

# ZOONOTIC DISEASE RISK AND PREVENTION PRACTICES AMONG BIOLOGISTS AND OTHER WILDLIFE WORKERS—RESULTS FROM A NATIONAL SURVEY, US NATIONAL PARK SERVICE, 2009

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**ABSTRACT:** In 2007, a National Park Service (NPS) biologist died from pneumonic plague after unprotected exposure to an infected mountain lion. This incident increased awareness of occupational zoonotic disease transmission and prompted an assessment of employees who handle wildlife. During April–June 2009, we conducted a national online survey of NPS biologists and other wildlife workers to assess in the preceding 12 mo: 1) potential work-related zoonotic disease exposures; 2) protective practices, including use of personal protective equipment (PPE); and 3) barriers and facilitators to PPE use. Summary protective measure scores were calculated and compared with sociodemographic and work-related factors. Surveys were completed by 238 employees from 131 parks in all NPS regions. Seventy-one percent were biologists or technicians, 16% natural resource specialists or managers, and 13% had other job titles. Among a majority of respondents, interactions with animals were infrequent and occurred approximately several times per year as follows: handling live (39%), sick (43%), or dead animals (46%), and drawing blood from animals (42%). The most frequently reported protective measures used were hand hygiene and gloves. Commonly agreed-upon measures that would facilitate PPE use included having PPE stocked and readily available (92%) and having specific PPE kits for use during necropsies (91%) and in remote field settings (91%). Significantly higher summary protective measure scores were found if respondents had either read or reviewed “NPS safe work practices for employees handling wildlife” with their supervisor, had zoonotic disease safety or PPE use included in their employee performance appraisal plans, or had conducted a job-hazard analysis for handling wildlife. Ninety (38%) respondents reported receiving zoonotic disease training. Our findings support the development and implementation of workplace interventions to increase zoonotic disease awareness and promote a culture of prevention among wildlife professionals.

**Key words:** Occupational health, personal protective equipment, risk reduction behavior, zoonoses.

## INTRODUCTION

Zoonotic diseases, or zoonoses, are diseases transmitted between vertebrate animals and humans (Hugh-Jones et al., 1995). Zoonotic pathogens are twice as likely to be associated with emerging diseases as nonzoonotic species (Taylor et al., 2001). Since 1940, the majority of infectious diseases that have emerged worldwide are considered to be zoonotic, and of these emerging diseases, 72% are believed to have originated among wildlife (Jones et al., 2008). In the United States, zoonotic pathogens that have been documented among wildlife populations include *Baylisascaris procyonis* in raccoons; rabies in skunks, foxes, raccoons, and bats;

and hantaviruses in rodents (American Veterinary Medical Association, 2010). The Centers for Disease Control and Prevention (CDC) recommends that persons who handle wildlife undertake specific disease-prevention measures, including rabies pre-exposure prophylaxis (Centers for Disease Control and Prevention [CDC], 2008) and use of personal protective equipment (PPE; CDC, 2002; Mills et al., 2007).

Occupational risk for zoonotic disease transmission has been well documented for professions that directly handle wildlife or other animals (e.g., animal control officers and veterinarians). Among 152 animal control officers in New Mexico, the animal bite rate was approximately 175–500 times

greater than general population-based rate estimates, placing the animal control officers at potentially greater risk for rabies exposure (Mann et al., 1984). Baker and Gray (2009) reviewed 66 published reports and concluded that veterinarians have an increased risk for infection from zoonotic pathogens compared with the general population. In particular, work-related accidents were associated with a higher likelihood of zoonotic infection, and veterinarians were often noncompliant with wearing appropriate PPE. Similar descriptive studies of zoonotic disease risk and prevention among wildlife biologists have not been reported.

Our study was led by the US National Park Service (NPS) after the death of a wildlife biologist from pneumonic plague resulting from exposure to an infected mountain lion at Grand Canyon National Park in 2007 (Wong et al., 2009). After this incident, NPS developed and disseminated a document entitled, "NPS Safe Work Practices for Employees Handling Wildlife" (NPS, 2008). Although timely, these guidelines were developed with limited knowledge regarding exposures and personal protective practices of wildlife workers servicewide. To understand occupational disease risks among this population more fully, we conducted focus-group discussions with NPS field biologists in 2008 (Anderson Bosch et al., 2010) and used the qualitative results as the basis for the design of a national survey. The objectives of our survey were to assess frequency of potential work-related zoonotic disease exposures, current protective measures used by wildlife workers (including PPE), and factors that influence the use of protective measures.

