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A review of ticks in Canada and health risks from exposure

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Key Messages

- Tick species are undergoing range expansions across Canada due to global warming, animal migration, and land fragmentation. It is estimated that their range is expanding northwards by 35–55km per year.
- Species posing the greatest risk to humans are the *Ixodes scapularis* (blacklegged tick) and the *Ixodes pacificus* (Western blacklegged tick).
- The risk of human tick-borne infections is increasing. Populations at greatest risk of tick exposure are those who spend time outdoors. Populations at greatest risk of health complications are the immunocompromised and older adults. Treatment options during pregnancy and chestfeeding are limited, increasing the risk of potential complications in this group.
- Personal protection measures, such as tick checks and application of insect repellents, can help to reduce tick encounters and subsequent infection.
- Continued surveillance and additional research are warranted to better understand the public health threat.
- Heightened awareness of the risk for tick bites and tick-borne infections in endemic areas is warranted.

Introduction

It is well established that the range of tick populations is expanding due to global warming, changing animal migration patterns, and land fragmentation.[1-5] Ticks are known vectors for bacterial, viral and protozoan pathogens, capable of infecting humans. As the range of tick vectors increases across Canada so does the potential for exposure to emerging tick-borne pathogens. The aim of this document is to review risk factors and health risks associated with tick exposure for Canadians and to review preventative measures to reduce tick exposures. This review is the first of four in a series on tick vectors in Canada.

Literature search methodology

Scholarly research and grey literature were searched for information on risk factors and health risks associated with tick exposure. Web of Science, EBSCO (includes Medline, CIHAHL, Academic Search Complete, and ERIC), Google Scholar and Google were used to identify relevant sources. Relevant English language results were collected. The search was primarily restricted to the years 2000–present; some earlier pivotal publications were also included. Additional references were identified using forward and backward chaining of initial results. Peer reviewed scholarly literature as well as grey literature and reports from academic institutions, federal government, provincial and territorial governments, and public health agencies were reviewed.

Articles, reports and websites were selected for review if they pertained to tick-borne infections among humans (including Lyme disease, anaplasmosis, babesiosis, *Borrelia miyamotoi* disease, tick-borne relapsing fever, Rocky Mountain spotted fever, Powassan virus disease, and tularemia, as well as other newly emerging tick-borne infections), epidemiology (prevalence and incidence), and personal protection measures. Latin names of pathogens and of known tick vectors were also included in the search. Where possible, literature pertaining to Canada was emphasized. After selection, 92 items were included for review. All literature was analyzed and synthesized by one reviewer. A complete list of search terms and the full list of results are available upon request.

Results

Overview of ticks and tick-borne illnesses in Canada

Ticks continue to pose a threat to public health in Canada. Although there are over 40 species of ticks found in Canada, the primary tick vectors of concern in Canada are the blacklegged tick (*Ixodes scapularis)* east of the Rocky Mountains, and the Western blacklegged tick *(Ixodes pacificus)* west of the Rocky Mountains, predominantly along the southern border but also in other regions.[6-12] *While Ixodes scapularis* has been identified in all provinces east of the Rocky Mountains, endemic populations are not known to be established in Alberta and Saskatchewan.[8,13] It is possible their population has been underestimated here due to fewer surveillance efforts. Other vectors of concern include *Dermacentor variabilis* (American dog tick), *Dermacentor andersoni* (Rocky Mountain wood tick) and *Amblyomma americanum* (Lone Star tick)—all found in Canada.[1,14] The range of such vectors has been expanding, and will continue to expand, primarily due to global warming, animal migration, and land fragmentation through deforestation and urbanization.[1-5] It is estimated that their range is expanding northwards by 35–55km per year.[3] There are also known tick vectors that may pose new public health threats. For example, the tick species *Ixodes angustus,* endemic to North America, has recently been discovered to carry a new Borrelia species (*Borrelia mayonii)* in British Columbia, Canada.[15] Recent research also indicates an expanding range of *Haemaphysalis longicornis* (Asian longhorned ticks) northwards in the United States, with a potential to continue north into Canada.[16,17]

