Knowledge and perceptions on zoonoses in Mayan communities from the state of Yucatán, Mexico

Conocimiento y percepciones sobre zoonosis en comunidades mayas del estado de Yucatán, México

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ABSTRACT

It is estimated that 60% of infectious diseases, and up to 75% of emerging and reemerging diseases are zoonotic. Inhabitants of tropical rural areas are the most affected by zoonotic diseases. However, knowledge of these inhabitants in vulnerable areas about zoonotic diseases is rarely known and taken into consideration for prevention programs and disease control. Semi–structured questionnaires were applied to 96 inhabitants of Mayan communities from the state of Yucatán, Mexico, to investigate their knowledge and risk perception of rabies, taeniasis/cysticercosis complex, trichinosis, toxoplasmosis, rickettsiosis, Chagas disease, leishmaniasis, leptospirosis and brucellosis. Rabies (88.5%) and Chagas disease (35.4%) were the most well-known diseases while taeniasis/cysticercosis complex (7.5%), brucellosis (3.1%), toxoplasmosis (1%) and trichinosis (1%) were the lesser-known diseases. None of the interviewees mentioned knowing rickettsiosis, leishmaniasis or leptospirosis. Of the inhabitants who had knowledge about rabies, 98.7% mentioned that the disease is spread by the bite of an animal, 60% indicated that the vaccination of animals prevents the disease, and 65% considered that this disease represents a high risk for health. Of the people who recognized Chagas disease, 93.7% mentioned that the disease is acquired through the bite of blood–sucking bugs, commonly referred to as "pics" in the Mayan language. In general, Chagas disease prevention measures were varied and infrequent, such as not touching "pics" (11.8%). Informative talks (46.9%) and television (29.2%) were the means through which they would like to receive information about diseases. Due to the inhabitants of tropical rural communities living with multiple socioeconomic and environmental conditions that increase the risk of exposure and transmission of zoonotic diseases, it is necessary to implement educational programs for control and prevention of zoonosis for short–, medium–, long–term that consider the knowledge, perceptions and necessities of the communities.

Key words: Diseases prevention; one health; rural areas; zoonotic diseases

RESUMEN

Se estima que el 60 % de las enfermedades infecciosas y hasta un 75 % de las enfermedades emergentes y re–emergentes son zoonóticas. Los habitantes de las áreas rurales tropicales son más afectados por las enfermedades zoonóticas. Sin embargo, el conocimiento sobre las zoonosis por parte de los habitantes de áreas vulnerables es poco conocido y tomado en consideración en los programas prevención y control de enfermedades. Cuestionarios semi–estructurados fueron aplicados a 96 habitantes de comunidades mayas del estado de Yucatán, México, para investigar su conocimiento y percepción de riesgo sobre la rabia, el complejo teniasis/cisticercosis, la triquinosis, la toxoplasmosis, las rickettsiosis, la enfermedad de Chagas, la leishmaniasis, la leptospirosis y la brucelosis. Los resultados indicaron que la rabia con 88.5 % y la enfermedad de Chagas con un 35.4 %, respectivamente, fueron las enfermedades más reconocidas, mientras que teniasis/cisticercosis (7.5 %), brucelosis (3.1 %), toxoplasmosis (1 %) y triquinosis (1 %) fueron poco conocidas. Ninguno de los encuestados reconoció la rickettsiosis, leishmaniasis o leptospirosis. De los entrevistados que reconocieron la rabia, el 98.7 % mencionó que es transmitida por la mordida de un animal, el 60 % indicó que la vacunación de los animales la previene y el 65 % consideró que representa un riesgo alto para la salud. Entre las personas que reconocieron la enfermedad de Chagas, el 93.7 % mencionó que es adquirida a través de chinches hematófagas llamadas "pics" en lengua Maya. En general, las medidas de prevención de esta enfermedad fueron variadas e infrecuentes, como no tocar a los "pics" (11.8 %). Así mismo, se conoció que las charlas informativas (46.9 %) y la televisión (29.2 %) fueron los medios a través de los cuales los entrevistados les gustaría recibir información sobre enfermedades. Debido a que los habitantes de comunidades rurales tropicales viven en múltiples condiciones socioeconómicas y ambientales que incrementan el riesgo de exposición y transmisión de las zoonosis, es necesario implementar programas de educación, control y prevención de zoonosis a corto, mediano y largo plazo que consideren el conocimiento, percepción y necesidades de las comunidades.

