Characteristics Associated with Contact with Rodents In, Around, and Outside Homes in Khon Kaen Province, Thailand

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Abstract. Rodents are an important reservoir for zoonotic diseases. To enhance the evidence on the human-rodent interface, this cross-sectional study was conducted in 2011 to investigate characteristics associated with rodent contact in Khon Kaen Province, Thailand. A standardized, interviewer-administered questionnaire elicited information from 201 adults (101 males and 100 females). Overall, 86.6% of participants reported encountering or seeing evidence of rodents in or near the home, whereas 57.2% encountered rodents while working with crops. Encountering rodents in or near the home was positively associated with the number of agricultural activities, whereas encountering rodents during crop work was positively associated with perceiving that disease can be acquired from rodents, the number of food crops grown, the number of agricultural activities, and living in a house with wooden walls. Surprisingly, neither outcome was associated appreciably with gender, age, or setting (urban, forest, or agricultural). These results provide information on the potential risk of rodent-borne zoonoses; this evidence has implications for risk communication strategies in this province and likely elsewhere.

INTRODUCTION

Rodents are known to be an important disease reservoir, with potential health impact globally for at least 60 zoonotic diseases.^{1,2} These include plague,³ hantavirus,^{4–6} scrub typhus,⁷ Lassa virus,⁸ and leptospirosis.⁹ Improved information on risk factors for human-rodent interaction could therefore have significant benefit for efforts to prevent and control rodent-borne diseases at the local and international levels.

Consequently, the U.S. 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 was one of four projects under the EPT program, and has aimed to identify populations at the highest risk of exposure to emerging pathogens based on their behaviors and practices, particularly their interactions with animals. Research results from this project are intended to support efforts to characterize “high-risk” practices that increase the potential for new human disease threats from wildlife or wildlife products, and to develop strategies for improved communication and/or behavior change, to meet the challenges posed by emerging infectious diseases.

The current study was a part of PREVENT’s human-animal interface study, which focused on factors associated with rodent-human contact in, around, and outside homes in Khon Kaen Province, Thailand, during November–December 2011. Results of this study are expected to enhance evidence-based understanding of the human activities that might increase risk of rodent-borne diseases, and to assist in identifying feasible prevention and control measures in areas with similar environmental contexts.

MATERIALS AND METHODS

Study area. Khon Kaen Province is one of 20 northeastern (I-San) provinces in Thailand, consisting of 26 districts with a total population of about 1.8 million. This province was

selected for study because it has experienced rodent-related public health problems in the past.^{9–11} Specifically, in recent decades the Khon Kaen Provincial Health Office (KKPHO) of the Ministry of Public Health (MOPH) has reported important rodent-borne diseases (e.g., leptospirosis) by its passive surveillance system.¹² The study setting in Khon Kaen exhibits similarities to the Lao PDR, in which PREVENT planned a similar study. This similarity should provide useful comparison between the two countries.

Study sites are shown in Figure 1. Sites were selected to enable comparison of rodent contact and its risk factors, in urban, agricultural, and forest settings. Participants lived in four districts of Khon Kaen:

- a) Urban: Muang district;
- b) Agricultural: Phu Wieng and Wieng Khao districts; and
- c) Forest: Phu Pa Man district

Study design, respondents, and household selection. This was a cross-sectional study, conducted during November–December 2011. Study respondents were males and females 18–50 years of age who had lived in the selected study areas for at least 6 months before data collection. A two-stage cluster sampling procedure was used. In the first stage, villages were selected randomly, using probability proportional to size 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 research team used a predetermined walking route that covered the entire village so that all households in the village had an equal chance of being included in the survey. This route was determined before the start of field work, using village maps provided by local health offices. In households with more than one eligible adult, one adult was selected by using a Kish grid table,¹³ which essentially gave an equal probability of selection to each eligible respondent in the village.

