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Discrepancies between self-reported tick bites and evidence of tick-borne disease exposure among nomadic Mongolian herders

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Abstract

Twenty-six per cent of Mongolians live pastoral lifestyles, increasing their likelihood of exposure to ticks and placing them at a higher risk for contracting tick-borne diseases (TBDs). *Anaplasma* spp. and *Rickettsia* spp. have been identified in ticks, livestock and humans in Mongolia, but no known qualitative research has been conducted investigating the association between nomadic herder characteristics, tick bite history and exposure to TBDs. To better understand the association between self-reported tick bites and symptoms versus actual exposure to TBDs, this study paired serological data with 335 surveys administered to Mongolian herders, ages 12–69, from 2014 to 2015. Logistic regression results identified no significant associations between reported tick bites or symptoms with serological evidence of *Anaplasma* spp. and *Rickettsia* spp. controlling for age, gender and aimag. Among the 335 respondents who were seropositive to either *Anaplasma* spp. or *Rickettsia* spp., 32.9% self-reported experiencing abnormal symptoms such as redness, inflammation, headache, arthritis or fever after being bitten. Alternatively, 17.3% (58/335) of individuals reported experiencing symptoms following a tick bite in instances where serological results indicated no exposure to *Anaplasma* spp. or *Rickettsia* spp. Results also identified inconsistencies in reporting and seroprevalence among different age groups, with children having the highest reporting and treatment seeking rates but low levels of exposure in comparison with other groups. While survey results showed that individuals were aware of peak tick seasons and tick species that inhabit specific areas, 58% of heads of households (49/84) were unaware that ticks can cause disease in livestock or dogs. This study suggests that herders are an at-risk population in Mongolia with gaps in awareness of TBD risk. Increased surveillance paired with focused outreach to prevent TBDs targeted to the herder population is encouraged.

KEYWORDS
anaplasmosis, Mongolia, nomadic herders, rickettsia, tick-borne diseases

1 | INTRODUCTION

Tick-borne diseases (TBDs) are recognized as an emerging public health threat worldwide (Brown, 2004), with numerous reports of severe TBDs occurring in Asia (Cao, Gao, et al., 2000; Cao, Zhao, et al., 2000; Parola, Paddock, & Raoult, 2005; Takada et al., 2001). In Mongolia, nomadic herders account for approximately 26% of the country's population and live a pastoral lifestyle that may place them at a higher risk of TBDs (Papageorgiou, Battsetseg, Kass, & Foley, 2012). Previous reports have documented spotted fever group *Rickettsia* (Boldbaatar et al., 2017; Lewin, Bouyer, Walker, & Musher, 2003; Moore et al., 2018; Pulscher et al., 2018; Speck et al., 2012; von Fricken et al., 2018), *Borrelia* sensu lato (Iwabu-Itoh et al., 2017; Masuzawa et al., 2014; Scholz et al., 2013; Walder et al., 2006), *Anaplasma* (Haigh, Gerwing, Erdenebaatar, & Hill, 2008; Javkhlan, 2014; Masuzawa et al., 2014; Walder et al., 2006; Ybañez et al., 2013) and tick-borne encephalitis virus (Frey et al., 2012; Muto et al., 2015). Nomadic herders in rural Mongolia account for approximately 26% of the country's population and live a pastoral lifestyle that may place them at increased risk of TBDs (Papageorgiou et al., 2012). Working outdoors in any capacity has been shown to increase likelihood of infection of TBDs by as much as 10-fold (Donohoe, Pennington-Gray, & Omodior, 2015). Paired with the remote nature of their environment, this exposure profile presents unique barriers for the integration of health care and health education in their communities (Strasser, 2003).

