From the Field: An occupational safety program for wildlife professionals involved with bovine tuberculosis surveillance

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Abstract The discovery of bovine tuberculosis (caused by *Mycobacterium bovis*) in white-tailed deer (*Odocoileus virginianus*) and other free-ranging Michigan wildlife has made ongoing surveillance for the disease a reality for wildlife professionals. The wide susceptibility of mammals, including humans, to *M. bovis* led us to be concerned with the potential risks of acquiring tuberculosis that Michigan Department of Natural Resources staff face in their occupational activities. Consequently, we developed a bovine tuberculosis occupational safety program for our staff and volunteer cooperators taking part in disease surveillance. Close similarities between bovine and human tuberculosis allowed occupational safety principles used in human health care to be used as a guide. We produced an occupational safety training document to educate personnel about bovine tuberculosis in humans, evaluate the risk posed by job duties, and make recommendations on risk mitigation. Following implementation, the National Institute for Occupational Safety and Health conducted field evaluations of the occupational safety program that validated its protectiveness for workers. As wildlife disease surveillance becomes a greater responsibility for management agencies across the United States, we believe the lessons learned in development of the Michigan program can be widely adapted to other areas and potentially to other diseases, and can raise awareness of occupational exposure to zoonotic diseases.

Key words bovine tuberculosis, *Mycobacterium bovis*, occupational safety, wildlife disease surveillance

Mycobacterium bovis infection (often called bovine tuberculosis [bTB], in reference to the species which is its historic maintenance host and which introduced the disease to North America) is a chronic bacterial disease that can affect domestic livestock, wildlife, and humans (O'Reilly and Daborn 1995). It is very closely related to *M. tuberculosis*, the causative agent of human tuberculosis (hTB). The principal routes of bTB transmission are inhalation and ingestion, with wound inoculation and congenital transmission possible but rare. Although programs to control the disease have been a priority for decades in many parts of the world, bTB is still widely present in livestock outside Europe and North America (Meslin and Cosivi 1995). In affected areas human illness and death due to bTB remain a major public health problem, particularly in immunocompromised individuals. In areas where it has spread from livestock to free-ranging wildlife, bTB can maintain itself and act as an ongoing reservoir of infection for other wildlife, humans, and transmission back to livestock (de Lisle et al. 2002).

In 1994 a 4.5-year-old, hunter-harvested, free-ranging male white-tailed deer (*Odocoileus virginianus*) from Alpena County in northeastern lower Michigan, USA, was diagnosed with bTB (Schmitt et al. 1997). It was the second deer from the area diagnosed with the disease in 20 years; the cases were harvested only 13 km apart. At the time, wildlife managers with the Michigan Department of Natural Resources (MDNR), as well as wildlife disease experts elsewhere (Nettles 1997), believed the cases were likely to be isolated. Sadly, they were not. That initial discovery of enzootic bTB proved to be a watershed and has drastically altered the work activities of MDNR Wildlife Division staff. Since then, the formidable scientific, political, social, and logistical challenges of large-scale disease surveillance and control responsibilities have become a sobering reality (de Lisle et al. 2002).

The principal concern of MDNR with bTB is its maintenance in wild populations and risks of transmission to and from livestock. However, the wide susceptibility of mammals to *M. bovis* (Francis 1958, Grange and Collins 1987, O'Reilly and Daborn 1995) and, more specifically, the ability for humans to be infected by contact with animals (Grange and Yates 1994), including cervids (Fanning and Edwards 1991), led us to be concerned about the occupational risks MDNR staff might face in their ongoing bTB surveillance activities. Occupational safety issues related to transmission of bTB have been explored extensively, particularly in health-care settings (e.g., Centers for Disease Control and Prevention [CDC] 1994). However, little treatment of occupational safety issues for bTB apparently exists, and none specific to exposure situations faced by wildlife professionals. Consequently, our objective was to develop a bTB occupational safety program for MDNR staff and volunteer cooperators taking part in wildlife disease surveillance. We describe the development and implementation of that program here.