Palabras clave: Áreas rurales; enfermedades zoonóticas; prevención de enfermedades; una salud

INTRODUCTION

Zoonotic diseases are caused by pathogens transmitted between vertebrate animals and humans [1]. These pathogens can be transmitted to humans through direct contact with secretions from any vertebrate animal, consumption of animal meet or they can be indirectly transmitted through biological vectors [2]. It is estimated that 60% of infectious diseases, and up to 75% of emerging and reemerging diseases are zoonotic [3] and that every year there are up to 2.5 billion cases affecting humans and 2.7 million deaths associated with zoonotic diseases [4].

Zoonotic diseases have a significantly greater impact on less developed countries and regions. This is due to the presence of risk factors such as elevated population growth, lack of healthcare systems and programs to deal with the spur of diseases, along with a high prevalence of immunocompromised people who have HIV or parasitic infections [5]. In this sense, Latin America and the Caribbean are regions where 48.6% and 22.5% of the population living in rural areas are in poverty and extreme poverty, respectively, despite poverty decreasing over the last decade [6].

The emergence of zoonotic diseases originating from wildlife, such as COVID–19 from SARS–CoV2, demonstrates the necessity for future research on activities that put animals and humans in close proximity [7]. People in rural areas typically live with multiple socioeconomic and environmental factors that increase their risk of exposure and transmission of zoonotic diseases, such as contact with livestock and wildlife [8, 9]. With the use of wildlife being a vital part of daily activity in rural Mexico, whether through food, pets, traditional medicine [10], the risk for the emergence of zoonotic diseases is heightened in these areas.

The complexity of implementing and designing effective zoonotic disease prevention strategies makes them especially difficult to be successful in rural areas [8]. It is necessary to create an intervention based on studies that thoroughly consider the knowledge, perceptions, practices and habits of the target population to establish preventive measures of zoonotic diseases in both rural and urban areas, as considering these social factors can increase motivation and overall participation of the residents [11, 12]. Furthermore, understanding why people participate in activities that increase zoonotic disease transmission is important for developing disease control [8, 12]. Essentially, the purpose of this research was to investigate the knowledge and perceptions on zoonotic diseases of national and local importance in the residents of four Mayan communities in the state of Yucatán, Mexico.

MATERIALS AND METHODS

Ethical statement

The present study was approved by the Bioethics Committee of the Campus de Ciencias Biológicas y Agropecuarias, Universidad Autónoma de Yucatán (Protocol Approval No. CB–CCBA–L–2021–001).

Study areas, design and populations

A cross sectional descriptive study was carried out in the communities of Dzoyaxché (20°47'20" N, 89°35'23" W), San Ignacio Tesip (20°50'31.92" N, 89°36'42.12" W), Hunxectamán (20°52'54" N, 89°33'28" W) and Yaxnic (20°47'24" N, 89°37'10.92" W), all belonging to the municipality of Mérida, in the state of Yucatán (FIG. 1). The first
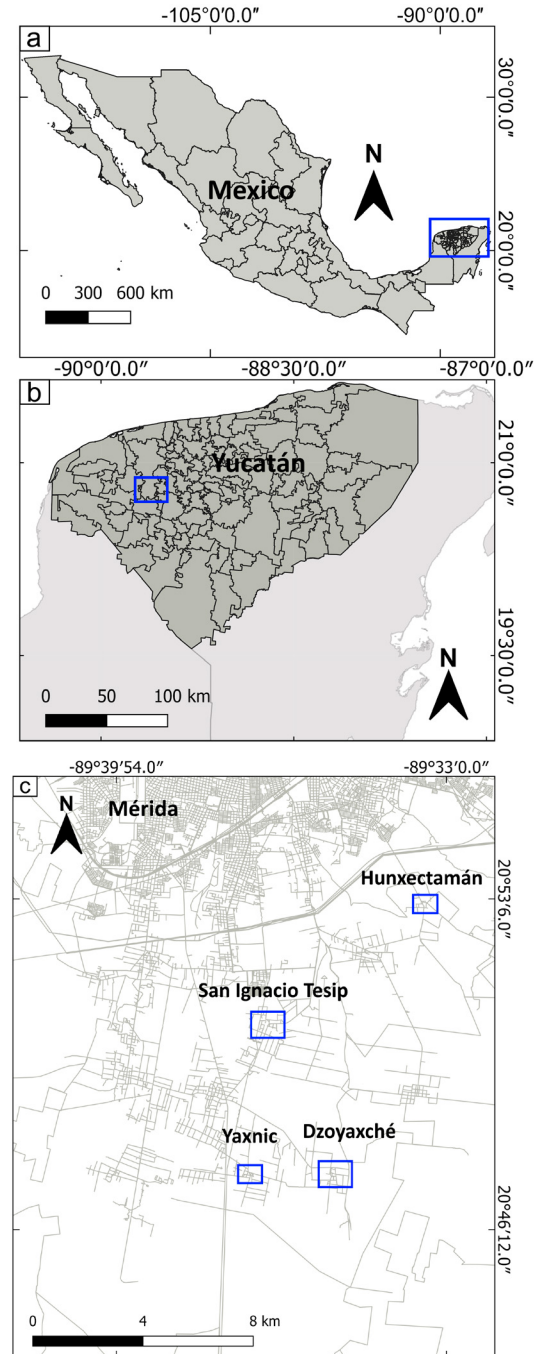