Despite the documentation of emerging tick-borne pathogens in rural Mongolia, little to no qualitative research has been conducted among nomadic herders investigating the history of tick bites, reported illness and treatment seeking after the onset of symptoms. Vaccines and community-wide interventions are not currently available for the majority of these diseases (Hook, Nelson, & Mead, 2015; Shen, Mead, & Beard, 2011), with prevention depending almost entirely upon individual behaviours to reduce the risk of exposure (Connally et al., 2009; Curran, Fish, & Piesman, 1993; Schulze, Jordan, & Hung, 1995; Schulze et al., 1994; Stafford, 2004). As such, the use of existing preventative countermeasures depends on community awareness to the risk of TBDs. To our knowledge, this study is the first survey conducted in Mongolia investigating how the self-reported tick bite exposure relates to biomarker-confirmed history of *Rickettsia* and *Anaplasma* spp. exposure.

Impacts

- There is a discrepancy between number of reported tick bites, reported symptoms and evidence of exposure to tick-borne diseases (TBDs) among nomadic Mongolian herders.
- There are gaps in awareness among Mongolian herders about TBD transmission to livestock.
- Children had highest rates of reporting, while adults over 60 years old had lowest reporting rates and seroprevalence.

2 | MATERIALS AND METHODS

2.1 | Study design and settings

Surveys focusing on the demographics, history of tick bite, peak observed tick seasons and years of herder experience were administered across three Mongolian provinces (aimags) between August and October in 2014 and 2015, as part of a larger "One Health" research project. After obtaining informed consent, individual surveys and serum samples were collected from 335 individuals and household surveys were collected from 84 heads of households. All respondents were surveyed in the districts (soums) Tushig and Eroo in Selenge aimag, Terelj area in Tov aimag, as well as Dalanjargalan and Sainshand soums in Dornogovi aimag.

2.2 | Survey instrument

Individual surveys consisted of 28 questions across four sections including the demographics, previous medical history, animal exposure and tick bite history. Variables of interest included the following: years of herding experience, education, age, gender, profession, months they recalled experiencing tick bites, participant recall of tick-borne illness after bite, specific symptoms associated with bite and if treatment was sought.

2.3 | Serology

Surveys were matched to serological results, which have been previously described (von Fricken et al., 2018). Briefly, indirect immunofluorescence (IFA) was used to detect IgG antibodies against *Rickettsia* spp. and *Anaplasma* spp. Commercially prepared slides (ProtaTek International Inc., ST. Paul, MN) coated with *Rickettsia rickettsia* and *Anaplasma phagocytophilum* antigens were used as recommended (http://www.protatek.com/IFASlides/IFAProcedures.pdf) with minor modifications.

2.4 | Statistics

All data were analysed using STATA v 15 (StataCorp, College Station, TX, USA). Logistic regression was used to assess the level of association between reports of tick bites or symptoms and seroprevalence of *Rickettsia* spp. and *Anaplasma* spp., controlling for age, aimag and gender. Results were determined significant with a p value <0.05.

2.5 | Ethical approval

This project received ethical approval from both Duke University's Institutional Review Board and from the Mongolian Monitoring Committee of Medical Ethics—Ministry of Health.

3 | RESULTS

Among the 335 respondents, the mean age was 36 years (95% CI: 34.35, 37.63), 50.4% were male, 52.4% had a secondary education, and 73.8% (247/335) of respondents identified themselves as herders, reporting two or more years of experience herding or spending multiple hours per day with livestock (Table 1).

3.1 | Perceived exposure versus tested exposure

Of the 335 respondents, 36.1% tested positive for previous exposure to *Anaplasma* spp. and 19.4% for *Rickettsia* spp. A total of 46.3% (155/335) were seropositive to either *Anaplasma* spp. or *Rickettsia* spp.; 65.8% (102/155) of whom reported history of one or more tick bites. Half of those who reported tick bites (51/102) also reported experiencing symptoms such as redness at site of tick bite, inflammation, headache, arthritis or fever following the bite. Alternatively, 17.3% (58/335) of individuals reported experiencing symptoms following a tick bite, but did not test positive for *Rickettsia* or *Anaplasma* antibodies. Table 2 depicts the number of individuals who were positive for *Anaplasma* spp. or *Rickettsia* spp. with and without self-reported tick bite and symptoms. Results of the logistic regressions showed no statistically significant associations between reported tick bite or symptoms and exposure when controlling for age, gender and aimag (Tables 3 and 4). Fifty-eight per cent (49/84) of heads of households responded that they did not know ticks cause disease in livestock or dogs.

