Personal Protection

Tick Bite Prevention

Personal protection behaviors, including avoidance and reduction of time spent in tick-infested habitats, using protective clothing and tick repellents, checking the entire body for ticks, and promptly removing attached ticks before transmission of *Borrelia* spirochetes can occur, can be very effective in preventing Lyme disease. However, surveys and the continuing incidence of disease suggest that few people practice these measures with sufficient regularity. Preventive measures are often considered inconvenient and, in the summer, uncomfortable. Despite the efficiency of tick repellents, particularly with DEET applied to skin and permethrin applied to clothing, they are under-utilized.

Checking for ticks and prompt removal of attached ticks is probably the most important and effective method of preventing infection!

Important points to consider in tick bite prevention and checking for ticks include:

Tick Behavior

- Most Lyme disease cases are associated with the bite of the nymphal stage of the blacklegged tick, of which 10-36% may be infected with Lyme disease spirochetes.
- Nymphal blacklegged ticks are very small (about the size of a pinhead), difficult to spot, and are active during the late spring and summer months when human outdoor activity is greatest. The majority (about 75%) of Lyme disease cases are associated with activities (play, yard or garden work) around the home.
- Adult blacklegged ticks are active in the fall, warmer days in the winter, and in the spring when outdoor activity and exposure is more limited. They are larger, easier to spot, and therefore associated with fewer cases of Lyme disease (even though infection rates are higher).
- Ticks do not jump, fly or drop from trees, but grasp passing hosts from the leaf litter, tips of grass, etc. Most ticks are probably picked up on the lower legs and then crawl up the body seeking a place to feed. Adult ticks will, however, seek a host (i.e., deer) in the shrub layer several feet above the ground.
- Children 5-13 years of age are particularly at risk for tick bites and Lyme disease as playing outdoors has been identified as a high-risk activity. Take notice of the proximity of woodland edge or mixed grassy and brushy areas from public and private recreational areas and playing fields. While ticks are unlikely to be encountered in open fields, children chasing balls off the field or cutting through woods to school may be entering a high-risk tick area.
- Pets can bring ticks into the home, resulting in a tick bite without the person being outdoors. A veterinarian can suggest methods to protect your pets. Engorged blacklegged ticks dropping off a pet will not survive or lay eggs in the house, as the air is generally too dry.

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Prevention

- Wear light-colored clothing with long pants tucked into socks to make ticks easier to detect and keep them on the outside of the clothes. Unfortunately, surveys show the majority of individuals never tuck their pants into their socks when entering tick-infested areas. It is unclear just how effective this prevention measure is without the addition of a repellent. Larval and nymphal ticks may penetrate a coarse weave sock. Do not wear open-toed shoes or sandals.
- Use a DEET or permethrin-based mosquito and tick repellent, which can substantially increase the level of protection (see section on repellents). This approach may be particularly useful when working in the yard, clearing leaves, and doing other landscaping activity with a high risk of tick exposure. A separate set of work or gardening clothes can be set aside for use with the permethrin-based clothing tick repellents.
- When hiking, keep to the center of trails to minimize contact with adjacent vegetation.
- Unattached ticks brought in on clothing can potentially result in a later tick bite. Blacklegged ticks can survive for many days in the home depending upon the humidity. In the laboratory, nymphal *I. scapularis* can survive for over 6 months at 93-100% relative humidity (RH), but over half will die in less than 4 days at 65% RH (RH in modern homes is generally <65%). On returning home, remove, wash and dry the clothing. Many blacklegged ticks and lone star ticks can survive a warm or hot water wash, but they cannot withstand one hour in a hot dryer.
- Carefully inspect the entire body and remove any attached ticks (see below). Ticks may feed anywhere on the body. Tick bites are usually painless and, consequently, most people will be unaware that they have an attached tick without a careful check. Also, carefully inspect children and pets. A hypersensitivity reaction to tick bite may aid detection in a few individuals, but most people will be unaware a tick is attached and feeding.

