RODENT CONSUMPTION IN KHON KAEN PROVINCE, THAILAND

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Abstract. Rodents are important reservoirs of rodent-borne infections worldwide, including Southeast Asia and Northeast Thailand (Isaan), where rodent consumption may be a source of rodent-borne diseases. The behavior of consuming rodents is related to a population's traditions, knowledge, cultural, and household contexts, among other factors. This cross-sectional survey was conducted in Khon Kaen Province, Thailand during November-December 2011. It aimed to elicit information about rodent consumption among residents of this province, and to identify factors associated with rodent consumption there. Multiple logistic regression analysis indicated that male gender, large family size, and use of rainwater as the main source of drinking water were positively associated with reported rodent consumption in this province, while having proper knowledge/attitudes towards animal-borne disease was negatively associated. These results provide evidence-base information for further studies, such as participatory action research, to further explore how people interact with rodents in different contexts. Further research is also needed to characterize risk of zoonotic diseases in relation to rodent consumption.

Keywords: Akaike's Information Criteria (AIC), Emerging Pandemic Threats (EPT) program, PREVENT Project, rodent-borne disease, rodent consumption, Thailand

INTRODUCTION

The United States Agency for International Development (USAID) launched an Emerging Pandemic Threats (EPT) program in 2009 with the main objective of combatting any zoonotic emerging diseases that could be harmful to human health (USAID, 2013). The PREVENT Project, implemented by FHI 360, is one of projects under the EPT program and has been tasked with understanding and addressing the risk of transmission at the interface of human-animal behaviors.

PREVENT focuses largely on bats, non-human primates, and rodents, as these are the types of animals that have most frequently been implicated in the transmission of zoonotic diseases to humans. PREVENT has launched research activities in several regions of the world, including a wide-ranging study to understand and quantify human exposure to animals. Quantifying exposure will help to determine which human populations

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are at greatest risk of contracting emerging infectious diseases and what types of interventions could reduce this risk.

Rodents are the largest group of mammals worldwide (Singla *et al*, 2008). They are considered an important disease reservoir species with potential to impact the human economy and public health, locally and internationally (Mills and Childs, 1998; Meerburg *et al*, 2009). Several studies have shown that rodents act as reservoirs for at least 60 zoonotic diseases (Mills and Childs, 1998; Mills, 2005; Taylor *et al*, 2008). These diseases include leptospirosis (Gratz, 1973; Bunnag *et al*, 1983; Tangkanakul *et al*, 2000, 2001, 2005; Kawaguchi *et al*, 2008; Victoriano *et al*, 2009), hantavirus (Gamage *et al*, 2011), scrub typhus (Lerdthusnee *et al*, 2008), plague (Limpakarnjanarat, 1987; Walker, *et al*, 1996; Davis *et al*, 2005; Meerburg *et al*, 2009), parasitic diseases (Shih *et al*, 1997), Lassa virus (Ter Meulen *et al*, 1996; Meerburg *et al*, 2009), and food poisoning (Oosterom, 1991).

The incidence of rodent-borne diseases has increased during recent decades; for example, leptospirosis (Tangkanakul *et al*, 2000). Incidence is evidently related to rodent abundance, population dynamics, dispersal of rodents to human habitations, and behavioral human-rodent interactions (Ostfeld and Holt, 2004). Diseases can be spread from rodents via direct and indirect routes (Meerburg *et al*, 2009). Pathogens (such as viral, bacterial, or protozoan) exit a rodent host, either in excreta (feces, urine, or saliva) or through the bite of a blood-sucking arthropod.

They can enter a new host (either rodent or human) through inhalation (Meerburg *et al*, 2009), skin puncture (Ostfeld and Holt, 2004), human consumption as food products (Ter Meulen *et al*, 1996) that are not thoroughly cooked, contact with water contaminated by rodent urine and/or feces, handling of dead infected rodents (especially while hunting, slaughtering, or butchering them), or contamination with saliva after being bitten while trying to capture them.

The consumption of 'wild foods' is an integral part of people's eating habits in many societies and is closely related to populations' traditions, knowledge, cultural, and household contexts (Setalaphruk and Price, 2007). Rodent consumption is common in many Asian communities, including some in rural northeast Thailand, where knowledge of wild food resources and hunting-gathering practices has been passed from generation to generation. This human activity has been found to be a cause of certain rodent-borne disease infections. For example, a study conducted in the Republic of Guinea suggested that rodent consumption is a risk factor for rodent-to-human transmission of the Lassa virus (Ter Meulen *et al*, 1996).

