FACTORS RELATED TO RODENT CONTACT INDOORS AND OUTDOORS IN BOLIKHAMXAY PROVINCE, LAO PDR

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ABSTRACT: Zoonotic diseases from wildlife such as rodents have elicited increasing public health concern in Southeast Asian countries including Thailand and Lao PDR. A cross-sectional study was conducted to characterize human-rodent exposure in Bolikhamxay Province, Lao PDR, from March to May 2013, aiming to understand any characteristics which might be associated with rodent contacts. Five hundred eighty four participants were interviewed using a modified version of a questionnaire previously used by the research team in Thailand in 2011. About 85.3% of respondents reported finding rodents entering their homes, 99.0% reported encountering rodents while working around gardens/crops, 56.3% reported noticing rodents in the past year while gathering things in the forest and other places, and 35.6% reported finding dead rodents in the past year, respectively. Two characteristics were related to reports of rodents coming into the homes: having drinking water from open natural sources and having a wooden floor in their dwelling. Two characteristics were related to reports of encountering rodents while working around gardens/crops: working as a farmer, the number of cultivation-related tasks undertaken, and the number of food crops grown. In addition, the number of food crops grown was associated with reports of both noticing rodents in the past year while gathering things in the forest and other places, and finding dead rodents in the past year. However, having flush toilets was a protective factor related to reporting that they noticed rodents in the past year while gathering things in the forest and other places. While, having waste collected as part of waste disposal was also a protective factor related to reporting that they found dead rodents in the past year. These findings suggested that proper environmental management, such as having proper sanitation and waste disposal systems, can help reducing the exposure to rodents, which indirectly would lead to reduce the risk of rodent-borne disease in the community.

Keywords: Rodent, Contact, Exposure, Interaction, Hmong, Lao-Tai, Lao PDR

INTRODUCTION

Emerging infectious diseases (EIDs) have recently been increasing in various parts of the world. Several literatures have shown that EIDs account for at least 12% of all [1] and zoonotic pathogens cause approximately three-fourths of human emerging infections [2]. Taylor, et al. (2004) also confirmed that of the emerging pathogens reported, 75% (132) are zoonotic. Zoonotic pathogens are twice as likely to be associated with emerging disease that are non-zoonotic pathogens [1]. In the past decade, zoonoses which associated with wildlife have garnered increasing public health concern worldwide [3].

To address these EID threats, the United States Agency for International Development (USAID) launched the Emerging Pandemic Threats (EPT) program in 2009 to combat emerging diseases that could be harmful to human health. PREVENT is one of four projects under the EPT program, and aims to identify populations at the highest risk of exposure to emerging pathogens based on their behaviors and practices, particularly their

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interactions with animals. Research results from this project are intended to support efforts to characterize "high-risk" practices that increase the potential for new disease threats from wildlife or wildlife products to spread and infect people, and formulate behavior change and/or communication strategies and interventions that meet the challenges posed by the emergence of a new infectious disease.

Rodents are one of the animals of interest under the EPT Program, as they can serve as reservoirs of zoonotic diseases worldwide, including Southeast Asian countries. These zoonotic diseases include hantavirus pulmonary syndrome [4, 5] and leptospirosis [6, 7]. Rodents have become an increasingly significant health risk [8, 9] for several reasons. These include the increased movement of people between rural and urban areas as well as across country borders; increased population density, which augments the ability of a disease to spread through populations; and increased clearance of natural habitats, which promotes rodent-human contact [10].

This study was a part of the PREVENT project, sponsored by the U.S. Agency for International Development. The project is intended to identify characteristics that increase the likelihood of contact with animals, including rodents that could in turn increase risk of zoonotic disease. This report focuses on characteristics associated with rodent contact in Bolikhamxay Province, Lao PDR Data were collected in March to May 2013. Study results may ultimately contribute to the development of prevention and control measures for rodent-borne diseases in this province, as well as in other comparable locations.

MATERIALS AND METHODS

Study area and study sites

The survey study was conducted in Khamkeuth District of Bolikhamxay province, in central Lao People's Democratic Republic. This province hosts several dams (i.e., Theun Hinboun Power Company (THPC) dam) and a protected area that is home to both wild animal and human communities.

