aquatic and produce large litters in a short period of time thus making them abundant in the ecosystem.[1] Rodents are divided into three families including *Muridae*, *Microtidae,* and *Sigmodontidae*. Species of rodents under the *Muridae* family are omnivorous and most abundant in Africa and Australia, while in *Microtidae* family are mostly found in Eurasia and members of *Sigmodontidae* are found in America.[1,2]

Rodents are potential hosts and reservoirs of several zoonotic disease agents that are transmissible to humans.[2-4] About 143 different infectious agent genera were discovered, including 14 viral genera, 31 bacterial genera, 83 parasitic species, and 15 fungal

genera.[5,6] Over 75% of these infectious agents were zoonotic.[6] Commonly reported rodent-borne zoonoses include: bacteria (Leptospirosis, Plaque, Lyme disease, relapsing fever), viruses (*e.g.*, Hantavirus diseases, Lassa fever, Rift Valley fever), protozoan (*e.g.*, Toxoplasmosis, Leishmaniasis) and Helminths (*e.g.*, Echinococcosis, Trichinosis).[2,3] Transmission of rodent-borne diseases occurs through direct and indirect ways.[7] Direct transmission can be through arthropod bites or inhalation of germs in rodent feces.[5] Indirect transmission occurs through the consumption of food and/or water contaminated by feces or urine from rodents.[5] Additionally, rodents act as amplifier hosts for the pathogens that spread to humans via arthropod vectors.[8]

Most rodent-borne zoonotic diseases are endemic in rural Africa and sporadically lead to serious epidemics.[9] But more often than not, rodent-borne diseases are not identified, and as such, are generally poorly diagnosed and managed.[5] Consequently, the majority of poor rural individuals die from rodent-borne diseases across Africa each year.[3] Based on the fact that rodents spread more than 50% of diseases to humans and animals,[5] besides crops and home items destructions, rodents are a vital concern to the community's health. Despite this, studies on knowledge about rodent-borne zoonoses and management are limited in Tanzania. Various studies carried out worldwide have shown that knowledge about the impact of rodent-related diseases on public health continues to be extensively under-reported.[3,4,10]

Over time, population growth and demographic shifts have increased contact with wild rodents and enhanced disease transmission possibilities.[7,9,10] Numerous studies carried out around the world have shown that community awareness of rodents is essential for the government to formulate measures for the control of rodent-borne diseases.[11,12] So, the objective of this study was to assess the knowledge, attitude, and practice (KAP) levels of the communities toward rodent-borne infections and control in the Ngorongoro district

Materials and Methods

Description of the study area

The proposed study was conducted between July 2021 and January 2022 in the Ngorongoro District (Figure 1) where wild animals interact with humans in the grazing and residential areas. For example, humans, livestock, and wildlife live together in the Ngorongoro crater, making this district to be unique in the world. Ngorongoro District is one of the seven districts of the Arusha Region of Tanzania.[13] It is bordered to the east by Monduli District, to the south by the Karatu District, and to the west by the Mara Region. The district has an area of about 14,036 square kilometers located between latitudes 30.30'south of the equator and longitudes 35.42 'east of Greenwich and it is between 1,009 and 3,645 meters above sea level.[13] According to the 2012 Tanzania National Census, the population of the district was 174,278. Administratively the district is divided into three divisions (Ngorongoro, Loliondo, and Sale) and 20 Wards (villages). The district has a moderate temperature and tropical climate with an average rainfall of 800 mm to 1,000 mm.[13] The majority of residents are Maasai and Sonjo who are pastoralists and agropastoralists.[14] The district is characterized by low undulating plains with low-lying altitudes. The main vegetation is shrubs of acacia species and grass and open and thick forests.[14]

Study design and sampling procedures

A cross-sectional study was conducted to assess knowledge, attitudes, and practices about rodent management and rodent-borne diseases among communities of the Ngorongoro district. The study population was all households in each study village. The villages were selected based on the factors like population density, ease of access, human-wildlife interfaces, and rodent availability. Additionally, the selection of the households in the villages was done purposively based on indications of rodents' inhabitation. Prior to conducting the questionnaire survey at the household level, the household head was requested to sign an agreement. Based on the following presumptions: i) knowledge of diseases; ii) ability to decide whether or not to participate in the study, the household head or any resident person (18 years or older) was interviewed.

Sample size determination

The sample size of the interviewed households was calculated by this formular,[15] where n= sample size approximation, Z= 1.96; standard normal variety at 5% error (P<0.05), and assuming a response distribution of 50%. (1-p) = the probability of knowledge and d= absolute error or precision (5%). The calculated household sample size (n) was 384, however, due to reluctance of participants and difficulties in reaching various parts of the villages, only 352 households were reached. A proportional formula (N=HV1+HV2+HV3) was used to calculate the number of surveyed households in each village; where N = total number of interviewed households in the district, and HV= number of households in the selected village.

Data collection

Before doing the fieldwork, researchers secured the necessary approval to conduct the research from the Ethical Review Committee of the Tanzania Medical Research Institute (NIMR) (Ref. No. NIMR/HQ/R.8a/Vol. IX/3676 and date 19th May 2021), to guarantee adherence to Tanzanian and international research guidelines and regulations. Researchers explained the purpose of the study to participants, including community leaders. Participation in the study was voluntary and all participants gave written consent prior to interviews. All data and information collected from respondents were confidentially stored.