Context and intended audiences

In Michigan, primary responsibility for monitoring and control of disease in free-ranging wildlife falls to the MDNR Wildlife Division. Staff at 48 field offices located across the state typically have the first contact with sick or dead animals, having collected them themselves or through contacts with the public. Specimens for surveillance and diagnosis are delivered to the Rose Lake Wildlife Disease Laboratory (RLWDL) in the south-central Lower Peninsula, where diagnostic tests and postmortem examinations are performed. Diagnoses are documented and archived for historical purposes. The RLWDL employs 2 veterinarians, a wildlife biologist–pathologist, 2 laboratory scientists, several technicians, and seasonal workers.

To document the intensity of bTB in free-ranging wildlife and its geographic distribution, as well as to broadly assess the risk for transmission to cattle and humans, large-scale testing of deer, elk (*Cervus elaphus nelsoni*), and 16 species of noncervids (principally of the Order *Carnivora*) has taken place since 1996. Methodologies used for surveillance (Bruning-Fann et al. 2001, O'Brien et al. 2002) and diagnosis (Fitzgerald et al. 2000) of bTB, as well as findings (O'Brien et al. 2001, 2002; Schmitt et al. 2002), are detailed elsewhere. Very briefly, heads and carcasses of hunter-harvested or found dead deer, elk, and noncervids are collected and bagged in the field, stored for a brief period (~2–3 days during firearm season), concentrated at regional sites, and transported to RLWDL by pickup trucks. The location and date of collection, species, age, and sex of each specimen is recorded, after which specimens are transported to the Animal Health Diagnostic Laboratory (AHDL) at Michigan State University, where most postmortem exams occur. Some necropsies are performed at RLWDL.

Because of the large number of specimens processed (averaging approximately 15,000 deer, 160 elk, and 220 noncervids per year since 1996), sample handling is not limited to scientific and technical staff. During firearm deer season, virtually all of the 178 Wildlife Division employees are involved in checking deer and collecting specimens for bTB surveillance, staff whose normal job assignments range from seasonal laborers and clerical staff to managers. Other groups working with, or in place of, Division personnel are potentially exposed to bTB as well. These include state employees outside the Wildlife Division who share MDNR facilities, volunteers working with Division staff at deer check stations, state and county transportation employees who have contact with road-kills, AHDL staff and students, deer processors, and, to a lesser extent, taxidermists and the general public.

Development of an occupational safety document

Following internal discussions, we determined that the cornerstone of the bTB occupational safety program would be a training document. The document needed to educate personnel about the biology, epidemiology, diagnosis, and treatment of bTB in humans, evaluate job duties performed by Division employees and risk of exposure to bTB that each entailed, and make general and job-specific recommendations on how exposure risks could be mitigated. It also was important that it be understandable to all employees despite diverse educational backgrounds. Extensive conversations with personnel of agencies involved in infectious disease surveillance (for example, the National Animal Disease Center, Animal and Plant Health Inspection Service, and Food Safety Inspection Service of the United States Department of Agriculture, and the Centers for Disease Control and Prevention) failed to identify an existing bTB safety document suitable for adaptation to a wildlife management context. However, the extensive work on hTB occupational safety in health-care settings was apparent (CDC 1994, National Institute for Occupational Safety and Health [NIOSH] 1995, 1996). Because bTB and hTB are closely related taxonomically and the signs of disease they cause in infected humans are clinically indistinguishable (Grange and Collins 1987, Grange and Yates 1994, O'Reilly and Daborn 1995), occupational safety measures designed to prevent hTB exposure were considered likely to prevent bTB exposure as well. These 2 factors provided the keys to move forward with document development.

The document was organized into 3 principal sections devoted to a description of tuberculosis in humans, the steps necessary for bTB to be transmitted in a work setting, and recommendations for occupational safety. In describing the disease, we concentrated on explaining its characteristics in humans, how some individuals (for example, with predisposing medical conditions) are at a greater risk of contracting the disease and becoming clinically ill, and how tuberculosis is diagnosed and treated. We invested considerable time and text to the description of events that likely would be necessary for the disease to be transmitted in our occupational setting (Figure 1). We used Michigan-specific data and familiar situations wherever possible to emphasize that transmission to humans from wildlife was possible. Without describing all possible transmission scenarios, our intent was to train staff to avoid placing themselves in situations where conditions necessary for transmission were present. To ease unfounded fears, we also wanted to dispel the notion that the disease would be easily acquired by casual contact.