This site was proposed as suitable site for this study based on the criteria that it is an area with changing of environments and human activities (such as logging, construction of dams, and presence of other extractive industries) that can transform the human-animal interface in ways that can promote new exposures to disease. In addition, this study site was located where people are likely to have a high level of contact with animals that may be reservoirs of emerging infections, and where the human population is sufficiently dense and/or sufficiently mobile to spread infections.

Study design, respondents, and household selection

This was a cross-sectional study. Four village-communities were selected. A two-stage cluster sampling procedure was used. In the first stage, villages were selected randomly using probability proportional to size (PPS) sampling. In the second stage, independent samples of males and females in households in each village were selected using systematic sampling with different random starts for the two genders, and with a specified interval between selected households. Each team used a predetermined walking route that covered the entire village so that all households in the villages had an equal chance of being included in the survey. This route was determined prior to the start of field work using village maps provided by local authorities. Starting with the first household of each sample and walking in the predetermined route, the survey team screened for eligible respondents in households.

In each village-community, household interviews were conducted among the following subgroups: adult females and males aged 18 -50 years of old. These subgroups were selected to assess the effect of gender and age on exposure to animals. It was hypothesized that men and women have different types or rates of exposure related to specific gender roles in the society. In households with more than one eligible adult, one adult was selected by using a Kish grid table [11], which essentially gave an equal probability of selection to each eligible respondent in the village.

Data collection tools and procedures

The household survey questionnaire collected information about exposure to animals in different locations and in association with different activities. The period of exposure was standardized to the past twelve months. For exposures that are frequent or for which seasonal variation is large (such as animals eaten and hunted) the questionnaire was structured to aid recall by focusing on the last month, then on previous seasons. The covered topics were included in 13 sections. The questionnaire was administered after pre-testing to ensure that questions would be clearly understood by respondents. The questionnaire was developed in Lao and Hmong languages. Interviews were conducted by trained field researchers, closely supervised by a field supervisor.

Study Variables

There were four outcomes (dependent variables) assessed in this study, as follows:

1) Respondents reported encountering rodents in/around their home

2) Respondents reported encountering rodents while working around gardens/crops

3) Respondents reported noticing rodents in the past year while gathering things in the forest and other places

4) Respondents reported finding dead rodents in the past year

Twenty-two independent variables were considered in the analysis, based on our unpublished PREVENT's formative research in Khon Kaen Province of Thailand during 2011 [12]. This research indicated that potential factors such as age, gender, economical status, and cultural context might be associated with rodent exposure. Likewise, previous research [13] shown several environmental factors (e.g. household types) were associated with rodent contact and rodent-borne disease infections (e.g. hantavirus). Of these, nineteen were dichotomous and three continuous. For each dichotomous variable, the comparison group was described first, followed by the reference group. The numbers and percentages of participants in the comparison group were also given. Of these, 18 were dichotomous and three were continuous. The independent variables were grouped into 4 types, socio-demographic, environmental, behavioral, and cultural. Details are shown below.

a) Socio-demographic Information
   - Age group (>36 vs. ≤36 years)
   - Gender (male vs. female)
   - Ethnicity (Lao-Tai, Hmong and other)
   - Religion (Spirit vs. other)
   - Education attainment level (≥ secondary school vs. other)
   - Marital status (married or cohabiting vs. other)
   - Types of occupation (farmer vs. other)
   - Family size (> 6 vs ≤6 people)
   - Has a car (yes vs. no)

b) Environmental Information
   - Sanitation types (flush toilet vs. other)
   - Main drinking water source (using rainwater in all seasons vs. other)
   - Animals have access to drinking water (yes vs. no)
   - Waste disposal (waste collected vs. other)
   - Main cooking fuel (biomass vs. other)
   - Dwelling has wooden floor (yes vs. no)
   - Dwelling has wooden walls (yes vs. no)
   - Dwelling has zinc roof (yes vs. no)

c) Behavioral Information
   - Number of food crops grown (continuous)
   - Number of cultivation-related tasks (continuous)
   - Takes measures to avoid rodent-borne disease (yes vs. no)

d) Cultural Context
   - Knowledge/attitude toward animal-borne disease (continuous score)
   - Aware that rodents can cause human disease (yes vs. no)