Data collection tools and procedures. The questionnaire consisted of nine sections, which elicited information on socio-demographic and other descriptive characteristics, and on contact or evidence of contact with rodents and other

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FIGURE 1. Maps of Thailand. Khon Kaen Province, the four study districts in Khon Kaen, and the setting (urban, agricultural, forest) of each district.

animals, including poultry and domestic animals. (Findings regarding animals other than rodents will be reported elsewhere.) After the original questionnaire was translated from English into Thai, a pre-test was conducted to test for the validity and clarity of the questions, among 30 respondents who lived in villages near but not within the study area. As a result of the pre-tests, questionnaires in both English and Thai were refined before they were used in actual data collection. Interviews were conducted by trained field researchers.

Study variables. Two outcomes were studied, as follows.

1. Respondent had contact with or had seen evidence of rodents in or near the home in any of the following ways:

- Rodents stole or ate food or grain (items eaten by respondent or family);
- Probable rodent feces or urine in or near the house;
- Probable rodent feces or urine in things eaten or drunk by respondent or family, including water;
- Dead rodent in or near the house;
- Dead rodent in things eaten or drunk by respondent or family;
- Chewed clothes, bedding, or other household materials; and
- Rodent stole or killed an animal kept or raised by respondent or family.

2. Contact with rodents while working with crops outside the home.

Twenty-two independent variables were considered in analysis (please see Table 3 for complete list). Selection of the independent variables was based on literature reviews that identified factors that had been, or plausibly could be, associated with likelihood of rodent contact or risk of rodent-borne diseases (e.g., leptospirosis and hantavirus). These included socio-demographic factors (e.g., age, gender, education, and economic status),^{9,14,15} behavioral factors (e.g., cultivation-related tasks), environmental factors (e.g., home characteristics),⁴ and cultural context factors (e.g., knowing of the existence of leptospirosis).¹⁶

Of these independent variables, 19 were dichotomous and three were continuous. For each dichotomous variable, the comparison group is described first, followed by the reference group. Numbers and percentages of participants in the comparison group are also given.

Statistical analysis. Data were analyzed separately for the two dependent variables. The analysis of contact or evidence with rodents in or near the house included all 201 subjects. The analysis of rodent contact while working with crops included only the 164 subjects who reported growing any crops. During analysis, descriptive statistics were calculated for dependent and independent variables. Data were then

TABLE 1
Reported frequencies of contact with rodents in or near the home, by mode of contact

Mode of contact	No. of rodent contacts	No. of people with contact*
Rodent stole or ate food or grain	149	146
Rodent feces or urine in or near the house, including in things eaten or drunk	123	119
Dead rodent in or near the house, including in things eaten or drunk	97	94
Rodent chewed clothes, bedding, or other materials	109	109
Rodent stole or killed an animal raised by the respondent	12	12
Total	490	174

* Entries in this column do not add to 174 because many respondents reported more than one type of rodent contact.

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. The χ^2 or Fisher's exact tests were used for categorical independent variables, and logistic regression was used for continuous ones.¹⁷

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 final logistic regression model, which included independent variables for which $P \leq 0.15$ in the initial model, was constructed for each dependent variable. P values ≤ 0.05 were considered statistically significant. Data analysis were conducted with SPSS software (SPSS Inc., Chicago, IL).

Ethical considerations. The authors obtained FHI 360 Institutional Review Board approval for the study. The Khon Kaen Provincial Health Office also allowed the research team to conduct the study with the cooperation of local staff in the study areas. The authors also obtained approval from the Ethics Committee of the College of Public Health Sciences, Chulalongkorn University, for the data analysis.

RESULTS

Study respondents. Two hundred and one respondents (100 females and 101 males), all of Thai ethnicity, participated in this study. The mean age of respondents was 36.5 years. One hundred and sixty-one respondents (80.1%) came from non-urban settings (forest and agricultural). Most were married or cohabitating (152, 75.6%) and the most frequently reported occupation was farmer (91, 45.3%). Ninety-three respondents (46.3%) had secondary school education or higher, and 73 (36.3%) lived in households with ≥ 6 people.