Because there is limited knowledge and few published papers on rodent consumption among humans, especially in Thailand and Southeast Asian countries, increased attention should be devoted to this area (Cosson *et al*, 2014). In response to this need, the present cross sectional study was conducted in November-December 2011.

The study aimed to characterize rodent consumption among Khon Kaen residents who lived in urban, agricultural, and forest settings. The study also aimed to identify characteristics associated with the likelihood of consuming rodents. In this effort, the study addressed four research questions: 1) How important are socio-demographic characteristics as determinants of rodent consumption, 2) How important are environmental characteristics as such determinants, 3) How important are behavioral characteristics as such determinants, and 4) How important is the cultural context as such a determinant?

The results of this study are expected to advance the understanding of frequency and determinants of various forms of contact with rodents in the PREVENT study areas. Ultimately, it is expected that findings will contribute to interventions to reduce rodent contact in ways that will reduce risk of zoonotic diseases. The present report focuses on frequency of, and associations with, rodent consumption. Characteristics associated with other forms of rodent contact (*eg*, contact while inside or outside homes), and with contact with animals other than rodents, will be reported elsewhere.

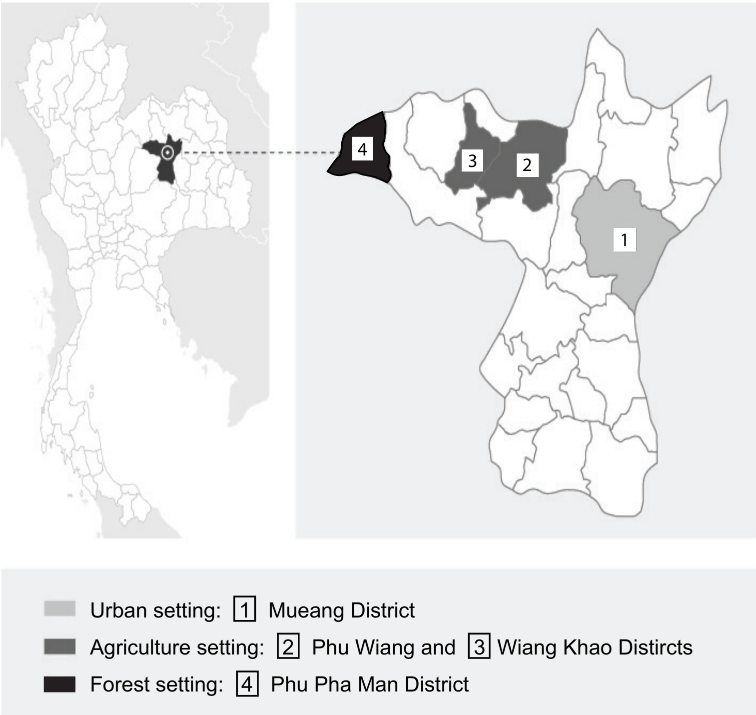

Fig1–Maps of Thailand and Khon Kaen Province (with districts selected per setting).

MATERIALS AND METHODS

Study design and setting

This study was a cross-sectional survey that focused on rodent consumption among residents of Khon Kaen Province in northeastern Thailand during November-December 2011. The study elicited information on all types of interactions with wild and domestic animals, including rodents. Thailand was selected for the study because there have been increasing reports of emerging, re-emerging, and rodent-borne zoonotic infections in the country. The study focused on residents who lived in different settings within the province, including: a) urban (Mueang District) and b) non-urban (agriculture and forest: Phu Wiang, Wiang Khao, and Phu Pha Man districts) (Fig 1).

Respondents

Respondent selection criteria were as follows: males or females, 18-50 years old, and those who had stayed in the study areas continuously for at least six months before data collection. A two-stage cluster sampling procedure was utilized. In the first stage, villages were selected randomly using probability proportional to size (PPS) sampling. In the second stage, independent male and female samples from the households in each village were selected by systematic sampling, with different random starts.

