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Francisella tularensis Exposure Among National Park Service Employees During an Epizootic: Devils Tower National Monument, Wyoming, 2015

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Abstract

Introduction: Tularemia is a zoonotic infection caused by the highly infectious bacterium *Francisella tularensis*. Persons having outdoor professions are more likely than others to be exposed to *F. tularensis* through increased contact with arthropods, infected animals, and contaminated aerosols.

Materials and Methods: After a tularemia epizootic during July and August 2015 at Devils Tower National Monument and an associated tularemia infection in a park employee, we assessed seroprevalence of *F. tularensis* antibodies, risk factors for *F. tularensis* seropositivity, and use of protective measures among park employees.

Results: Seroprevalence among participating employees was 13% (3/23). Seropositive employees reported multiple risk factors for *F. tularensis* exposure through both job-related and recreational activities. Activities reported by more seropositive than seronegative employees included using a power blower (67% vs. 5%, $p = 0.03$), collecting animal carcasses (100% vs. 30%, $p = 0.047$), and hunting prairie dogs recreationally (67% vs. 5%, $p = 0.03$). Seropositive employees reported exposure to more ticks (median 30, range 25–35) than seronegative employees (median 6, range 0–25, $p = 0.001$). Most employees used protective measures (e.g., insect repellent) inconsistently but increased use after receiving educational materials.

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Supplementary Material
Supplementary Data

Conclusions: Educating and enabling at-risk employees to use protective measures consistently, both at work and during recreational activities, can reduce exposure during epizootics.

Keywords

Francisella tularensis; tularemia; national parks; occupational exposure; zoonotic infections

Introduction

Tularemia is a potentially fatal zoonosis caused by the highly infectious bacterium *Francisella tularensis*. Tularemia has various clinical presentations, depending on the route of exposure, and although effective antibiotic therapy has reduced mortality, overall case fatality rates approach 2% (Evans et al. 1985, Dennis et al. 2001, Nigrovic and Wingerter 2008, Nelson et al. 2013). Humans can contract *F. tularensis* through multiple mechanisms, including arthropod bites, contact with infected animal tissue, and inhalation of contaminated aerosols (Nigrovic and Wingerter 2008, Nelson et al. 2013, Penn 2015). Human cases of tularemia have been temporally and spatially associated with epizootics among susceptible animals that include lagomorphs and rodents (Seys et al. 2005, Petersen et al. 2008, Calanan et al. 2010). Persons having outdoor professions and who recreate outdoors are more likely than others to be exposed to *F. tularensis* through increased contact with arthropods, infected animals, and contaminated aerosols (Philip et al. 1967, Feldman et al. 2001, 2003, Nigrovic and Wingerter 2008, Nelson et al., 2013).

Tularemia occurs throughout the continental United States, with highest incidence in central and western states (Nelson et al., 2013). *F. tularensis* subspecies tularensis and subspecies *holarctica* cause nearly all human tularemia cases (Staples et al. 2006, Penn 2015). Infection with subspecies tularensis, typically associated with lagomorph exposure, results in more severe disease and higher mortality than infection with subspecies holarctica, which is typically associated with rodent exposure (Staples et al. 2006).

During 2005–2014, the crude incidence rate of tularemia in Wyoming was 0.37 cases per 100,000 persons. During 2015, the incidence of tularemia in Wyoming and surrounding states increased substantially (Pedati et al. 2015). Twenty-one cases of tularemia were reported in Wyoming during 2015, a crude incidence rate of 3.6 cases per 100,000 persons (Wyoming Department of Health 2016).

