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Knowledge, attitudes, and practices of Native Americans in northern California regarding ticks and tick-borne diseases

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ABSTRACT

Reports of tick-borne diseases (TBDs) are increasing worldwide, particularly in North America where a diversity of endemic and exotic tick species and pathogens occur. Native American populations have unique outdoor cultural and occupational practices that may impact their exposure to ticks, yet this risk remains understudied in the context of TBD. To address this gap, we examined knowledge, attitudes, and practices regarding ticks and TBDs among Native American communities in Humboldt County, California. We conducted semi-structured interviews with participants, who represented various tribes, at a cultural gathering. Cultural practices intertwined closely with outdoor activities (e.g., ceremonies, dances), potentially influencing local tick exposure patterns. Most research participants had been bitten by ticks and reported tick exposure by children and pets. Research participants demonstrated low knowledge about ticks and TBDs, as well as low levels of risk perceptions pertaining to TBDs. Research participants most commonly conducted tick checks after outdoor activity, wore long-sleeved clothing outdoors, and used homeopathic remedies or essential oils to prevent exposure to ticks and TBDs. Culturally appropriate outreach and education initiatives are needed to address TBD risk among Native American communities. Our study lays the groundwork for future research on the intersection of cultural practices and tick exposure, with implications for public health interventions that are tailored to the needs of indigenous populations.

1. Introduction

Tick-borne diseases (TBD) are on the rise in North America, threatening the health of humans and animals [1–3]. Indeed, tick-borne bacterial and protozoan diseases now account for approximately 75 % of all reported vector-borne diseases in the United States [4]. Native Americans experience disproportionate burdens of chronic and infectious diseases [5], yet the risk of TBD for Native American populations remains understudied. The most poignant example of heightened TBD risk for Native Americans was the outbreak of Rocky Mountain spotted fever (RMSF) in the early 2000s. Three Native American reservations in the southwestern United States were affected in an area where, historically, the disease was seldom reported [6,7]. RMSF is a tick-borne infection caused by the bacterium *Rickettsia rickettsii* and can be fatal if left untreated [8–10]. From 2003 to 2011, 219 cases of RMSF were reported, of which 16 were fatal [11]. Children aged 10 and under comprised 53 % of total cases and 47 % of fatal cases [11]. At the time, the national average incidence for RMSF was 0.9 per 100,000 people, but the region experiencing the outbreak had an incidence of 136 cases per 100,000 people [11]. Case investigations revealed that proximity to tick-infested dogs was positively associated with RMSF reports [6]. Further investigations implicated the common brown dog tick (*Rhipicephalus sanguineous*) in the transmission of *R. rickettsii*, a previously unrecognized vector for RMSF [6].

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While the RMSF outbreak in the Southwest was notable for its severity and hyperendemicity, high incidence rates and case fatalities of RMSF in Native Americans have been observed in other parts of the United States [12]. Patient records from the Indian Health Service revealed that the Great Plains region, encompassing Oklahoma, Kansas, and northern Texas, had the highest average annual incidence of RMSF among Native Americans at 277.2 cases per 1,000,000 between 2000 and 2008 [13]. Native Americans were hospitalized for RMSF at a rate of 48.2, compared to 16.9 for the general Oklahoma population [13]. However, significant epidemiological differences exist between RMSF cases in the Great Plains and the Southwest. In the Southwest, RMSF was associated with the brown dog tick (*R. sanguineus*), while in the eastern United States, the American dog tick (*Dermacentor variabilis)* was the primary vector [6]. Age group patterns were also different, with pediatric cases being most common in Arizona, while the incidence rate in Oklahoma was highest among people aged 50–59 years [12]. Such differences demonstrate that a one-size-fits-all approach to surveillance, awareness, and prevention may be inadequate for mitigating the risk of TBDs to Native American populations.

