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Full Research Article

CLIMATE CHANGE AND VECTOR-BORNE ZOONOSES: INSIGHTS FROM A CROSS-SECTIONAL STUDY ON PERCEPTIONS, KNOWLEDGE, AND PRACTICES IN PORTUGAL

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Abstract

Climate change is regarded as a critical issue for public health. Each year, its impact on human and animal health becomes increasingly evident as the risk of zoonosis transmission is exacerbated by extreme weather events and the movement of vectors into new areas. These changes are causing extensive consequences, affecting human health, the environment, and the global economy. Therefore, collective action is considered essential to mitigate the effects of climate change and safeguard public health for future generations. This study investigates the perceptions, knowledge, and practices of Portuguese citizens concerning vector-borne zoonoses and their connection to climate change.

A descriptive cross-sectional study was carried out by distributing a survey to 147 individuals.

The findings indicated that, on average, 80% of participants were aware of zoonoses, with the least recognised vector-borne zoonoses identified as the chikungunya virus and West Nile virus. Approximately 93% of the study population reported that they perceived temperatures in the warmer months have risen each year, with more than half of the participants noting an increase in the prevalence of vectors in the country during these months in recent years. Additionally, the results demonstrated that the majority of participants, about 93%, believed that veterinarians provided inadequate information regarding vector-borne zoonoses. The findings further revealed that the sampled population was unprepared for the realities increasingly faced in Europe and Portugal, with only 42% of participants reporting the use of preventive measures, such as repellents, against vectors. Consequently, there is a need for enhanced education and awareness campaigns, as well as a more proactive role from veterinarians in disseminating information and prevention strategies.

Keywords: climate, global warming, knowledge, One Health, perceptions, Portugal, zoonoses

INTRODUCTION

The concepts of global warming, climate change, and emerging pandemics are now widely recognised by people. The scientific community is expressing growing concern about global warming and its potential consequences in the coming years. Factors such as environmental changes resulting from human activity, increased international mobility, inadequate public health systems, and adaptations in pathogens are identified as significant contributors to the spread of zoonoses (Howard and Fletcher, 2012; do Vale et al., 2021).

According to recent data from the Portuguese Institute for the Sea and Atmosphere (IPMA), the average maximum temperature in Portugal during the summer months of June, July, and August 2022 was 3 to 5°C higher than the data collected between 1971 and 2000 (IPMA, 2022). These figures are not merely numbers; they represent a harsh reality experienced across Europe in the summer of 2022, particularly in Mediterranean countries like Portugal, Spain, and Italy. The rising temperatures have led to severe droughts, wildfires, and other environmental challenges.

The life cycle and distribution of vectors, and reproductive rates of parasites, fungi, bacteria and viruses within vectors and humans, are significantly influenced by climatic conditions (Semenza and Menne, 2009; WHO, 2014; Afonso et al., 2024). An increase in temperature correlates with a decrease in the incubation period of these pathogens, thereby heightening the risk of disease transmission due to the high population density of vectors (Semenza and Suk, 2018). Recent research indicated that vectors are colonising new regions of the planet, leading to increased incidences of newly-endemic diseases (Semenza and Suk, 2018; Ryan et al., 2019; Chala and Hamde, 2021; Carlson et al., 2023).

Examples of mosquito-borne zoonoses emerging in novel locations include malaria, Zika fever, West Nile fever, chikungunya, yellow fever, Japanese encephalitis, and Rift Valley fever (Chala and Hamde, 2021). Tick-borne diseases encompass babesiosis, anaplasmosis, Crimean-Congo haemorrhagic fever, Lyme disease, and other tick-related illnesses. Phlebotomine sandflies transmit pathogens such as leishmaniosis (El-Sayed and Kamel, 2020).

Although the emergence and re-emergence of vector-borne zoonoses influenced by climate change is pertinent to the scientific community, public awareness and understanding of this issue remain insufficient. The increasing prevalence of zoonotic diseases underscores the urgent need for effective public health education and awareness campaigns. Veterinarians, as vital professionals in animal health, play a crucial role in the care and treatment of animals, as well as in educating the public about the risks and preventive measures associated with zoonoses. Consequently, a survey was conducted in Portugal to assess knowledge and practices related to vector-borne zoonoses and global warming, providing an overview of the current state of knowledge and practices among Portuguese citizens. The study also aimed to investigate the role of veterinarians in raising awareness and educating the general population regarding zoonotic diseases. Specifically, it sought to understand how veterinarians contribute to disseminating knowledge, influencing public attitudes, and promoting behaviours that reduce the transmission of zoonoses.