In the field, two separate teams interviewed the men and the women. In each village, households were selected by systematic random sampling, using a random starting point and a specified interval between households. Each team used a predetermined walking route that covered the entired village so that all households in each village had an equal chance of being included in the survey. The route was determined by using village maps provided by local health offices. Starting with the first household of each sample and walking the predetermined route, the lead survey team screened for eligible respondents in the households. In households with more than one eligible adult, one adult was selected using a Kish grid table (Kish, 1965), which essentially gave an equal probability of selection to the eligible respondents in each village.

Data collection tools and procedures

Trained field researchers conducted face-to-face interviews using a standardized questionnaire to collect information on rodent consumption, socio-demographic, and other descriptive characteristics from the study respondents. A pilot test was conducted among 30 respondents who lived in Khon Kaen, but who were not the same as the respondents, to test the validity and precision of the translated questionnaire and the correct understanding of each question.

Study variables

Respondents were asked what kinds of animals, including rodents, they had consumed in the month and year prior to data collection. Aside from the consumption, the respondents were also asked about contacts with rodents while working crops and encountered with crops; however, this current paper is only focused on rodent consumption.

Responses to these two questions were combined into a single binary outcome: rodent consumption in the month or year preceding data collection.

Twenty-two independent variables were considered in the analysis. The selections of the independent variables were based on literatures, which indicated that potential factors such as socio-demographic (*eg*, age, gender, types of occupation, and economical status) (Assogbadjo *et al,* 2005; Setalaphruk and Price, 2007; Navegantes de Araujo *et al*, 2013; Suwannarong *et al,* 2014), behavioral (*eg*, cultivation-related tasks) and environmental factors (*eg,* household types) (Watson *et al*, 2014) as well as cultural context factors (*eg,* knowledge of leptospirosis) (Navegantes de Araujo *et al*, 2013), might be associated with rodent contact, rodent consumption and rodent-borne disease infections (*eg*, hantavirus and leptospirosis).

Of these, nineteen were dichotomous and three were 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.

Socio-demographic information: Age [>mean age of 36 years (60, 53.1%) *vs* ≤36 years]; Gender [male (74, 65.5%) *vs* female]; Area of residence [non-urban (forest and agricultural 102, 90.3%) *vs* urban]; Education [≥secondary school (47, 41.6%) *vs* other]; Occupation reported as farmer (64, 56.6%) *vs* other; Has a car [yes (49, 43.4%) *vs* no]; Marital status [married and cohabiting (87, 77.0%) *vs* other]; Family size [≥6 people (46, 40.7%) *vs* <6 people].

Environmental information: Has flush toilet (10, 8.9%) *vs* other; Household waste disposal [waste is collected (37, 32.7%) *vs* other]; Main drinking water source in all seasons is rainwater (103, 91.2%) *vs* other sources; Animals have access to drinking water [yes (35, 31.0%) *vs* no]; Main cooking fuel [biomass (74, 65.5%) *vs* other]; Dwelling has wooden floor [yes (42, 37.2%) *vs* no]; Dwelling has wooden walls [yes (32, 28.3%) *vs* no]; Dwelling has zinc roof [yes (91, 80.5%) *vs* no].

Behavioral information: Number of food crops grown, among vegetables, rice, grain, and others (continuous); Number of cultivation-related tasks [preparing land for planting, planting crops; maintaining crops, or harvesting crops (continuous)]; Takes measures to avoid animal contact, in order to avoid disease from animals [yes (24, 21.2%) *vs* no].

Cultural context: Knowledge/attitudes towards animal-borne disease (continuous score); Aware that rodents can cause human disease [yes (86, 76.1%) *vs* no]; Has heard of leptospirosis [yes (84, 74.3%) *vs* no].

Statistical analysis

The household interview data were entered into a database using CSPro© (version 5.0.3; Washington, DC: US Census Bureau). Then data were analyzed using SPSS software (version 22; IBM: Armonk, NY). The dependent and independent analytical variables listed above were created after data cleaning.

Data were analyzed in three steps: Step 1 consisted of a bivariate analysis, in which the degree of association between an dependent variable and each of the independent variables was ascertained separately (Bursac *et al*, 2008). For categorical independent variables, associations were assessed with Pearson chi-square tests (or Fisher exact tests when expected cell counts were <5). For continuous independent variables, associations were assessed with logistic regression. In Step 2, a preliminary multiple logistic regression model was constructed. This model included all independent variables for which $p<0.15$ in bivariate analysis. In Step 3, a final multiple logistic regression model was constructed. This included all independent variables for which $p<0.15$ in the preliminary model.