TABLE 1 Summary of demographic features of surveyed individuals (*n* = 335)

Groups	Parameters	No.	%
Sex	Male	173	51.6
	Female	162	48.4
Age Mean (*SD*) 36 (15.44)	Under 18	65	19.4
	18–34	94	28.1
	35–54	134	40.0
	55–64	37	11.0
	Above 64	5	1.50
Aimag	Selenge	135	40.3
	Tov	107	31.9
	Dornogovi	93	27.8
Education level	Literate	2	0.60
	Primary	17	5.08
	Inc. Secondary	116	34.6
	High School	139	41.5
	University & above	31	9.25
	None	4	1.19
	No response	26	7.76
Occupation	Nomadic herder	176	52.5
	Other	69	20.6
	No response	90	26.9

3.2 | Distribution by gender and age

Consistently more men than women reported being bitten, experienced symptoms related to the bite and tested positive for previous exposure to *Anaplasma* spp. and *Rickettsia* spp. While very few respondents that experienced symptoms reported seeking treatment (12/110), eight of those 12 were women.

Figure 1 depicts inconsistencies in reporting and seroprevalence among different age groups. The youngest group, ages 0–18, had the highest count of self-reported bites, symptoms and treatment sought, yet this group was also the second lowest group for seroprevalence. Results for those 60 years and older (21/335) were consistent with their reports of tick exposure, as they reported bites and symptoms least and had the lowest seroprevalence of any age group. After adjusting for age, there were no significant associations between herding experience and exposure to TBDs.

3.3 | Distribution by aimag

The distribution of positive results for exposure to *Anaplasma* spp. and *Rickettsia* spp. is shown in Figure 2. Tov/Terelj had the highest percentage of positive exposure, followed by Selenge and Dornogovi, respectively. Individuals were provided with the photographs of tick species common in Mongolia, allowing them to report which species and approximate sizes they observed. Many of the identified ticks in Selenge (*n* = 220) were reported as *Ixodes* spp. (55.0%) and *Dermacentor* spp. (45.0%). A majority of respondents from Tov (*n* = 107) identified *Dermacentor* as the most prevalent species (75.7%). Respondents from Dornogovi (*n* = 92) presented more varied results, reporting *Dermacentor* spp. (51.1%) and *Hyalomma* spp. (47.8%) present in the area.

3.4 | Self-reported peak tick seasons and frequency of symptoms

The surveys also provided an indication of peak seasons for reported tick bites (Figure 3). The majority of tick bite occurrences, reported 472 times by 201/335 individuals, occurred during April, May and June with a significant increase in the month of May (p < 0.0001). The most commonly reported symptoms were redness and inflammation, followed less frequently by fever, headache and arthritis.

4 | DISCUSSION

This study lays a framework for future qualitative investigations into TBDs in Mongolia. A related study was performed in Mongolia linking reported symptoms and tick bites to serological evidence of tick-borne encephalitis, Lyme Borreliosis and human granulocytic anaplasmosis; however, it was performed in a hospital setting

TABLE 2 Self-reported tick bites and symptoms after bite for those seropositive for *Anaplasma* spp., *Rickettsia* spp., either or both

Seropositive for	Reported tick bite	No reported tick bite	Reported symptoms after bite	No reported symptoms after bite
Anaplasma spp.	(78/121) 64.5%	(43/121) 35.5%	(45/78) 57.7%	(33/78) 42.3%
Rickettsia spp.	(45/65) 69.2%	(20/65) 30.7%	(23/45) 51.1%	(22/45) 48.9%
Either	(102/155) 65.8%	(53/155) 34.2%	(51/102) 50.0%	(51/102) 50.0%
Both	(25/37) 67.6%	(12/37) 32.4%	(18/25) 72.0%	(7/25) 28.0%