MATERIALS AND METHODS

A cross-sectional voluntary study was conducted from February 2023 to March 2023 among a convenience sample of the Portuguese population. Individuals were eligible to participate if they met the following criteria: they were at least 18 years old, resided in Portugal, and could provide informed consent. Participants were invited via social networks such as Facebook® and Instagram®, using snowball sampling to complete an anonymous, confidential 15-minute self-administered written questionnaire on-site. The invitation posts on these platforms briefly explained the study and its purpose. The sample size of this study was determined using the survey sample size formula (Hajian-Tilaki, 2011). Assuming a 10% default prevalence, a 95% confidence level, and a 5% absolute error, a minimum of 138 participants was required for the study.

To accommodate a 5% non-response rate, the required sample size was increased to 147 participants. The questionnaire was developed based on a literature review (Chala and Hamde, 2021; do Vale et al., 2021; Semenza and Paz, 2021) and was designed by the authors, who are veterinarians and epidemiologists, to assess people's knowledge of global warming and zoonotic diseases. It comprised closed or short-answer questions that had been pre-tested to improve validity and reliability. Although the study aimed to include the general population, it also specifically targeted individuals who owned animals, as this was a key group for investigating the veterinarians' role in public health education. To ensure content validity and reliability, the questionnaire underwent pre-testing with 30 non-participant pet owners, during which the questions' clarity, relevance, and consistency were assessed. Feedback from pre-testing helped refine the wording of questions, eliminate ambiguity, and ensure the logical flow of the questionnaire. For instance, unclear or overly technical terms were simplified to enhance the comprehensibility of the questions. This process improved both the content validity and internal consistency of the questionnaire. Adjustments were made based on participant feedback to increase validity and to more accurately state the time needed to complete the survey (approximately 15 minutes). The questionnaire consisted of 32 questions regarding demographic characteristics, knowledge of vectors and zoonoses, perceptions about climate change and global warming in Portugal, and the role of veterinarians in providing information and preventive measures against vectors. A 5-point Likert scale was employed to analyse the level of concern regarding zoonoses (1 = extremely irrelevant; 2 = irrelevant; 3 = neutral; 4 = worrying; 5 = very concerning).

The study received ethical approval from the Ethics Commission of the University of Trás-os-Montes e Alto Douro (Doc11-CE-UTAD-2023). At the start of the survey, written informed consent was collected from each participant, and all data remained anonymous and confidential throughout the study. All data collected during the survey were anonymised and processed in accordance with the General Data Protection Regulation (GDPR) (Regulation (EU) 2016/679), and the "Lei n.º 58/2019, de 08 de agosto", which ensures the implementation of the GDPR in the national legal system.

Data were entered into an Excel® database (Microsoft Corp., Redmond, WA, USA) and subsequently exported and analysed using SPSS® 27.0 (SPSS, IBM Corporation, New York, NY, USA). For descriptive purposes, the Pearson χ^2 test was conducted for each variable in the study to assess socio-demographic differences. Statistical significance was established based on a p-value < 0.05.

RESULTS

Demographics

The study included 147 participants, 63.3% (*n* = 93) of whom were aged 18-29. Most of the participants were female. Regarding educational background, only 13.7% (*n* = 20) of individuals did not possess higher education. About 88.4% (*n* = 130) of the residents were from the country's North region (Table 1).

Table 1. Demographics of participants who responded to the survey (*n* = 147).

	Variable	n (%)
Age (years)	18-29	93 (63.3)
	30-50	19 (12.9)
	>50	35 (23.8)
Gender	Female	108 (73.5)
	Male	39 (26.5)
Region	North	130 (88.4)
	Centre	13 (8.8)
	South	4 (2.7)
Education	2nd cycle of Basic Education	1 (0.7)
	3rd cycle of Basic Education	2 (1.4)
	Secondary school	17 (11.6)
	Degree	82 (55.8)
	Master's degree	44 (29.9)
	Doctorate	1 (0.7)

When asked about their pets, 44% of the participants (*n* = 64) reported having one pet at home, while 20.4% (*n* = 30) reported having two pets, and 21.3% (n = 32) reported having three or more pets. On the other hand, 14.3% of the participants (*n* = 21) reported not owning any pets. Dogs were reported as the most popular pets, with 37.4% of the participants (*n* = 55) having them, followed by cats, owned by 27.2% (*n* = 40). In 21.1% (*n* = 31) of the cases, both dogs and cats were found to live together. Only 7.5% (*n* = 11) of the participants reported owning exotic pets, such as parrots, rodents, or reptiles.