## MATERIALS AND METHODS

### Participant recruitment

During 6 April–30 June 2009, an online survey was available to all NPS resource management employees who directly handled wildlife as part of their duties. Regional-level resource managers were asked to promote the

survey to park-level managers, who solicited participation from field staff. The survey was also advertised on the NPS intranet home page at launch and 1 wk before closure. A paper copy of the survey was available upon request.

### Survey and analytic methods

Participants were questioned regarding demographics, types of animals they managed (e.g., terrestrial herbivores, birds, etc.), potential work-related exposures, perceptions and attitudes on disease risk, barriers and facilitators to PPE use, PPE practices in specific situations, and training and education topics. All nonapplicable responses were excluded from analyses. Additional details on survey methodology are provided for the following topics.

*Work-related exposures:* Likert-scale questions were used to measure the frequency of potential zoonotic disease or animal exposures. Response options ranged from once a year to daily. Additional questions regarding zoonotic disease exposure from potential traumatic injury (e.g., animal bite, needle stick, being cut with a necropsy instrument) were also asked.

*Barriers and facilitators to PPE use:* We used Likert-scale questions to measure the level of agreement among respondents to a variety of occupational situations that could be viewed as either a barrier or a facilitator to their use of PPE. Response options ranged from "strongly disagree" to "strongly agree".

*Use of PPE and protective measures:* The frequency of using PPE and engaging in personal protective measures during the previous 12 mo was assessed for a variety of occupational situations. Four categories of protective measures were evaluated: 1) hand hygiene, defined as hand washing or using alcohol-based hand sanitizers; 2) glove usage, using disposable or leather gloves; 3) vector (insect) precautions, using repellents and protective clothing and conducting tick checks; and 4) other protective measures, questions regarding disinfection of field equipment and transporting and disposing of animal carcasses. Additional questions were asked about PPE use when conducting necropsies. Responses were coded based on a Likert scale of 1–5, where 1 = never and 5 = always.

*Summary protection scores:* Responses from the four categories of protective measures were aggregated to calculate summary protection

scores. Likert-scale responses for hand hygiene and glove-use questions (categories 1 and 2) were used to calculate a mean hand protection score ranging from 1 to 5, where higher scores indicate increased compliance with hand protection measures. Similarly, Likert-scale responses for questions from all four categories (hand hygiene, glove usage, vector precautions, and other) were used to calculate a mean all-protection score. Necropsy-specific PPE questions were excluded from aggregated analyses.

Sociodemographic and work-related factors were analyzed to assess association with the summary hand protection and all protection scores. These factors included demographic information, frequency of wildlife exposure, and use of workplace safety initiatives. Three specific workplace safety initiatives were examined: having read or reviewed “NPS safe work practices for employees handling wildlife” with their supervisor; conducting a job-hazard analysis (JHA) for handling wildlife; and having zoonotic disease safety or PPE use included in an employee performance appraisal plan (EPAP). Wilcoxon ranked sums (Wilcoxon, 1945) were used to compare responses with two possible choices, whereas Kruskal-Wallis (Kruskal and Wallis, 1952) tests were used to compare responses with three or more possible choices. All data were analyzed using SAS version 9.2® (SAS Institute, Incorporated, Cary, North Carolina, USA).

## RESULTS

### Characteristics of respondents

Completed questionnaires were received from 238 resource management personnel who worked at 131/395 (33%) national park units across all seven NPS regions and the Washington Support Office. The total number of NPS resource management employees who directly handle wildlife as part of their job duties is unknown; therefore, a response rate for this survey could not be calculated.

Selected demographic characteristics of the respondents are displayed in Table 1. Ages ranged from 19 to 65 yr (median: 42 yr); 128 (54%) respondents were male. Lifetime work experience with the NPS ranged from 11 days to 38 yr (median: 10 yr). The majority of respondents (71%) held a job title of wildlife biologist,

biological technician, or supervisory biologist. Almost all (98%) worked outdoors. Fifty-six percent of respondents managed at least four categories of animals at work (defined as generalists for this study); 26% spent more than half of their time managing only one animal category (defined as specialists). Forty-eight respondents (20%) handled live animals at least once a week, and 90 (38%) reported receiving zoonotic disease training in their lifetime.