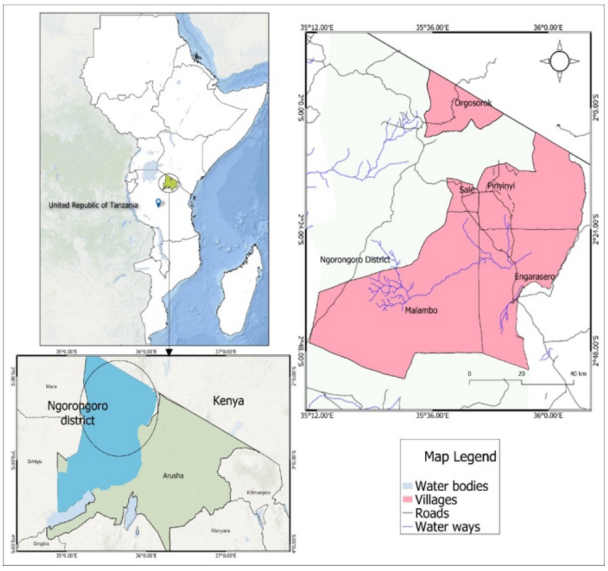

Figure 1. Map of Arusha region and Ngorongoro district showing the villages where the study was done (by the researcher using the QGIS).

Questionnaire survey

A semi-structured questionnaire tool was created based on a literature review of rodents and rodent-borne diseases. The questionnaire tool embraced five groups: i) respondent demography; ii) household characteristics; iii) knowledge of rodent control and rodent-borne diseases; iv) attitude toward rodents; v) practices against prevention of rodent-borne diseases. The questionnaire was pretested in 15 families and changed in accordance with the issues identified to ensure that questions were appropriate. Enumerators fluent in English and Swahili languages were deployed in the administration of the questionnaire. To buy time for retranslation, questions were posed in Swahili, and answers were written down in English. The researchers took great effort to observe the administration of surveys and to check the completed forms in order to ensure the integrity of the data acquired. Also, local translators were employed to interpret the Masai language into Swahili for the respondents who did not speak the Swahili language.

Focus group discussions

Three focus group discussions were conducted with a total of 36 participants. A purposive sampling technique was used to select members for the focus group discussion (FGD). Criteria for selection included adult individuals of 18 years and above and permanent inhabitants of the Ngorongoro district. The focus group discussion was facilitated by trained community health workers of the Ngorongoro district together with the researcher and there were two note-takers. A semi-structured FGD guide was used during the discussions.

Key informants' interview

A total of 20 key informants (KI) interview was conducted to collect data about rodent-borne diseases in the Ngorongoro district. A purposive sampling technique was used and participation was voluntary. All participants were identified by local leaders in each selected ward; two to three personnel per ward. The KI members were health workers and selected local authority leaders. Participants were asked about awareness of rodent-borne zoonoses and control of the rodent population. Trained researchers carried out the interviews and keynotes were taken by a notetaker. Additionally, the interviews were recorded using a phone recorder and the audio records were transcribed. The KI interview information was summarized and analyzed manually based on themes. Themes were explained in the text and speech marks were used where necessary.

Personal observation

The researcher collected information about rodent inhabitation in households and surrounding using the observation form. The observation form included indications like the presence of runways, burrows, droppings, and live captured rodents.

Data analysis

Quantitative data analysis

For each question in the knowledge part, scores ranging from 1 to 4 were given to correct responses based on the kind of question. Moreover, wrong and don't know responses were assigned zero scores. A knowledge score for each respondent was calculated by summing the number of correct answers out of the total scores. Attitudes regarding rodent management and diseases transmitted by rodents were evaluated by using a Likert scale approach.[16] Responses ranged from 1 (completely disagree) to 5 (completely agree). Responses were divided into two categories for cross-tabulation analysis: i) completely disagree/disagree/neutral; ii) completely agree/agree. Respondents who responded, "completely disagree/ disagree/neutral" were thought to have negative attitudes toward rodents, whereas those who "completely agreed or agreed" were believed to have positive attitudes. In the practices section, the score of each correspondent was computed by summing the number of correct answers out of the four questions posed. The respondent was regarded to have good practice if the score was 50% and above and bad practice when the score was below 50% of the total score points.

The variables in the data were coded for easy entry and analysis. Data were entered into Microsoft Excel 2010 and edited to remove the invalid variable and thereafter, exported to R software version 4.1.0 (2021) for analysis. Findings were presented in descriptive statistics like means, proportions, and frequencies. The relationship between demographic characteristics and knowledge was done by using a logistic regression model. The outcome variables were knowledge and attitude toward rodent management and rodent-borne diseases. Odds ratios and their corresponding 95% confidence interval were calculated and were considered statistically significant at $P<0.05$.

Qualitative data analysis

A deductive analytical method was applied for qualitative information collected from FGD and KIs interviews.[17] The topics for discussions and interviews were developed from the literature review on rodent-borne diseases and management. The FGD and KIs data were manually analyzed based on topics presented during the discussions and interviews. In the text, the results are described together with any pertinent speech marks.

Ethical consideration

The procedure to conduct this study was revised by the Ethical Review Committee of the Tanzania Medical Research Institute (NIMR) (Ref. No. NIMR/HQ/R.8a/Vol. IX/3676; 19th May 2021). Similarly, Sokoine University of Agriculture gave an approval letter for leading this study (Ref. No. SUA/ADM/R.1/8A/718; 3rd February 2021). Additionally, the local administrative authorities of Arusha region (Ref. No. FA.132/95/01/38; 12th February 2021) and Ngorongoro district (Ref. No. AB.114/354/01/134; 1st April 2021) provided permission too. Before the commencement of the face-to-face interview, the respondent gave written informed assent. In case the respondent can't write and read, verbal consent was obtained.