Collinearity and potential confounding were evaluated by inspection of variance inflation factors (derived from multiple linear regression models that included the same dependent and independent variables as the preliminary and final logistic regression models described above). Standard errors of variables in analytical models were also inspected. The relative importance of socio-demographic, environmental, behavioral, and cultural characteristics was assessed by comparing Akaike's Information Criteria (AICs) in models that did and did not include these characteristics.

Ethical considerations

The FHI 360 Institutional Review Board approved the conduct of this study (FHI 360 IRB: Project Nº 3879-06100; 2011 Nov 29). The Khon Kaen Provincial Health Office allowed the research team to conduct the study with the cooperation of local staff in the study areas (verification provided). The College of Public Health Sciences, Chulalongkorn University Ethics Committee approved the analysis of the database (Ref No. 005.1/56; 2013 Apr 30).

Researchers obtained consent from each respondent before information was collected. They informed all participants of the purpose of the study, the benefits and risks to them, and the fact that their participation was voluntary. Researchers told respondents that no risks were anticipated from participating in this study, except possible discomfort in answering some questions. They also assured respondents that all information would be confidential, and that no names or identifying information would be used in any reports resulting from the study.

Researchers asked all respondents to sign or make a mark on an informed consent form that detailed all this information; the researchers countersigned the consent form. Respondents were offered a copy of the completed consent form. Respondents were not paid for participation, but were provided with refreshments.

All data were entered onto a laptop computer as soon after data collection as was realistically possible. The household questionnaire was entered into a database on a password-protected computer at field base, and stored in a password-protected location there and on the FHI 360 computer system. Once data from questionnaires and notes were entered and checked, all hard copies were destroyed.

RESULTS

Among 201 (100 female and 101 male) respondents, 113 respondents (56.2%), including 39 females and 74 males, reported consuming some type of rodent during the previous one-month or 12-month periods. Among these 113 respondents, 104 (92.0%), 4 (3.5%), 6 (5.3%), 33 (29.2%), 19 (16.8%), and 3 (2.7%) reported consuming only rats (not specific species), field rats, squirrels, burrowing squirrels, flying squirrels, and porcupine, respectively.

The mean age was 36.5 years among the 113 respondents. Based on this mean age, 60 respondents (53.1%) were aged >36 years. One hundred and two (90.3%) came from non-urban settings (agriculture and forest). Most of them were married or cohabiting (87, 77.0%) and 64 (56.6%) respondents were farmers (rice, grains, or vegetables). Forty-seven respondents (41.6%) attained educational levels ≥secondary school.

Thirteen independent variables (gender, area of residence, occupation, family size, educational attainment level, main cooking fuel, sanitation, main drinking water source, dwelling has wooden floor, dwelling has zinc roof, number of crops grown, number of cultivation-related tasks, and knowledge/attitudes towards animal-borne disease) from bivariate analysis results were eligible to enter into Step 2, preliminary multiple logistic regression model (Table 1).

Five variables (gender, family size, main cooking fuel, sanitation, main drinking water source, and knowledge/attitudes towards animal-borne disease) were eligible for addition to Step 2 of preliminary multiple logistic regression (Table 2). Four variables (gender, family size, main drinking water source, and knowledge/attitudes towards animal-borne disease) were statistically significantly associated with reported rodent consumption at Step 3 of final multiple logistic regression. Male gender (OR 7.45; 95% CI: 3.51-15.85, p<0.001), family size ≥six persons (OR 2.31; 95% CI: 1.10-4.84, p=0.027), and use of rainwater as the main source of drinking water in all seasons (OR 8.61; 95% CI: 3.28-22.57, p<0.001) were positively associated with reported rodent consumption, while having proper knowledge/attitudes towards animal-borne disease (OR 0.96; 95% CI: 0.92-0.99, p=0.030) was negatively associated with rodent consumption (Table 3).

Table 4 presents Akaike's Information Criteria (AICs) for the preliminary model, the final model, and models in which socio-demographic, environmental, and cultural characteristics were omitted from the final model. (The final model did not include any behavioral characteristics as

Table 1
Bivariate analysis results, odds ratios, confidence intervals, and *p*-values of independent variables with rodent consumption in the past 12 months.