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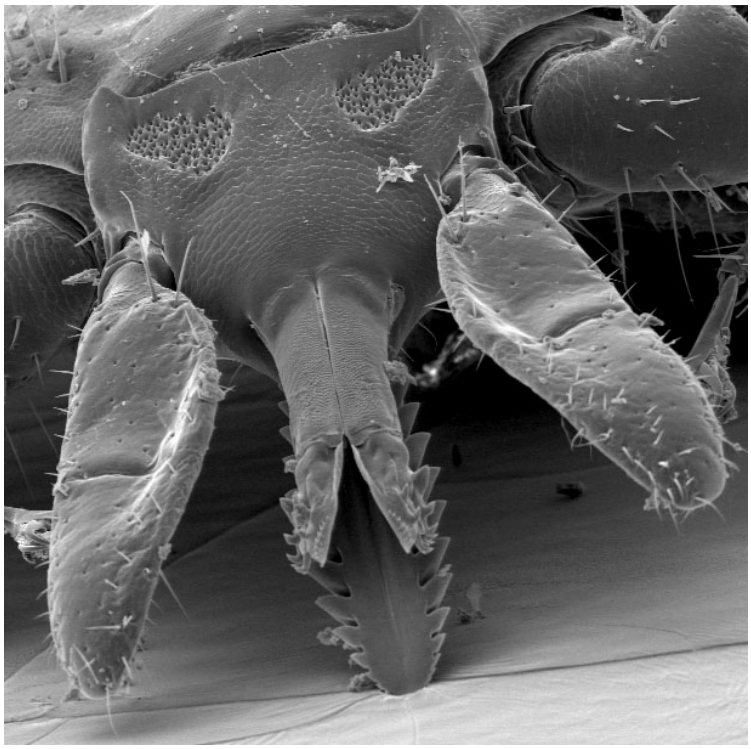
Transmission

- It takes 36-48 hours or more for transmission of *B. burgdorferi* or *B. microti* to occur from an attached tick and not all ticks are infected. Therefore, a tick bite does not necessarily mean a person will get infected. Prompt removal of an attached tick will reduce the chance of infection. However, transmission of the agent of ehrlichiosis can occur within 24 hours.
- Lyme disease may result from an unrecognized tick rather than the tick that was detected and removed, as the primary Lyme disease rash is sometimes found at a different location than the detected tick. It is not unusual to have more than one tick attached at one time.
- In some areas, tick-testing services for the presence of Lyme spirochetes may be available from a government or commercial laboratory. The detection of spirochetes in a tick does not necessarily indicate transmission and an estimate of risk is difficult without a measure or estimate of length of attachment.

How a Tick Bites and Feeds

The term tick bite may be misleading as ticks do not bite and depart or feed rapidly like a mosquito. Ticks attach and feed gradually over a period of several to many days. Once a tick has found a suitable place to feed, it grasps the skin, tilts the body at a 45-60° angle, and begins to cut into the skin with the paired chelicerae. The palps splay outwards on the skin surface. After the chelicerae and hypostome penetrate the skin, they become encased in "cement" secreted by the tick. The cement serves to hold the mouthparts in place while the tick feeds. Mouthparts on larval and nymphal ticks are small with less penetration and produce a smaller host reaction. Adult *Ixodes* and *Amblyomma* ticks have long mouthparts that can reach the subdermal layer of skin, produce a larger reaction, and make the tick harder to remove. Insertion of the mouthparts often takes around 10-30 minutes, but can take longer (1-2 hours). The reaction to a feeding tick may make the tick appear imbedded, but only the slender mouthparts actually penetrate the skin.



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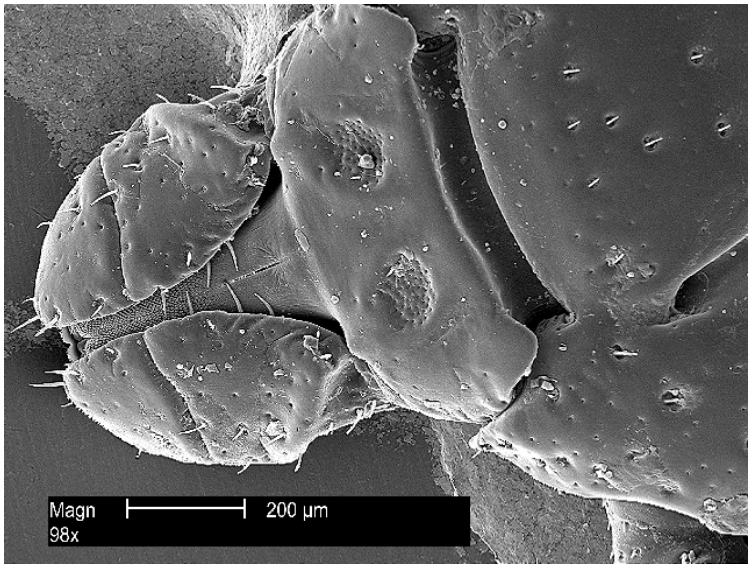