The factors contributing to such disproportionately high rates of TBDs among Native Americans remain poorly understood. Discrepant reporting mechanisms among health agencies and medical institutions further complicate any understanding of TBDs in Native American populations [8,13]. It is likely that Native American people's engagement in outdoor cultural, recreational, and occupational practices increases their exposure to ticks and pathogens transmitted by ticks [12]. Outdoor practices such as hunting, fishing, ceremonial dances, and gatherings are integral to Native American cultures. However, although differences in recreational, social and community activities may offer a partial explanation for the high prevalence of TBDs in Native American populations, further research is needed to better understand these disparities [12].

Another critical research gap exists in understanding how Native American communities respond to ticks and TBDs [14,15]. Accordingly, we designed an exploratory study to investigate Native Americans' awareness of TBDs, their exposure to ticks and TBDs, and their attitudes and practices pertaining to ticks and TBDs. Aligned with a One Health framework, we conducted semi-structured interviews with Native Americans in Humboldt County, California.

California is endemic to many tick species and pathogens of human and veterinary concern such as *Borrelia burgdorferi* and *Anaplasma phagocytophilum,* the causative agents of Lyme disease and anaplasmosis, respectively [16]. Reported TBD rates in California have increased, and new pathogens have been identified in recent decades [3,16]. For example, median annual cases of anaplasmosis increased from one in 2013 to eight in 2022 [16]. Pacific Coast tick fever, caused by *Rickettsia philipii* and transmitted by ticks (*Dermacentor occidentalis)*, has exclusively been reported in California [17]. We conducted our study in Humboldt County because it is home to several Native American Tribes, including the Wiyot, Yurok, and Hoopa Tribes, and the Bear River, Blue Lake, Trinidad, and Resighini Rancherias. Humboldt County has robust timber and agricultural industries and features a diverse array of ecotones that support ticks, including redwood forests, oak woodland, grasslands, coastal prairies, and coastal marshes [18]. Humboldt County has one of the highest rates of Lyme disease in the state [17], and the risk of exposure to *B. burgdorferi* is four times higher than in other northern California counties [19]. The prevalence of *Anaplasma* spp. and *B. burgdorferi* antibodies in dogs is higher in northern California compared with the rest of the state [20,21]. Finally, the prevalence of *Rickettsia* spp. antibodies in dogs in the western United States can be quite high with prevalences as high as 42 % and 66 % being reported in California and onArizona reservations, respectively [22,23]. Similarly, Allen's chipmunks (*Neotamias senex*) on the Hoopa Valley Tribe reservation, northeastern Humboldt County, have high seroprevalence for *B. burgdorferi* [24], while the prevalence of *A. phagocytophilum* in dusky-footed woodrats (*Neotoma fuscipes*) and squirrels (*Sciurus griseus* and *Tamiasciurus duglasii*) has been reported to be as high as 40.5 % [25].

Unfortunately, the highly variable patterns of tick-borne pathogen prevalence observed in vertebrate hosts and vectors in Humboldt County is difficult to predict with precision, signaling the need for strong preventative efforts. To help inform the design of preventative measures, we conducted interviews with Native Americans to investigate 1) their knowledge of ticks and habitat in which ticks are likely to be encountered, 2) understanding of the appropriate actions to prevent human exposure to ticks and TBDs, 3) attitudes towards ticks and TBDs, 4) level of engagement in activities that may result in exposure to ticks, 5) efforts to prevent children and domesticated dogs being exposed to TBDs, and 6) sources of information pertaining to TBDs. Our study is intended to provide insights into how Native Americans view and respond to TBDs. Qualitative approaches such as the one used here are important for tailoring public health messaging and gaining insights that inform ecological studies [14,15].

2. Methods

2.1. Questionnaire design

Research participants were asked a series of open-ended questions about their cultural practices and how much time they spend outdoors to assess their potential exposure to ticks and TBD. To measure participants' knowledge about ticks, we asked them if/when they had observed ticks in the environment, whether free-ranging or on a host. Participants were asked their opinions on which factors influence tick presence in the areas where they have observed ticks. Participants were also asked about the time of year they observed ticks, whether they had been bitten by ticks, how they remove ticks from themselves, family members, and pets, and what measures they take to prevent exposure to ticks. We showed participants an educational handout from the California Department of Public Health with pictures of adult males and females for common tick species in California (*Dermacentor variabilis* [now renamed *Dermacentor similis*], *Dermacentor occidentalis, Ixodes pacificus*, and *Rhipicephalus sanguineus*), and asked if they could identify the species of ticks they encountered. Finally, we asked participants about their awareness and concern about TBDs, what actions they take to avoid TBDs, and how they receive information about TBDs.