General knowledge of vector-borne zoonoses

Most participants reported regularly vaccinating and deworming their pets, although only 8.2% had experienced a vector-borne disease in their animals, most frequently leishmaniosis. Regarding the frequency of ectoparasiticide use, the most common option was every three months (34.7%). A majority (81.6%) understood the concept of "vector", and 80.3% acknowledged that vectors can transmit viruses. Recognition of leishmaniosis as a vector-borne zoonosis was higher among younger participants (p =

0.007) and those from the North ($p = 0.046$) than in other comparable groups. Notably, 70.7% were unaware that West Nile virus is present in Portugal, with unawareness also associated with the same demographics ($p = 0.033$; $p = 0.046$) (Table 2).

Table 2. General knowledge of vector-borne zoonoses ($n = 147$)

Questions and answer options		**n (%)**
Do you know what a vector is?	Yes	120 (81.6)
	No	27 (18.4)
Can a vector transmit viruses?	Yes	118 (80.3)
	No	0 (0.0)
	I don't know	29 (19.7)
Is a mosquito a vector?	Yes	123 (83.7)
	No	0 (0.0)
	I don't know	24 (16.3)
Is leishmaniosis a vector-borne zoonosis?	Yes	96 (65.3) *;**
	No	4 (2.7)
		47 (32.0)
		p=0.007; p=0.046 **
Is West Nile virus present in Portugal?	Yes	20 (13.6)
	No	23 (15.6)
	I don't know	104 (70.7) *;**
		p = 0.046; p = 0.033**

***** $p < 0.05$ for participants aged 18 to 29 years; ****** $p < 0.05$ for participants from the northern region

Participants were asked to identify from a list of diseases those that were zoonotic and which ones were familiar to them, irrespective of the source of their knowledge (internet, radio, etc.). Multiple options could be selected. The most recognised diseases were Mediterranean spotted fever (95.2%), leishmaniosis (87.8%), dengue fever (77.6%), and malaria (76.9%). Conversely, the least recognised diseases were chikungunya, filariasis, and West Nile fever, as illustrated in Figure 1.

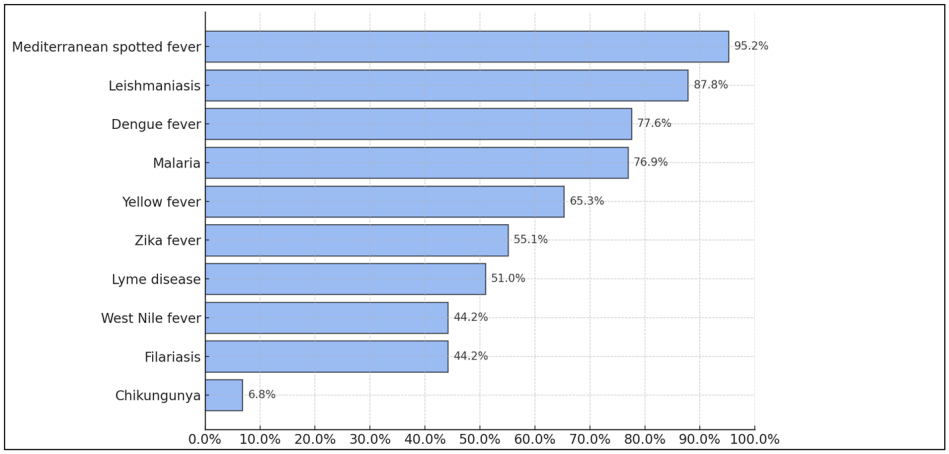

Figure 1. Identification of potentially zoonotic diseases by the participants (n = 147).

Promotion of knowledge in the field of zoonoses by veterinarians

Most pet owners (62.6%) reported receiving information from their veterinarian about vector-borne zoonoses, with younger participants (18-29 years) more likely to have been informed (p = 0.043) than other age groups. Despite this, 93.2% felt that veterinarians should provide more information. Regarding satisfaction with the information provided, half of the participants rated it as level 3 (Table 3).