FIGURE 1. Location of the Mayan communities. a) Location of the state of Yucatán, in the Mexican republic (blue square). b) Location of the city of Merida (blue square) in the state of Yucatán. c) Location of the communities (blue squares) in relation to the municipality of Merida

three mentioned communities are found inside the Cuxtal Natural Reserve, in a natural protected area consisting of 10,757 ha, located in the south of the municipality of Mérida, while Yaxnic borders the natural reserve. In general, the communities have fewer than 1,000 inhabitants who live with levels of marginalization and social deprivation [13, 14, 15] (TABLE I).

TABLE I
Characteristics of the studied communities

Community	Population	Mayan people	Inhabited dwellings	Marginalization index	Social deprivation index
Yaxnic	907	825	254	Low	Low
Dzoyaxché	533	503	145	Low	Low
San Ignacio Tesip	405	359	113	Very low	Low
Hunxectamán	177	160	47	Low	Low

The vegetation of the Cuxtal Natural Reserve is low deciduous forest and secondary vegetation, with 242 species of plants, including native and introduced species in patios, parks and gardens [16]. The fauna includes 53 species of mammals, 168 species of birds, 55 species of reptiles, 12 species of amphibians and 410 species of invertebrates [16]. The region's climate is warm and subhumid with precipitation in the summer from June to October, with an average precipitation of 1,100 mm annually. The annual average temperature is 26°C with a maximum of 36°C in May and a minimum of 16°C in January.

Data collection

To collect the socioeconomic data, along with the knowledge, attitude and risk perceptions of zoonotic diseases, a non–probability convenience sample was used due to the low participation from the inhabitants of a community in the Cuxtal Natural Reserve in a pilot study during the COVID–19 pandemic. Between June and July 2021, the chosen communities were visited and with the help of a map, street blocks were visited house by house to explain the objective and methodology of the project. The inclusion criteria of the people interviewed were the following: a) currently inhabiting the house, b) inhabitants 18 years of age or older and c) signing the informed consent. The exclusion criteria were: a) not currently residing in the house, b) being under 18 years of age and c) not signing the informed consent. In the case of the inclusion criteria being met, we proceeded with the interview. Due to health concerns caused by the COVID–19 pandemic, it was decided to only interview one member of the household as to not have proximity with several people. In addition, sanitary measures, such as the use of face masks, antibacterial gels and a safety distance of at least 3 m between the interviewer and the interviewed, were used during the interview.

A semi–structured questionnaire was created *ad hoc* to obtain socioeconomic information from the participants, as well as their knowledge of the term zoonosis and their knowledge and risk perception of rabies, taeniasis/cysticercosis complex, trichinosis, toxoplasmosis, rickettsiosis, Chagas disease, leishmaniasis, leptospirosis and brucellosis. The selection of zoonotic diseases was based on both the diseases included in the Epidemiological Bulletin of the National Epidemiological Surveillance System and those of importance in Yucatan [17]. In order to collect the socioeconomic information of the participants, aspects such as age, gender, income, and education of the participants were asked during the interviews. Also, the contact with animals, whether by possession, consumption, or visits to the residence, was also investigated. To explore the information of the inhabitant's knowledge of zoonotic diseases, they were asked about their ideas and knowledge on the term zoonotic disease and what animals transmit diseases to humans, as well as the transmission routes and what prevention measures are used for the zoonotic diseases selected. To obtain information on the risk perception, we asked whether the diseases represent a risk – understood as a danger which harms or affects their health – classifying them as high, medium or low risk. The survey was created by consulting relevant literature related to the region's topics [18, 19, 20]. To check the clarity, duplicity and interpretation of the information and questions, a first version of the survey was applied to five residents of the community of San Ignacio Tesip [21]. To create the final version, the feedback from this assessment was used to make the modifications needed.