Devils Tower National Monument (DETO) encompasses 1347 acres in northeastern Wyoming. During July 2015, National Park Service (NPS) officials noted eight dead voles in multiple areas of the park; this was an unusually high number, as it is rare to find any vole carcasses on the landscape without an obvious cause of traumatic or predation death. Tissues from four vole (*Microtus spp*.) and two black-tailed prairie dog (*Cynomys ludovicianus*) carcasses collected from the park during July to August tested positive for *F. tularensis* by PCR at a referral laboratory (NPS unpublished data). *F. tularensis* isolated from two vole and two prairie dog carcasses was identified as *F. tularensis* ssp. *holarctica* by the Bacterial Diseases Branch, Diagnostic and Reference Laboratory (BDB DRL) at the Centers for Disease Control and Prevention (CDC) Division of Vector-Borne Diseases using subspecies-specific PCR and glycerol fermentation (WHO 2007). Tick collection and testing were not conducted. During July, NPS One Health Office and DETO staff distributed tularemia educational materials to employees through email.

In July 2015, a DETO employee developed fever and was confirmed to have tularemia by paired serologic testing, with a negative *F. tularensis* antibody titer on July 14, 2015 and a titer of 1:2048 on August 7, 2015. Two additional cases of tularemia among non-NPS employees were also identified in the county surrounding DETO during the summer of 2015.

NPS employees can be at increased risk for tularemia and other zoonoses because of extensive amounts of time spent outdoors for work-related activities (*e.g.*, handling animal carcasses and landscaping areas with potential *F. tularensis* contamination) (Adjemian et al. 2012). Defining NPS employee risk for acquiring tularemia during a local active epizootic and patterns of protective measure use would facilitate response planning and improve understanding of occupational risk during both epizootics and periods of baseline *F. tularensis* activity. Objectives of this investigation were to determine the proportion of DETO employees who were seropositive for antibodies against *F. tularensis*, characterize risk factors associated with seropositivity, and assess protective measure use.

Materials and Methods

Study population

All 44 current DETO employees were invited to participate in the investigation. At the time of the investigation, 36 NPS paid employees, 3 NPS volunteer employees, and 5 concessions employees worked at DETO.

Data collection

Initial data collection from participating employees who provided informed consent occurred during September 1–2, 2015. Participants completed a standardized, 42-item, written questionnaire addressing demographics, employment history, work-related duties, outdoor activities (leisure and work-related), animal and arthropod exposure, use of protective measures, and illness history (Supplementary Data).

Serum samples were collected from participants at the time of survey completion. The BDB DRL conducted *F. tularensis* serology using microagglutination (WHO 2007); single titers of ≥ 1:128 were considered positive. During October 2–7, 2015, investigators obtained serum samples for repeat serologies from seropositive employees at the initial test and employees who had intercurrent illness or high-risk exposures. Repeat serum samples were tested alongside initial samples.

Case–control study

A case–control study was conducted to characterize risk factors associated with *F. tularensis* seropositivity among DETO employees. A case was defined as an employee who worked at DETO during July and/or August who was seropositive for *F. tularensis* (single titer ≥ 1:128) and a control as an employee who worked at DETO during the same period who was seronegative for *F. tularensis* (single titer <1:128).

Data analysis

Survey data were entered into a standardized database using Epi Info 7.1.5.0, then imported into SAS 9.2 (SAS Institute, Inc., Cary, NC) for analysis. For the case–control study, odds ratios (ORs) and associated exact 95% confidence intervals (CIs) were determined for dichotomous variables; Fisher's exact test was used to compare frequencies between seropositive and seronegative employees. The Mann– Whitney exact *U* test was used to compare continuous numeric variables between seropositive and seronegative employees. Values of $p < 0.05$ were considered statistically significant.

This investigation was reviewed by CDC for human subject protection and determined to be nonresearch.

Results

Participation and demographic information

Twenty-four of 44 (55%) employees participated in the serosurvey and completed the questionnaire. One employee sample was misplaced and could not be tested; therefore, 23 (52%) employees were included in the analysis. One participating employee was the patient diagnosed with tularemia in August. That employee completed the questionnaire but was not asked for a serum sample because *F. tularensis* infection had previously been confirmed. Of the 23 employees included in the analysis, most were men (13/23), between the ages of 21 and 40 years (16/23), and worked in the Resource Management Division (8/23) or Facility Management Division (6/23) (Table 1).