Table 3. Promotion of knowledge in the field of zoonoses by veterinarians.

Questions and answer options		n (%)
Has your pet's veterinarian enlightened you about vector-borne zoonoses (e.g. transmitted by ticks, fleas, etc.)?	Yes	92 (62.6)
	No/ I do not know/ I do not remember/ I am not sure/ Not applicable	55 (37.4)
Has the veterinarian informed you about existing preventive measures or treatments that combat vector-borne zoonoses?	Yes	89 (60.5) *
	No/ I do not know/ I do not remember/ I am not sure/ Not applicable	58 (39.5)
		*p=0.043**
Do you think that veterinarians should provide more information about the transmission of zoonoses by vectors?	Yes	137 (93.2)
	No	10 (6.8)

* $p < 0.05$ for participants aged 18–29 years

Level of concern about vector-borne zoonoses

Participants were asked to rate their concern about several vector-borne zoonoses (Table 4). The diseases considered most concerning were leishmaniosis (40.1% selected level 5), Mediterranean spotted fever (42.2%), malaria (46.9%), and dengue fever (42.2%). In contrast, a large proportion of participants were unfamiliar with chikungunya (54.4%), filariasis (30.6%), and West Nile fever (33.3%). A significant association was found between younger participants (18-29 years) and higher levels of concern about Lyme disease ($p = 0.014$) and vector-borne zoonoses in general ($p = 0.028$).

Table 4. Level of concern about vector-borne zoonoses.

Level of concern	1 – Extremely Irrelevant (n; %)	2 – Irrelevant (n; %)	3 – Neutral (n; %)	4 – Worrying (n; %)	5 – Very Concerning (n; %)	Don't know / Never heard of (n; %)
Leishmaniosis	5 (3.4)	5 (3.4)	19 (12.9)	53 (36.1)	59 (40.1)	6 (4.1)
West Nile fever	8 (5.4)	8 (5.4)	31 (21.1)	25 (17.0)	26 (17.7)	49 (33.3)
Lyme disease *	9 (6.1)	6 (4.1)	23 (15.6)	36 (24.5)	34 (23.1)	39 (26.5)
[a]Malaria	10 (6.8)	2 (1.4)	21 (14.3)	40 (27.2)	69 (46.9)	5 (3.4)
Filariasis	6 (4.1)	7 (4.8)	22 (15.0)	39 (26.5)	28 (19.0)	45 (30.6)
[a]Yellow fever	7 (4.8)	3 (2.0)	29 (19.7)	39 (26.5)	51 (34.7)	18 (12.2)
Dengue fever	9 (6.1)	3 (2.0)	29 (19.7)	33 (22.4)	62 (42.2)	11 (7.5)
[a]Zika fever	8 (5.4)	7 (4.8)	27 (18.4)	35 (23.8)	46 (31.3)	24 (16.3)
Chikungunya	9 (6.1)	6 (4.1)	26 (17.7)	17 (11.6)	9 (6.1)	80 (54.4)
Mediterranean spotted fever	5 (3.4)	3 (2.0)	17 (11.6)	55 (37.4)	62 (42.2)	5 (3.4)

***$p = 0.014$** – Significant association with participants aged 18-29 years selecting Level 4 or 5 (worrying/very concerning) for Lyme disease; **[a]** Disease that is zoonotic in other continents, but is not considered zoonotic in Europe due to the absence of the animal species involved in transmission.

Global warming in Portugal

As shown in Table 5, regarding the impact of climate change, 92.5% of participants perceived that temperatures have been rising during the warmer months, and 57.8% noticed an increase in vector prevalence. Although 42.2% reported using preventive measures for their pets (e.g., repellents, deworming), the majority believed that more should be done. Most participants (96.6%) acknowledged the potential emergence of zoonotic diseases in Portugal in the next decade, with 80.3% recognising the link between rising temperatures and vector-borne disease incidence. Younger participants

(18-29 years) showed greater awareness of this relationship ($p = 0.018$) than older participants. Notably, 83.7% felt the media was not adequately addressing the issue.

Table 5. Participants' views on global warming in Portugal.