Data analysis

A database was constructed to store the information collected. To compare the socioeconomic characteristics of the inhabitants interviewed between the four communities, the Chi square test for homogeneity was used with R software version 1.3.959 with a level of significance of $P < 0.05$. As the four communities had similar socioeconomic characteristics, data were pooled into rural. For quantitative variables (e.g., age), the mean, standard deviation and range are presented. For qualitative variables (e.g., knowledge of the term zoonosis) frequencies and percentages are presented [22].

RESULTS AND DISCUSSION

Demographic and socio–economic characteristics of participants

A total of 96 inhabitants were interviewed in the study, of which 26 were from Dzoyaxché, 26 from San Ignacio Tesip, 26 from Yaxnic and 18 from Hunxectamán. The majority of those interviewed were female (79.2%), housewives (66.7%), with an average age of 43.6 years, with basic education (75%) and with an average family income of less than or equal to USD 216.8 (TABLE II). The majority (88.5%) had or raised animals, most commonly dogs and chickens or turkeys. The most widely consumed meats by the interviewed inhabitants were chicken or turkey (100%), pork (97.9%) and beef (97.9%), while from the wild animals, venison (52.1%) was commonly consumed. The wild animals the interviewed inhabitants observed most frequently in their yards or near their homes were opossums (68.7%), rats/mice (61.5%) and skunks (54.2%) (TABLE III).

Knowledge and perceptions on zoonoses of participants

The majority of those interviewed (97.9%) did not know of the term zoonosis (TABLE IV). However, 78.1% of them did recognize which animals can transmit diseases to humans. Dogs (51%) and cats (29.2%) were the most mentioned animals as disease transmitters. The most well–known diseases were rabies (88.5%) and Chagas disease (35.4%), meanwhile the least known were taeniasis/cysticercosis (7.5%), brucellosis (3.1%), toxoplasmosis (1%) and trichinosis (1%).

TABLE II
Socioeconomic characteristics of the respondents from Dzoyaxché (DZO), Hunxectamán (HUN), San Ignacio Tesip (SIT), and Yaxnic (YAX)

Variable	Category	DZO n (%)	HUN n (%)	SIT n (%)	YAX n (%)	Total n (%)
Gender	Female	21 (80.8)	15 (83.3)	20 (76.9)	20 (76.9)	76 (79.2)
	Male	5 (19.2)	3 (16.7)	6 (23.1)	6 (23.1)	20 (20.8)
Age (years)	Mean ± SD	39 ± 16.1	46.7 ± 18.0	46.2 ± 15.8	43.6 ± 18.9	43.6 ± 17.2
Education Level	None	2 (7.7)	0 (0)	2 (7.7)	2 (7.7)	6 (6.3)
	Primary school	17 (65.4)	17 (94.1)	20 (76.9)	18 (69.2)	72 (75)
	Secondary school	6 (23.1)	1 (5.6)	4 (15.4)	5 (19.2)	16 (16.7)
	University	1 (3.8)	0 (0)	0 (0)	1 (3.8)	2 (2.1)
Occupation	Housewife	17 (57.7)	14 (77.8)	18 (69.2)	15 (57.7)	64 (66.7)
	Employee	2 (26.9)	2 (11.1)	4 (15.4)	7 (26.9)	20 (20.8)
	Student	2 (7.7)	0 (0)	2 (7.7)	4 (15.4)	8 (8.3)
	Retiree	0 (0)	1 (5.5)	2 (7.7)	0 (0)	3 (3.1)
	Unemployed	0 (0)	1 (5.5)	0 (0)	0 (0)	1 (1)
Monthly Family Income	≤ US$216.8	11 (42.3)	8 (44.4)	10 (38.5)	6 (23.1)	35 (55.3)
	> US$216.8	13 (50)	10 (55.6)	16 (61.5)	20 (76.9)	59 (31.9)
	Do not answer	2 (7.7)	0 (0)	0 (0)	0 (0)	2 (2.1)