Contact with, or evidence of, rodents in or near the home. A very high percentage of respondents in both urban and rural households reported contact with, or seeing evidence of, rodents in or near the home (83 females and 91 males,

86.6% of respondents). This percentage was similar in urban and non-urban settings (82.5% and 87.5%, respectively). Ninety-eight respondents (56.3%) were > 36 years of age, and 141 (81.0%) lived in non-urban settings. Most were married or cohabitating (131, 75.3%), and 79 (45.4%) of respondents reported their occupation as farmer. Eighty-two respondents (47.1%) had equal to or higher than secondary school education, and 60 respondents (34.5%) lived in households with ≥ 6 people.

These respondents reported several signs of rodents coming in or near the home: a) rodents stole or ate food and grains; b) animal feces or urine; c) dead animals; d) chewed clothes, bedding, or other materials; and e) rodents stole or killed an animal respondents kept/raised (Table 1). Evidence of types of rodents was reported as follows: rats, house mice, bamboo rats, white-bellied rats, and squirrels (Table 2). Among these types, all types of rodent contact in or near the house were reported only for "house mice."

Five independent variables (gender, has a car, dwelling has wooden walls, number of food crops grown, and number of cultivation-related tasks) were included in the initial multiple logistic regression model, because they met the criterion of P value < 0.15 in bivariate analysis (Tables 3 and 4). Three variables were carried forward to the final logistic regression model (Table 5). In this model, only one variable—the number of cultivation-related tasks—was significantly associated with rodent contact in or near the home (positive association, odds ratio [OR] = 1.39, 95% confidence interval [CI] 1.09–1.77, $P = 0.008$) (Table 5). Having a car and living in a dwelling with wooden walls were positively and marginally significantly associated with such contact.

Contact with rodents while working with crops outside the home. One hundred and sixty-four respondents reported growing any crops (vegetables, rice, grain, or others). Of these, 115 (57.2%) respondents (52 females and 63 males) reported encountering rodents while working with crops outside the home; 113 reported contact with rats only, one reported contact with squirrels only, and one reported contact with both

TABLE 2
Types and numbers of rodents reported for modes of contact with rodents in or near the home

Mode of contact	Rodent types and numbers reported				
	Modes of contact*				
	Rat	House mice	Bamboo rat	White-bellied rat	Squirrel
Stole or ate food or grain	113	32	1	2	3
Feces or urine in or near the house, including in things eaten or drunk	99	22	1	1	0
Dead animal in or near the house, including in things eaten or drunk	75	21	0	0	1
Rodent chewed clothes, bedding, or other materials	88	20	0	1	0
Rodent stole or killed an animal raised by the respondent	0	6	0	0	0
Total	381	4	2	4	2

*The headings for types of rodents reflect respondents' questionnaire answers. The terms "rat" and "house mice" are not intended to indicate specific species of rats and mice.

TABLE 3
Bivariate analysis of associations with rodent contact in or near the home

Variable no.	Independent variables		Respondents who reported contacting or seeing evidence of rodents that came in or near the home (N = 174)		
	Variable	Levels	No.	Prevalence (%) or odds ratio	P value
Categorical variables					
1	Gender	Female	83	83.0	0.140
		Male	91	90.1	
2	Age group	> 36 years of age	98	88.3	0.427
		≤ 36 years of age	76	84.4	
3	Area of residence	Urban	33	82.5	0.399
		Non-urban	141	87.6	
4	Occupation	Non-farmer	95	86.4	0.926
		Farmer	79	86.8	
5	Marital status	Other status	43	87.8	0.779
		Married and Cohabiting	131	86.2	
6	Family size	< 6 persons	114	89.1	0.170
		≥ 6 persons	60	82.2	
7	Educational attainment level	Other	92	85.2	0.536
		≥ Secondary school and other	82	88.2	
8	Main cooking fuel	Other	82	89.1	0.328
		Biomass	92	84.4	
9	Has heard of leptospirosis	No	42	89.4	0.521
		Yes	132	85.7	
10	Aware that rodents can cause human disease	No	46	88.5	0.642
		Yes	128	85.9	
11	Takes measures to avoid rodent-borne diseases	No	133	86.9	0.789
		Yes	41	85.4	
12	Sanitation	Other	152	86.4	0.822
		Has flush toilet	22	88.0	
13	Has a car	No	87	82.9	0.107
		Yes	87	90.6	
14	Main drinking water source	Other	37	80.4	0.165
		Using rainwater in all seasons	137	88.4	
15	Animals have access to drinking water	No	125	86.8	0.875
		Yes	49	86.0	
16	Waste disposal	Other	121	86.4	0.930
		Waste collected	53	86.9	
17	Dwelling has wooden floor	No	116	85.3	0.444
		Yes	58	89.2	
18	Dwelling has wooden walls	No	125	83.9	0.060
		Yes	49	94.2	
19	Dwelling has zinc roof	No	44	83.0	0.377
		Yes	130	87.8	
Continuous variables					
20	Number of food crops grown	Range 0–4		1.46	0.062
21	Number of cultivation-related tasks	Range 0–4		1.40	0.005
22	Knowledge/attitude toward animal-borne disease	Range 0–5		1.00	0.974