TABLE 3 Logistic regression of tick-borne disease exposure (*Rickettsia* spp. and *Anaplasma* spp.) by reported tick bites, controlling for gender, age and aimag

Disease exposure	Tick bite	OR (95% CI)	*p*–value
Anaplasma (*n* = 316)	Reported tick bite	1.25 (0.74, 2.11)	0.400
	No reported bite	Reference	
Rickettsia (*n* = 321)	Reported tick bite	1.67 (0.88, 3.20)	0.119
	No reported bite	Reference	

TABLE 4 Logistic regression of tick-borne disease exposure (*Rickettsia* spp. and *Anaplasma* spp.) by reported symptoms, controlling for gender, age, reported tick bite and aimag

Disease exposure	Tick bite	OR (95% CI)	*p*–value
Anaplasma (*n* = 198)	Reported symptoms	1.39 (0.74, 2.59)	0.300
	No reported symptoms	Reference	
Rickettsia (*n* = 197)	Reported symptoms	1.01 (0.50, 2.10)	0.952
	No reported symptoms	Reference	

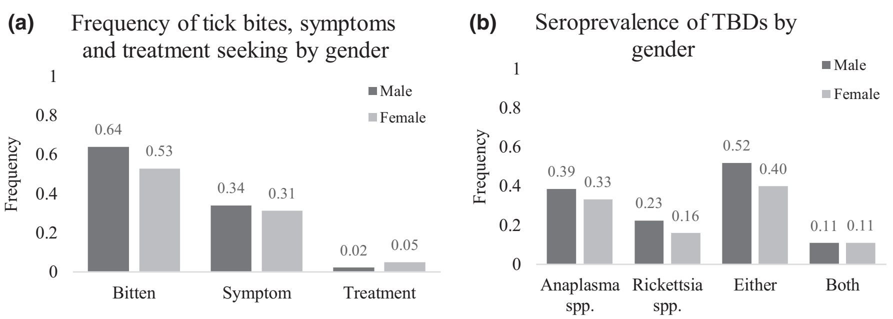

FIGURE 1 (a) Distribution of reported tick bites, symptoms, and treatment seeking by gender and (b) distribution of seroprevalence by gender (*n* = 335)

potentially introducing selection bias for those who present to the hospital for treatment and likely did not capture the nomadic herder population (Walder et al., 2006). Given the remote lifestyle of Mongolian herders and their significant exposure to ticks, tick-borne pathogens may be causing a high burden of untreated and undiagnosed disease, as suggested by the high percentage of reported illness and low healthcare seeking rates in this study, which future studies could elucidate.

As described previously, the lack of association between reported tick bite or symptom and exposure to TBDs shows that the recall of tick bite is not an explanatory factor one should use to identify risk (Berglund et al., 1995; Biggs, 2016; Razzaq & Schutze, 2005; Thorner, Walker, & Petri, 1998). Prior studies of ticks and TBDs suggest that the past experience of tick bites may influence the use of personal preventative measures; however, tick bites frequently go undetected and therefore may not influence personal habits (Beaujean, Bults, van Steenbergen, & Voeten, 2013; Marcu, Uzzell, & Barnett, 2011). Therefore, herders who may have been bitten, but do not recall a bite may feel less inclined to take personal precautions to prevent tick exposure.

The low seroprevalence and lack of reported bites and symptoms reported in those 60 years and older could be an artefact of less exposure among elderly herders, immune senescence, exposure to strains of pathogens for which our serology did not detect antibodies or increased time from exposure leading to recall bias. The large discrepancy between those who reported experiencing symptoms after tick bites and those who reported seeking treatment may indicate a knowledge or resource gap.