The comparison of the variables between the communities did not show statistical differences ($P>0.05$)

TABLE III
Animals with which the interviewees had contact, whether as pets, as source of meat or as peridomestic animals

Variable	Categories	Frequency (%)
Keep domestic animals	Yes	85 (88.5)
	No	11 (11.5)
Kept animals	Dogs (*Canis lupus familiaris*)	77 (80.2)
	Chickens / turkeys (*Gallus gallus / Meleagris gallopavo*)	47 (49)
	Cats (*Felis catus*)	29 (30.2)
	Sheep / goats (*Ovis aries / Capra hircus*)	12 (12.5)
	Cattle (*Bos taurus / Bos indicus*)	6 (6.4)
	Rabbits (*Oryctolagus cuniculus*)	4 (4.2)
	Turtles (Testudines)	2 (2.1)
	Fishes	2 (2.1)
	Pigs (*Sus scrofa domesticus*)	1 (1.0)
Consumption of animals	Chicken / turkey	96 (100)
	Pigs	94 (97.9)
	Cattle	94 (97.9)
	Deer (*Odocoileus virginianus*)	50 (52.1)
	Ocellated turkey (*Meleagris ocellata*)	11 (11.5)
	Armadillo (*Dasypus novemcinctus*)	8 (8.3)
	Peccary (*Pecari tajacu*)	6 (6.2)
	Rabbit	5 (5.2)
	Wild small birds	4 (4.2)
	Iguana (*Iguana iguana*)	3 (3.1)
Peridomestic animals	Opossums (*Didelphis virginiana*)	66 (68.7)
	Rats / mice (*Rattus rattus / Mus musculus*)	59 (61.5)
	Skunks (*Spilogale yucatanensis*)	52 (54.2)
	Bats (Chiroptera)	21 (21.9)
	Gray foxes (*Urocyon cinereoargenteus*)	8 (8.3)
	Raccoons (*Procyon lotor*)	1 (1)

TABLE IV
Knowledge about zoonoses of respondents from the Mayan communities

Variable	n	Category	Frequency (%)
Do you know the term zoonosis?	96	Yes	2 (2.1)
		No	94 (97.9)
Do animals can transmit diseases to people?	96	Yes	75 (78.1)
		No	21 (21.9)
What animals do you think can transmit diseases to people?	96	Dogs	49 (51.0)
		Cats	28 (29.2)
		Rats / mice	8 (8.3)
		Opossums	6 (6.2)
		Cattle	5 (5.2)
		Pigs	5 (5.2)
		Bats	5 (5.2)
		Chickens / turkeys	5 (5.2)
		Rabbits	1 (1.0)
		Iguanas	1 (1.0)
		All animals	4 (4.2)
What disease do you know?	96	Rabies	85 (88.5)
		Chagas disease	34 (35.4)
		Taeniasis/cysticercosis	7 (7.5)
		Brucellosis	2 (2.1)
		Trichinellosis	1 (1.0)
		Toxoplasmosis	1 (1.0)
		Rickettsiosis	0 (0.0)
		Leishmaniasis	0 (0.0)
		Leptospirosis	0 (0.0)
Sources of information for identified zoonoses	96	Television	31 (36.0)
		Relatives	23 (26.7)
		Acquaintances	12 (13.9)
		Radio	10 (11.6)
		Presentations/exhibitions	8 (9.6)
		Government institutions	6 (7.0)
		Social medias	6 (7.0)
		Had the disease	5 (5.8)
		School	2 (2.3)
		Newspaper	4 (4.6)
		Doctor	4 (4.6)
		Internet	4 (4.6)
		Veterinarian	3 (3.5)
		Flyer	1 (1.2)
		Book	1 (1.2)
		Research project	1 (1.2)
Through what means would you prefer to receive information about zoonoses?	96	Presentations/exhibitions	45 (46.9)
		Television	28 (29.2)
		Newspaper	17 (17.7)
		Radio	16 (16.7)
		Social medias	16 (16.7)
		Posters	10 (10.4)
		Internet	2 (2.1)
		Cell phone messages	2 (2.1)
In what language would you prefer to receive information about zoonoses?	96	Maya	7 (7.3)
		Spanish	44 (45.8)
		Maya or Spanish	44 (45.8)
		Do not answer	1 (1.0)

None of the interviewees mentioned knowing about rickettsiosis, leishmaniasis or leptospirosis. The interviewed inhabitants mentioned their sources of knowledge on diseases were primarily television (36%) and family members (26.7%). They said they would like to receive information about diseases from informative talks and television. Of the interviewed inhabitants, 45.8% stated they would prefer receiving this information in Spanish due to their lack of proficiency in the Mayan language, while another 45.8% indicated they could receive the information in either Mayan or Spanish because they were bilingual.