Results

Questionnaire

This study involved 352 people in all, most of them were men (67.61%). The respondents were aged 18 to 65, with 54.5% being adults. The majority of the people (58.9%) were pastoralists and attended primary school in high numbers (39.5%) (Table 1).

Household characteristics

In the Ngorongoro district, a high percentage (48%) of households had one to five individuals. The majority of respondents possessed homes that were built using animal feces or mud (Table 2). The grass was found to be the main thatching material for roofs, and 41.2% of homes had open windows. Finally, the findings revealed that 53.4% utilize pit latrines, as shown in Table 2. More information about households' characteristics is well described in Table 2.

The source of information among the study communities

The findings showed that the communities in the study area prefer the use of phones (42.8%) and radio (29%) as the major source of communication (Figure 2). Only 5% and 6% of respondents receive information regarding diseases from health and veterinary servants respectively (Figure 2).

Knowledge about rodent control and rodent-borne zoonoses

The analysis of the knowledge score showed that out of the maximum of 19 points, the respondents' scores ranged from 3 to 12. Only 30 respondents (8.81%) scored 50% and above 50% of the total score, indicating a low level of knowledge of the communities on rodent diseases and management. Among 352 respondents, only 99 (28.13%) were aware of rodent-borne zoonoses as indicated in Table 3.

Relationship between demographic factors and knowledge

The findings showed that most of the participants' demographic factors do not have a significant ($P \geq 0.05$) influence on knowledge about rodent-borne diseases and management (Table 4). However, level of education and religion had a significant ($P \leq 0.05$) positive influence on knowledge about rodent management and diseases. The detailed description is well narrated in Table 4.

The attitude of the communities toward contracting rodent-borne diseases

In the present study, 35.5% (n=125) and 65.5% (n=227) of respondents had positive and negative attitudes toward rodent-borne diseases, respectively. The proportion of responses on each statement is well illustrated in Figure 3.

Table 1. Respondents' demographic variables.

Variable	Female n (%)	Male n (%)	Total N (%)
Age categories			
Youth (18-34 years)	57(16.2)	89(25.3)	146 (41.5)
Adult (35-64 years)	54(15.3)	138(39.2)	192(54.5)
Elderly (≥65 years)	3(0.9)	11(3.1)	14(4.0)
Total number of participants	114(32.4)	238(67.6)	352(100)
Education levels			
Not attended school	58(16.0)	71(20.2)	129(37.2)
Did not complete school	7(2.0)	23(7.0)	30(9.0)
Primary	40(11.4)	99(28.0)	139(39.4)
Secondary	8(2.3)	35(10.0)	43(12.3)
College	1(0.3)	10(2.8)	11(3.1)
Total number of participants	114 (32.0)	238(68.0)	352(100)
Marital status			
Single	8(2.3)	15(4.2)	23(6.5)
Married	106(30.1)	223(63.4)	329(93.5)
Total number of participants	114 (32.4)	238(67.6)	352(100)
Occupation			
Agropastoral	53(15.1)	94(26.7)	147(41.8)
Pastoralists	61(17.3)	144(40.9)	205(58.2)
Total number of participants	114 (32.4)	238(67.6)	352(100)
Locality (villages)			
Orgosorok	37(10.5)	74(21.0)	111(31.5)
Malambo	16(4.5)	38(10.8)	54(15.3)
Sale	27(7.7)	64(18.2)	91(25.9)
Engarasero	15(4.3)	30(8.5)	45(12.8)
Pinyinyi	19(5.4)	32(9.1)	51(14.5)
Total number of participants	114 (32.4)	238(67.6)	352(100)

Relationship between attitude and respondents' demographic factors

The results indicate that among the demographic characteristics of respondents; gender, level of education, and occupation have a significant ($P<0.05$) positive influence on attitude toward rodent-borne diseases and rodent management (Table 5).

Practices of the communities toward rodent-borne diseases

The overall results indicated that about 94.3% (n=332) of respondents showed good practices in rodent-borne disease prevention. All participants do not consume rodents and shrews as shown in Figure 4. Though, the general results showed good practices, only 0.57% of respondents reported wearing protective gear during environmental cleanliness (Figure 4).

General proportions of knowledge, attitude, and practices score among the study communities in Ngorongoro

Although the majority of participants described good practices still, they demonstrated low knowledge and poor attitude toward rodent-borne diseases as shown in Figure 5.

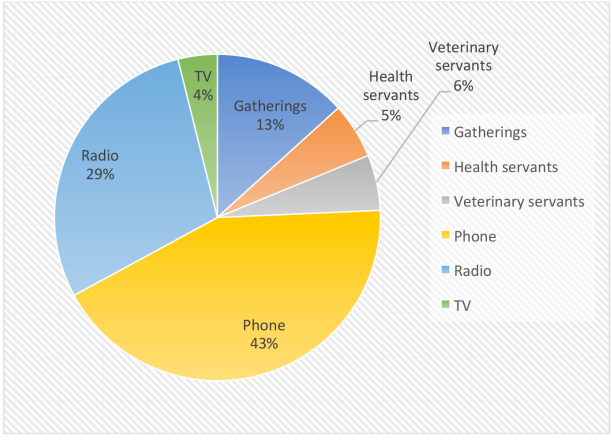

Figure 2. The source of information dissemination among communities in the Ngorongoro district (N=352).