### Work-related exposures

Participants reported frequency of work-related activities during the previous 12 mo that might result in exposure to a zoonotic disease (Table 2). Interactions with animals were most frequently reported as occurring several times a year, including handling live (39% of respondents), sick (43%), or dead animals (46%), and drawing blood from animals (42%). Handling tissues, body fluids, or excretions occurred at a similar frequency, with 59% of respondents engaging in these activities several times a year or less. Among respondents who reported performing necropsies or tissue collections ( $n=205$ ), more reported conducting these activities in the field (65%) versus indoors (35%); both activities usually occurred several times a year or less (field, 63%; indoors, 69%). Respondents frequently worked in mosquito- or tick-infested areas, often on a daily basis (41% and 37%, respectively). Additional potentially hazardous exposures reported included being bitten by an animal (10%), being cut with a field or necropsy instrument (8%), or being inadvertently stuck with a needle (1%).

### Barriers and facilitators to PPE use

Respondents reported how much they agreed or disagreed with statements describing potential barriers and facilitators to PPE use. Among barriers, the most commonly agreed-upon statements (defined as those who responded with agreed

TABLE 1. Demographic characteristics of 238 National Park Service survey respondents, 2009.

Characteristic	<i>n</i>	%
Male	128	54
NPS region		
Alaska	9	4
Intermountain	84	35
Midwest	21	9
National capital	10	4
Northeast	13	5
Pacific west	52	22
Southeast	47	20
Washington support office	2	<1
Senior staff (supervisor or manager)	65	27
Job title		
Wildlife biologist	61	26
Biological technician	90	38
Supervisory biologist	16	7
Natural resource specialist	16	7
Natural resource manager	20	9
Other (e.g., ecologist, division chief, ranger)	31	13
Employment status		
Permanent	141	59
Permanent subject to furlough	23	10
Seasonal	44	18
Limited term	30	13
Hours/week worked outdoors		
I do not work outdoors	4	2
<10	68	29
11–20	65	27
21–30	53	22
31–40	34	14
≥41	14	6
Types of animal categories managed by wildlife specialists <sup>a</sup>		
Terrestrial herbivores	16	7
Terrestrial carnivores	20	8
Birds	9	4
Aquatic species	16	7
Amphibians or reptiles	1	<1
Insects	1	<1
Number of different animal categories <sup>a</sup> managed by all respondents		
1	39	16
2	25	11
3	41	17
≥4	132	55
Handle live animals at least once a week	48	20
Received zoonotic disease training in lifetime	90	38

<sup>a</sup> Respondent spends >50% of time working with the listed animal type.

or strongly agreed), included PPE being difficult to use in extreme environmental conditions (42%) or being inconvenient (22%); low levels of agreement were

reported for consistent animal handling techniques reducing the need for PPE (4%), animal welfare needs taking priority over PPE (6%), and PPE only being

TABLE 2. Frequency of National Park Service employee activities that can result in zoonotic disease exposure, 2009.

Activity	% reported <sup>a</sup>				
	Daily	Weekly	Monthly	Several times a year	Once a year
Handle live animals (n=212)	2	21	16	39	22
Handle sick animals (n=133)	0	3	14	43	40
Handle dead animals (n=178)	<1	13	20	46	21
Draw blood from animals (n=92)	2	11	17	42	27
Handle tissues/body fluids/excretions (n=179)	5	20	17	39	20
Perform necropsies/tissue collections indoors (n=72)	3	10	18	30	39
Perform necropsies/tissue collections in the field (n=133)	4	17	17	28	35
Handle animals in darkness (n=97)	4	5	10	56	25
Work in areas infested with ticks (n=206)	37	24	14	19	6
Work in areas infested with mosquitoes (n=231)	41	23	10	21	5

<sup>a</sup> Reported values might not equal 100% because of rounding.

needed in high-risk situations (7%). Among facilitators to PPE use, commonly agreed-upon statements included having PPE stocked and readily accessible (92%), having PPE kits for use in specific situations (e.g., necropsies) 91%, and having portable PPE kits for use in remote field settings (91%).