Tick vectors are known to carry bacterial, viral, and protozoan pathogens, capable of infecting humans through prolonged attachment during a blood meal. In Canada, the predominant tick-borne infections are Lyme disease (*Borrelia burgdorfei*), anaplasmosis (*Anaplasma phagocytophilum*), babesiosis (*Babesia microti*), *Borrelia miyamotoi* disease, Rocky Mountain spotted fever (*Rickettsia rickettsii*), Powassan virus disease, and tularemia.[8] There are several other emerging tick-related pathogens of concern in North America, including alpha-gal syndrome (allergy specific to red meat), Ehrlichiosis (*Ehrlichia chaffeensis)*, Heartland virus, tickborne encephalitis, and toxoplasmosis (*Toxoplasmosis gondii*).[16,18,19] The increasing range and identification of new tick vectors highlights the importance of being vigilant of all tick bites and subsequent symptoms regardless of the tick vector species. Below, the key tick-borne pathogens of concern in Canada are reviewed.

Tick-borne pathogens of concern in Canada

Mixed surveillance and reporting methodologies combined with underreporting of cases leads to challenges in understanding the true magnitude of the public health concern around tick-borne infections.[20,21] Surveillance and reporting of tick-borne pathogens varies by province and territory. As of 2022, only Lyme disease and tularemia are reportable nationally.[1] In the absence of Canadian specific data, comparable epidemiological estimates from the United States have been provided when available (Table 1. Overview of tick vectors and pathogens currently of concern in Canada).

Table 1. Overview of tick vectors and pathogens currently of concern in Canada

	Pathogen	Primary tick vector(s)	Geographic range+	Nationally reportable	Estimated incidence (per 100,000 population)
Bacteria	*Analplasma phagocytophilum*	*Ixodes scapularis* *Ixodes pacificus* *Ixodes spinipalpis*	BC, AB, SK, MB, ON, QC, NB, NL NS, PEI	No	1.54 in 2018 (Manitoba)[22]
	Borrelia burgdorferi	*Ixodes scapularis* *Ixodes pacificus*	BC, AB, SK, MB, ON, QC, NB, NS, NL, PEI	Yes	7.0 in 2019[23]
	Borrelia hermsii	*Ornithodoros hermsi*	BC	No	-
	Borrelia mayonii	*Ixodes scapularis* *Ixodes angustus*	BC, ON	No	-
	Borrelia miyamotoi	*Ixodes scapularis* *Ixodes pacificus*	BC, AB, MB, ON, QC, NC, NS, NL, PEI	No	-
	Rocky Mountain spotted fever *(Rickettsia rickettsia)*	*Dermacentor variabilis* *Dermacentor andersoni* *Rhipicephalus sanguineus*	BC, AB, SK, ON, NS	No	0.2 in 2019 (British Columbia)[24]
	Tularemia (*Francisella tularenis)*	*Dermacentor variabilis* *Dermacentor andersoni* *Amblyomma americanum*	Canada wide	Yes	0 in 2022[24]
Parasite	*Babesia*	*Ixodes scapularis* *Ixodes angustus*	BC, MB, ON, QC, NC, NS	No	0.9 in 2019 (United States)[25]
Virus	Powassan virus	*Ixodes cookei* *Ixodes marxi* *Ixodes spinipalpis* *Ixodes scapularis* *Dermacentor andersoni*	MB, ON, QC, NB, NS, PEI	No	-

⁺ *Ixodes scapularis* are found east of the Rocky Mountains; Ixodes pacificus are found west of the Rocky Mountains.
*Adapted and updated from Bouchard et al, 2019[1]

Lyme disease (Borrelia burgdorferi)

Lyme disease, caused by the bacterium *Borrelia burgdorferi*, is the most commonly reported tick-borne infection in North America.[9] Symptoms for Lyme disease vary depending on the stage of the disease. Initial symptoms can include erythema migrans lesions (bulls-eye rash) and flu like symptoms 3 to 30 days after exposure. The disease can progress to cardiac and neurological symptoms and arthritis in the later stages of infection.[9,26,27] One of the challenges with Lyme disease is timely diagnosis, especially in the absence of a known tick bite, as many of the symptoms are non-specific.[28]

Vector: In North America, primary vectors are *Ixodes scapularis* (blacklegged tick) east of the Rocky Mountains, *Ixodes pacificus* (Western blacklegged tick) west of the Rocky Mountains.[9] *Ixodes angustus* has recently been identified as a vector in British Columbia.[15]