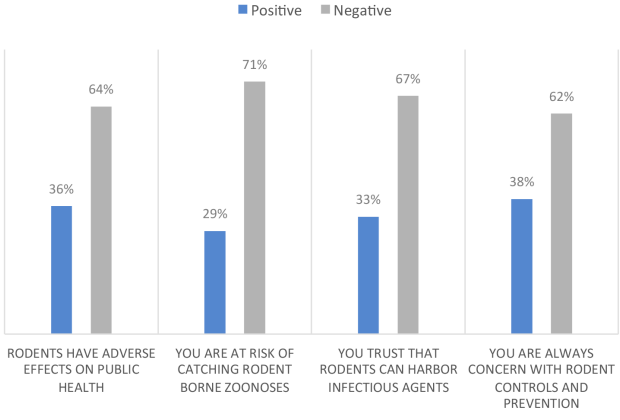

Figure 3. Proportion of communities' attitude toward rodent-borne diseases transmission and prevention (N=352).

Focus group discussions

Communities' knowledge about rodent-borne diseases and transmission

In the current study, three FGD were conducted with a total of 36 participants (Table 6). All FGD participants explained the presence of rodents in their living environment. They see rodents at night and during daytime inside the house, around home compounds, and in the farms or bushes. Most of them were able to describe rodents by their body size and color, whereby they mentioned black, brown, and straw colors. Most individuals complained that rodents are destructing animals because they destroy crops, eat clothes and other household stuff, and store food or cooked food. Most FGD participants were not aware of rodent-borne diseases, so their level of knowledge was regarded as low. The disease transmission through rodents was observed to be of minimal concern in the study communities. Only, three men and four women out of 36 respondents believed that rodents could harbor and transmit pathogens to humans through contamination of food or water, nevertheless, among them, none was able to describe any disease. One female participant described that rodent cause fever and diarrhea. Two male participants said rodents cause wounds because of bites during the night. The majority of FGD participants did not associate rodents with any zoonotic diseases. The majority of the participants insisted that they have been intermingling with wild animals including rodents for years and no person has contracted a disease from them.

Key informants' interviews

Information collected from KIs about rodents' control and rodent-borne diseases differs from the FGDs' discussions. Most of the KIs participants were community health workers and health professionals so they had knowledge about diseases. All KIs participants described that rodent may harbor and spread infectious agents to their communities. Most participants reported that they regularly see rodents around home compounds and farms during the daytime and evening. The majority mentioned that rodents may spread infectious agents to humans through food or water contaminated with feces or urine because of unhygienic activities. One community health worker mentioned that some of the community members do not cover food and water properly. The majority of participants mentioned Plaque as the key disease associated with rodents. Additionally, two clinical officers mentioned Leptospirosis, Salmonellosis, rat bite fever, and toxoplasmosis.

When probed about the possibilities of their communities acquiring rodent-borne diseases, two nurses and one medical officer reported that the possibility is high because humans and rodents live in the same compound. This was also observed by the researchers during the survey because rodents were trapped inside the houses and around home surroundings. The most common

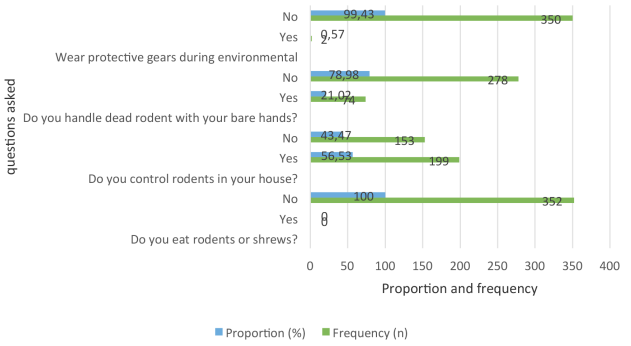

Figure 4. Proportions of communities' preventive practices toward rodent-borne diseases (N=352).

Table 2. Proportions of participants' household characteristics based on the study villages.

Variable	Engarasero n (%)	Orgosorok n (%)	Malambo n (%)	Pinyinyi n (%)	Sale n (%)	Total N (%)
Household size						
1-5	20(11.8)	71(42.0)	30(17.8)	19(11.2)	29(17.2)	169(48.0)
6-10	17(12.7)	33(24.6)	13(9.7)	21(15.7)	50(37.3)	134(38.1)
Above 10	8 (16.3)	7 (14.3)	11 (22.4)	11(22.4)	12(24.5)	49(13.9)
House walls						
Block	1 (2.1)	23(47.9)	5(10.4)	2(4.2)	17(35.4)	48 (13.6)
Concrete block	0(0.0)	9(75.0)	0(0.0)	3(25.0)	0(0.0)	12(3.4)
Mud	0(0.0)	48(28.6)	1(0.6)	46(287.4)	73(43.5)	168(47.7)
Livestock feces	44(35.5)	31(25.0)	48(38.7)	0(0.0)	1(0.8)	124 (35.2)
Window types						
No window	24(15.7)	43(28.1)	15(9.8)	9(5.9)	62(40.5)	153(43.5)
Open window	14(9.7)	44(30.3)	35(24.1)	32(22.1)	20(13.8)	145(41.2)
Net window	5(21.7)	9(39.1)	1(4.3)	3(13.0)	5(21.7)	23(6.5)
Shuttered windows	2(6.5)	15(40.4)	3(9.7)	7(22.6)	4(12.9)	31(8.8)
House roof						
Grass	33(16.8)	42(21.4)	38(19.4)	28(14.3)	55(28.1)	196(55.7)
Mud and grass	0(0.0)	27(90.0)	3(10.0)	0(0.0)	0(0.0)	30(8.5)
Iron sheet	12(9.5)	42(33.3)	13(10.3)	23(18.3)	36(28.6)	126(35.8)
Electrical power						
None	38(16.0)	67(28.3)	38(16.0)	38(16.0)	56(23.6)	237(67.3)
Solar panels	7(6.2)	42(37.2)	16(14.2)	13(11.5)	35(31.0)	113(32.1)
TANESCO	0(0.0)	2(100.0)	0(0.0)	0(0.0)	0(0.0)	2(0.6)
Toilet types						
No toilet	24(14.6)	27(16.5)	31(18.9)	6(3.7)	76(46.3)	164(46.6)
Pit toilet	21(11.2)	84(44.7)	23(12.2)	45(23.9)	15(8.0)	188(53.4)