#### Use of PPE and protective measures

Participants reported how often they had used PPE or engaged in other personal protective measures in specific situations during the previous 12 mo (Table 3). A majority of biologists reported always washing their hands with soap and water or using an alcohol-based hand sanitizer after handling live, apparently healthy animals (65%); after handling carcasses, tissues, blood, body fluids, or excretions (82%); and before eating or drinking while at work (53%).

Among respondents, 75% reported they always wore leather gloves when working in situations where bites or scratches from animals were possible, and 85% always wore disposable gloves when handling sick animals. When handling animal carcasses, tissues, blood, body fluids, or excretions, 68% reported always wearing disposable gloves.

Use of insect repellent on the body, clothes, or on animal carcasses varied

among biologists. However, 76% reported wearing protective clothing (e.g., long pants or long sleeves), and 74% checked themselves for fleas or ticks a majority of the time after potential exposure.

Reported frequencies of engaging in other protective measures were: 30% always wore goggles or a face shield during situations where splashing of body fluids was possible; 15% always transported carcasses in a tarp, bag, or container; 52% always disinfected field equipment after use; 33% always cleaned the work vehicle after transporting animals; and 16% always used a biohazard bag when disposing of carcasses or tissues. Among 102 respondents who cleaned minimally ventilated spaces, approximately half reported never wearing particulate respirators.

**Necropsies:** Seventy-five (32%) respondents reported performing at least one necropsy during the previous 12 mo. Reported frequencies of PPE use while performing necropsies are presented in Table 4. When asked the type of animal on which respondents had performed the majority of necropsies, 50 (67%) reported terrestrial herbivores; 13 (17%), terrestrial carnivores; 6 (8%), birds; 5 (7%), aquatic species; and 1 (1%) reported reptiles. When performing necropsies, disposable

TABLE 3. Reported frequencies of use of personal protective equipment and other personal protective measures during the previous 12 mo among National Park Service employees, 2009.

Situation	% reported <sup>a</sup>				
	Never	<Half of the time	Half of the time	>Half of the time	Always
Hand washing or use of hand sanitizer					
After handling live, apparently healthy animals ( <i>n</i> =211)	1	8	5	21	65
After handling animal carcasses, tissues, blood, body fluids, or excretions ( <i>n</i> =216)	<1	5	1	12	82
Before eating or drinking while at work ( <i>n</i> =236)	1	10	10	26	53
Glove usage					
Wear leather gloves when severe bites or scratches from animals were possible ( <i>n</i> =162)	5	4	3	13	75
Wear disposable gloves when handling a sick animal ( <i>n</i> =144)	1	3	1	9	85
Wear disposable gloves when handling animal carcasses, tissues, blood, body fluids, or excretions ( <i>n</i> =215)	6	3	4	19	68
Vector precautions					
Use insect repellent on your body, clothes, or animal carcasses ( <i>n</i> =226)	17	29	16	24	14
Wear protective clothing such as long sleeves or long pants ( <i>n</i> =233)	1	8	14	36	40
Check yourself for ticks or fleas ( <i>n</i> =219)	6	14	6	24	50
Other protective measures					
Wear goggles/face shield when splashing of body fluids was possible ( <i>n</i> =134)	22	16	8	24	30
Wear a respirator when cleaning minimally ventilated indoor spaces ( <i>n</i> =102)	51	15	7	13	15
Transport animal carcasses in a tarp, bag, or container ( <i>n</i> =176)	9	17	6	25	43
Disinfect field equipment after use ( <i>n</i> =186)	14	9	5	20	52
Clean work vehicle after transporting animals ( <i>n</i> =160)	18	13	10	26	33
Use biohazard bags when disposing of carcasses or tissues ( <i>n</i> =130)	56	11	5	12	16

<sup>a</sup> Reported values might not equal 100% because of numerical rounding.

gloves were the most common type of PPE used (87%, always). Other types of PPE were used infrequently during necropsies and were often reported as never being worn, including protective clothing (36%), goggles or face shields (43%), surgical masks (75%), and particulate respirators (e.g., N95 or N99 [93%]).