Statistical Analysis

Data were analyzed separately for the four outcome dependent-variables. The analyses of respondents who reported rodents entering their homes and respondents who reported finding dead rodents in the past year included all 584 subjects. Analyses of respondents who reported encountering rodents while working around gardens/crops included only respondents (578 persons) who reported growing any crops. Analyses of respondents who reported noticing rodents in the past year while gathering things in the forest and other places included only respondents (329 persons) who reported gathering in this way.

Data were analyzed in three steps. Step 1 consisted of bivariate analysis in which associations between the dependent variables and each of the independent variables, considered separately, were ascertained. Chi-square or Fisher's exact tests were used for categorical independent variables, and logistic regression was used for continuous independent variables. In Step 2, an initial multiple logistic regression model, which included all independent variables for which $p \leq 0.15$ in the bivariate analysis, was constructed for each dependent variable. In Step 3, a second and final logistic regression model, which included independent variables for which $p \leq 0.15$ in the Step 2 model, was constructed for each dependent variable. *P-values* ≤ 0.05 were considered statistically significant. Data analysis was conducted with SPSS software (Chicago, IL).

In the Results section below, results from the final logistic regression models (step 3 of data analysis) are given for each of the 4 studied outcomes. Results of step 1 and step 2 of data analysis are available on request.

Ethical Considerations

This study was conducted after obtaining the ethical approval from the FHI 360 Institutional Review Board (IRB), the Lao PDR National Ethics

Table 1 Ethnic distribution of the respondents

Ethnicity of the respondents	Frequency	Percentage
Hmong	292	50.0
Lao-Tai	152	26.0
Manh	22	3.8
Meuy	57	9.8
Other	61	10.4
Total	584	100.0

Table 2 Final multiple logistic regression model for reporting that rodents came into the home

Variables	Coefficient	Odds Ratio	95% C.I. for ORs		*P-value*
			Lower	Upper	
Socio-demographic					
Male gender	-0.438	0.646	0.404	1.032	0.067
Environmental					
Drinking water from open natural water sources	0.445	1.560	0.979	2.485	0.061
Dwelling has wooden floor	0.828	2.288	1.266	4.137	0.006
Constant	1.563	4.774			<0.000

Committee for Health Research (NECHR) within the National Institute of Public Health (NIOPH), and the College of Public Health Sciences, Chulalongkorn University.

This study included no invasive or medical procedures of any kind. Participation in the study was strictly voluntary. Written informed consent was obtained from all respondents before proceeding to interview/discussion. Participants were assured that their responses were not shared by the researchers and were kept completely confidential and private.

RESULTS

Study respondents

Five-hundred-eighty-four (584) respondents participated in this study. Among respondents, 50.0% were Hmong, while 26.0% were Lao and 24.0% were other ethnic groups, such as Phu Thai, Thai Neua, and Manh (from 29 villages of Khamkeuth District within Bolikhamxay Province) (Table 1). The mean duration of living at the same location as during the interview was 20.52 years. Minimum and maximum living periods at the same location were between 1 and 47 years. The mean age of the respondents was 33.06 years-old and minimum and maximum respondent ages were 18 and 50 years old. Two-hundred and twelve (36.3%) were older than 36 years of age. Half of all respondents (292) were female.

Overall, 498 (85.3%) respondents reported rodents coming into their homes, 491/578 (84.9%) respondents reported encountering rodents while working around gardens/crops, 329 (56.3%) respondents reported noticing rodents in the past year while gathering things in the forest and other places, and 208 (35.6%) respondents reported finding dead rodents in the past year.

1) Respondents reporting rodents coming into their homes

Four-hundred-ninety-eight (498, 85.3%) respondents (256 females and 242 males) reported finding rodents coming into their homes; the mean age of these respondents was 33.02 years-old, and 183 (36.7%) were >36 years-old. Most of them were married or cohabitating (453, 91.0%) and their main occupation was farmer (398, 79.9%). One-hundred-fifty-three (30.7%) had higher than a primary school education, and 261 (52.4%) lived in households with >6 people.