2.2. Recruitment of research participants

Participants were recruited at the annual Big Time & Social Gathering, Humboldt County, California in April 2023. This event is a culturally focused gathering of Native American people from northern California that includes dances and vendors. We set up a booth with educational materials about ticks and TBDs. Every adult (aged $\geq$18 years) who visited the booth was asked to participate in a semi-structured interview about their knowledge, attitudes and practices regarding ticks and TBD (see Supplementary Material). Participants elected to either participate in an audio-recorded interview or to provide written responses to questions. Interviews lasted five to 10 min. Participants were compensated with their choice of a $5 gift card, or small gifts purchased from local vendors (e.g., jam, earrings, stickers, which were all valued at $\leq$$5).

2.3. Data analysis

We transcribed the interview recordings verbatim and analyzed both the transcripts and the written responses using Dedoose, a qualitative analysis software [26]. Data were analyzed inductively based on participants' answers to the questionnaire. Following the systematic thematic analysis approach described by Vaismoradi et al. [27], we examined each transcript to identify patterns and overarching themes within the data.

2.4. Ethical review

We recognized the importance of cultural sensitivity, safety, and Tribal sovereignty when researching communities historically subjected to unethical research practices by investigators and institutions [28–30]. Unethical research practices have caused harm and led to mistrust within Native American communities [28–30]. Upholding best practices for respectful research with Native Americans mandates the establishment of formal agreements and processes, such as Institutional Review Board (IRB) oversight by Tribal jurisdictions, to safeguard the cultural safety and well-being of Indigenous peoples [30]. Accordingly, our research protocol was reviewed and approved by the University of Georgia IRB (PROJECT00006040) and the research committee at United Indian Health Services (UIHS), an Indian health organization forged through partnerships with several northern California Tribes. The approval granted by the UIHS research committee signified their endorsement of our research endeavor. Participants' anonymity and confidentiality were prioritized throughout the study. Verbal informed consent was obtained from each participant after the investigator read aloud a passage outlining the purpose of the research and explaining that participation was voluntary. All digital files were protected by encryption and all data was securely stored on password protected computers or in a locked file cabinet to ensure that data could only be accessed by authorized personnel involved in data analysis. Finally, we established a collaborative platform to conduct the current study and facilitate future investigations stemming from this research initiative through a Memorandum of Understanding (MOU) with the University of Georgia.

3. Results

In total, we completed 18 semi-structured interviews with Native Americans (eight audio interviews and 10 written interviews). Most participants ($n = 14$) were from Humboldt County, California (Table 1). Most participants were employed (n = 14), largely in indoor jobs (e.g., social worker, cashier, librarian, other administrative work). Half of the participants had caretaking responsibilities for elders in their families ($n = 3$) or children ($n = 6$).

3.1. Engagement in outdoor leisure and cultural practices

All participants engaged in cultural practices in the past year, including traditional dance ceremonies (Brush dance, Flower dance), stick games, sweat ceremonies, regalia making (e.g., beading, basketry), toolmaking, fishing, hunting, gathering (e.g., bear grass, acorns), and language classes. Two participants stated that the COVID-19 pandemic interrupted their cultural practices in the past two years. Six participants last participated in a cultural event during the previous summer because that is when most dance ceremonies take place. Eight participants stated most of their leisure time is spent with family either indoors or outdoors (walking, hiking, gardening, swimming, walking dogs, fishing, and hunting). Only one participant explicitly said they did not spend much time outdoors (Fig. 1). Four participants said they were unsure how much time they spent outdoors each day or that time spent outdoors was dependent on the weather and/or season. The remaining 13 participants spent between 2 and 7 h outdoors each day.