rats and squirrels. Sixty-five (56.5%) were > 36 years of age. One hundred and three (89.6%) lived in non-urban settings. Most of them were married or cohabitating (91, 79.1%) and their main occupation was farmer (75, 62.2%). Forty-seven (40.9%) had higher than primary school education, and 42 (36.5%) lived in households with ≥ 6 people.

Fourteen independent variables were included in the initial logistic regression model because they had *P* values ≤ 0.15 in

bivariate analysis (Tables 6 and 7). Six independent variables were included in the final model: awareness that rodents can cause human diseases, having a flush toilet as sanitation, main drinking water is rain water during all seasons, dwelling has wooden walls, number of food crops grown, and number of cultivation-related tasks (Table 8).

In this model (Table 8), four variables were positively and significantly associated with increased reported contact with

TABLE 4
Step 2, initial multiple logistic regression model for rodent contact in or near the home

Variables	Coefficient	Odds ratio (OR)	95% CI for odds ratio		P value
			Lower	Upper	
Gender (male)	0.429	1.536	0.635	3.714	0.341
Has a car	0.81	2.249	0.917	5.517	0.077
Dwelling has wooden walls	1.249	3.485	0.957	12.69	0.058
Number of food crops grown	−0.002	0.998	0.616	1.618	0.993
Number of cultivation-related tasks	0.318	1.375	1.005	1.881	0.046
Constant	0.436	1.546			0.313

TABLE 5

Step 3, final multiple logistic regression model for rodent contact in or near the home

Variables	Coefficient	Odds ratio (OR)	95% CI for odds ratio		<i>P</i> value
			Lower	Upper	
Has a car	0.868	2.383	0.980	5.794	0.055
Dwelling has wooden walls	1.226	3.409	0.949	12.238	0.060
Number of cultivation-related tasks	0.329	1.389	1.091	1.769	0.008
Constant	0.580	1.786			0.115

rodents while working crops outside their households: perceiving that disease can be acquired from rodents (OR = 2.98, 95% CI 1.11–7.97, $P = 0.030$), having wooden walls (OR = 5.44, 95% CI 1.50–19.79, $P = 0.010$), increasing number of food crops grown (OR = 2.22, 95% CI 1.25–3.93, $P = 0.006$), and increasing number of cultivation-related tasks (OR = 2.52, 95% CI 1.75–3.62, $P < 0.001$). Having food waste collected

from households was negatively and significantly associated with rodent contact (OR = 0.35, 95% CI 0.14–0.91, $P = 0.031$). Having a flush toilet was negatively and non-significantly associated with rodent contact.

DISCUSSION AND CONCLUSIONS

The results showed a high prevalence of contact with rodents in Khon Kaen Province, both in or near the home and while working with crops outside the home (86.6% and 70.1%, respectively). This finding raises concern that risk of rodent-borne zoonoses could be substantial in the study area and in numerous similar areas across Southeast Asia. It is of special note that prevalence of rodent contact were high even in urban residents (82.5% and 54.5%, respectively), and in females (83.0% and 65.8%, respectively). This suggests that risk of such zoonoses is not limited to specific demographic or socioeconomic groups.