Epidemiology: Over 300,000 cases are reported annually in the United States.[26,29] In Canada, the incidence of reported Lyme disease is increasing, with 2,634 cases reported in 2019 and an incidence of 7.0 cases per 100,000 population. Surveillance indicates that the greatest concentration of Lyme disease infections occur in Manitoba, Ontario, Quebec, and Nova Scotia, with confirmed cases of Lyme disease in every province (Table 2 – Incidence of Lyme disease across Canada).[27] The steadily increasing incidence of Lyme disease is in part due to an increasing geographic range of vectors.[14]26-Aug-2022 9:49:00 AM

Several other *Borrelia* species can also cause Lyme disease. Of note, *Borrelia mayonii* was recently discovered in British Columbia. It is transmitted through a different tick species endemic to North America, *Ixodes angustus*.[15] It has also been documented in Ontario.[1] This highlights the importance of being vigilant of all tick bites and subsequent symptoms, regardless of the tick vector species.

Table 2. Incidence (per 100,000 population) of Lyme disease across Canada, 2019[23]

Province	Incidence per 100,000 population
British Columbia	0.3
Alberta	0.3
Saskatchewan	0.1

Manitoba	4.8
Ontario	8.0
Quebec	5.9
New Brunswick	4.6
Nova Scotia	85.6
Prince Edward Island	3.8
Newfoundland & Labrador	0
Yukon	0
Northwest Territories	0
Nunavut	0

Anaplasmosis (Anaplasma phagocytophilum)

Anaplasmosis (also known as human granulocytic anaplasmosis) is caused by the bacterium *Anaplasma phagocytophilum*. Symptoms usually include an acute fever, 5–21 days after exposure, followed by flu-like symptoms. Infection is self-limiting in the majority of cases. However, older adults and those with compromised immune systems are at risk of complications.[30]

Vector: *Ixodes scapularis, Ixodes pacificus,* and *Ixodes spinipalpis* (mouse ticks).[30]

Epidemiology: Currently, Manitoba is the only province where anaplasmosis is reportable. Since 2013, the incidence has been steadily rising in Manitoba where surveillance is available. The latest data show an incidence of 1.54 per 100,000 in 2018 that is twice as high as the incidence in 2017 (0.66 per 100,000).[22] The same steady increase has been seen in the United States.[31] Though surveillance data is limited across the rest of Canada, there is a risk of anaplasmosis infection in any community with an established population of blacklegged ticks. Areas with a greater risk of Lyme disease also carry a higher risk of anaplasmosis.[22,30]

Babesiosis (Babesia microti, Babeisa duncani, Babesia divergens)

Babesiosis is primarily transmitted by the parasite *Babesia microti* through *Ixodes scapularis.*[25] However, infection is also possible by the parasite *Babesia duncani* and *Babesia divergens*.[32] Infection is usually mild to moderate with flu-like symptoms; however, complications and death are possible among susceptible populations (immunocompromised persons and older adults).[25]

Vector: *Ixodes* species and *Dermacentor albipictus*.[33]

Epidemiology: Babesiosis became a reportable disease in the United States in 2011.[33] In 2015, there were 2,074 babesiosis cases across 33 states with an incidence of 0.9 per 100,000.[25] The number of cases has been steadily increasing since 2011, with more states making babesiosis a reportable disease. In Canada, babesiosis is not reportable. However, a small number of cases have been reported in Manitoba and Ontario.[34-36] *Babesia microti* has also been detected in *Ixodes angustus* in British Columbia.[10]

Borrelia miyamotoi disease

Borrelia miyamotoi is a bacterium that causes tick-borne relapsing fever. Symptoms are often non-specific and include fever, chills, and headache.[37,38]

Vector: *Ixodes scapularis* and *Ixodes pacificus*.[39]

Epidemiology: Case surveillance is limited due to a lack of reporting. However, preliminary research indicates that *Borrelia miyamotoi* has been detected in ticks in Canada, and is an emerging risk in the northeast of the United States where infection rates coincide with Lyme disease incidence.[1,38,40]

Tick-borne relapsing fever can also be caused by *Borrelia hermsii* spread by the tick species *Ornithordoros hermsi*, and identified in British Columbia. However, limited data is available on the incidence, likely due to a lack of awareness of the presence of *Borrelia hermsii* in British Columbia.[41]

Rocky Mountain spotted fever (Rickettsia rickettsii)