Questions and answer options		n (%)
Do you take any preventive measures against vectors for your pet during the warmer months of the year?	Yes	62 (42.2)
	No	50 (34.0)
	I don't know	35 (23.8)
In recent years, have you noticed significant changes in Portugal regarding the prevalence of vectors (e.g. ticks, fleas, etc.) in the warmer months?	Yes	85 (57.8)
	No	62 (42.2)
Despite global warming being widely covered in the media, do you personally feel that the temperatures in the warmer months are getting higher and higher every year?	Yes	136 (92.5)
	No	11 (7.5)
Many vector-borne zoonoses can arise due to rising environmental temperatures. Do you think that Portugal is already or could be affected by this problem in the next 10 years?	Yes	142 (96.6)
	No	5 (3.4)
Did you know that the rise in the planet's temperature will lead to an increase in the frequency of vector-borne zoonoses?	Yes	118 (80.3)
	No	29 (19.7)
Do you think that this issue of the emergence of vector-borne zoonoses is addressed by the media in Portugal?	Yes	24 (16.3)
	No	123 (83.7)

DISCUSSION

Climate change is recognised as having a significant impact on the spread and transmission of vector-borne diseases in Europe. The warming of the Earth, caused by human-induced greenhouse gas emissions, is already affecting the dynamics of these diseases and is expected to exacerbate their effects in the future. Mosquitoes and ticks are vectors that are known to thrive in warmer climates, which leads to an increase in disease transmission (Semenza and Suk, 2018; Rocklöv and Dubrow, 2020; Rupasinghe et al., 2022). Recent research has emphasised the importance of integrating climate data with epidemiological information to develop early warning systems for vector-borne diseases. Collaborative efforts by experts across various disciplines, including educators, ecologists, virologists, and entomologists, are deemed essential for effective prevention and control strategies (Semenza and Suk, 2018; Rupasinghe et al., 2022). The impacts of climate change on vector-borne diseases in Europe are

projected to result in the expansion of disease transmission areas towards the north. According to models, regions in southern Europe, for instance, could face higher risks of dengue fever due to the invasion of disease-carrying vectors such as *Aedes aegypti*. These projections highlight the necessity of taking urgent action to confront climate change through adopting mitigation strategies and adapting public health measures. This should include enhancing public health education and health literacy to combat the growing threat of vector-borne zoonoses (Paz, 2020; Adepoju et al., 2023).

Literacy regarding vector-borne zoonoses remains limited in various contexts, as evidenced by recent studies. Spence et al. (2022) demonstrated that public perception of zoonotic disease risk differs significantly among individuals, influenced by disease-specific characteristics and individual knowledge levels. This finding supports our own results, which revealed a general lack of awareness among participants concerning diseases such as West Nile virus. Furthermore, Rupasinghe et al. (2022) highlighted that climate change has a direct impact on zoonotic disease epidemiology, influencing the dynamics of hosts, vectors, and pathogens. This link between climate change and the increasing prevalence of vector-borne diseases was acknowledged by 80.3% of our participants, indicating growing public awareness of this emerging issue. In the context of veterinary practice, Kinnunen et al. (2022) identified that, although veterinarians are frequently exposed to zoonotic pathogens, there remains an ongoing need to improve education and protective practices within the profession. This is particularly relevant to our findings, as 93.2% of participants expressed the desire to receive more information from their veterinarians regarding vector-borne zoonoses. Finally, Ulrich et al. (2023) emphasised the importance of a One Health approach in understanding and controlling viral zoonoses, underlining the need for collaboration between human, animal, and environmental health sectors. This holistic perspective is crucial for addressing the challenges posed by emerging and re-emerging zoonotic diseases. Collectively, these studies reinforce the need for more effective communication strategies and targeted educational programmes to improve public health literacy, especially concerning vector-borne zoonoses.

In this study, it was found that most participants were already familiar with the primary concepts of global warming and zoonoses and were taking preventive measures to deworm and/or vaccinate their pets, with roughly 80% of participants doing so. However, only 42% of them reported taking measures against vectors during the hottest months of the year. Most participants felt that temperatures in the warmer months were increasing each year. Different scenarios for Europe predict that temperatures will continue to rise, and that the duration, frequency, and intensity of heatwaves will be exacerbated (Martinez et al., 2019). Furthermore, temperature differences are expected to increase in northwestern Europe and Scandinavia during winter, and in southwestern and southeastern Europe during summer, according to the European Environment Agency (EEA, 2017). In Europe, less rainfall is anticipated during the summer season, and the temperature rise is expected to result in more frequent and severe droughts, exacerbating water scarcity. Additionally, heavy rains and floods,

similar to those that occurred in Western Europe in July 2021, are expected to happen more frequently (EEA, 2020).