Although the majority of those interviewed (97.9%) did not know the term zoonosis, or zoonotic disease; most were knowledgeable (78.1%) of animals being able to transmit diseases to humans. Several studies in Latin America have resulted in similar outcomes. Garaycochea *et al.* [23] determined that 91.6% of the women attending in the Instituto Nacional Materno Perinatal of Lima, Peru, did not know of the term zoonosis, though 82.8% of them knew animals could transmit diseases

to humans. Tarabla *et al.* [24] found that 88.2% of the housewives interviewed in Coronda, Santa Fe, Argentina, did not know of the term zoonosis, however 80% did mention the transmission of diseases from animals to humans. A different study by Ayala–Servín *et al.* [25], found that 86.7% of the inhabitants interviewed at San Lorenzo, Paraguay, claimed to know of the existence of diseases transmitted from animals to humans. Therefore, though a high percentage of the general population might be unfamiliar with the specific term "zoonosis," this does not seem to be problematic, as people are generally aware that animals can transmit diseases to humans.

From the inhabitants who claimed to know about rabies (TABLE V), 91% of them mentioned knowing how the disease is spread. Of these people, 98.7% of them mentioned that rabies is spread through the bite of a rabid animal, with dogs being stated as the animal that transmits rabies the most (83.3%). The signs and symptoms which they most associated with animal or human rabies were excessive

TABLE V			
Knowledge and perception towards rabies			
Variable	**n**	**Categories**	**Frequency (%)**
Do you know how rabies spreads to people and animals?	85	Yes	78 (91.8)
		No	7 (8.2)
How rabies spreads to people and animals?	78	Animal bite	77 (98.7)
		Contact with the saliva of an infected animal	10 (12.8)
		Scratch from an infected animal	1 (1.3)
What animals can transmit rabies?	78	Dogs	65 (83.3)
		Bats	8 (10.3)
		Rats/mice	4 (5.1)
		Cats	3 (3.8)
		Opossums	3 (3.8)
Do you know the signs/symptoms of rabies in animals/humans?	85	Excessive salivation	23 (27.1)
		Aggressiveness	15 (17.6)
		Sudden death	12 (14.2)
		Fever	5 (5.9)
		Thirst	3 (3.5)
		Inappetence	2 (2.3)
		Wound infection	2 (2.3)
		Disorientation	2 (2.3)
		Convulsion	1 (1.2)
		Muscle pain	1 (1.2)
		Headache	1 (1.2)
What measures prevent the rabies?	85	Vaccinate animals	51 (60)
		Go to the doctor post–exposure	8 (9.4)
		Prevent pets leaving from the dwelling	7 (8.2)
		Use traditional cures	6 (7.1)
		Avoid contact with animals	4 (4.7)
		Take pets to the veterinarian	2 (2.3)
		Kill suspicious rabid animals	2 (2.3)
		Neuter dogs and cats	1 (1.2)
		Isolate suspicious rabid animals	1 (1.2)
What level of risk does rabies represent to your health?	85	High	56 (65.9)
		Medium	8 (9.4)
		Low	10 (11.8)
		I don't know	11 (12.9)

salivation (27.1%), aggressiveness (17.6%) and sudden death (14.2%). The most frequently mentioned method of prevention against rabies was animal vaccination (60%). Of the interviewed residents, 65% of them considered rabies as a high health risk.

Although a high percentage (91.8%) of the interviewed adequately recognized the sources of transmission of rabies (animal bites, scratches or contact with contaminated saliva), only 9.6% of them mentioned that wild mammals, such as bats, can carry and transmit this disease. Furthermore, no person mentioned carnivores like foxes or skunks. In the Americas, human rabies transmission by dogs has been drastically reduced; however, transmission through wild mammals (e.g., bats, foxes, skunks) has obtained greater epidemiological importance [26, 27]. In 2019, Mexico was the first country to receive validation from the World Health Organization for eliminating human rabies transmitted by dogs as a public health issue [28]. Currently, wild mammals have taken a bigger role in the epidemiology of human rabies, between 2007 and 2020, the Institute of Epidemiological Diagnosis and Reference (InDRE) analyzed 407 cases of human exposure to the rabies virus, identifying positive cases in primarily bats (63%) and skunks (28%), and with less frequency (9%) foxes, coatis, felines, coyotes, deer and opossums [29]. This highlights the need to modify human rabies prevention strategies by considering the role of wild mammals and the contact of rural community members with these animals, whether for meat consumption (e.g., deer) or due to their presence in households (e.g., skunks, gray foxes, bats, opossums).