Persons who engaged in agricultural activities (e.g., prepared land, planted crops, cared for plants, harvested crops)

TABLE 6

Bivariate analysis of associations with rodent contact while working with crops outside the home

Independent variables			Respondents who reported encountering rodents while working with crops outside their homes (<i>N</i> = 164 persons)		
Variable no.	Variable	Categories	No.	Prevalence (%) or odds ratio	<i>P</i> value
Categorical variables					
1	Gender	Female	52	65.8	0.246
		Male	63	74.1	
2	Age group	> 36 years of age	65	71.4	0.683
		≤ 36 years of age	50	68.5	
3	Area of residence	Urban	12	54.5	0.086
		Non-urban	103	72.5	
4	Occupation	Non-farmer	40	54.1	< 0.001
		Farmer	75	83.3	
5	Marital status	Other status	24	58.5	0.061
		Married and cohabiting	91	74.0	
6	Family size	< 6 persons	73	70.2	0.979
		≥ 6 persons	42	70.0	
7	Educational attainment level	Other	68	75.6	0.094
		≥ Secondary school and other	47	63.5	
8	Main cooking fuel	Other	43	63.2	0.105
		Biomass	72	75.0	
9	Has heard of leptospirosis	No	26	68.4	0.794
		Yes	89	70.6	
10	Aware that rodents can cause human disease	No	25	58.1	0.046
		Yes	90	74.4	
11	Takes measures to avoid rodent-borne diseases	No	90	68.8	0.849
		Yes	25	71.4	
12	Sanitation	Other	106	72.1	0.102
		Has flush toilet	9	52.9	
13	Has a car	No	62	74.7	0.195
		Yes	53	65.4	
14	Main drinking water source	Other	14	51.9	0.023
		Using rainwater in all seasons	101	73.7	
15	Animals have access to drinking water	No	76	67.9	0.352
		Yes	39	75.0	
16	Waste disposal	Other	85	73.9	0.104
		Waste collected	30	61.2	
17	Dwelling has wooden floor	No	71	65.7	0.089
		Yes	44	78.6	
18	Dwelling has wooden walls	No	75	63.6	< 0.001
		Yes	40	87.0	
19	Dwelling has zinc roof	No	23	59.0	0.081
		Yes	92	73.6	
Continuous variables					
20	Number of food crops grown	Range 0–4		2.81	< 0.001
21	Number of cultivation-related tasks	Range 0–4		2.25	< 0.001
22	Knowledge/attitude toward animal-borne disease	Range 0–5		1.01	0.503

TABLE 7
Step 2, initial multiple logistic regression model for rodent contact while working with crops outside the home

	Coefficient	Odds ratio	95% CI for odds ratio		P value
			Lower	Upper	
Non-urban residence	-1.379	0.252	0.029	2.198	0.212
Reported occupation is farmer	0.741	2.097	0.721	6.104	0.174
Married or cohabitating	0.760	1.169	0.724	6.309	0.169
Education $\geq$ secondary school	0.193	1.213	0.437	3.366	0.711
Main cooking fuel is biomass	0.016	1.016	0.370	2.791	0.975
Aware that rodents can cause human diseases	1.235	3.439	1.191	9.935	0.022
Has flush toilet	-1.257	0.285	0.067	1.212	0.089
Rainwater is main drinking water source in all seasons	0.773	2.166	0.273	17.186	0.465
Household waste is collected	-1.342	0.261	0.093	0.736	0.011
Dwelling has wooden floor	0.275	1.316	0.365	4.743	0.674
Dwelling has wooden walls	1.557	4.744	0.952	23.649	0.058
Dwelling has zinc roof	-0.397	0.593	0.210	2.150	0.503
Number of food crop types grown	0.877	2.404	1.240	4.659	0.009
Number of cultivation-related tasks	0.847	2.333	1.594	3.414	< 0.001
Constant	-4.023	0.018			< 0.001

had significantly increased opportunity for rodent contact in or near the home. In the study area, rice paddies and other agricultural fields are usually located near homes. Furthermore, food crops attract rodents.^{8,18,19} Thus, it is plausible that in many cases, rodents gained access to homes via the food crops under cultivation.