Variable	Rodent consumption in the past 12-months			
	Odds ratio	Confidence interval Lower	Confidence interval Upper	*p*-value
Male (Ref female)	4.287	2.361	7.783	<0.001
Age (Ref age < 36 years)	0.821	0.468	1.440	<0.001
Non-urban (Ref urban)	4.558	2.122	9.790	<0.001
Farmer (Ref non-farmer)	2.951	1.642	5.303	<0.001
Marital status (Ref other aside from married or cohabiting)	1.184	0.620	2.260	<0.001
Family size (Ref < 6 persons)	1.551	0.861	2.793	<0.001
Educational attainment level (Ref < secondary school)	0.650	0.371	1.140	<0.001
Main cooking fuel (Ref using other main cooking fuel except biomass fuel)	2.873	1.614	5.115	<0.001
Had heard of leptospirosis (Ref had not heard of the disease)	0.745	0.382	1.453	<0.001
Aware that rodents can cause human disease (Ref not aware that rodents can cause human diseases)	1.264	0.671	2.382	<0.001
Takes measures to avoid rodent-borne diseases (Ref didn't take measures to avoid rodent-borne diseases)	0.719	0.375	1.378	<0.001
Sanitation (Ref other except flush toilet)	0.472	0.201	1.110	<0.001
Has a car (Ref other vehicle except cars)	0.668	0.381	1.170	<0.001
Main drinking water source (Ref other sources of drinking water except rainwater)	7.131	3.282	15.492	<0.001
Animals have access to drinking water (Ref animals had no access to drinking water)	1.346	0.720	2.517	<0.001
Waste disposal (Ref other waste disposal except collecting it)	1.298	0.704	2.394	<0.001
Dwelling has wooden floor (Ref other except wooden floor)	1.672	0.909	3.076	<0.001
Dwelling has wooden walls (Ref other except wooden walls)	1.343	0.705	2.560	<0.001
Dwelling has zinc roof (Ref other except zinc roof)	2.250	1.188	4.261	<0.001
Number of food crops grown (continuous)				
Number of cultivation-related tasks (continuous)				
Knowledge/attitude toward animal-borne disease (continuous)				

independent variables). AICs are shown in smaller-is-better format. The AIC was smallest for the final model, suggesting that this was the most informative model among those assessed. Omitting socio-demographic and environmental characteristics from the final model caused large increases in AICs, indicating the important influence of both of these types of characteristics on rodent consump-

Table 2
Preliminary multiple logistic regression model for rodent consumption.

Variable	Coefficient	Odds ratio	95% CI for ORs		*p*-value
			Lower	Upper	
Socio-demographic information					
Gender (male)	2.063	7.869	3.594	17.229	<0.001
Non-urban residence	-0.874	0.417	0.068	2.554	0.344
Occupation as farmer	0.382	1.465	0.587	3.657	0.413
Family size (> 6 persons)	0.886	2.427	1.133	5.197	0.023
Educational attainment level (> secondary school)	-0.403	0.669	0.302	1.481	0.321
Environmental information					
Main cooking fuel (biomass fuel)	0.666	1.947	0.914	4.146	0.084
Sanitation (having flush toilet)	0.046	1.047	0.364	3.012	0.933
Rainwater as main drinking water source	2.550	12.806	2.132	76.934	0.005
Dwelling has wooden floor	0.010	1.010	0.463	2.204	0.980
Dwelling has zinc roof	0.146	1.157	0.476	2.814	0.748
Behavioral information					
Number of food crops grown	0.154	1.167	0.760	1.792	0.480
Number of cultivation-related tasks	0.045	1.046	0.807	1.354	0.736
Cultural context					
Knowledge/attitudes towards animal-borne diseases	-0.035	0.966	0.926	1.007	0.098
Constant	-1.400	0.247			0.223

tion. Omitting the cultural characteristic (knowledge/attitude toward rodent-borne diseases) caused only a small increase in AIC, indicating that this was less important than socio-demographic and environmental factors.

Variance inflation factors (VIFs) were very small for the final model, ranging from only 1.007 (for knowledge/attitude toward rodent-borne diseases) to 1.197 (for drinking rainwater). The smallest possible VIF is 1.000, indicating no collinearity whatsoever. Standard errors of independent variable coefficients were also very small in the final model ranging from only 0.003 to 0.077. These findings strongly suggest that collinearity among independent variables was negligible in the final model, and would not have led to misinterpretation.