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Scanning electron micrographs of the mouthparts of the blacklegged tick (top) and American dog tick (bottom). On the top picture the two palps are spread apart showing the upper two chelicerae and the lower hypostome bracketing the oral cavity.

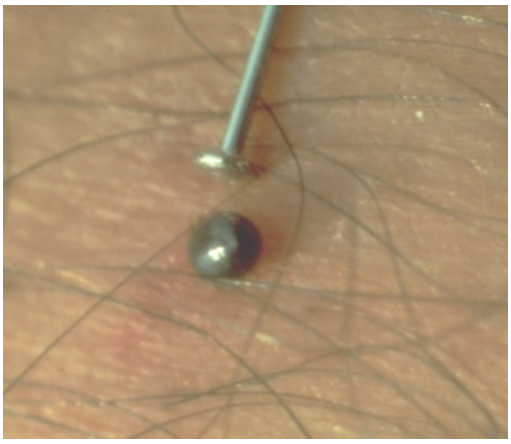
Physical and enzymatic rupture of tissue creates a lesion or cavity under the skin from which blood is imbibed. A variety of pharmacologically active compounds that aid the feeding process and possibly increase pathogen transmission are introduced in the tick's saliva (e.g., blood platelet aggregation inhibitors, anticoagulants, anti-inflammatory and immunosuppressive agents,

enzymes, and vasodilators to increase blood flow). Feeding is not continuous and most of the blood meal is taken up during the last 12-24 hours of feeding. The body weight of a feeding female tick can increase 80-120 times. Male ticks are intermittent feeders, take smaller amounts of blood, and do not change appreciably in size (male *I. scapularis* do not need to feed and are rarely found attached).

The probability of transmission of Lyme disease spirochetes increases the longer an infected tick is attached (0% at 24 hours, 12% at 48 hours, 79% at 72 hours, and 94% at 96 hours in one recent study). The estimated average time for attachment before detection and removal was 30 hours for nymphs and 10 hours for adult ticks, nymphal ticks were twice as likely as adult ticks to be partially engorged.

Tick Removal

To remove a tick, use thin-tipped tweezers or forceps to grasp the tick as close to the skin surface as possible. Pull the tick straight upward with steady even pressure. This should remove the tick with the mouthparts intact. Commercial tick removal devices have been shown to vary widely in their efficacy for removing nymphal blacklegged ticks: some worked in every attempt, some failed in every attempt, some were in between. Tick removal devices that have been shown to successfully remove *I. scapularis* nymphs attached for 48 hours in all attempts in a recent study include #4 forceps, Original Tick Kit (Tick Kit, Inc.), Pick-Tick (Encepur, Chiron), Pro-Tick Remedy (SCS, Ltd.), and the Nick Nipper (Josyln Designs, Inc.). Squeezing the tick will not increase the risk of infection.



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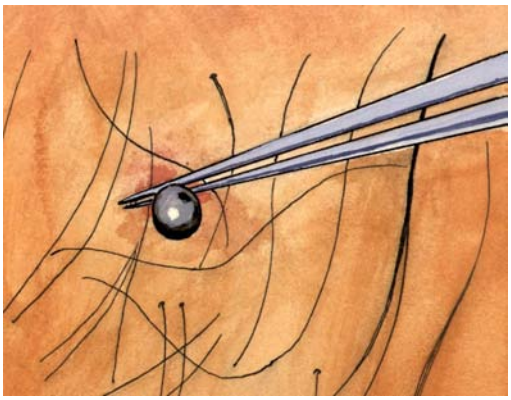
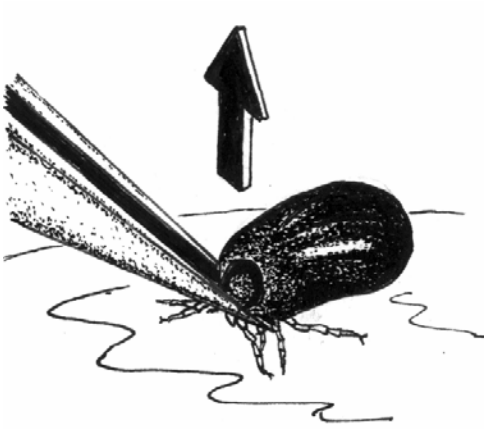