Table 3. Knowledge of the communities about rodent-borne diseases and control measures.

Variable	Frequency (n)	Proportion (%)
Have you seen rodents?		
Yes	352	100.00
Why do rodents get inside the house?		
Hide from predators	5	1.42
Looking for food	342	97.16
Do you know that rodents harbor zoonotic diseases?		
Yes	99	28.13
Mentioned zoonotic diseases transmissible from rodents to humans		
Bite fever	28	7.95
Plague	49	13.90
Applied control measures of rodents		
Rodenticides	122	34.66
Set traps	9	2.56
Use of cats	134	38.07
Form of rodenticides used		
Rat poison pellet	1	0.28
Rat poison powder	157	44.60
Described the health risks of using rodenticides in your house		
Can kill animal	1	0.28
Kill chicken	43	12.22
Risk to kids	79	22.44
Mentioned the adverse effects of rodents in the communities		
Bites on humans	10	2.84
Destroying crops	272	77.27
Eat clothes	100	28.41
Eat stored or cooked food	53	15.06
Transmission of diseases	7	1.99

Table 4. Logistic regression analysis of the relationship between demographic factors and knowledge about rodent-borne diseases and control measures.

Variable	OR	Confidence interval (95%)	P-value
Gender			
Female	Reference		
Male	3.27	0.41-4.22	0.314
Age			
Elderly	Reference		
Adult	0.21	0.04-1.21	0.062
Youth	0.26	0.05-1.64	0.129
Level of education			
Not attended school	Reference		
Did not complete school	1.07	0.23-4.46	0.931
Primary	3.11	0.98-10.67	0.060
Secondary	7.96	1.40-45.31	0.017**
College	7.56	0.33-73.79	0.111
Occupation			
Agropastoral	Reference		
Pastoralist	1.79	0.52-6.79	0.367
Marital status			
Single	Reference		
Married	2.36	0.41-21.73	0.386
Ward (locality)			
Orgosorok	Reference		
Engarasero	0.23	0.03-1.20	0.109
Malambo	0.44	0.05-2.32	0.376
Pinyinyi	0.41	0.02-2.89	0.443
Sale	1.89	0.46-8.07	0.378

**= Moderately significant at P<0.005.

route of disease transmission was reported to be the contamination of food with feces or urine of rodents. Lastly, they mentioned the signs of rodent invasions at home like the presence of droppings, burrows, and runways in surroundings, and the unpleasant odor of urine from rodents.

Personal observation

The researchers conducted rodent assessments through direct observation of runways, droppings, burrows, and live trapping inside the houses, stores, and around home compounds. Observational results are presented in Figure 6.

Correlation between knowledge, attitude, and practices

In general, the results showed a significant positive correlation among the scores. Knowledge was significantly positively correlated to practice likewise to attitude and practice (Table 7).

Discussion

Based on literature reviews this is the first KAP study to be conducted in Tanzania on rodent-borne diseases. Rodents have a considerable effect on crops and public health in several locations

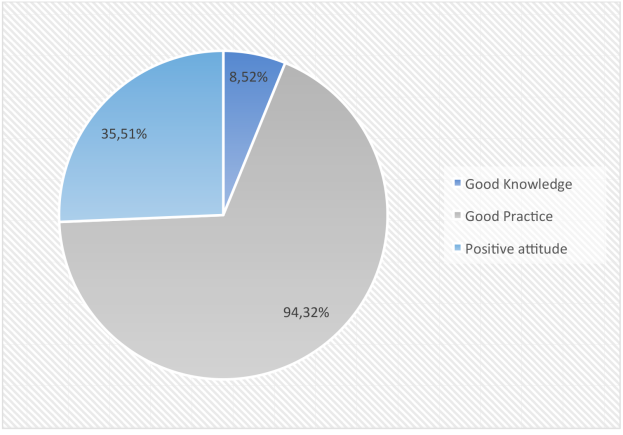

Figure 5. Percentage of respondents' scores on knowledge, attitude, and practices regarding rodent-borne diseases and prevention (N=352).

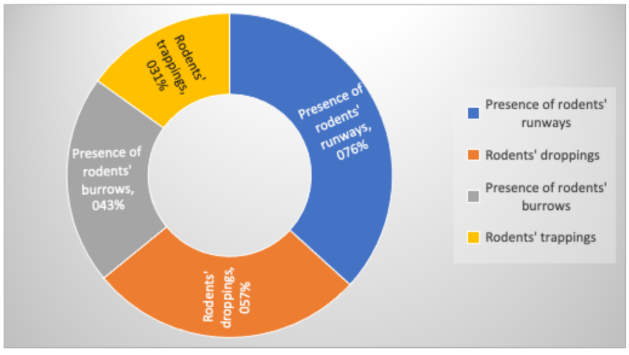

Figure 6. The various indications used in the assessment of rodents' inhabitations in the households visited (N=352) in the Ngorongoro district.