The sampled population was aware of the impact of climate change. Most participants believe that temperatures in the warmer months are increasing each year. Approximately 80% of those surveyed acknowledged that Portugal is either already affected by or could be impacted by the emergence or re-emergence of vector-borne zoonoses. However, despite this awareness, there is a lack of sufficient information among the Portuguese population regarding the risks and vulnerabilities that may arise in the future.

Most participants (approximately 84%) felt that the media in Portugal do not cover the subject of vector-borne zoonoses, and satisfaction with the information provided by veterinarians on zoonoses was regarded as only reasonable, scoring a 3 on a scale of 1 to 5, according to 33% of participants.

Regarding the various diseases that can be transmitted through vectors and affect Europe and Portugal, the three diseases most commonly recognised by our participants were Mediterranean spotted fever, leishmaniosis, and malaria. Additionally, a high proportion of participants expressed concern about the spread of leishmaniosis, which has been observed to advance across Portugal and could even become endemic in regions outside the Mediterranean basin, such as Central and Eastern Europe, according to some studies (Maia et al., 2016; Chalghaf et al., 2018; Afonso et al., 2023; Mateus et al., 2023). However, a recent survey conducted in northern Portugal regarding awareness of leishmaniosis revealed that although 62.5% of participants had heard of the disease, 56.0% were unaware of its zoonotic potential (Mateus et al., 2023).

It is important to note that Mediterranean spotted fever is widely recognised by the general population due to people's exposure to ticks during the warmer months. Most cases of infection occur during the summer season when the prevalence of ticks is higher (MacConnachie and Tishkowski, 2023; Afonso et al., 2024a). Consequently, as exposure to ticks increases owing to the expansion of rodent and deer populations and climate change, the number of people and animals exposed to tick-associated rickettsioses will also rise (Karim et al., 2021).

Many individuals were deeply concerned about malaria, as the number of cases is expected to rise due to global warming. Although malaria was once present in Europe, the World Health Organization (WHO) successfully launched a malaria eradication programme in the 20th century, resulting in eradication in 79 countries worldwide (El-Sayed and Kamel, 2020). The disease was officially eradicated from Europe in 1975 through measures such as the installation of drainage systems for standing water, chemical treatment of patients, and improved sewage systems (Talapko et al., 2019). These measures allowed for better control of the vectors responsible for malaria transmission, namely mosquitoes from the *Anopheles* genus. However, there remains a risk of the disease re-emerging in Europe as resistance to antiplasmodic

drugs and insecticides has increased (Gunda et al., 2017; Ssempiira et al., 2018). It is concerning that the diseases chikungunya, filariasis, and West Nile fever are not well-known among the Portuguese population. In the present study, 54%, 30%, and 33% of participants had never heard of these diseases, respectively. This lack of awareness is particularly worrying given that West Nile virus has recently emerged in the country (WHO, 2015). Only 14% of participants were aware of this situation, indicating a need for increased education and awareness about these zoonotic diseases in Portugal. It was projected that by 2025, due to climate change, the number of areas in Europe at risk of West Nile fever is expected to rise. Depending on the level of CO_2 emissions, significant outbreaks of the virus could be experienced in Western Europe later this century. The emergence of this disease in new regions, such as Portugal, has direct and indirect implications for public health. For example, West Nile virus can also be transmitted through blood transfusions, and the high proportion of asymptomatic infected individuals raises concerns about the safety of blood banks. Although cases of infection were reported in horses, no human infections were recorded in Portugal in 2022, unlike other Mediterranean countries affected by West Nile virus. In 2022, West Nile virus caused 104 human deaths across Europe (ECDC, 2023).