Four-hundred-ninety-eight respondents (85.3%) reported rats/mice coming into their houses, while three respondents (0.5%) reported squirrels coming into their houses.

The final multiple logistic regression model is summarized in Table 2. The model includes 3 independent variables. Respondents whose main drinking water source was open natural water sources and whose dwellings had a wooden floor were statistically positive with reporting that rodents came into their homes (OR=1.560, 95% CI 0.979–2.485, p 0.061), and (OR=2.288, 95% CI 1.266 – 4.137, p 0.006), respectively.

2) Respondents reporting encountering rodents while working around gardens/crops

Five-hundred-seventy-eight (99.0%) respondents (249 females and 267 males) reported growing any crops. Of these, 491 (84.9%) reported encountering rats/mice, nine respondents (1.5%) reported encountering squirrels and three respondents (0.5%) reported encountering porcupines while working around gardens/crops.

Table 3 Final multiple logistic regression model for reporting encountering rodents while working around gardens/crops

Variables	Coefficient	Odds Ratio	95% C.I. for ORs		*P-value*
			Lower	Upper	
Socio-demographic					
Male Gender	0.498	1.646	0.905	2.996	0.103
Occupation as farmer	1.155	3.173	1.724	5.839	<0.001
Environmental					
Dwelling has wooden floor	0.970	2.639	1.140	6.108	0.023
Dwelling has zinc roof	-0.950	0.387	0.196	0.764	0.006
Behavioral					
Number of cultivation-related tasks	0.566	1.762	1.261	2.461	0.001
Number of food crops grown	0.310	1.363	1.049	1.771	0.020
Constant	-0.892	0.410			0.049

Table 4 Final multiple logistic regression model for reporting noticing rodents in the past year while gathering things in the forest and other places

Variables	Coefficient	Odds Ratio	95% C.I. for ORs		*P-values*
			Lower	Upper	
Socio-demographic					
Occupation as farmer	0.279	1.322	0.824	2.120	0.247
Environmental					
Sanitation as flush toilet	-1.081	0.339	0.164	0.700	0.003
Behavioral					
Number of food crops grown	0.695	2.003	1.655	2.425	<0.001
Cultural					
Knowledge/attitude toward animal-borne diseases	0.050	1.051	0.995	1.110	0.075
Constant	-2.863	0.057			<0.001

Six independent variables (male gender, working as a farmer, having a dwelling with a wooden floor, having a dwelling with an iron roof, number of cultivation-related tasks, and number of food crops) were included in the final logistic regression model for this outcome (Table 3). Among these all were statistically significant except gender (p=0.103).

Being a farmer, (OR = 3.173, 95% CI 1.724 - 5.839, p <0.001.), having a dwelling with a wooden floor (OR=2.639, 95% CI 1.140 – 6.108, p 0.023), cultivation-related tasks (OR=1.762, 95% CI 1.261 – 2.461, p 0.001), and number of food crops grown (OR=1.363, 95% CI 1.049 – 1.771, p 0.020) were statistically positive with reporting that they encountered rodents while working around gardens/crops, while having a dwelling with an iron roof was statistically negative with reporting that they encountered rodents while working around gardens/crops (OR=0.387, 95% CI 0.196 – 0.764, p 0.006).

3) Respondents reporting noticing rodents in the past year while gathering things in the forest and elsewhere

Three-hundred-twenty-nine (329, 56.3%) respondents (219 females and 110 males) reported noticing rodents in the past year while gathering things in the forest and other places. The mean age of this group was 32.3 years-and 110 (33.4%) were > 36 years-old. With regard to specific types of species, the respondents reported noticing the following types of rodents in the past year while gathering things in the forest and other places:

- Chipmunks (24, 7.3%)
- Porcupines (3, 0.9%)
- Rats/mice (222, 67.5%)
- Squirrels (201, 61.1%)

Four independent variables (working as a farmer, having a flush toilet, number of food crops grown, and knowledge/attitude toward animal-borne diseases) were included in the final logistic regression model for this outcome (Table 4). Of these, 2 (having a flush toilet for sanitation, and number of food crops grown) were statistically significant with reporting that they noticed rodents in the past year while gathering things in the forest and other places.