Serosurvey

Two employees had single positive antibody titers against *F. tularensis*, and their titers were 1:128 and 1:512, respectively. The overall frequency of *F. tularensis* seropositivity among participating DETO employees was 3 of 23 (13%), including the previously diagnosed employee. Neither of the two seropositive employees identified in the serosurvey reported ever being diagnosed with tularemia, being diagnosed with pneumonia or having a festering sore in the 3 years before, or having a febrile illness during the past 3 months.

All three seropositive employees were DETO paid employees (Table 1). All three also worked for NPS during previous years at DETO and other parks. All seropositive employees reported contact with wild rodents, including prairie dogs, either through the job duty of collecting animal carcasses at DETO or recreational hunting outside the park (Table 2). All seropositive employees reported ticks crawling on their clothes or bodies during the previous 3 months (Table 2).

Second serum samples were tested from eight employees as follows: two employees found to be seropositive on initial serosurvey and six employees who were seronegative on the initial serosurvey who reported either possible *F. tularensis* exposure ($n = 3$), intercurrent illness ($n = 2$), or both ($n = 1$) since the initial blood draw. Those with possible *F. tularensis* exposure had participated in a prairie dog relocation project within DETO. Titers of the two seropositive employees were unchanged, and none of the initially seronegative employees seroconverted.

Case–control study

The case–control study included the three seropositive employees as cases and 20 seronegative employees as controls. No significant differences were reported between seropositive and seronegative employees in sex, age, housing status, division of employment, hours worked per week outdoors, or employment history before working at DETO (Table 1).

Three types of animal exposures were associated with seropositivity (Table 2). A higher frequency of seropositive than seronegative employees reported touching dead mice with gloves (2/3 vs. 1/20; OR = 38.0, exact 95% CI = 0.8–2349.5; $p = 0.034$); one seropositive employee performed this activity both at DETO and at home, whereas the other seropositive employee and the seronegative employee performed this activity at DETO only. Hunting prairie dogs recreationally outside the park was also associated with seropositivity (2/3 vs. 1/20, OR = 38.0, exact 95% CI = 0.8–2349.5, $p = 0.034$). Prairie dog hunting is often recreational, and none of the hunters reported physical contact with prairie dog carcasses. Collecting animal carcasses was the third type of animal contact associated with seropositivity (3/3 vs. 6/20, OR = undefined, $p = 0.047$); one seropositive employee reported collecting animal carcasses at DETO and at home, whereas other employees performed this activity at DETO only. Contact with rabbits was uncommon and not associated with seropositivity (Table 2).

A higher frequency of seropositive employees than seronegative employees reported using a power blower (2/3 vs. 1/20, OR = 38.0, 95% CI = 0.8–2349.5, $p = 0.034$). All employees who used a power blower did so at DETO only. No other work-related or recreational activities were associated with seropositivity (Table 3).

No differences were observed between the proportions of seropositive and seronegative employees who reported any tick exposure (both groups reported ticks crawling on their bodies or clothes and ticks attached to their skin) (Table 2). Seropositive employees, however, reported a median of 30 ticks (range, 25–35) crawling on their skin or clothing during the previous 3 months, significantly higher than the median number of 6 (range, 0–25) reported by seronegative employees ($p = 0.001$). No significant difference in the number of ticks attached was reported between seropositive and seronegative employees. No other arthropod or insect exposures were associated with seropositivity (Table 2).

We compared the frequencies of seropositive and seronegative employees who reported always using individual protective measures and found no significant differences (Table 4). Among both seropositive and seronegative employees, none reported always wearing insect repellent or always wearing a mask when performing outdoor work, including landscaping activities. All three seropositive staff, however, reported always wearing gloves when handling live animals or carcasses, compared with 5 of 10 (50%) seronegative employees who performed this activity (OR = undefined; $p = 0.23$).