The low percentage of people with knowledge about chikungunya is considered a cause for concern, as models predict that the transmission of this disease could moderately adapt to the climate of European countries (Semenza and Paz, 2021). This virus spreads through mosquitoes belonging to the genus *Aedes*, and the advance of the Asian tiger mosquito, *Aedes albopictus*, into Europe over the past decade has been associated with an increased risk of chikungunya outbreaks in southern European countries, including Portugal (Tilston et al., 2009). Since 2004, outbreaks of chikungunya have become more frequent and widespread due to the virus's adaptations, which facilitate its spread with the help of its vectors (WHO, 2022). The same applies to diseases caused by Dengue and Zika viruses, which are also transmitted by these same vectors. Therefore, an increase in these viruses' climate adaptability is projected in southern Europe and the Mediterranean basin in the coming decades (Semenza and Paz, 2021). Worldwide, *Ae. aegypti* has been established in 61 countries, but no documentation of autochthonous transmission of Zika virus has been identified. Conversely, populations of *Ae. albopictus* exist in some countries and are deemed capable of transmitting the virus, albeit on a smaller scale than *Ae. aegypti*. Thus, *Ae. albopictus* is considered less likely to cause large-scale Zika fever outbreaks (Tham et al., 2018). Regarding Dengue fever, approximately half of the world's population is considered at risk of contracting the disease. It is estimated that around 100-400 million cases of infection occur annually (Brady et al., 2012; WHO, 2023). Dengue fever is recognised as an endemic disease in more than 100 countries, with the Asian continent being the most affected, accounting for 70% of the world's cases (WHO, 2023). Although malaria, Zika fever, and yellow fever are included in this study as zoonotic diseases, it is important to clarify that in Europe (including Portugal), these diseases are not currently considered zoonotic due to the absence of animal species involved in their transmission in this region.

However, they are zoonotic in other continents, where animal reservoirs play a role in their transmission cycles. Their inclusion in the discussion reflects their potential relevance in a broader context of zoonoses and vector-borne diseases globally. This is further emphasised to provide a comprehensive perspective on diseases that could pose risks under changing ecological or epidemiological conditions.

While the data collected is deemed valuable for this study, it should be noted that most participants believe that more information about vector-borne zoonoses should be provided by veterinarians. Moreover, only a relatively high level of satisfaction was expressed regarding the information provided by their veterinarians. The finding that 62.6% of pet owners reported being informed by their veterinarians about vector-borne zoonoses highlights the critical role veterinarians play as trusted sources of information on these issues. This suggests that veterinarians are well-positioned to contribute to public health education, particularly concerning zoonotic disease prevention and treatment (do Vale et al., 2021). Nonetheless, the study also revealed that while many participants felt informed, the majority expressed a desire for even more information on vector-borne disease transmission. This indicates an opportunity to expand veterinarians' educational role through targeted communication strategies or information campaigns addressing prevention measures and available treatments. The association between participant age and the likelihood of receiving information from veterinarians, with younger pet owners (aged 18-29) being more likely to report such discussions, suggests that tailored communication approaches might be required to ensure information reaches all demographic groups effectively. When asked about their satisfaction level with the information provided, the majority (31%) rated it as 3 on a scale of 1-5, while 93% of the participants thought that more information about zoonoses should be made available by veterinarians.

Therefore, it is suggested that a stronger stance be taken by veterinarians to impart information on preventive measures, such as the use of mosquito nets, repellents, and anti-parasitic drugs, during consultations with pet owners. Leveraging veterinarians' influence through structured training programs or partnerships with public health authorities could enhance their capacity to disseminate critical information, ultimately contributing to improved awareness and proactive measures among pet owners to address vector-borne zoonoses. A One Health approach should be adopted, where veterinarians conduct awareness-raising campaigns about these diseases and ways to combat them through information leaflets and vaccination drives, among other initiatives. This is expected to help reduce health illiteracy among the Portuguese population.

The conducted survey may not have accurately represented the animal-owning population, as it was based on a convenience sample that primarily reflected the opinions and knowledge of individuals from the North region (approximately 88% of participants were from this region). Therefore, further studies are recommended across other regions in the country to understand geographical and cultural differences. Additionally, a higher response rate was observed from females (around 73.5%)

and those with a high level of education (only 13.7% of participants lacked higher education) than among other groups, which does not provide an accurate sample of the Portuguese population. The gender imbalance observed in the study, with a higher proportion of female than male participants, could have influenced the findings, as women could have different levels of concern, awareness, or engagement with environmental and health-related issues compared to men (Li et al., 2022). This could have potentially skewed the results and limits the generalisability of the findings to the broader Portuguese population.

The strengths of this study lie in its timely and relevant focus on the intersection of climate change, public health, and vector-borne zoonoses. By surveying pet owners' perceptions, knowledge, and practices in Portugal, the study provides valuable insights into climate-related health risk awareness among the general population. The inclusion of questions specifically addressing veterinarians' role in educating pet owners about vector-borne diseases highlights an often-overlooked aspect of public health communication. The study also offers a unique perspective on the gaps in public knowledge and the opportunities for intervention, particularly through a One Health approach that connects human, animal, and environmental health. These strengths significantly enhance the study's contribution to understanding how climate change could impact public health awareness and response to vector-borne diseases in Portugal.