3.2. Knowledge, attitudes, and practices (KAP) pertaining to ticks

Participants possessed some knowledge about tick habitats, identifying environments such as riparian areas, forests, brush near the ocean, mountainous regions, and large fields. They linked tick presence to vegetation like madrone trees (*Arbutus menziesii*), hazelnut bushes (*Corylus cornuta*), tall grass, and lush green areas. Specific locations mentioned included Pecwan, Petrolia, the mouth of the Klamath River, Loleta, Hoopa, Centerville Beach, Humboldt Bay, and Lake County.

Table 1
Demographic characteristics and caretaking responsibilities for participants ($n = 18$) in a study of Native Americans' knowledge, attitudes and practices (KAP) pertaining to ticks and tick-borne diseases (TBD) in Humboldt County, California in April 2023.

	Number	Percent
Tribal affiliation[a]		
Yurok	6	33.3
Hoopa	4	22.2
Wiyot	2	11.1
Pomo	2	11.1
Karuk	1	5.6
Tolowa	1	5.6
Walla Walla	1	5.6
Declined to state	2	11.1
Residence		
Humboldt County		
Eureka	9	50.0
Arcata	1	5.6
Hoopa	1	5.6
Loleta	2	11.1
Trinidad	1	5.6
Del Norte County		
Crescent City	1	5.6
Lake County	1	5.6
Mendocino County		
Willits	1	5.6
Klamath, Oregon	1	5.6
Employment status		
Employed	14	77.8
Unemployed	1	5.6
Stay at home parent	1	5.6
Student	1	5.6
Disabled	1	5.6
Caretaking responsibilities		
Care for children	6	33.3
Care for elders	3	16.7
None	9	50.0

[a] Participants could belong to more than one tribe.

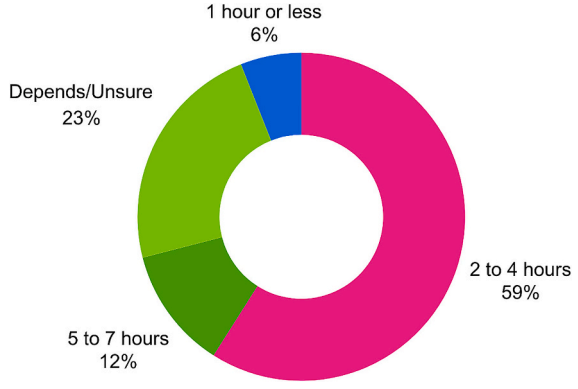

Fig. 1. Hours spent outside per day.
Distribution of participant responses to the question, "How many hours per day do you spend outside?" ($n = 18$), April 2023.

Some participants ($n = 6$) noted seasons (e.g., summer) or months (e.g., August to April) when ticks were prevalent, while others were unsure, simply stating "lots of places" or "outside."

Tick exposure was a common theme, with 15 participants reporting at least one tick attachment in their lives (Table 2), although respondents couldn't recall how many ticks had been attached to them. Participants recognized ticks but lacked knowledge of tick species. Two participants stated that they had been exposed to *Dermacentor while* one participant pointed to the *Dermacentor* ticks and said, "it kind of looked like that". One participant identified *I. pacificus,* while another said they had been exposed to "western blacklegged and dog ticks" (*I. pacificus*

Table 2
Participants' exposure to ticks, preventative actions and tick removal practices for themselves and their pets.

	Number	Percent
Human exposure to ticks		
Participant had been bitten by a tick at least once in their lifetime	15	83.3
Preventative measures for tick exposure in humans:		
Tick checks after outdoor activity	5	27.8
Wearing long-sleeved clothing	4	22.2
Homeopathic remedies or essential oils	5	27.8
Avoiding areas known for ticks	1	5.6
Using products that contain DEET	2	11.1
Methods to remove ticks from humans:		
Bare hands	6	33.3
Vaseline to smother ticks	1	5.6
Cold pack to cause tick to de-attach	1	5.6
Tweezers or other tool designed for tick removal	2	11.1
Did not specify	5	27.8
Post removal actions for humans:		
Sought medical attention	1	5.6
Cleaned, monitored area, and monitored body temperature	1	5.6
Pet exposure to ticks		
Participant had found ticks on pets	13	72.2
Preventative measures for tick exposure in pets:		
Topical preventative	4	22.2
Collar preventative	2	11.1
Oral preventative	1	5.6
Essential oils	1	5.6
No regular use of preventatives	5	27.8
Methods to remove ticks from pets:		
Bare hands	1	5.6
Tweezers	1	5.6
Did not specify	10	55.6