Most participating employees (15/23; 65%), including all three seropositive employees, reported increasing their use of protective measures after learning about the presence of tularemia at DETO. The most commonly reported behavior change was increased protections against insect and arthropod bites (8/15; 53%), followed by cleaning hands more frequently (7/15; 47%). Furthermore, four of eight employees who used a lawnmower to mow grass reported they began checking areas for animal carcasses before mowing. None of the employees reported wearing a mask more frequently for outdoor work or wearing gloves more often when handling either live or dead animals. When asked what influenced them to increase protective measures, employees most commonly reported NPS educational materials (10/15; 67%), supervisor recommendations (7/15; 47%), and emails for all employees (6/15; 40%).

Discussion

This is the first investigation to describe the seroprevalence of anti-*F. tularensis* antibodies and risk factors for *F. tularensis* seropositivity among NPS employees after a local epizootic. We observed that employees were at risk for seroconversion through multiple work-related activities while using protective measures inconsistently; these findings have implications for ensuring employee safety during future epizootics.

Seroprevalence of anti-*F. tularensis* antibodies was 13% among 23 DETO employees after an epizootic of *F. tularensis* ssp. *holarctica* among wild voles and prairie dogs. A previous seroprevalence study of NPS employees at Great Smoky Mountains and Rocky Mountain National Parks reported that only 1 of 135 (0.7%) were seropositive for antibodies to *F. tularensis* at baseline, with no incident infections over the year of study (Adjemian et al. 2012). The greater seropositivity among DETO employees indicates possible evidence of increased risk of *F. tularensis* exposure during an active epizootic. The seroprevalence among DETO employees is comparable with that noted in other studies of persons with occupational risk for tularemia exposure. Using the same titer cutoff of ≥ 1:128, investigators reported the seroprevalence among landscapers on Martha's Vineyard after 2 years of increased local *F. tularensis* transmission was9.1% (Feldman et al. 2003). Estimates of *F. tularensis* seroprevalence among North American trappers range from 2.4% to 17%, although testing standards vary (Philip et al. 1967, Heidt et al. 1985, Levesque et al. 1995). In contrast, seroprevalence among U.S. populations without occupational exposure risk has been found to be ≤ 1% (Engelfried 1968, Feldman et al. 2003).

NPS employees are at risk for acquiring zoonotic and vector-borne diseases through occupational arthropod and wildlife exposure (Boyer et al. 1977, Paul et al. 2002, Wong et al. 2009, Adjemian et al. 2012, Geissler et al. 2014, Kosoy et al. 2016). Exposure to ticks, work-related activities involving exposure to potentially contaminated aerosols and possibly infected animals, and hunting prairie dogs recreationally were all associated with *F. tularensis* seropositivity among DETO employees. The individual contribution of each risk factor to *F. tularensis* seropositivity at DETO is difficult to distinguish because any job-related or recreational activity performed outdoors also increased the risk of tick exposure. The employee with clinical tularemia presented with systemic illness without a clear route of infection. Small sample size precluded multivariate analyses.

This investigation underscores the difficulty in distinguishing between occupational and recreational exposures. Although the epizootic was detected in DETO, it was unlikely restricted to park borders, indicated by two human cases of tularemia reported among residents of the surrounding county during 2015. DETO employees lived in or near the park, participated in recreational activities (*e.g.*, hunting in the area), and in some cases, performed similar land maintenance activities (*e.g.*, animal carcass removal), both at DETO and on their personal properties.

Although one of the three seropositive DETO employees had clinical tularemia, two did not report ever being diagnosed with tularemia or having recent symptoms compatible with tularemia. Because the titers among these two employees were stable, the possibility exists that they were infected before the summer of 2015, and do not remember being ill. The presence of anti-*F. tularensis* antibodies in persons who do not recall having an illness compatible with tularemia has been reported in numerous studies (Philip et al. 1967, Engelfried 1968, Levesque et al. 1995, Feldman et al. 2003), and anti-*F. tularensis* antibodies can persist for many years after infection (Evans et al. 1985, Koskela and Salminen 1985). Infection with the less virulent strain, *F. tularensis* subsp. holarctica, which was isolated from rodent carcasses found in DETO, might be more likely to result in subclinical illness than infection with subsp. *tularensis* (Levesque et al. 1995). Evidence from Martha's Vineyard, however, where only subsp. *tularensis* was identified, indicates that this more virulent strain can also be associated with subclinical infection (Feldman et al. 2003).