DISCUSSION

The results indicated that males, large family size (≥six persons in the family), and using rainwater as a source of drinking water in all seasons were associated with reported rodent consumption, while having proper knowledge/attitudes towards animal-borne disease was associated with fewer reports of rodent consumption in this province. This may be because males were the main family members who worked crops, and they were thus at greater risk of exposure to rodents and would also be more likely to eat them. This was compatible with

Table 3
Final multiple logistic regression for rodent consumption.

Variable	Coefficient	Odds ratio (ORs)	95% CI for ORs		*p*-value
			Lower	Upper	
Socio-demographic information					
Gender (male)	2.009	7.454	3.505	15.852	<0.001
Family size (≥ 6 persons)	0.835	2.305	1.097	4.842	0.027
Environmental information					
Main cooking fuel (biomass fuel)	0.724	2.063	0.998	4.266	0.051
Rainwater as main drinking water source	2.153	8.610	3.284	22.572	<0.001
Cultural context					
Knowledge/attitudes towards animal-borne diseases	-0.041	0.959	0.924	0.996	0.030
Constant	-1.011	0.364			0.314

Table 4
Akaike's Information Criteria (AICs) for preliminary and final logistic regression models, and for models in which the indicated types of characteristics were omitted from the final model.

Model	AIC[a]
Preliminary model (13 variables)	220.3
Final model (5 variables)	210.7
Final model omitting indicated characteristic	
Socio-demographic (2 variables)	241.6
Environmental (2 variables)	245.2
Cultural (1 variable)	213.7

[a]Small is better.

findings of a PREVENT formative study, conducted in Khon Kaen Province during June to July 2011,which found that males had a greater chance to interact with wild animals than females did (unpublished findings).

The locations for catching and storing rainwater for drinking purposes in rural areas of Thailand are usually outside the house. Behaviors stemming from this might place this population at higher risk of exposure to rodents outside their homes, and promote increased rodent consumption. Respondents who used rainwater as a source of drinking water might be considered to be of low-to-middle economic status, because persons who have higher incomes are more likely to purchase bottles of drinking water from groceries or factories, or have well water in their household to produce clean water for family consumption.

Having proper knowledge/attitudes towards animal-borne diseases appeared to be protective factors against rodent consumption. This maybe because the more people had proper knowledge/attitudes towards animal-borne disease, the more likely they were to avoid eating rodents.

For reasons given above, we believe that the final model was not subject to misinterpretation due to collinearity among the independent variables included in that model. At the same time, two variables in the preliminary model, namely, nonurban residence and drinking rainwater, were tightly correlated (VIFs 3.46 and 3.56, respectively). Of the nonurban and urban residents, 94.4% and 7.5%, respectively, drank rainwater (p<0.001 by Pearson chi-square test).

When drinking rainwater was replaced with nonurban residence in the final model, the AIC was 222.3, which is larger than the actual final model AIC of 210.7. Nevertheless, it is conceivable that the positive and significant association between drinking rainwater and rodent consumption (Table 3) might, to some extent, reflect a concurrent positive association with nonurban residence. This issue should be assessed in future research.

As per our research methodology, we found benefits in utilizing this sampling method because we could get equal numbers for genders from different starting directions. Kish grid tables could assist to identifying a respondent from several eligible respondents in each household, which would assist in practical sampling methodology during fieldwork.

However, one limitation of the study was that it was not a hypothesis generating study, but rather than hypothesis testing study. It did not measure disease-risk directly, but rather measured risk behaviors toward disease risk.

Moreover, this was a part of the PREVENT human-animal interface study that focused on other outcome variables (*eg*, rodent contact), aside from rodent consumption, and other types of animals (*eg*, primates, bats, and domestic animals). Therefore, it would be beneficial to have future epidemiological studies that would study direct associations between rodent consumption and specific rodent-borne disease infections (*eg*, leptospirosis, hantavirus, food poisoning).

In conclusion, the results likely represent information on rodent consumption activities in northeastern Thailand or even in the entire Asia region, and might be able to generalize to other areas that have similar characteristics. These findings should help to improve knowledge and attitudes towards rodent-borne diseases. This could serve for several PREVENT studies, such as participatory action research, to advance understanding of human-rodent interactions in this province. It will also be important to conduct epidemiologic studies to characterize zoonotic disease risk in relation to rodent consumption and other types of rodent contact. Information from these efforts should provide a sound scientific basis for policies to reduce risk of these diseases.

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