Table 5. Logistic regression analysis of the relationship between various factors and attitudes toward rodent-borne diseases and control measures.

Variable	OR	Confidence interval (95%)	P-value
Gender			
Female	Reference		
Male	1.89	1.07-3.34	0.003**
Age			
Elderly	Reference		
Adult	1.34	0.36-4.90	0.245
Youth	0.92	0.24-3.55	0.125
Level of education			
Not attended school	Reference		
Did not complete school	2.29	0.85-6.19	0.027*
Primary	1.63	0.87-3.056	0.005**
Secondary	7.77	3.05-19.78	0.001**
College	34.13	3.71-314.0	0.000***
Occupation			
Agropastoral	Reference		
Pastoralist	1.44	0.76-2.75	0.047*
Marital status			
Single	Reference		
Married	2.01	0.65-6.21	0.094
Ward (locality)			
Orgosorok	Reference		
Engarasero	0.62	0.27-1.43	0.661
Malambo	0.21	0.09-0.51	0.196
Pinyinyi	0.48	0.22-1.04	0.957
Sale	0.67	0.29-1.54	0.668

*= Significant at P≤0.05; **= Moderately significant at P≤0.005; ***= Highly significant at P≤0.0001.

.

in Tanzania.[3,18] The recent study was aimed at assessing the level of knowledge, attitudes, and practices toward rodent management and zoonoses among communities in the Ngorongoro district. The majority of participants were adults between the ages range of 35-64, and the majority had only primary education. Men appeared to be more than women because the questionnaire targeted the heads of households. Also, due to the traditional customs of the Maasai tribe, men are the heads of the household and are the ones who give information to the respective household.[19] Women may give information but they often have to ask permission from household heads.[19]

Dissemination of health information among communities is a fundamental factor in disease prevention. Our study found that most of the respondents use phones and radios as preferred methods of information dissemination at the proportion of 42.8% and 29% respectively. It has been reported that mobile phones contributed to the improvement of rural livelihood by providing the fastest and easy means of communication among households.[20] Therefore, information dissemination among communities through phones and radios should be well organized in order to increase health education deliverance. Additionally, planned dissemination of information about rodent-borne diseases will probably help in reducing the population of rodents through the application of proper rodent control methods in the communities.

Rodent-borne diseases are a major threat to residents of poor housing areas which can lead to severe public health issues. The results of this study have revealed that the majority (82.9%) of the respondents live in poorly constructed houses or huts which can facilitate the entry of rodents. Most houses were constructed by using muds and thatched with grasses and had open windows. Furthermore, the study revealed that 67.3% of households had no access to power, implying that the majority of respondents live in dark environments. These findings could be attributed to poverty and lack of awareness of health safety measures, as the majority of people do not communicate with health care providers. Begon's (2003) findings are in agreement with the results of this study. Begon's (2003) study reported that most rural communities live in poor environments with a high risk of contracting rodent-borne diseases. Furthermore, rodent interaction activities were reported among villagers, such as hunting, transportation, preparation for food, and selling processes in countries like Thailand, Zambia and Southern Tanzania.[21-23]

According to this study, only 8.52% of respondents were found to have good knowledge about rodent-borne diseases and management. Participants with a secondary education who had a substantial (P=0.017) high level of knowledge about rodent-borne infections and management were likely responsible for this proportion. This level of knowledge indicates that the communities of Ngorongoro district lack good knowledge about rodent-borne diseases and control measures. Similar findings were observed in Trinidad, where less than half of the population was knowledgeable about rodent-borne diseases and their transmission routes.[8] Also, Begon (2003) and Suwannarong *et al.*, (2022), reported that a high population of individuals in rural settings lack knowledge of rodent-borne illnesses as well as proper control measures. Moreover, Banda *et al.* (2022), documented that some community members may have awareness of zoonotic diseases, although they lack knowledge of specific rodent-borne diseases.

The living condition of rural communities was found to be harsh which may increase the risk of acquiring infections from rodents.[23] For instance, this study revealed that 67.3% of respondents live in dark unhygienic houses which are good for hiding rodents. In direct eye observations, rodent paths were identified in 78% of the households. Additionally, rodent tunnels, droppings, and live captured rodents were discovered inside the houses. These results demonstrate the populations' vulnerability to diseases transmitted by rodents. The improper storage of agricultural products like maize and a lack of hygiene may be the cause of rodent activity in residential areas. Whereby, a high percentage of rodents were trapped in the maize stores and sometimes in the kitchens. This was due to the fact that food was more readily available in these areas than in other parts of the house but was not protected. Last but not least, 97.16% of respondents reported seeing rodents in their houses hunting for food. Our findings somehow reflect the previous study by Mulungu *et al*. (2015) in Morogoro-Tanzania, where poor hygiene and improper storage of cereals were found to enhance rodent invasion in homes.

The majority of participants were not aware that rodents may harbor and transmit infectious agents to humans and livestock. The majority of them (77.27%) think that rodents are pests that solely damage homes' properties, stored cereals, and crops only. These results are very similar to those recorded in other studies carried

Table 6. Composition of focus group discussions in Ngorongoro district.