The mouthparts of larval and nymphal ticks will seldom be left in the skin. With proper removal, they usually come out intact. Adult ticks are more difficult to remove intact because of the the longer mouthparts. If the mouthparts break off, it will not change the chance of getting Lyme disease. Spirochetes in the mouthparts or cement plug, and therefore the feeding lesion, means the tick was removed too late and transmission has already occurred. Other methods of tick removal (e.g. petroleum jelly to suffocate the tick, heat from matches to make the tick back out or gasoline or other chemicals) are not effective.



After removing the tick:

- Disinfect the area with alcohol or other skin disinfectant; a topical antibiotic may also be applied.
- Save the tick for reference and in some cases testing (if available). A live tick can be placed in a crush proof container with a blade of grass to keep it alive (a sealable plastic bag will also work). A small plastic vial is best.

Dead ticks are tested by DNA methods and should be held dry in a crush proof container. For long-term storage, ticks are held in 70-80% ethyl alcohol (rubbing alcohol will work). Avoid placing ticks in black film containers or using cellophane tape to mount the tick to paper, a note card or a slide if it needs to be identified or tested. Ticks under cellophane tape are difficult to handle. If the tick is removed by a health professional, ask to keep the tick for future reference or testing.

- Note the site and date of the bite.
- Watch for signs and symptoms of Lyme disease or consider prophylactic treatment if tick is engorged or infected (see below). Watch for evidence of secondary infection.

Localized tick bite reactions develop rapidly and can sometimes resemble a small Lyme disease rash, but these transient reactions generally disappear in 24-48 hours and do not continue to expand like an EM rash. Mouthparts left in the skin may cause irritation as the body attempts to absorb or reject the foreign tick tissue (analogous to a minute splinter that is difficult to remove) with a slight risk of secondary bacterial infection. A foreign body granuloma may persist for weeks, especially if the mouthparts remain. A physician should be consulted if there is evidence of infection.

Tick Bite Prophylaxis

The prophylactic use of antibiotics following a tick bite has not generally been recommended by most medical authorities in the U.S. as the chance of Lyme disease from a known tick bite with *I. scapularis* appears low (< 5%; 0% with flat ticks, 10% with engorged ticks in one study). Only 14-32% of patients diagnosed with Lyme disease remember a feeding tick.

Factors against prophylactic (preventative) treatment:

- The infection status and degree of engorgement of the tick, and therefore the risk of infection, are generally not known. Routine testing of ticks attached <24-36 hours is not necessary.
- Not infrequently, ticks submitted for identification or testing turn out not to be a tick (i.e., a scab, beetle, spider , etc.) or a tick that is not a vector for Lyme disease (better training of physicians or clinic staff to recognize major tick species is important).
- There may be a risk of an adverse reaction to the antibiotic.

Factors in favor of prophylactic (preventative) treatment:

- A single 200 mg dose of doxycycline within 72 hours following a tick bite can prevent Lyme disease. A single dose is less likely to stain teeth in children or produce adverse reactions.
- For a partly or fully engorged blacklegged tick, the risk of infection may be high. It can equal the prevalence of infection in the tick, which can be as high as 36% for a nymphal tick and greater than 60% for an adult tick.
- If a tick is infected (determined by testing at a competent laboratory) and the tick is engorged, infection by Lyme disease spirochetes is highly likely and treatment may be seriously considered. However, results from tick testing may not be available in time for prophylactic treatment or Lyme disease symptoms may already be evident.