Rocky Mountain spotted fever is transmitted by the bacteria, *Rickettsia rickettsii*. It is the only observed rickettsial disease in Canada. Symptoms can include fever and a rash, with an incubation period of between 2–15 days. Risk of complication increases with age and lack of treatment. The risk of fatality is estimated to be between 5–30%, depending on access to treatment.[42,43]

Vector: *Dermacentor andersoni* (Rocky Mountain wood tick) in Western Canada, and by *Dermacentor variabilis* (American dog tick) in Eastern Canada.[44] It can also be transmitted by *Rhipicephalus sanguineus.*[1]

Epidemiology: Reporting of cases varies by province and territory. As a result, there is limited information on the distribution and prevalence of Rocky Mountain spotted fever, despite established vector populations.[43] In 2019, there were nine cases in BC, an incidence of 0.20 per 100,000 population.[24] In the United States, incidents of Rocky Mountain spotted fever have been steadily increasing, with 5,666 cases between 2017 and 2019, and an incidence of 1.31 per 100,000 in 2015; the majority of cases are located in the Midwest and Southern states.[43]

Powassan virus

Powassan virus is a tick-borne flavivirus. It is endemic to North America and Russia. It was first discovered in 1958 in Ontario, Canada.[45] Infection can be asymptomatic or cause mild flu-like symptoms, with an incubation period of one to four weeks. Half of infections lead to long-term neurological issues, and 1 in 10 serious infections can lead to encephalitis and death.[46,47]

Vector: Predominantly *Ixodes scapularis*. Other vectors include: *Ixodes cookei, Ixodes marxi,* and *Ixodes spinipalpis.*[1,47,48]

Epidemiology: In Canada, there have been 21 cases since 2017. It is currently considered a serious but rare pathogen. The incidence of Powassan virus may increase as the geographic range of *Ixodes scapularis* expands and populations become endemic, as surveillance efforts are enhanced, and as physicians and the general public develop a greater awareness of the disease.[47,49]

Tularemia

Tularemia is caused by the bacterium *Francisella tularensis*. It can be transmitted through insects, including tick, deer fly, and mosquito bites. Other sources of infection can result from contact with infected animals, drinking contaminated water, and inhaling contaminated dust particles.[50,51] Symptoms include a skin ulcer, swollen lymph glands, and flu-like symptoms. Treatment with antibiotics is almost always curative.[50]

Vector: *Dermacentor variabilis*, *Dermacentor andersoni*, and *Amblyomma americanum*. There are also other non-tick vectors.[1]

Epidemiology: Five cases were reported in Canada in 2020 (incidence of 0 per 100,000). In BC, there was one reported case in 2018.[24] In Ontario, there was one reported case in 2020, and four cases between 2011–2022.[52] Tularemia continues to be a rare disease in Canada. The incidence was similarly low in the United States at 0.1 per 100,000 residents in 2019.[53]

Additional tick-borne pathogens of concern

There are numerous other emerging tick-borne pathogens in the United States that are already present and may pose future risks to human health in Canada:

Alpha-gal syndrome

Alpha-gal syndrome, otherwise known as red meat allergy, is not a pathogen but an allergic reaction to the alpha gal sugar molecule found in most mammals. Current evidence suggests vectors include the *Amblyomma americanum* (Lone Star tick) and *Ixodes scapularis*.[19] Allergic reactions range from mild to life threatening and may require diet alteration to avoid mammalian products.[54] The range of the Lone Star tick is expanding northwards in the United States, and has been detected in Canada.[16]

Ehrlichiosis (Ehrlichia chaffeensis)

Ehrlichiosis is caused by several *Ehrlichia bacteria* species, with the majority of infections due to *Ehrlichia chaffeensis.* Symptoms are clinically similar to anaplasmosis, and usually involve mild to moderate flu-like symptoms, with one in three presenting a rash appearing as red splotches or pinpoint dots.[55] Reported cases are increasing in the United States with 2,093 cases in 2019.[55] The incidence was 0.32 per 100,000 between 2008–2012.[56] While the principal vector is the *Amblyomma americanum* (Lone Star tick), *Ehrlichia* species have also been found in *Ixodes* species, including *Ixodes scapularis.* Ehrlichiosis is correlated with anaplasmosis infection in the United States.[57] To date, there have been no reported human cases in Canada; however, it is currently not a reportable disease.[1]

Others

Heartland virus, tick-borne encephalitis, and toxoplasmosis (*Toxoplasmosis gondii*) have also been identified to be transmitted by ticks in the United States and Europe.[4,18,58,59] They have the potential to pose a human health risk in Canada in the future.