The number of food crops grown (OR=2.003, 95% CI 1.655 - 2.425, p<0.001) was statistically positive with reporting that they noticed rodents in the past year while gathering things in the forest and other places.

Having a flush toilet (OR=0.339, 95% CI 0.164 - 0.700, p 0.003) was negatively statistically

Table 5 Final multiple logistic regression model for reporting finding dead rodents in the past year

Variables	Coefficient	Odds Ratio	95% C.I. for ORs		*P-values*
			Lower	Upper	
Socio-demographic					
Ethnicity (reference = "other")					<0.001
Lao-Tai	-0.035	0.966	0.595	1.567	0.887
Hmong	-1.239	0.290	0.172	0.489	<0.001
Spirit-based Religion	0.474	1.606	0.979	2.635	0.061
Educational attainment	0.442	1.556	1.060	2.285	0.024
Environmental					
Waste collected as part of waste disposal	-0.392	0.676	0.457	0.998	0.049
Behavioral					
Number of food crops grown	0.304	1.356	1.170	1.570	<0.001
Constant	-1.077	0.340			<0.001

Table 6 Independent variables entered and not entered in final logistic regression models for the four studied outcomes

Independent variables	Outcome (rodent contact as indicated)			
	Home	Gardens/ crops	Gathering	Dead rodents
Socio-demographic				
Age				
Gender	X	X		
Ethnicity				X
Religion				X
Education				X
Married or cohabiting				
Occupation		X	X	
Large family				
Has car				
Environmental				
Flush toilet			X	
Drinking natural water	X			
Animals access drinking water				
Waste collected				X
Use biomass fuel				
Dwelling has wooden floor	X	X		
Dwelling has wooden walls				
Dwelling has zinc roof		X		
Behavioral				
Number of food crops grown			X	X
Number of cultivation-related tasks				
Takes measures to avoid rodent-borne disease				
Cultural				
Knowledge/attitude toward animal-borne disease			X	
Aware that rodents can cause human disease				

significant with reporting that they noticed rodents in the past year while gathering.

4) Respondents reporting finding dead rodents in the past year

Two-hundred-thirty-eight (208, 35.6%) respondents (101 females and 107 males) reported finding dead rodents in the past year. With regard to specific types of species, the respondents reported hunting or capturing the following rodents in the past four weeks:

- Rats/mice (206, 35.3%)
- Squirrels (6, 1.0%)

Five independent variables (ethnicity, spirit-based religion, educational attainment level, having waste collected as part of waste disposal, and number of food crops grown) were included in the final logistic regression model for this outcome (Table 5). Four independent variables (ethnicity, educational attainment level, having waste collected as part of waste disposal, and number of

food crops grown) were statistically significant with reporting that they found dead rodents in the past year. Educational attainment level (OR=1.556, 95% CI 1.060–2.285, p 0.024) and number of food crops (OR=1.356, 95% CI 1.170–1.570, p<0.001) were positively statistically significant with reporting that they found dead rodents in the past year.

Ethnicity if compared with overall ethnicity (p<0.001), Hmong if compared with Lao-Tai (OR=0.290, 95% CI 0.172–0.489) was statistically negatively significant with reporting that they found dead rodents in the past year. Likewise, having waste collected as part of waste disposal (OR=0.676, 95% CI 0.457–0.998, p 0.049) was statistically negatively significant with reporting that they found dead rodents in the past year.

Independent variables entered and not entered in the four final models (step 3 models) are summarized in Table 6. Among the 22 variables considered, 12 were entered in at least one model, and 10 were not entered in any model. On balance, socio-demographic and environmental characterizes were associated with outcomes more frequently than were behavioral and cultural characteristics. Four variables were entered in models for two outcomes. These were gender, occupation, dwelling has wooden floor, and number of food crops grown.

