Long-lasting Permethrin Impregnated Uniforms

A Randomized-Controlled Trial for Tick Bite Prevention

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Background: Because of frequent exposure to tick habitats, outdoor workers are at high risk for tick-borne diseases. Adherence to National Institute for Occupational Safety and Health–recommended tick bite prevention methods is poor. A factory-based method for permethrin impregnation of clothing that provides long-lasting insecticidal and repellent activity is commercially available, and studies are needed to assess the long-term effectiveness of this clothing under field conditions.

Purpose: To evaluate the protective effectiveness of long-lasting permethrin impregnated uniforms among a cohort of North Carolina outdoor workers.

Design, setting, and participants: A double-blind RCT was conducted between March 2011 and September 2012. Subjects included outdoor workers from North Carolina State Divisions of Forestry, Parks and Recreation, and Wildlife who worked in eastern or central North Carolina. A total of 159 volunteer subjects were randomized, and 127 and 101 subjects completed the first and second years of follow-up, respectively.

Intervention: Uniforms of participants in the treatment group were factory-impregnated with long-lasting permethrin whereas control group uniforms received a sham treatment. Participants continued to engage in their usual tick bite prevention activities.

Main outcome measures: Incidence of work-related tick bites reported on weekly tick bite logs.

Results: Study subjects reported 1,045 work-related tick bites over 5,251 person-weeks of follow-up. The mean number of reported tick bites in the year prior to enrollment was similar for both the treatment and control groups, but markedly different during the study period. In our analysis conducted in 2013, the effectiveness of long-lasting permethrin impregnated uniforms for the prevention of work-related tick bites was 0.82 (95% CI=0.66, 0.91) and 0.34 (95% CI=−0.67, 0.74) for the first and second years of follow-up.

Conclusions: These results indicate that long-lasting permethrin impregnated uniforms are highly effective for at least 1 year in deterring tick bites in the context of typical tick bite prevention measures employed by outdoor workers.

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Introduction

In the U.S., more than 34,000 cases of tick-borne illnesses including Lyme disease, spotted fever group rickettsioses, ehrlichiosis, and anaplasmosis were reported in 2010.[1] The true incidence is likely to be higher because of under-reporting.[2] The incidence of tick-borne diseases is rising and new tick-borne pathogens are emerging.

Tick-borne diseases are an occupational risk for outdoor workers, particularly among forestry workers.[3] A recent serosurvey of National Park Service employees showed that 22% of employees were seropositive for previous exposure to spotted fever group rickettsiae, 3% for *Ehrlichia chaffeensis*, and 8% for *Anaplasma phagocytophilum*.[4]

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Tick bite prevention methods recommended by the National Institute for Occupational Safety and Health for outdoor workers include wearing light-colored protective clothing (long sleeves, long pants, and a hat); tucking pants into socks or boots; regular application of insect repellent (at least 20% *N*,*N*-diethyl-*meta*-toluamide [DEET]) to exposed skin and clothing; spraying work clothing with permethrin; and thoroughly checking one's body for ticks daily.[5] The most commonly used form of permethrin for clothing treatment is a self-applied permethrin aerosol spray. Under controlled conditions, self-application of permethrin to clothing can provide nearly 100% protection against questing ticks including *Amblyomma americanum*,[6–9] *Dermacentor variabilis*,[6,7] *Ixodes scapularis*,[6,9,10] and *Ixodes pacificus*.[11] This high rate of protection, however, is not sustained over long periods of wear or multiple washings.[8,11] Furthermore, adherence to these recommendations, even among those who work in highly endemic areas for tick-borne disease, appears to be poor.[4,12–14] Thus, more effective and user-friendly tick bite prevention methods are needed.

A factory-based method for long-lasting permethrin impregnation (LLPI) of textiles using a proprietary formulation of permethrin has been shown to retain tick-repellent activity over 70 washes in laboratory studies.[15,16] Clothing treated with this method is commercially available at many outdoor retailers and is a key component of the Department of Defense Insect Repellent System.[17,18] An open-label pilot study was conducted to assess the effectiveness of LLPI clothing for the prevention of tick bites among 16 outdoor workers from the North Carolina Division of Water Quality.[19] Subjects wearing LLPI clothing had 93% fewer tick bites compared to those using standard tick bite prevention measures. To evaluate this intervention in a more rigorous manner, a double-blind RCT of LLPI uniforms was conducted among outdoor workers from North Carolina's Divisions of Parks and Recreation, Forestry, and Wildlife.

Methods

Study Design

A double-blind randomized intervention was conducted to determine whether wearing LLPI uniforms results in fewer tick bites among outdoor workers. The study included follow-up over two tick seasons (March–September 2011 and 2012). The IRB of the University of North Carolina at Chapel Hill approved the study protocol (IRB no. 10-1027). All subjects provided written informed consent.

Participants

Eligible participants included employees of the North Carolina Forest Service, North Carolina Division of Parks and Recreation, North Carolina Wildlife Resources Commission, and North Carolina County and Local Parks and Recreation who worked in eastern or central North Carolina, were aged ≥18 years, spent an average of ≥10 hours/week working outdoors during tick season, and were required to wear a uniform while on the job. Exclusion criteria were pregnancy, being a non-English speaker, or having a known allergy to insecticides. Informational meetings were conducted at state and local parks, forestry, and wildlife offices throughout the study area between October 2010 and April 2011, and eligible employees were invited to enroll. Subjects were assigned a study identification (ID) number upon enrollment and given a small flashlight and six pairs of boot socks as a token of appreciation for their participation. After the first year of follow-up, subjects were given six additional pairs of socks as an incentive to complete the final year of follow-up.

Randomization and Masking

Prior to the start of enrollment, each ID number was assigned to either the treatment or control group through block randomization using block sizes of six, which were generated randomly by computer, with 1:1 allocation for the treatment or control interventions. The randomization list was generated by the study statistician, and none of the study personnel or investigators had access to this list until after data collection was completed.

Intervention

All subjects were asked to send all of their spring and summer work uniforms, including shirts, T-shirts, pants, shorts, hats, and socks, directly to the treatment facility. Once the uniforms were received, all items were labeled with the subject's ID number and either treated with permethrin according to the factory-based proprietary LLPI process for clothing (treatment) or simply washed and dried in a commercial washer/dryer (control). In addition, according to their treatment group, subjects were either given six pairs of treated or untreated boot socks at the start of each tick season. Subjects were instructed to send any new uniforms purchased during the study period to the treatment facility before wearing them. All subjects were instructed to launder their clothing as they normally would and to continue with their usual tick bite prevention measures (including use of repellents).

Data Collection

After providing informed consent, participants completed a baseline questionnaire, which collected demographic and occupational information, history of tick-bites and tick exposure in the past year, history of tick-borne disease, and use of tick bite prevention measures. The follow-up periods consisted of two consecutive tick seasons (2011 and 2012) starting the week of March 15, 2011, or the week the subject started wearing their study uniforms and continuing through the last week of September. During the follow-up periods, all subjects were asked to keep a diary of all tick bites (attached ticks), which were recorded on weekly tick bite logs. For each entry in the log, subjects recorded the date of the tick bite(s), number of tick bites, location of the tick bites on the body, county where the tick bite(s) were most likely to have been acquired, whether they were on the job when the tick bite(s) were acquired, whether they had been using insect repellent at the time of the bite(s) and the type of repellent, and whether the tick(s) were collected.