This study was designed using a cross-sectional approach, which means that the conclusions that can be drawn are limited to associations, and causality cannot be clearly determined. Biased results could have been introduced due to self-reported preventive behaviours, which could not be verified. Moreover, only climate factors responsible for the spread of these vectors were considered, and it was not possible to address all the existing vector-borne zoonoses. Additionally, the predominance of younger participants (aged 18–29) could have influenced some findings, and results should be interpreted with this in mind.

CONCLUSION

In recent decades, there has been a rise in epidemic outbreaks of vector-borne zoonoses, driven by socio-economic and environmental factors as well as climate change. This reality will increasingly manifest in the daily lives of the Portuguese. Although there is growing awareness among Portuguese citizens about the risks associated with climate change and vector-borne diseases, this study revealed substantial knowledge gaps and insufficient communication, especially regarding emerging zoonoses, such as West Nile virus and chikungunya virus. These findings are consistent with international studies, confirming that limited public understanding of vector-borne zoonoses is not unique to Portugal, but is a broader public health challenge. To address this, veterinarians must be empowered to assume a more proactive role in public education, supported by coordinated strategies involving health authorities and media platforms.

In this regard, the One Health approach should be prioritised, with initiatives, such as vaccination campaigns and the distribution of information leaflets, to enhance health literacy and improve communication between veterinarians and pet owners.

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Authors' contributions

Conceptualisation, D.P.; methodology, D.P., L.C. and A.C.C.; validation, D.P., L.C. and A.C.C.; investigation, DP., L.C. and A.C.C.; writing—original draft preparation, D.P., A.P.L., T.L.M. L.C. and A.C.C.; writing—review and editing, D.P., A.P.L., F.L., T.L.M., P.A., L.C. and A.C.C. All authors read and approved the final manuscript.

Competing interests

The authors declare that they have no known competing interests or personal relationships that could have appeared to influence the work reported in this paper.

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KLIMATSKE PROMENE I VEKTORIMA PRENOSIVE ZOONOZE: UVIDI IZ STUDIJE PRESEKA O PERCEPCIJAMA, ZNANJU I PRAKSAMA U PORTUGALU

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Kratak sadržaj

Klimatske promene smatraju se ključnim problemom za javno zdravlje. Svake godine njihov uticaj na zdravlje ljudi i životinja postaje sve očigledniji, jer ekstremni vremenski uslovi i širenje vektora na nova područja dodatno povećavaju rizik od prenosa zoonoza. Ove promene izazivaju dalekosežne posledice, utičući na ljudsko zdravlje, životnu sredinu i globalnu ekonomiju. Stoga se smatra da je kolektivno delovanje od suštinskog značaja za ublažavanje efekata klimatskih promena i očuvanje javnog zdravlja za buduće generacije. Ova studija ispituje percepcije, znanja i prakse građana Portugala u vezi sa vektorima prenosivim zoonozama i njihovom povezanošću sa klimatskim promenama.

Sprovedena je deskriptivna studija preseka putem ankete koja je distribuirana među 147 ispitanika.

Rezultati su pokazali da je u proseku 80% učesnika bilo upoznato sa zoonozama, pri čemu su najmanje prepoznate zoonoze koje prenose vektori bile virus čikungunja i virus Zapadnog Nila. Oko 93% ispitanika izjavilo je da primećuje porast temperatura tokom toplijih meseci svake godine, dok je više od polovine učesnika navelo da je poslednjih godina zabeležen porast učestalosti vektora u zemlji tokom ovih meseci. Pored toga, rezultati su pokazali da većina ispitanika, oko 93%, smatra da veterinari pružaju nedovoljno informacija o zoonozama koje prenose vektori. Nalazi su dalje ot-

krili da ispitana populacija nije spremna za realnosti sa kojima se Evropa i Portugal sve češće suočavaju, budući da je samo 42% učesnika navelo da koristi preventivne mere protiv vektora, kao što su repelenti. Shodno tome, postoji potreba za unapređenjem obrazovnih i informativnih kampanja, kao i za proaktivnijom ulogom veterinara u širenju informacija i strategija prevencije.

Ključne reči: klimatske promene, globalno zagrevanje, znanje, Jedno zdravlje, percepcije, Portugal, zoonoze