The association of multiple job-related and recreational activities with seropositivity indicates the importance of consistent and proper use of protective measures. CDC recommends using insect repellent when working outdoors and wearing gloves when handling sick or dead animals to protect against *F. tularensis* infection by arthropod and percutaneous exposure (www.cdc.gov/tularemia/prevention/index.html)(CDC 2015). Our investigation demonstrated that DETO employees used insect repellent inconsistently but used gloves more consistently. Our results are consistent with previous surveys of protective measure use among larger groups of NPS employees. Bosch et al. (2013) conducted a survey of more than 200 NPS employees at 131 NPS units and found that only 14% reported always using insect repellent, whereas 85% and 68% reported always wearing gloves when handling sick animals and animal carcasses, respectively. Adjemian et al. (2012) reported only 44% of NPS employees at two units reported ever using insect repellent while at work.

Inhalation of aerosolized *F. tularensis* is also a mechanism of infection (McCarthy and Murphy 1990, Feldman et al. 2003). As in Martha's Vineyard, we found that using a power blower was associated with *F. tularensis* seropositivity, suggesting that aerosolization might have played a role in transmission at DETO. Although tularemia prevention while using a power blower was not specifically addressed, DETO had incorporated strategies to prevent inhalation of contaminated aerosols generated while mowing at the time of investigation, including instructing employees to check for and remove carcasses before mowing and to cease mowing infrequently mowed areas. Few employees, however, reported wearing protective masks while performing aerosol-generating landscaping activities such as using a power blower or mowing. Although masks covering the nose and mouth would likely protect workers against inhalation of *F. tularensis*-contaminated aerosols, no assessments of the effectiveness of various types of masks in preventing *F. tularensis* exposure are published (Feldman et al. 2003, www.cdc.gov/tularemia/prevention/index.html CDC 2015). In settings where occupational exposure to contaminated aerosols is possible, employees should be in formed of the risks and potential benefits of respirator use and given the opportunity to voluntarily wear N95 filtering facepiece respirators approved by the National Institute for Occupational Safety and Health through employer-sponsored respiratory protection programs.

Most DETO employees increased use of protective measures after receiving written and verbal information from NPS and their supervisors. In the survey conducted by Bosch et al. (2013), similar factors were associated with increased protective measure use, and NPS workers also reported that having protective equipment stocked and accessible would facilitate use. Although protective measure use among NPS employees is inconsistent at baseline, it can be improved by using educational materials, effective supervisor communication, and providing readily available equipment. These measures are especially important during active epizootics; however, because human cases occur in the absence of identified epizootics, employees should be encouraged to use them at any time they are performing an activity with potential risk of exposure.

Identification of the epizootic within DETO enabled NPS officials to provide timely information to employees regarding preventive measures. DETO had an established wildlife surveillance system that facilitated detection of the epizootic, which included weekly visual wildlife counts throughout the summer by an NPS biologist and submission of carcasses to a reference laboratory for examination and testing for multiple pathogens. After the vole deaths were observed, the biologist conducted enhanced surveillance for prairie dog deaths by regularly walking the perimeter of the colony. Protocols for identifying, collecting, and testing animal carcasses facilitate timely identification of epizootics to inform public health interventions and should be encouraged.

This investigation has multiple limitations. Twenty-one of 44 (48%) DETO employees were not included in the study; thus, our results are not representative of all employees. We could not specify any one method of exposure because of the low number of cases and common exposures among employees. Titers among the two seropositive employees without illness did not change in the interval between first and second sample collection, and exposure information before the current epizootic was not obtained. Therefore, we were unable to determine whether employees were exposed to *F. tularensis* at DETO during the summer of 2015 or before.

Conclusions

This investigation reports that NPS employees are at occupational and recreational risk of exposure to *F. tularensis* during epizootics and should be a focus of public health prevention measures. NPS and other organizations with outdoor workers should educate employees about potential risks and encourage and enable employees to use protective measures consistently, especially during active epizootics.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

Acknowledgments

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Table 1.