and *D. similis*, respectively). The remaining participants were either unsure or didn't remember what ticks they had encountered. Ten participants said they had found ticks on their children, grandchildren, or other children under their care. Three mentioned finding ticks on children's scalp and hairline. Thirteen participants reported finding ticks on pets, which they removed immediately. Approximately 50 % of participants with pets used some form of tick prevention on their pets, indicating awareness of the importance of parasite prevention for pet health.

Four participants experienced tick bites while working outdoors. One participant who worked as a childcare provider stated tick bites on children required an injury report to parents, but not when one of the providers was bitten. Another participant who was a logging company employee mentioned mandatory reporting of tick bites and received regular education on tick prevention. The two remaining participants said they did not report tick bites to their employer and did not receive any tick prevention education.

3.3. Knowledge, attitudes, and practices (KAP) pertaining to tick borne diseases (TBD)

Most participants (14) were aware and concerned about Lyme disease, often sharing anecdotes about friends or family affected by the disease. For instance, one participant said, "My cousin wound up getting bit and having Lyme disease. It did a number on her body." Another mentioned, "I 100% have concerns. I know people with Lyme disease," and a third said, "Lyme disease is most concerning but doesn't keep me from going out." No other TBDs were mentioned by participants.

Although participants expressed concerns about Lyme disease, they appeared to be less concerned about other TBDs. One participant said, "I know that if a tick is on there long enough, it can give you a disease. That's it, that's all I know." Overall, seven participants expressed little to no concern about TBDs, three were unsure if they were concerned about TBDs, and eight participants were somewhat concerned. Low levels of concern appeared to be related to participants' beliefs that they are unlikely to contract TBDs. For example, one participant expressed concerns about TBDs "only when we are in heavily wooded areas, but we're mostly in the city." Another participant said, "I think [TBDs are] not too serious. I'm sure a couple of cases happen, but not too often."

One participant noted that dogs on one of the reservations were commonly sick and infested with ticks, stating, "I know, down river, all the animals have [ticks] really bad. We're pulling off like 30 or 40 ticks a day." Three participants expressed concern that their dogs will contract TBDs, specifically mentioning Lyme disease.

Only six participants said they had adequate information about TBDs (Table 3). Participants most frequently stated that they received information about ticks and TBDs from family members and elders ($n = 9$). One participant received information from their employer. Other information sources included online public health messaging, state park and US Forest Service educational materials, and common knowledge or commonsense.

3.4. Limitations

Our study had three limitations. First, few participants were currently or previously employed in outdoor occupations, and most participants resided in cities. As such, our sample may not have been representative of Native Americans who reside on rural reservations, areas where tick exposure risk may be very different. Our sample included people from seven different Tribes and although there are many commonalities across these communities, each Tribe is unique in its customs and practices, which may have implications for knowledge, attitudes, and practices pertaining to TBDs. Finally, we recruited study participants at a cultural gathering and our sample was small, which precludes drawing inferences for the Native American population residing in our study region because our sample may not be representative of the larger population.

4. Discussion

Although our study is exploratory, we obtained valuable insights into the knowledge, attitudes, and practices of Native American people in northern California regarding ticks and TBDs. Most research participants had been bitten by ticks, but they had incomplete knowledge about ticks and TBDs and varied in their concern about contracting TBDs. Most research participants stated that they received inadequate information on TBDs. Inadequate messaging and outreach about TBDs may underpin incomplete adoption of appropriate actions to prevent exposure to ticks and TBDs. This is concerning because research participants routinely spent time outside in cultural and recreational activities, which are critical to the identity of Native American peoples. Our study underscores the need for a One Health approach to examine the intersection between cultural practices, environmental factors, and tick exposure, and the design and implementation of outreach about TBDs that is tailored to Native American communities in northern California to help protect the health of Native Americans.