In relating the occupational safety recommendations themselves, we also attempted to explain our rationale. Noting parallel scenarios in a wildlife management context, we adapted general categories of prevention recommendations described in health-care settings (CDC 1994), which included background prevalence of bTB in the source population, administrative controls (for example, job assignments), engineering controls (for example, ventilation), and personal protective measures (for example, use of respirators). Division employee exposure risks were assumed to be related to the prevalence of bTB in the source deer population for their check station, jobs duties, indoor versus outdoor work location, and personal protective equipment worn on the job. Occupational safety

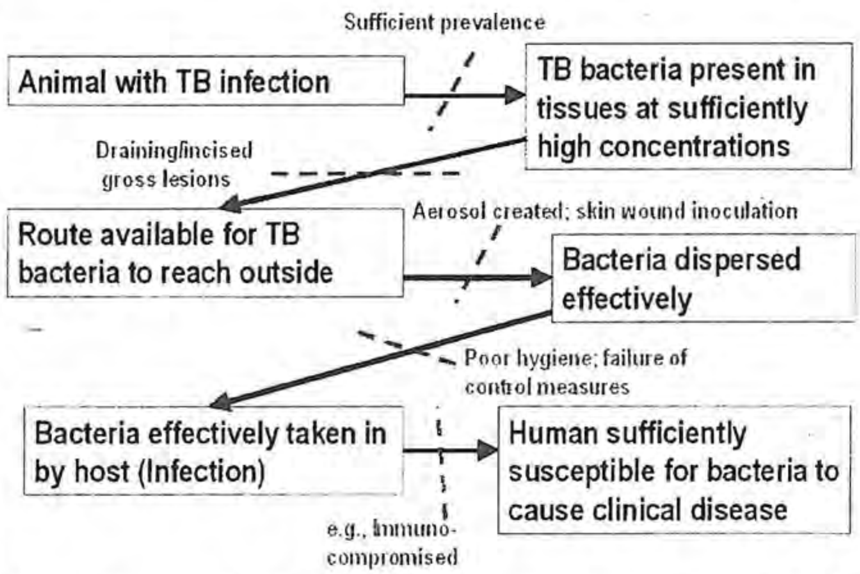

Figure 1. Steps (denoted by boxes) necessary for transmission of *M. bovis* to humans. Dashed lines denote points where the chain of transmission can be disrupted, each with an example of an event that can facilitate transition from one step to the next.

recommendations were intended to be implemented at three levels: human resources, field administration, and job classifications.

At the human resource level, we recommended that all Division employees who might be exposed to bTB-infected animals be administered the tuberculosis skin test (TST) at the time of hire and annually thereafter. A positive initial skin test usually indicates prior exposure to either hTB or bTB. Following the initial TST, the employee should be tested each spring if the person's only potential exposure was during the prior deer season. This would allow enough time for the employee's immune system to react positively to the TST, had exposure occurred. Employee TST results would be confidentially maintained in a secure database. Division safety officers or public health personnel would periodically review the results for evidence of employees converting from TST negative to positive. Any employee converting would be counseled regarding appropriate healthcare follow-up. In addition, staff were encouraged to make their supervisors aware of any personal circumstances that they believed put them at a higher risk of becoming infected, or if they fell into one of the groups with predisposing medical conditions. With that information, supervisors could assign higher-risk staff to job assignments in areas of the state where they were much less likely to contact a bTB-infected deer, to tasks that minimized exposure to deer carcasses, or to tasks that did not involve checking deer at all.

A related recommendation, falling under field administration, was the classification of deer check stations based on the risk of bTB exposure faced by staff that work there. Since a data field for check station of origin is included on the identification tags with which all specimens are marked, the path of bTB-positive specimens can be tracked geographically through the collection network. That allows check stations to be ranked according to the number and severity of bTB-positive animals handled, making classification by risk of exposure possible. We also recommended that "isolation" areas (IA) be established in each deer check station. These were not intended to be true isolation areas where infected animals could be completely separated from contact with people, but rather simply areas away from other activities (and as many people as possible) where specimens suspect for bTB or bearing lesions could be examined and processed. Animals with visible signs of bTB typically have more advanced disease and harbor larger numbers of bacteria. Handling them in an IA exposes as few people as possible to the modest number of specimens (about 80/year statewide) that have the greatest potential to transmit bTB. Staffing of the IA is limited to 1 or 2 more experienced, specially equipped staff, with all unnecessary staff and the public excluded.