Having a car and living in a home with wooden walls were positively and marginally significantly associated with rodent contact in or near the home. The observed association with having a car might reflect a secondary association with one or more unmeasured indices of socioeconomic status. Wooden walls could conceivably be associated with increased ease of rodent entry into homes. In any event, further research is needed to confirm and explain these associations.

Awareness that diseases can be acquired from rodents, having wooden walls, the number of food crops grown (e.g., rice, vegetables, grains, and other types), and the number of cultivation-related tasks were positively and significantly associated with increased prevalence of reported contact with rodents while working with crops outside the home. The observed associations with number of food crops grown and number of cultivation-related tasks are not at all surprising. Conceivably, persons who are often in fields have higher concern regarding risk of animal-borne diseases than do other persons, and thus might acquire higher awareness of animal-disease relationships. If so, the observed association with awareness could reflect reverse causality.

Living in a home with wooden walls was positively and significantly associated with likelihood of rodent contact while working with crops outside the home. The reasons for this observation are not entirely clear. The two outcomes

assessed here were positively and significantly associated with each other; 73.3% and 44.4% of persons with and without rodent contact in or near the home, respectively, reported rodent contact outside the home ($P = 0.012$). Conceivably, the observed association of having wooden walls with the latter outcome could reflect a secondary association with the former outcome. It is also conceivable that this association could reflect an underlying association with unmeasured environmental or socioeconomic factors.

Having household waste collected and having a flush toilet were associated with reduced prevalence of rodent contact while working with crops. This observation suggests that improved sanitation is a protective factor against rodent contact in the study area and other similar areas. At the same time, it is not clear why improved sanitation was associated with reduced rodent contact while working with crops, but not with reduced contact in or near the home. Again, further research is needed to confirm and clarify the present findings.

The results of this study are broadly consistent with a recent literature review by Watson and others,⁴ which stated that several factors might be associated with rodent exposure during different daily activities, e.g., working with crops. These factors include area of residence (setting), types of occupation, sanitation, food waste disposal system, source of drinking water, cooking fuel, household characteristics (dwelling had wooden walls or wooden floor or iron roof), and knowledge, attitudes, and beliefs.

The results in Table 2 of this report can be compared with two studies on hantavirus in Laos, Thailand and other Southeast Asian countries,^{5,6} which found hantavirus seropositivity in bamboo rats (*Bandicoot indica*), pacific rats (*Rattus*

TABLE 8
Step 3, final multiple logistic regression model for rodent contact while working with crops outside the home

Variables	Coefficient	Odds ratio	95% CI for odds ratio		P value
			Lower	Upper	
Aware that rodents can cause human diseases	1.090	2.975	1.110	7.972	0.030
Has flush toilet	-1.084	0.338	0.090	1.270	0.108
Waste is collected	-1.052	0.349	0.135	0.906	0.031
Dwelling has wooden walls	1.695	5.444	1.498	19.785	0.010
Number of food crop types grown	0.797	2.220	1.253	3.933	0.006
Number of cultivation-related tasks	0.925	2.521	1.754	3.622	< 0.001
Constant	-3.903	0.020			< 0.001

exulans), and white-bellied rats or oriental house rats (*Rattus tanezumii*) in Nan Province in Thailand. Some respondents in this study reported contact with bamboo rats and white-bellied rats. These observations raise concern that persons who contact bamboo rats or white-bellied rats could be at increased risk of hantavirus infection, both inside and outside the study area.

To advance understanding of rodent exposure and associated factors, further quantitative and qualitative studies are needed. Qualitative research is in progress, and will be reported elsewhere. Information on proper waste disposal (e.g., collection and removal of food waste) and other aspects of rodent-borne zoonoses should be provided to local health offices, to reduce rodent contact and consequent risk of disease. Results such as these can also be used to inform rodent exposure mitigation strategies in Thailand and beyond.

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