Native American people's engagement in outdoor cultural, recreational, and occupational practices increases their exposure to ticks and pathogens transmitted by ticks [12]. Although research participants were mostly employed in indoor jobs, participants commonly spent 2–7 h outdoors each day. By contrast, ~59 % of US residents spend ≤1 h outside each day [31]. Participants' engagement in outdoor leisure (e.g.,

Table 3
Participants' responses when asked "would you describe the information you've gotten about TBD as adequate?".

	Number	Percent
No	8	44.4
Yes	6	33.3
Somewhat	2	11.1
Unsure	2	11.1

hiking, swimming and gardening) and cultural activities (e.g., hunting, fishing, gathering, and traditional dance ceremonies) likely increased their exposure to ticks [32,33] Notably, research participants who engaged in outdoor employment reported experiencing tick bites, but only one individual was required to report tick bites and to participate in regular education about tick prevention. Improved reporting and monitoring of TBDs in Native American communities in Northern California is needed to better protect Native Americans' health.

Although more time spent outdoors increases the risk of tick exposure, the seasonality of outdoor activities is equally important due to tick phenology [34]. Indeed, some research participants stated that there are seasons and months during which ticks are more prevalent on the landscape. Tick activity exhibits unimodal or bimodal peaks representing when nymphs and adults are active during the year [34]. Further detailed information is needed on how much time Native Americans spend outside during different seasons, as well as the timing of cultural activities, the types of habitats in which Native Americans engage in outdoor activities, and whether outdoor recreational and cultural activities take place on trails or on lands with some degree of vegetation management (e.g., campgrounds, parks). Tick exposure may be greater in unmaintained areas with thick vegetation, which provide optimal questing habitats for ticks [35], although human-dominated spaces like gardens may also provide tick habitat (e.g. leaf litter; [33]).

Research participants had limited knowledge of different ticks or TBDs. This is concerning because 15 research participants had been bitten by ticks, 10 participants had found ticks on children under their care, and 13 participants had found ticks on their pets. Few participants could identify tick species and Lyme disease was the only TBD of which participants were aware. Our findings are consistent with other studies in which individuals who live in areas with ticks and TBDs or engage in activities that expose them to ticks (e.g., hunting) have limited knowledge about ticks, tick ecology [33], and TBDs [36,37].

The Centers for Disease Control and Prevention (CDC) recommends EPA-registered products like DEET, picaridin, and permethrin to prevent exposure to ticks and TBDs [38]. However, multiple research participants did not use recommended measures (e.g., wearing long-sleeved clothing, tick checks after time spent outdoors, using products with DEET) to avoid exposure to ticks, and did not engage in post-removal actions to prevent TBDs. Other studies have also shown that people are unlikely to use tick repellents when they engage in outdoor activities [33,36,39], and hunters are less likely to use tick repellents because game species can then detect and avoid hunters [37]. Interestingly, some research participants used essential oils to prevent exposure to ticks [33], but the CDC has cautioned that unregulated products containing essential oils have variable tick-killing efficiency [38].

Research participants appeared to be aware and concerned about their pets contracting TBDs, possibly because they are aware that dogs on the reservation are commonly sick from exposure to ticks. In rural areas lacking animal control services, stray dogs are common and can exacerbate TBD risk [6]. Given the proximity of dogs to ticks and wildlife reservoir hosts, attention should be paid to the pathogen load of dogs in rural areas. The outbreaks of RMSF in the Southeast highlighted the serious TBD hazard posed by tick-infested dogs [23]. Outreach and education about TBDs should enhance existing understanding of the threats that ticks pose to pets to increase the use of appropriate preventative measures for pets.