DISCUSSION AND CONCLUSION

Twenty-two independent variables (socio-demographic, environmental, behavioral and cultural context) were considered, based on unpublished data from PREVENT's formative research that was conducted in Khon Kaen Province of Thailand in 2011 [12]. Gender as male was into the multiple logistic regression models for both reporting rodents came in their homes and encountering rodents while working around garden/crops. Ethnicity was into the final model of reporting found dead rodents in the past year. Occupation as farmer was into the final models for both reporting encountering rodents while working around garden/crops and noticed rodents in the past year while gathering things in the forest and other places. Environmental factors (e.g. drinking water from open natural water sources, dwelling has wooden floor, dwelling has iron roof, sanitation, waste disposal as waste collected) were in the final logistic model for all focused outcome variables. Moreover, behavioral factors (e.g. number of cultivation-related tasks and number of food crops grown) were into the final models of most outcome variables except reporting that rodents came in their homes. However, cultural context factors (e.g. knowledge/attitude toward animal-borne diseases) was into the final model of reporting noticed rodents in the past year while gathering in the forest and other places.

This suggests that there were several factors associated to study respondents' contact with rodents, such as reporting that rodents came into their homes, encountering rodents while working around gardens/crops, reporting that they noticed rodents in the past year while gathering things in the forest and other places, and finding dead rodents in the past year in this province. These factors are likely to put people at increased risk of contact with rodents and might lead to an increased risk of rodent-borne disease transmission and infection.

Obtaining drinking water from open natural resources (e.g., from open or protected wells in the yard, a protected public well, a borehole in the yard/plot or in public, springs and rivers) and having a dwelling with a wooden floor were related to respondents reporting that rodents came into their houses. This might be because households in this province are located near open natural water resources (e.g., rivers, dams or springs), which could be close to rodent nests. Likewise, having wooden floors might be a factor that would lead to observing more rodents in their homes.

Working as a farmer, the number of cultivation-related tasks and the number of food crops grown are related to reports of encountering rodents while working around gardens/crops. Also, the number of food crops grown was associated with both reporting that they noticed rodents in the past year while gathering things in the forest and other places, and finding dead rodents in the past year. These findings may indicate that people who work outside their households, especially in areas where crops are grown, might be attracted to rodents as a food source, and thereby increase their risk of contact with rodents [14]. Having a dwelling with an iron roof was a protective factor to encountering rodents while working around gardens/crops. This might indicate that if houses have an iron roof, there is less of a chance that rodents can enter their homes. This might be because rice or farm fields (corn, cassava, grains, or vegetables) usually are located near households in rural areas. Thus, because crops attract rodents [8, 15, 16], these individuals could have more opportunities to encounter rodents.

However, having a flush toilet for sanitation was associated with reduced likelihood of noticing rodents in the past year while gathering things in

the forest and other places. Proper sanitation might reduce number of rodents breeding around the houses or toilet. Similarly, having waste collected as part of waste disposal was a protective factor for reporting that they found dead rodents in the past year. These findings could confirm that proper environmental management, such as having a proper sanitation and waste disposal system, can reduce the rodent exposure rate.

Higher educational attainment level seemed to be a factor for reporting that they found dead rodents in the past year. Lao-Tai respondents seemed to report finding dead rodents more than those in the Hmong and other ethnic group.

The present results appear to be comparable to a study of Puumala hantavirus (PUUV) infection in Belgium in September to November 1994 [16] that focused on human activities and risk factors leading to PUUV infection. The Belgian study found that seeing rodents at a work site (OR= 11.5, 95% CI 3.1–42.9), seeing living rodents at home (OR=3.5, 95% CI 1.2 – 10.3), seeing rodent droppings (OR=5.2, 95%CI 1.9–14.2), and male gender (OR=7.2, 95% CI 2.9 – 17.9) were statistically associated with PUUV infection among cases and all groups of controls.

These results suggested that providing and promoting environmental and sanitation management in households and food crop areas could reduce the chance of interacting with rodents and thereby the risk of rodent-borne disease infections – both in this province and in areas or countries that have similar environmental and agricultural characteristics. Further research is needed regarding the degree to which the observed associations indicate causality, and regarding the degree to which rodent contact is associated with risk of zoonotic diseases in the study area.

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