Within the people that recognized Chagas disease, 94.1% of them mentioned understanding how this disease is transmitted to humans. The main form of transmission mentioned (93.7%) was through the bite of blood-sucking bugs (*Triatoma dimidiata*), commonly referred to as "pics" in the Mayan language (TABLE VI). The most mentioned effect related to Chagas disease by the interviewed inhabitants were inflammation and or infection at the site of the bite (44.1%). The main prevention method mentioned was avoiding contact with blood-sucking bugs (11.8%). Among the interviewed inhabitants, 85% considered Chagas disease to be a high health risk.

Chagas disease is endemic to various Mexican states, including Yucatán. According to the National Committee for Epidemiological Surveillance, from 2010 to 2020, the cases of Chagas disease reported annually in Yucatán ranged from 27 to 166 and from 391 to 980 in the country [30]. However, these numbers may be lower due to the amount of cases not reported to government agencies [31]. In this study, Chagas disease was the second most recognized zoonotic disease, though still with a low frequency (35.4%). All participants who recognized the disease associated it with the bug "pic"; however, only a few (6.2%) connected it to contact with the vector's feces, and none mentioned other transmission routes, such as blood transfusion or congenital transmission. Additionally, the most associated signs and symptoms were inflammation or infection around the bitten area (44.1%) and heart damage (26.5%). Overall, knowledge of transmission methods among the interviewed residents was very limited. A previous study in three rural communities in the state of Yucatán showed that 50% of the interviewed residents recognized that the "pic" insect could transmit the disease and how this insect causes inflammation and infection (61%) and affected the heart (38%) [32]. In other countries such as Honduras and Bolivia, the acknowledgement and identification of this zoonotic disease has had a higher frequency (88–90%). However, the knowledge of transmission routes, in general, was also low due to only 1.3–2% being able to recognize a different transmission route other than the vector one [33, 34]. Since Chagas disease is prevalent in Latin America, it is essential to enhance the

TABLE VI
Knowledge and perceptions about Chagas disease

Variable	n	Categories	Frequency (%)
Do you know how people get Chagas disease?	34	Yes	32 (94.1)
		No	2 (95.9)
How people get Chagas disease?	32	Bites of "pics"	30 (93.7)
		Contact with feces of "pics"	2 (6.2)
Do you know the signs/symptoms of Chagas disease?	34	Inflammation/infection of the wound	15 (44.1)
		Heart damage	9 (26.5)
		Fever	2 (5.9)
		Heart attack	2 (5.9)
		Liver damage	1 (2.9)
		Headache	1 (2.9)
What measures prevent Chagas disease?	34	Not touch "pics"	4 (11.8)
		Fumigate the dwelling	3 (8.8)
		Go to the doctor post–exposure	3 (8.8)
		Keep the dwelling clean	2 (5.9)
		Not accumulating useless objects	2 (5.9)
		Use mosquito nets	1 (2.9)
		Kill "pics"	1 (2.9)
		Use ducks as biological control	1 (2.9)
What level of risk does Chagas disease represents to your health?	34	High	29 (85.3)
		I don't know	5 (14.7)

communication methods that effectively disseminate information about the disease to communities, so that it is long lasting and can be reinforced through informal methods based on the experience of rural communities [33].

Those interviewed who recognized the taeniasis/cysticercosis complex considered it a disease purely spread by pigs. Everyone stated knowing it is transmitted and acquired, by consuming pork contaminated with worms (71.4%) or raw or undercooked (28.6%) (TABLE VII). According to those interviewed, the people with this disease can suffer from brain damage caused by the worms (28.6%) and experience increased headaches, seizures, fainting and loss of appetite (14.3%). To prevent this disease the main consensus was to not eat contaminated (42.9%) or raw or undercooked (42.9%) pork. Out of the people interviewed, 85.7% of them considered taeniasis/cysticercosis to be of high health risk.