Our findings are somewhat consistent with the health belief model, in which people adopt preventative behaviors based on perceived risk [40]. According to this model, low levels of knowledge about ticks and TBDs are likely to result in low uptake of appropriate preventative measures, which was reflected in our findings. However, recent findings suggest that knowledge about tick biology and identification is not correlated with people's adoption of most appropriate preventative practices [33], and higher levels of knowledge about Lyme borreliosis may reduce risk perceptions pertaining to tick bites and Lyme disease [36]. The health belief model suggests that internal or external stimuli triggers preventative actions. This aligns with our finding that participants who knew someone who had contracted Lyme disease were more concerned about TBD, although it is unclear if heightened risk perceptions resulted in preventative behaviors. Interestingly, Slunge et al. [36] found that individuals who had been diagnosed with Lyme borreliosis had lower risk perceptions pertaining to this disease. It is possible that the perceived difficulty or low perceived benefits of preventative measures, such as the cost of repellents or the time required for tick checks, may contribute to inconsistent implementation of these preventative measures [40]. More research is needed on how risk perceptions influence Native Americans' adoption of preventative measures.

In common with other studies [15,33,36,37] our findings suggest that increased education and outreach on ticks, TBDs, and appropriate preventative measures are needed. However, selecting the appropriate educational methods is a very important consideration. Intergenerational mistrust by Native Americans of the government and healthcare system, owing to historical and contemporary injustice, prejudice and miscommunication [41–43], means that trusted individuals should provide TBD education to increase the likelihood that information is received by Native American communities [44]. Research participants most frequently received information about ticks and TBDs from family members and elders, rather than from government sources. Research participants demonstrated a strong cultural identity, which translated to communal and family-based outdoor leisure and cultural activities. Elders may play an important role in communicating about the importance of adopting the appropriate actions to mitigate TBDs to protect the health of the Native American community. Care should be taken to ensure that messaging is culturally appropriate. Recognizing and invoking the importance of family and kinship in Native American cultures may increase uptake of appropriate actions by Native Americans to reduce the risks of TBDs across both children and adults.

Finally, further information is needed on how frequently Native Americans encounter ticks and the age demographics of individuals who are exposed to ticks. Children may have unique factors that influence their exposure to ticks, including more time outdoors engaged in play, more time outside of maintained trails and/or parks in vegetation where ticks are found, and less awareness of ticks and tick prevention. Unfortunately, TBDs are often confused with common childhood diseases because of non-specific initial clinical findings, which delays appropriate therapy and increases the likelihood of adverse outcomes from TBDs [45].

5. Conclusion

The risk of TBDs for Native American populations remains understudied, despite the fact that Native Americans engage in an array of outdoor cultural and recreational activities that may increase their exposure to ticks. Based on a One Health paradigm, we conducted semi-structured interviews of attendees at a Native American cultural gathering in Humboldt County, California to identify research participants' knowledge, attitudes, and practices concerning ticks and TBDs. Research participants had encountered ticks on themselves or their children at least once in their lives. However, research participants had incomplete knowledge of ticks and TBDs, expressed low concern about TBDs (excepting Lyme disease), and adopted an array of preventative measures to reduce exposure to ticks and TBDs. More research is needed to achieve a deeper understanding of the intersection of cultural practices and tick exposure in northern California Native Americans. Ultimately, our work highlights the importance of targeted, culturally appropriate outreach and education in promoting the health and well-being of Native American communities.

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CRediT authorship contribution statement

Patricia Torres: Writing – original draft, Software, Project administration, Investigation, Funding acquisition, Formal analysis, Data curation, Conceptualization. **Elizabeth F. Pienaar:** Writing – review & editing, Methodology, Conceptualization. **Michelle A. Ritchie:** Writing – review & editing, Methodology. **Mourad W. Gabriel:** Writing – review & editing. **Michael J. Yabsley:** Writing – review & editing, Supervision, Conceptualization.

Declaration of competing interest

The authors declare the following financial interests/personal relationships which may be considered as potential competing interests:

Patricia Torres reports financial support was provided by Helminthological Society of Washington. If there are other authors, they declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.onehlt.2025.100976.

Data availability

The data that has been used is confidential.

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