We grouped the specific jobs performed in bTB surveillance into 4 broad categories based on their likely degree of exposure to bTB. Category-specific occupational safety recommendations were then specified (Table 1). Discussion of the rationale for these recommendations can be found in the occupational safety document, available from the corresponding author.

We recommended respiratory protection for workers in the IA, RLWDL staff, and truck drivers collecting and transporting specimens to RLWDL. Truck drivers were included because they sometimes assist in loading or unloading specimens, a small percentage of which will be infected with

Table 1. Recommendations for use of personal protective equipment (marked by "X") by job categories of likely exposure to *Mycobacterium bovis* for Department of Natural Resources staff and cooperators involved with bovine tuberculosis surveillance in Michigan, implemented beginning September 2000.

Job category[a]	Representative job	*Mycobacteria*-cidal soap	Rubber gloves	Respiratory protection	Eye protection	Disposable coveralls	Waterproof boots
1	Receptionist						
2	Data recorder at check station	X	X				
3a	Ager at check station	X	X		X		
3b	Worker in Isolation Area of check station	X	X	X	X		
4	Veterinarian	X	X	X	X	X	X

[a] Jobs were categorized as follows: 1) Staff sharing facilities (but having no direct or aerosol contact) with specimens; 2) Staff having direct (but noninvasive) contact with specimens; 3) Staff having direct (invasive) contact with specimens; 4) Staff performing post-mortem exams or working in necropsy areas.

bTB. They may also be exposed to infectious aerosols generated during disinfection of trucks. The vast majority of Division personnel for whom respirators are recommended can wear disposable air-purifying, particulate-filter respirators (e.g., Figure 2A,B). These respirators are tested by NIOSH, and approved respirators are marked individually with their filter class (for example, N95). Filter classes N-, R-, and P-95, -99, and -100 are protective against tuberculosis (NIOSH 1996).

On completion, a draft of the occupational safety document was circulated to tuberculosis and occupational safety experts from the Animal and Plant Health Inspection Service, Centers for Disease Control and Prevention, Food Safety Inspection Service, Michigan Department of Community Health, National Animal Disease Center, NIOSH, and Southeastern Cooperative Wildlife Disease Study for external peer-review. We incorporated comments and recommendations from those reviewers prior to final publication and provided each reviewer with a copy for information and redistribution.

Training sessions for staff

After review by Wildlife Division management, and safety and training coordinators for the Division and MDNR, the contents of the occupational safety document were condensed into presentation format (Microsoft® PowerPoint®, Microsoft Corporation, Redmond, Wash.). In the year 2000 occupational safety for bTB surveillance became a dedicated segment of annual training sessions that occur prior to autumn deer hunting seasons for all Division personnel. Interested individuals from other agencies, Native American tribes, and sportsmen's groups that may submit samples for bTB testing are also invited to attend. These day-long sessions are carried out in a variety of locations across the state and cover topics relevant to working at deer check stations. Other training ses-

Figure 2. Air samplers used to detect airborne *M. bovis*. Workers wore personal samplers consisting of a belt-mounted air pump (A, solid arrow) connected by tubing (open arrow) to the filter cassette (B, arrow). Similar equipment was used in the chests of tuberculosis-positive deer (C; note tubercles [arrow]), and in processing and sampling areas (D).

sions are conducted for seasonal employees and for university student volunteers. Separate scheduling allows the presentation to be modified to provide time for the more extensive introduction appropriate for these 2 groups.

Annual in-service training programs are used as a venue to conduct TSTs for interested staff. Because these training sessions typically span 3 days in the spring, they are ideal for this purpose; the tests can be administered on the first day and read 48 hours later, as prescribed (CDC 1994). Moreover, testing in the spring allows sufficient time for skin-test conversion following the most likely period of bTB exposure for the majority of Division personnel (deer season).

Program review

To be confident that the occupational safety document, recommendations, and training were accurate and sufficiently protective, we decided that external review of the program by experts was in order. In September 2000 we requested technical assistance from NIOSH to assess the risk of transmission of bTB to MDNR staff handling deer in the workplace. More specifically, we asked NIOSH to provide recommendations for using Personal Protective Equipment (PPE) when handling deer, and to evaluate whether *M. bovis* can be transmitted to workers at check stations, handling stations, the RLWDL, and at the AHDL.