Tick exposure and infection considerations

Populations at risk of exposure to ticks

The risk of human exposure to ticks is proportional to the amount of time spent outdoors in tick habitats such as tall grass, brush, and leaf litter.[12,30,60] Deciduous woodlands and tall grasses appear to carry a greater risk of exposure to ticks than coniferous woodlands; however, ticks are found in both habitats. Exposure can also occur in urban and suburban settings due to tick dispersal via migratory birds.[6]

Activities such as hiking, fishing, hunting, camping, gardening, walking your dog, outdoor labour (e.g., landscaping, tree planting), and golf can increase one’s risk of encountering a tick.[61] Landscape changes, including forest fragmentation (change of natural continuous forests into smaller sections due to human development), can also increase tick encounters.[6,23,62-66]

Populations at greatest risk of tick exposure in Canada are children (ages 5–14) and adults aged 55–79. In the majority of age groups, incidence is greater among males than females. These age groups, and males in general, spend more time outdoors when ticks are active, which increases the risk of tick encounters.[23,31,67,68]

Ticks are most active between spring and late autumn.[23] Rather than time of day correlation to activity (as in mosquitoes), ticks are active throughout the day at temperatures above 4 degrees Celsius.[12] The risk of tick exposure is greatest when nymph ticks are active (May to July) and again in the fall when adult ticks become active (September to November).[23,30] Ticks can also survive winter months by being insulated under tree litter, brush, and snow.[12] Different tick vectors have varying life cycles, which can increase exposure potential at different times of the year.[6,23,30] In British Columbia, ticks are active year round.[61] Reporting of infection is greatest during the summer, coinciding with increased outdoor activity and tick activity.[23]

Populations at risk of infection

Individuals who sustain a tick bite are at risk of a tick-borne infection. The literature suggests that the duration of tick attachment may play a role in the transmission of infection, highlighting the importance of regular tick checks and prompt removal of ticks using appropriate methodology.[69] The majority of infections are easily treated if diagnosed early.[70] However, given the non-specificity of many tick-borne infections, timely diagnosis can be challenging. Individuals can also be infected with more than one pathogen from a tick bite; such co-infections provide an additional challenge for timely diagnosis.[70,71]

The risk of infection coincides with time spent outdoors and potential for tick encounters and bites. Children (ages 5–14) and adults (ages 55–79) are at the greatest risk of tick exposure and therefore infection.[23,67,68] Early diagnosis and prompt treatment of tick-borne infections is essential for a full recovery. Complications from infection can occur at all ages; immunocompromised populations and older adults have an increased risk of complications.[25,72] Treatment of children under the age of 8 can be complicated due to the risk of teeth staining from doxycycline, the recommended treatment for bacterial tick-borne infections.[73] Pregnant people are also a susceptible population, as safe treatment options during pregnancy and chestfeeding can be limited, potentially increasing the risk of complications in utero and in the newborn.[74,75] Of note, babesiosis can be transmitted via blood transfusion, organ transplant, and the placenta.[33,34,37] Transmission of ehrlichiosis and anaplasmosis can also occur through blood transfusions and organ transplants.[76] This may also be the case for other pathogens but research on these topics is limited, highlighting the importance of considering tick-borne pathogens in blood transfusions, organ safety protocols, and transplacental transmission.

Interventions to reduce personal exposure to ticks

The literature on personal protection measures to reduce the likelihood of tick exposure is predominately centred on Lyme disease, a well-established public health concern. However, the personal protection measures outlined below can be used to limit exposure to all tick species:

- ***Actions taken while recreating outdoors:*** Avoid high-risk areas with high grass and leaf litter; walk on cleared trails; wear light-coloured clothing covering arms and legs (to easily identify ticks); tuck clothing (e.g., pants into socks, shirt into pants), and wear closed-toed shoes to create a barrier for skin; apply insect repellent; wear permethrin-treated clothing; conduct regular checks for crawling ticks.[6,25,30,70,77-80]
- ***Actions taken indoors, after spending time outdoors:*** Thoroughly check for and promptly remove ticks using appropriate methods; check pets for ticks; change clothes; put clothes worn outdoors in the dryer on high heat to kill ticks; take a shower/bath.[6,25,30,70,77-80]