FGD	Number of participants		Total number of participants
	Male	Female	
FGD 1	6	6	12
FGD 2	6	6	12
FGD 3	6	6	12
Total participants	18	12	36

Table 7. Correlation between knowledge, attitude, and practice scores of respondents.

Scores	Mean	SD	n	Correlation coefficient (r)	P
Total knowledge score	7.14	1.65	352	0.1608	0.002*
Total practice score	1.33	1.64	352	0.1608	0.002*
Total knowledge score	7.14	1.65	352	0.0609	0.255
Total attitude score	2.36	0.59	352	0.0609	0.255
Total attitude score	2.36	0.59	352	0.3216	0.000**
Total practice score	1.33	1.64	352	0.3216	0.000**

*= Moderately significant at P<0.005; **= Highly significant at P<0.0001.

out in Tanzania and elsewhere in the world, where it was known that communities lack adequate knowledge of rodent management.[18,24,25] The results of this study can be used as an effective tool for encouraging the people of the Ngorongoro district to implement proper rodent control measures.

Knowledge about rodent control is crucial for preventing the spread of diseases because rodents carry pathogens of public health significance. This study revealed that the majority (38.08%) and (34.6%) of participants use cats and rodenticides as the preferred rodents control measures respectively. The use of rodenticides was also reported by Mulungu *et al*. (2015) whereby 53% of farmers used this technique. In addition, based on the researcher's direct observation many of these cats were found free roaming around the home compounds, which could also increase the risk of transmitting zoonoses like Toxoplasmosis, Leptospirosis, and Plague. This observation may suggest the need for training the communities on the proper and continuous use of rodenticides instead of using cats to control rodents. This result is somehow similar to the reports documented in other studies in Trinidad and Zimbabwe countries where individuals use cats as the main rodent control strategy and most cats were found to be Feral or semi-feral cats.[8,24]

The findings showed that most of the demographic factors didn't have a significant (P>0.05) influence on knowledge about rodent-borne diseases and prevention except education and religion (P<0.05). When compared to individuals who did not attend school, those with secondary education (P=0.017) had greater knowledge of rodent-borne diseases and control measures. Individuals who have completed their secondary education and/or college may be able to obtain information via books, magazines, radio, and/or television. It has been reported that education provides the opportunity for acquiring knowledge and skills that enable individuals to be potential members of the communities.[26] General knowledge and general practice scores were found to be significantly (P=0.002) connected, similar to how attitude and practice were found to be significantly (P=0.000) correlated. Therefore, based on these findings, it is reasonable to draw a conclusion that an increased level of knowledge will also influence how the communities perceive the prevention of rodent-borne diseases. Moreover, the study found that 94.3% of respondents have good practices in rodent-borne zoonosis prevention. Good rodent management practices noted include not eating rodents, not touching dead rodents with bare hands, and using cats and rodenticides. Despite receiving a good score in general practice, 99.43% of respondents admitted not using safety gear during cleaning the environment. This habit predisposes communities to rodent-borne diseases through direct contact with droppings or urine. The study conducted in America and elsewhere in the world reported that rodents transmit pathogens to humans through excreta and consumption.[4,6,23] In contrast to this study, previous studies conducted in Thailand,[23] Zambia,[21] Ghana,[26] and Tanzania,[22] reported that the majority of the villagers had direct contact with rodents and their ectoparasites through hunting, killing, and eating. Therefore, education about rodent-borne diseases should be delivered in the Ngorongoro district and in other places across the world.

In the present study, 35.5% of respondents showed a positive attitude toward rodent-borne diseases and 65% of respondents did not believe that they were at risk of acquiring rodent-borne zoonosis. These recent observations are probably attributed to poor knowledge of the communities on rodent-borne diseases (Table 4). The observations showed that there was a positive correlation (r=0.0609) between knowledge and attitude scores toward rodent-borne diseases and rodent control measures. Furthermore, among the demography of respondents, gender, level of education, and occupation all showed a significant (P<0.05) favorable impact on attitudes about rodent-related diseases and management (Table 5). Respondents who went to school had a much higher (P<0.05) positive attitude about rodent-borne diseases and prevention than those who didn't. It has been documented that education often adopts positive views of actions.[26]

Lastly, this study discovered that individuals with health education were more knowledgeable about rodent-borne infections compared to those without health education. This can be proved by the KIs participants as were able to mention rodent-borne diseases like plaque, leptospirosis, salmonellosis, rat bite fever, and toxoplasmosis. Whereas the FGD members were unable to describe any disease. Similarly, to our finding, the study by Salmón-Mulanovich *et al*. (2016) of Peru, documented that most of the participants could not mention any rodent-borne infection except for healthcare personnel. Additionally, KIs participants managed to describe the common routes of pathogens transmission from rodents to humans such as contaminated food and water by rodents' feces or urine. Moreover, they mentioned indications of rodent invasions at home including rodents' droppings, burrows, and runways in surroundings and unpleasant odor of urine from rodents. These findings suggest that improving public education will probably increase knowledge and practices towards rodent-borne diseases in the Ngorongoro district.