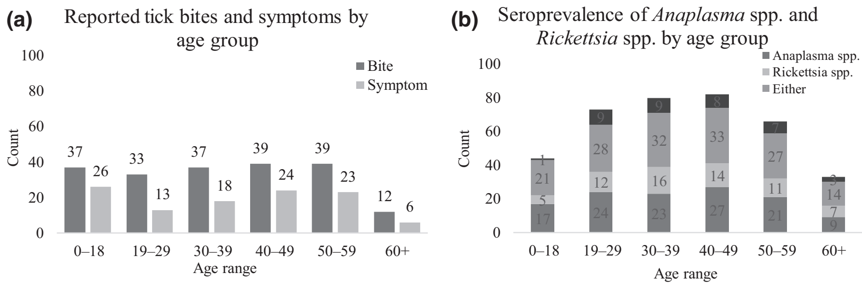

FIGURE 2 (a) Distribution of reported tick bites and symptoms by age group and (b) distribution of seroprevalence by age group (n = 335)

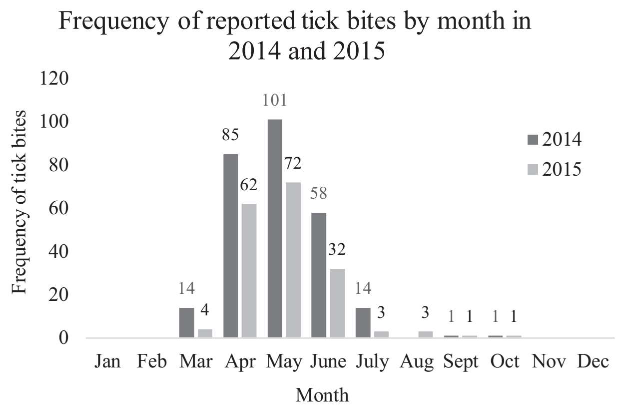

FIGURE 3 Frequency of reported tick bites each month out of the total number of tick bites reported (452) in years 2014 and 2015

Responses identifying tick species by aimag were consistent with previous descriptions of tick distribution (Boldbaatar et al., 2017; Speck et al., 2012; Walder et al., 2006), except for the 12/92 respondents from Dornogovi that reported seeing *Ixodes* ticks, which is likely due to misidentification, as *Ixodes* ticks are not native to the Gobi region. While herders may have local knowledge about endemic tick species and the months they are likely to be exposed, over half of the heads of households surveyed were not aware of possible TBD transmission to dogs or livestock, suggesting important knowledge gaps among the population. Future educational programmes on prevention and control could address this misunderstanding to improve both human and livestock health.

Prevention of TBDs in Mongolia will largely depend on the beliefs, practices and awareness of herder community members themselves. Seminomadic herder households with around 100 animals or less are often isolated and lack access to public services, particularly health care and education, which could explain the large gap between exposure and treatment seeking (Asian Development Bank, 2008). To address these systematic issues, a multifaceted approach should be considered that will develop the national public health and insurance system and increase the allocation of medical resources and personnel to expand coverage across Mongolia. With this in mind, strengthening the education of Mongolian nationals, tourists, clinicians and veterinarians will be central to the implementation of strategies meant to increase awareness and prevent exposure to tick bites, especially during peak tick seasons.

4.1 | Limitations

As with most surveys, results are subject to recall bias and other systematic errors. That said, these results provide an interesting framework that future studies targeting TBDs in Mongolia may consider. Additionally, detecting antibodies to *Rickettsia* spp. or *Anaplasma* spp. does not definitively indicate a clinically relevant exposure nor does it necessarily mean infection occurred via tick bite, as exposure can occur during the slaughter of infected livestock.

5 | CONCLUSION

This study identified nomadic Mongolian herders as both a source of information on endemic tick species and TBDs and an at-risk group requiring further education and resources to fill knowledge gaps on risks of exposure. There are discrepancies between reporting of tick bite history and actual exposure to TBDs that vary by demographic groups and should be further explored. Understanding the risks of TBD among nomadic herders can lay a foundation for culturally relevant efforts aimed at improving the health of this often isolated population. The results of this study only scratch the surface of social and behavioural drivers behind TBD exposure, with future in-depth qualitative studies needed to investigate knowledge, attitudes and practices among nomadic herders in Mongolia.

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CONFLICT OF INTERESTS

None.

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