Repellents

DEET

The primary active ingredient in most insect/tick repellents today is DEET (N,N-diethyl-3-methylbenzamide, also known as N,N-diethyl-m-toluamide). DEET is the most effective, broad-spectrum repellent ever discovered, effective against mosquitoes, biting flies, chiggers, fleas and ticks. The U.S. Environmental Protection Agency (EPA) estimates that over one-third of the U.S. population will use a DEET-based product. There are approximately 230 products containing DEET registered with the EPA (e.g., *Cutter*, *Off*, *Repel, Muskol, Ben's, Sawyer, and others*). Products range in concentration from 5% to 100% DEET and are available as an aerosol can, pump spray bottle, stick, lotion, cream, or towelette for application to skin or clothing. The duration of activity increases with the concentration used.

There are few firm guidelines on the concentration a consumer should use. The effectiveness of DEET on the skin is influenced by the concentration of DEET, absorption through the skin, evaporation, sweating, air temperature, wind, abrasion of the treated surface by rubbing or washing and the arthropod for which protection is desired. A recent study found that a repellent with 23.8% DEET provided an average of 302 minutes of protection against mosquitoes. Higher concentrations generally provide longer protection, but increasing the concentration does not proportionally increase protection time. Several controlled-release or extended-release DEET formulations have been developed which decrease skin absorption and increase protection time. These products may provide longer protection similar to products with a higher concentration of DEET. All active ingredients and their concentrations are listed on the product label.

DEET and ticks

DEET will repel ticks and decrease the chances of tick bite, but depending upon the concentration, it may not provide total protection against the blacklegged tick. Not all products with DEET are labeled for ticks. Little is known about the effectiveness of different concentrations of DEET against *I. scapularis*. Concentrations of DEET that might discourage tick attachment may not deter a tick from walking across the skin to unexposed and untreated areas. Some protection against tick attachment appears to come from the oily or creamy nature of some products. When applied to clothes, 30% and 20% DEET was found to be 92% and 86% effective against *I. scapularis*, respectively, but skin applications were reported to be only 75 to 87% effective against crawling ticks in a second study. For blacklegged ticks, DEET concentrations around 30 to 40% will probably be most effective for general use. A recent evaluation of repellent products by Consumer Reports found a 33% DEET cream-based formulation was effective against nymphal *I. scapularis* for at least 9 hours, while 100% DEET kept ticks off for up to 4 hours. Lower concentrations of DEET were also found repellent. The effectiveness of various concentrations of DEET against *I. scapularis*, especially higher (>50%) and lower (<20%) concentrations, needs to be examined more closely under natural use conditions.

Safe Use of DEET

DEET has been used by many millions of Americans for 40 years and the incidence of adverse reactions is low. The Environmental Protection Agency (EPA) conducted a review of DEET and believes that normal use of DEET does not present a health concern to the general population when used according to label directions (Reregistration Decision document available from the EPA). Some allergic, toxic, and neurological reactions to DEET have been reported in medical literature, but toxic encephalopathic reactions are rare. Reported adverse reactions appear to have involved high concentrations of DEET, over application of product contrary to label directions, or ingestion of product. Repeated applications have occasionally produced tingling, mild irritation or contact dermatitis. Important points in the safe use of DEET include:

- Follow the directions and precautions given on the repellent label.
- Apply DEET sparingly to exposed skin, and spray on clothing when possible.
- Do not use DEET under clothing or over cuts, wounds, or irritated skin.
- Use the lowest concentration necessary for protection and estimated time of needed protection. Minimize the use of higher concentrations on the skin. Lower concentrations, such as 10% DEET, will provide approximately 2 hours of protection against mosquitoes (but may be less effective against ticks), while a concentration of 24% will provide about 5 hours of protection against mosquitoes.
- A concentration of DEET up to 30% for adults and children over 2 years of age is the maximum concentration currently recommended by the American Academy of Pediatrics (AAP).
- The AAP does not recommend the use of DEET on children under 2 months of age. Apply sparingly to small children.
- AAP precautions suggest DEET should not be used in a product that combines the repellent with a sunscreen as sunscreens are often reapplied periodically. DEET is not water-soluble and will last many hours. Reapplications of DEET may increase the possibility of a toxic reaction to DEET.
- Apply the product to a child yourself. Repellent on a child's hands can end up in the eyes or mouth.
- Wash the hands with soap and water after applying DEET.
- People with certain skin conditions should be cautious about the use of DEET.
- Wash off the repellent with soap and water when returning indoors.
- DEET generally won't harm cotton, wool or nylon. DEET can damage some synthetic fabrics (acetate, rayon and spandex), plastics (watch crystals and eyeglass frames), and car and furniture finishes.
- If you suspect a reaction to DEET (or any other repellent), stop using the product, wash the treated skin, and call a poison control center or contact your physician.