Out of the three people surveyed with knowledge of brucellosis, only one of them associated its transmission with the consumption of infected beef. In relation to the signs and symptoms of the disease in humans, two of the interviewed residents mentioned the following: fever, low blood pressure, loss of appetite and stomach pain. One person surveyed mentioned that in animals the disease is contagious for pregnant cows, causing spontaneous abortions. Only one person mentioned knowing methods of prevention in animals, these being vaccines, quarantine after purchasing cows and notifying the livestock authorities. Two people said they perceived this disease as low risk for their health, while the third person considered it a medium risk. Only one person recognized toxoplasmosis and mentioned the disease is transmitted through cat feces; however, the signs or symptoms caused by the disease were not mentioned. This person also mentioned a method of prevention is by avoiding contact with stray or feral cats, and that this disease as a high risk for their health. Trichinosis was mentioned by one interviewed resident, who identified the consumption of contaminated pork as a source of transmission.

The interviewed resident mentioned lack of appetite and fever as signs and symptoms of the disease; however, that good hygiene and avoiding contaminated pork alone was enough as preventative methods. This disease was perceived as a high risk to human health.

Diseases such as taeniasis/cysticercosis, brucellosis, trichinosis and toxoplasmosis were rarely known by those interviewed (< 8%), whereas leptospirosis, rickettsiosis and leishmaniasis had no recognition. Although some cases of these diseases have decreased in the past decades (e.g., taeniasis/cysticercosis, trichinosis) [35, 36], others have been dealing with an increase in cases in the state of Yucatán, like localized cutaneous leishmaniasis and rickettsiosis. Recent autochthonous cases and infected vectors indicate that leishmaniasis is emerging in the state of Yucatán [37]. Similarly, an increase in human cases of rickettsiosis has been reported in Mexico, including the state of Yucatán [38]. The emergence of these diseases, and other zoonoses, shows the need for strength and an update to the intervention and control strategies through a One Health perspective.

The results found in the studied communities highlighted the necessity to implement educational programs and campaigns to increase the inhabitant's knowledge on important zoonotic diseases in the region. Beyond the dissemination of knowledge, these campaigns and programs must consider the community's necessities, like the preference on receiving information through television, talks and newspapers. The language level utilized is another important factor to consider due to the general population's lack of mastery of either Spanish or Mayan. They may not be able to fully understand the information disseminated due to illiteracy or the use of non-common words. Methods that include participatory learning activities in informal environments, such as plays, poster creations and seminars, involving different sectors of the population such as teachers, health module staff, parents, children and local authorities, are necessary to establish long-term community surveillance strategies.

TABLE VII Knowledge and perception about taeniasis / cysticercosis		
Variable	**Category**	**Frequency (%)**
Do you know how people get taeniasis / cysticercosis?	Yes	7 (100)
	No	0 (0)
How people get taeniasis /cysticercosis?	Eat contaminated pork with worms	5 (71.4)
	Eat raw or undercooked pork	2 (28.6)
Do you know the signs or symptoms of the taeniasis / cysticercosis?	Brain damage by worms	2 (28.6)
	Headache	1 (14.3)
	Convulsion	1 (14.3)
	Fainting	1 (14.3)
	Inappetence	1 (14.3)
	I don't know	1 (14.3)
What measures prevent the taeniasis / cysticercosis?	Not eat contaminated pork	3 (42.9)
	Eat well-cooked pork	3 (42.9)
	Wash fruits and vegetables	1 (14.3)
	I don't know	2 (28.6)
What level of risk does taeniasis / cysticercosis represent to your health?	High	6 (85.7)
	Low	1 (14.3)

CONCLUSION

The present study provides information on the knowledge and perception of zoonoses among inhabitants of Mayan communities. Although a high percentage of the interviewed people did not recognize the term zoonosis, most of them were knowledgeable of animals being able to transmit diseases to humans.

The results indicate that the interviewed inhabitants have moderate knowledge mainly about rabies and Chagas disease, while other zoonotic diseases were little known (e.g., taeniasis) or unknown (e.g., leptospirosis).

It is expected that the knowledge and perception of the inhabitants will be considered in education and health promotion programs. This will allow for greater participation and interest of the inhabitants in the strategies for the control and prevention of zoonotic diseases.

Availability of data

The data that support the findings of this study are available from the corresponding author upon reasonable request.

Conflict of interest

The authors declare no conflict of interests.

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