Demographic Characteristics Among Employees Seropositive and Seronegative for Antibodies Against *Francisella tularensis*—Devils Tower National Monument, September 2015

Characteristic	Seropositive (*N*=3)	Seronegative (*N*=20)	*P*[a]	OR (exact 95% CI)
Male, *n* (%)	2 (67)	11 (55)	1.000	1.6 (0.07–107.1)
Age in years,[b] *n* (%)			0.651[c]	
≤ 20	0 (0)	1 (5)		
21–40	2 (67)	14 (60)		
41–60	1 (33)	1 (5)		
≥ 61	0 (0)	4 (20)		
Park Housing, *n* (%)	1 (33)	10 (50)	1.000	0.5 (0.01–11.4)
Job type, n (%)				
Permanent full-time	1 (33)	4 (20)	0.539	2.0 (0.03–47.0)
Term or seasonal	2 (67)	11 (55)	1.000	1.6 (0.07–107.1)
Volunteer	0 (0)	3 (15)	1.000	0.0 (0.0–13.7)
Contractor or student	0 (0)	2 (10)	1.000	0.0 (0.0–26.1)
Division, *n* (%)				
Facility Management	2 (67)	4 (20)	0.155	8.0 (0.3–500.4)
Interpretation	0 (0)	1 (5)	1.000	0.0 (0.0–126.7)
Visitor and Resource Protection	0 (0)	3 (15)	1.000	0.0 (0.0–13.7)
Resource Management	1 (33)	7 (35)	1.000	0.9 (0.01–21.0)
Entrance Station	0 (0)	3 (15)	1.000	0.0 (0.0–13.7)
Concessions	0 (0)	1 (5)	1.000	0.0 (0.0–126.7)
Hours worked outdoors per week, median (range)	38 (31–62)	25 (8–54)[d]	0.109[c]	
Worked for NPS during previous years, *n* (%)	3 (100)	14 (70)	0.539	Undefined
Held previous outdoor jobs, including NPS, *n* (%)	3 (100)	16 (80)	1.000	Undefined

[a]Fisher's exact test unless otherwise indicated.

[b]Presented in age categories to protect identities because of small numbers.

[c]Mann–Whitney exact *U* test.

[d] $n = 19$.

CI, confidence interval; NPS, National Park Service; OR, odds ratio.

Table 2.

Animal Exposure Among Employees Seropositive and Seronegative for Antibodies Against *Francisella tularensis*—Devils Tower National Monument, September 2015

Animal contact	Seropositive, *N*=3	Seronegative, *N*=20	*P*[a]	OR (exact 95% CI)
Any wild rodent contact, *n* (%)	3 (100)	10 (50)	0.229	Undefined
Wild rodent type				
Prairie dog	3 (100)	7/19 (37)	0.078	Undefined
Vole	1 (33)	4/19 (21)	1.000	1.9 (0.02–44.3)
Mouse	2 (67)	2/19 (11)	0.073	17 (0.5–1058.6)
Contact type				
Touched live rodent no gloves	0 (0)	1 (5)	1.000	0.0 (0.0–126.7)
Touched live rodent with gloves	0 (0)	0 (0)	—	—
Touched dead rodent no gloves	0 (0)	0 (0)	—	—
Touched dead rodent with gloves	2 (67)	3 (15)	0.107	11.3 (0.4–706.2)
Prairie dog	1 (33)	2 (10)	0.356	4.5 (0.05–123.3)
Vole	1 (33)	2 (10)	0.356	4.5 (0.05–123.3)
Mouse	2 (67)	1 (5)	0.034	38 (0.8–2349.5)
Hunting prairie dogs recreationally	2 (67)	1 (5)	0.034	38 (0.8–2349.5)
Any wild rabbit contact, *n* (%)	0 (0)	3 (15)	1.000	0.0 (0.0–13.7)
Collected animal carcasses, *n* (%)	3 (100)	6 (30)	0.047	Undefined
Any ticks crawling on body or clothing, *n* (%)	3 (100)	15/19 (79)	1.000	Undefined
Number of ticks crawling on body or clothing, median (range)	30 (25–35)	6 (0–25)[b]	0.001[c]	
Any ticks attached to body, *n* (%)	2 (67)	9 (45)	0.590	2.4 (0.1–157.1)
Number of ticks attached to body, median (range)	1 (0–10)	0 (0–3)	0.326[c]	
Deerfly bite, *n* (%)	0 (0)	1 (5)	1.000	0.0 (0.0–126.7)
Horsefly bite, *n* (%)	1 (33)	1 (5)	0.249	9.5 (0.08–783.2)
Flea bite, *n* (%)	0 (0)	3 (15)	1.000	0.0 (0.0–13.7)
Midge or No-see-um bite, *n* (%)	1 (33)	6 (30)	1.000	1.2 (0.02–26.5)
Mosquito bite, *n* (%)	3 (100)	17 (85)	1.000	Undefined