Conclusions and recommendations

According to this study, it was found that few participants had good knowledge and positive attitude toward rodent borne-diseases due to a lack of education. However, the communities showed good practices especially in avoiding consuming rodents, avoiding touching dead rodents with bare hands, and use of some rodent control methods particularly the use of cats and rodenticides. The majority didn't know that rodents may harbor and transmit infectious agents to humans and livestock. Therefore, it is justifiable to say that limiting human interaction with all wild and peri-domestic rodents, wearing protective gear during cleanliness, good hygiene, proper storage of food and cereals, and improving building designs to prevent rodents' inhabitation should all be part of the public health education initiatives in the Ngorongoro district. Although this study was done in a single district, it has shown that further needs to be done to educate communities in the Ngorongoro district about rodent controls and the associated risks of zoonoses. Further studies are required to understand the common rodent-borne diseases present in the population and their transmission dynamic among communities in places with a human-animal interface. The recent study has given a piece of useful baseline information that will help in planning the surveillance of rodent-borne zoonoses in the Ngorongoro district and other places worldwide.

References

1. Kingdon J, Happold D, Butynski T, et al. Mammals of Africa. London, Bloomsbury, 2013;3.
2. Banda A, Gandiwa E, Muboko N, et al. Local community awareness and practices on Yersinia pestis plague disease management in Nkayi and Umzingwane districts, south-western Zimbabwe. Ecosyst People 2022;18:164-73.
3. Meerburg BG, Singleton GR, Kijlstra A. Rodent-borne diseases and their risks for public health. Critical Rev Microbiol 2009;35:221-70.

4. Begon M. Disease: health effects on humans, population effects on rodents. Aciar Monograph Series 2003;96:13-9.
5. Bingham AJ, Witkowsky P. Deductive and inductive approaches to qualitative data analysis. Analyzing and interpreting qualitative data: After the interview. SAGE Publications 2021;133-46.
6. De Luca DW, Mpunga NE. Leopard abundance, distribution and food habits in the Mt. Rungwe–Kitulo landscape, Southern Tanzania. Afr J Ecol 2018;56:358-67.
7. Diaz JH. Regional rodent-borne infectious diseases in north america: what wilderness medicine providers need to know. Wilderness Environ Med 2021;32:365-76.
8. Hardgrove E, Zimmerman DM, von Fricken ME, Deem S. A scoping review of rodent-borne pathogen presence, exposure, and transmission at zoological institutions. Prev Vet Med 2021;193.
9. Katakweba AA, Mulungu LS, Eiseb SJ, et al. Prevalence of haemoparasites, leptospires and coccobacilli with potential for human infection in the blood of rodents and shrews from selected localities in Tanzania, Namibia and Swaziland. Afr Zool 2012;47:119-27.
10. Kravitz DA, Klineberg SL, Avery DR, et al. Attitudes Toward Affirmative Action: Correlations with Demographic Variables and With Beliefs About Targets, Actions, and Economic Effects 1. J Appl Soc Psychol 2000;30:1109-36.
11. Magige FJ. Human-wildlife interaction in Serengeti and Ngorongoro districts of Tanzania: a case study on small mammals. Tanz J Sci 2012;38:95-103.
12. Mohan AR, Chadee DD. Knowledge, attitudes and practices of Trinidadian households regarding leptospirosis and related matters. Int Health 2011;3:131-7.
13. Mulungu LS, Mrosso FP, Katakweba AA, et al. Farmer's knowledge, attitude and practice on rodent management in lowland irrigated rice in Central-eastern Tanzania. Int Res J Plant Sci 2015.
14. Tanzania Ministry of Finance. 2012. Population and Housing Census General Report. National Bureau of Statistics, Dar es Salaam. Tanzania, 2013:264.
15. Nimo-Paintsil SC, Fichet-Calvet E, Borremans B, et al. Rodent-borne infections in rural Ghanaian farming communities. PLoS One 2019;24;14:4.
16. Nyirenda SS, Hang'ombe BM, Machang'u R, et al. Identification of risk factors associated with transmission of plague disease in eastern Zambia. Ame J Trop Med Hyg 2017;97:826.
17. Chulaluk K. Sample size Estimation. Faculty of Medicine Siriraj Hospital 2007:16.
18. Onesmo NP. Cultural drivers of zoonotic diseases and impact of the diseases on poverty in Ngorongoro district, Tanzania. Doctoral dissertation, Sokoine University of Agriculture, 2013.
19. Allen IE, Seaman CA. Likert scales and data analyses. J Qual Prog 2007;40:64-5.
20. Salmón-Mulanovich G, Powell AR, Hartinger-Peña SM, et al. Community perceptions of health and rodent-borne diseases along the Inter-Oceanic Highway in Madre de Dios, Peru. BMC Public Health 2016;16:1-10.
21. Sedaghat MM, Moghaddam A. Salahi. "Mapping the distribution of the important rodents reservoir in Iran. J Ann Mil Health Sci Res 2010;18:210-23.
22. Suu-Ire R, Obodai E, Bel-Nono SO, et al. Surveillance for potentially zoonotic viruses in rodent and bat populations and behavioral risk in an agricultural settlement in Ghana. One Health Outlook 2022,4:1-11.
23. Suwannarong K, Soonthornworasiri N, Maneekan P, et al. Rodent-Human Interface: Behavioral Risk Factors and Leptospirosis in a Province in the Central Region of Thailand. Vet Sci 2022;9:85.
24. Taylor PJ, Arntzen L, Hayter M, et al. Understanding and managing sanitary risks due to rodent zoonoses in an African city: beyond the Boston Model. Integr Zool 2008;3:38-50.
25. Sife AS, Kiondo E, Lyimo−Macha JG. Contribution of mobile phones to rural livelihoods and poverty reduction in Morogoro region, Tanzania. Electron J Inf Syst Dev Ctries 2010;42:1-15.
26. Tarayia GN. The legal perspectives of the Maasai culture, customs, and traditions. Ariz J Int Comp L 2004;21:183.