Given that ticks can be quite small in their nymph stage, similar to a poppy seed, thoroughly checking for ticks and engaging in multiple personal protection measures can be helpful.[81] However, literature on the effectiveness of personal protection measures is mixed. Effectiveness of personal protective measures is often a secondary focus of many studies, limiting the detail required to understand the variability in effectiveness.[77] There is also a varying degree of knowledge on effective preventive measures among Canadians, especially in areas with a high risk of Lyme disease.[82,83] Given the standalone effectiveness of insect repellents and permethrin-treated clothing, a combination of personal protection measures using at least one insecticide appears to be the most effective in preventing crawling and attached ticks. (See Box 1 for a list of products approved for use in Canada.)[84]

Environmental measures can also help to reduce tick habitats. Their effectiveness relies on individual property maintenance and upkeep as well as that of neighbouring properties. Measures include landscaping and landscape management (e.g., removing leaf litter and debris, keeping lawns short, and pruning plants), creating woodchip, mulch or gravel borders between lawn and wooded areas, and adding fencing to limit wildlife.[6,30,85,86]

Current data highlights a research gap on the effectiveness of personal protection measures and environmental measures to reduce tick encounters and tick habitats. Such evidence is essential for targeted risk communication strategies to guide public health educational programs aimed at promoting behaviour changes to limit tick-borne infections.

Box 1: Insect repellents approved in Canada

In Canada, the following insect repellents are approved for use against ticks (Government of Canada, 2012):

- Personal insect repellents containing DEET. The concentration varies according to age:
  - > 12 years of age, 30% DEET
  - Children 2–12 years, 10% DEET up to three times a day
  - Children 6 months–2 years, 10% DEET once a day.
  - Not recommended for infants under 6 months. Use mosquito net instead.[87]
- Icaridin insect repellent containing up to 20% icaridin (also known as picaridin). Safe for children 6 months to 12 years, and recommended by the PHAC Advisory Committee on Tropical Medicine and Travel.[79]
- The effectiveness of insect repellents containing soybean oil and/or citronella against ticks has not been established.[88]
- Permethrin-treated clothing is approved for those over the age of 16 (including pregnant people). Permethrin-treated clothing is used by the military and shown to have over 95% protection against *Ixodes* scapularis and *Ixodes pacificus*.[89,90] Initial research on the effectiveness of summer-weight permethrin clothing show 77% effectiveness against live nymphs on treated clothing.[91] Permethrin-treated clothing should be kept out of reach of children. Permethrin-treated items should contain a Health Canada Pest Control Product (PCP) number on the label. Permethrin sprays and liquids for treating one's own clothes are not approved in Canada.[92]

Summary

Tick-borne infections continue to be a public health concern in Canada with the expanding range of tick species northwards into and within Canada due to climate warming, migratory animals, and land fragmentation. Surveillance of such pathogens varies across Canada by province and territory, and many cases go underreported. Currently, the highest risk of infection from tick bites is Lyme disease, followed by anaplasmosis. There are numerous other pathogens that can be transmitted through tick vectors that are endemic in Canada.

Populations at greatest risk of exposure to ticks and subsequent infection are children (ages 5–14) and adults (ages 55–79), with males at a slightly increased risk of exposure to ticks due to activity levels. These groups are the ones most likely to recreate outdoors while tick activity is the highest. Immunocompromised individuals and older adults are at the greatest risk of health complications from infection. Treatment options during pregnancy and chestfeeding are limited, increasing the risk of potential complications in this group. Personal protection measures can reduce exposure to ticks and therefore the risk of infection.

This review highlights the importance of continued federal, provincial, and territorial surveillance of existing and emerging tick-borne infections. It also highlights several research gaps warranting attention, including: 1) the need to better understand the role of tick-borne infections among other susceptible groups (e.g., pregnant and chestfeeding people), and 2) the effectiveness of each personal protection measure, or any additive effects in preventing tick attachment. This information is essential for innovative and evidence-based risk communication strategies. By addressing such gaps, public health will be positioned to identify threats in a timely manner and respond accordingly. The evidence also reinforces the importance of being vigilant of all tick bites and subsequent symptoms regardless of tick vector species.

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