In November 2000 NIOSH conducted a site visit to Michigan and collected air samples to detect airborne *M. bovis* (Figure 2). Details of that study are reported elsewhere (NIOSH 2002). Breathing-zone air samples were drawn around workers as they performed their job duties (personal samples), from rooms where deer carcasses were being handled or bTB surveillance activities were being conducted (area samples), and from the chest cavities of deer grossly infected with bTB (carcass samples). Air samples were analyzed for antigens of *M. tuberculosis* complex (a group of closely related mycobacteria that includes *M. bovis*) by polymerase chain reaction (PCR) at NIOSH's Cincinnati laboratory (NIOSH 1994, Schafer et al. 1998).

We collected 26 personal, 8 area, and 2 carcass samples. Of these, NIOSH analyzed 2 personal, 3 area, and 1 carcass sample(s) drawn over 34, 164, and 12 hours of exposure, respectively. NIOSH targeted for analysis those samples considered most likely to yield *M. bovis*. Polymerase chain reaction failed to detect presence of *M. bovis* in any of the air samples tested. In their close-out report (NIOSH 2002:3), NIOSH concluded that "although the risk for exposure to *M. bovis* may exist when a lesioned deer is examined, personal and area airborne samples collected by NIOSH and DNR suggest that the risk of exposure to *M. bovis* in an outdoor environment and indoor check-in facility is negligible. ...Recommendations established by the MDNR in the selection of personal protective equipment (PPE), training and proper work practices appear to be appropriate and should be followed."

Long-term health monitoring

We next sought to ensure a means of long-term health monitoring. A database (Excel 97, Microsoft Corporation, Redmond, Wash.) of annual staff TST results was established. The database is maintained in a confidential manner at the Michigan Department of Community Health (MDCH), where public health professionals periodically review it. Should a TST conversion occur, the employee would be directed to seek appropriate medical follow-up and the potential source of tuberculosis exposure would be investigated. Field staff whose annual TSTs are performed by local health departments or private physicians forward a copy of the results to RLWDL in sealed envelopes marked "Test Results—Confidential." These are collected without being opened and are delivered to MDCH without any MDNR staff being made aware of TST results of fellow employees.

Ongoing challenges

A number of challenges continue to arise. All protective equipment is available for anyone who wants to use it, regardless of their actual risk. Recognizing that unnecessary use of PPE might alarm the public, we emphasize to staff that only specific, infrequently encountered circumstances necessitate respirators or disposable coveralls for most personnel. Maintaining the safety program, and particularly the respirator program, as voluntary minimizes administrative effort and avoids the perception of coercion. Also, maintaining annual tuberculosis skin testing can be difficult without in-service training sessions. Although staff can get TSTs at local health departments or physician's offices, the need to schedule leave and seek reimbursement may act as disincentives. Arranging TST for seasonal staff is most problematic.

The geographic proximity of people, livestock, and free-ranging wildlife brought about by human expansion into remote areas provides new opportunities for interspecies disease transmission. So does the global mobility of humans and commercial animals. In addition, the success of modern wildlife management practices in increasing populations has meant that contagious diseases, once introduced into the wild, can propagate more rapidly. Increasing recognition of the potential public health and economic risks of diseases at the interface of wildlife and domestic livestock (National Animal Disease Center 2003) likely will result in expectations of increased surveillance among free-ranging populations. All of these factors suggest that disease issues may demand greater attention from wildlife professionals in the near future. As wildlife disease surveillance becomes a greater responsibility for management agencies across the United States, we believe the lessons learned in development of the Michigan program can be widely adapted to other areas and potentially to other diseases, and can raise awareness of occupational exposure to zoonotic diseases.

Acknowledgments. We thank G. Truman for cooperation with air sampling at his venison-processing facility, and K. Siciliano Carter for her assistance in training staff. This work was supported by the Federal Aid in Wildlife Restoration Act under Michigan Pittman-Robertson Projects W-127-R and W-147-R-1. Copies of the occupational safety document, training presentations, and NIOSH close-out report described in this article can be obtained by contacting the corresponding author.

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