[a]Fisher's exact test unless otherwise specified.

[b] $n = 19$.

[c] Mann–Whitney exact *U* test.

Table 3.

Land Maintenance Activities Among Employees Seropositive and Seronegative for Antibodies Against *Francisella tularensis*—Devils Tower National Monument, September 2015

Activity	Seropositive (*N*=3) *n* (%)	Seronegative (*N*=20) *n* (%)	P^a	OR (exact 95% CI)
Mowing	2 (67)	6 (30)	0.269	4.7 (0.2–294.5)
Weed whacking	2 (67)	4 (20)	0.155	8.0 (0.30–500.4)
Raking grass clippings	0 (0)	3 (15)	1.000	0.0 (0.0–13.7)
Using a chainsaw	1 (33)	1 (5)	0.249	9.5 (0.08–783.2)
Construction	2 (67)	4 (20)	0.155	8.0 (0.30–500.4)
Mulching	0 (0)	0 (0)	—	—
Brush cutting	1 (33)	1 (5)	0.249	9.5 (0.08–783.2)
Using a power blower	2 (67)	1 (5)	0.034	38 (0.8–2349.5)
Working with hands in soil	3 (100)	8 (40)	0.093	Undefined
Hosing off outdoor structures/surfaces	2 (67)	3 (15)	0.107	11.3 (0.4–706.2)
Cleaning mowers/lawn equipment	2 (67)	5 (25)	0.210	6.0 (0.2–376.9)
Using powered digging equipment	2 (67)	2 (10)	0.067	18 (0.5–1117.5)
Mowing or weed whacking over dead animals	0 (0)	1 (5)	1.000	0.0 (0.0–126.7)

[a] Fisher's exact test.

Table 4.

Comparison of Protective Measures Always Used Between Employees Seropositive ($N = 3$) and Seronegative ($N = 20$) for Antibodies Against *Francisella tularensis*—Devils Tower National Monument, September 2015

Protective measure	Seropositive No. of responses (%)	Seronegative No. of responses (%)	P^a	OR (exact 95% CI)
Wearing a mask during outdoor work	0/3 (0)	0/16 (0)	—	—
Wearing gloves when handling animals	3/3 (100)	5/10 (50)	0.230	Undefined
Wearing insect repellent	0/3 (0)	0/20 (0)	—	—
Wearing long pants	3/3 (100)	12/19 (63)	0.523	Undefined
Wearing long sleeves	1/3 (33)	3/18 (17)	0.489	2.5 (0.03–61.9)
Performing tick checks	3/3 (100)	12/20 (60)	0.526	Undefined
Cleaning hands after outdoor work	1/3 (33)	10/17 (59)	0.566	0.4 (0.01–8.4)
Cleaning hands after touching live animals	2/3 (67)	3/7 (43)	1.000	2.7 (0.08–196.0)
Cleaning hands after touching dead animals	3/3 (100)	7/8 (88)	1.000	Undefined
Cleaning hands before eating or drinking	1/3 (33)	9/19 (47)	1.000	0.6 (0.01–12.8)

[a] Fisher's exact test.