Permethrin-based Repellents

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Several products contain 0.5% permethrin (e.g., *Duranon Tick Repellent, Repel Permanone, Sawyer's Permethrin Tick Repellent, Sawyer's Clothing Insect Repellent,* and others), which is for use only on clothing or other fabrics such as mosquito netting or tents. A synthetic pyrethroid insecticide rather than a true repellent, permethrin works primarily by killing ticks on contact with the clothes and can provide high levels of protection against ticks (and mosquitoes). Permethrin is available as an aerosol spray or pump, mainly in lawn and garden centers or sports stores. Permethrin has a relatively low mammalian toxicity, is poorly absorbed through the skin and is quickly metabolized and excreted by the body, although the EPA does list it as a potential carcinogen. Permethrin can cause mild skin and eye irritation, but reactions appear uncommon. Important points in the safe use of a permethrin repellent include:

- Follow the directions and precautions given on the repellent label.
- Apply to CLOTHING ONLY. Do not apply to skin. Immediately wash with soap and water if you get material on the skin.
- Do not apply to clothing while it is being worn. Apply before you put the clothing on.
- Apply in a well-ventilated area outdoors protected from the wind.
- Lightly moisten the fabric, do not saturate. Allow drying for 2 hours (4 in humid conditions).

- Allow clothing to dry prior to before wearing.
- Do not treat the clothing more than once every two weeks. Launder treated clothing at least once before retreating.

If you suspect a reaction to DEET, permethrin, or any other repellent, stop using the product, wash the treated skin, and call a poison control center or contact your physician.

Botanical and Other Repellents

Botanical products generally provide less protection time against mosquitoes than DEET or permethrin and, though information is limited, are likely to be even less effective against ticks. Many of these products are not labeled for ticks and do not make tick protection claims. Non-DEET products may contain compounds like IR3535 (ethyl butylacetylaminopropionate), or botanical oils such as 0.05% to 15% citronella, 2% soybean oil, or some other plant oil (i.e. eucalyptus, peppermint, lemongrass, geranium or cedar). Consumer Reports found that IR3535 repelled *I. scapularis* nymphs for 3-4 hours, and among plant oils tested, only the soybean oil product offered reasonable protection against mosquitoes (it is not labeled for ticks). Botanical repellents, even if they might reduce tick attachment, probably will not stop a tick from walking across the skin to an unprotected area. Avon's Skin-So-Soft Bath Oil, a widely used folklore mosquito repellent protects against mosquito bites for less than 10 minutes and is unlikely to deter ticks.

Medical and safety information about the active ingredients in an insect repellent is available from:

National Pesticide Information Center by telephone (1-800-858-7378) from 6:30 a.m. to 4:30 p.m. Pacific Standard Time or 9:30 a.m. to 7:30 p.m. Eastern Standard Time, 7 days week, except holidays.

Human Lyme disease vaccine

The Food and Drug Administration (FDA) approved a human Lyme disease vaccine, LYMErix™ (GlaxoSmithKline), which contained recombinant outer-surface protein A (OspA) of *B. burgdorferi*, in December 1998. However, the manufacturer took the vaccine off the market in February 2002 because of declining sales. In clinical trials, vaccine efficacy was 49% after 2 doses for those with definite Lyme disease and 76% after the third dose. Protection in an immunized individual was provided when levels of antibody to OspA in the blood were high enough to neutralize the spirochetes inside a feeding tick before transmission occurred. Protection in vaccinated individuals will wane after a year or two, so protection against Lyme disease in previously vaccinated people will be low to nonexistent. No human Lyme disease vaccine is currently available in the U.S. at this time.