#### Summary protection scores

Among factors examined, only those significantly associated with improved hand protection or all-protection summary scores are listed in Table 5. Respondents more frequently engaged in both hand

protection and all-protection measures if they were concerned about contracting a zoonotic disease ( $P=0.04$ ;  $P=0.07$ , respectively); primarily worked with terrestrial carnivores ( $P=0.002$ ;  $P=0.04$ , respectively); either had read or had their supervisor review with them NPS guidelines for safe work practices ( $P=0.003$ ;  $P<0.001$ , respectively); had zoonotic disease safety or PPE use included in their EPAP ( $P=0.01$ ;  $P=0.009$ , respectively); and performed a job-hazard analysis for handling wildlife ( $P=0.06$ ;  $P=0.03$ , respectively). Respondents who handled live animals at least weekly (hand protection,  $P=0.01$ ; all

TABLE 4. Reported frequencies of use of personal protective equipment (PPE) while conducting necropsies during the previous 12 mo among 75 National Park Service employees, 2009.

Type of PPE used	% reported <sup>a</sup>				
	Never	<Half of the time	Half of the time	>Half of the time	Always
Wear disposable gloves	4	3	1	5	87
Wear protective clothing (e.g., coveralls or a lab coat)	36	9	4	21	29
Wear goggles or a face shield	43	11	11	13	23
Wear a surgical mask	75	7	4	9	5
Wear a respirator	93	7	0	0	0

<sup>a</sup> Reported values might not equal 100% because of numerical rounding.

protection,  $P=0.03$ ) and who worked with aquatic species had lower scores in both categories ( $P=0.002$ ;  $P=0.06$ , respectively), correlating with less frequent use of protective measures.

#### Training and education

Of the 90 respondents who had received zoonotic disease training in their lifetime, 74 (82%) had been taught human symptoms of zoonotic diseases. Regarding existing NPS education materials, 84/238 (35%) had read or reviewed “NPS Safe Work Practices for Employees Handling Wildlife” with their supervisors.

Respondents were asked to provide feedback on how useful different educational formats would be for providing information on zoonotic diseases. In-person seminars or conferences scored highest, with 77% of respondents rating it as either useful or very useful, followed by brochures or fact sheets, 74%; learning aids (e.g., posters or pocket cards), 59%; online courses, 50%; and sessions to practice PPE use while simulating job duties, 49%.

#### DISCUSSION

This study identifies factors and motivations that can improve use of personal protective measures among biologists and other wildlife workers and is the first study to summarize zoonotic disease exposures and PPE practices among this population. In addition to NPS, wildlife professionals

are commonly employed at other federal land management agencies (e.g., Bureau of Land Management, US Forest Service, and US Fish and Wildlife Service), state wildlife agencies, universities, and conservation organizations. Results from our study have implications for developing practical workplace interventions to improve awareness of zoonotic diseases and increase prevention among wildlife workers at risk of exposure.

Hand hygiene and wearing gloves were the only protective measures that were consistently used by respondents in almost all situations. This information is encouraging because vigilant hand hygiene is considered the most important measure to mitigate disease spread (National Association of State Public Health Veterinarians [NASPHV], 2010). Wearing gloves further reduces the risk for pathogen transmission by providing barrier protection (Goldmann, 1991). Although the overall frequency of wearing gloves was higher, compared with other forms of PPE, ample room for improvement exists. Only 68% of respondents reported always using disposable gloves when handling potentially infectious carcasses, tissues, or blood. When conducting necropsies—another potentially high-risk activity—approximately 87% of respondents reported always wearing gloves, but fewer used other protective measures, such as masks or face shields.

Our data indicate that supervisor-level interventions might substantially improve

TABLE 5. Mean protection scores and factors associated with frequency of using hand protection measures (hand hygiene and glove usage) and all protection measures (hand hygiene, glove usage, vector precautions, and other measures). National Park Service (NPS) employees, 2009.

Characteristic <sup>b</sup>	n	Hand protection <sup>c</sup>			All protection <sup>c</sup>		
		Mean score	SD	P <sup>d</sup>	Mean score	SD	P <sup>d</sup>
Age ≥45	88	4.48	0.60	0.42	3.97	0.65	0.04
Age <45	150	4.39	0.71		3.81	0.64	
Concerned about contracting a work-related zoonosis	66	4.61	0.43	0.04	4.02	0.54	0.07
Not concerned	171	4.35	0.68		3.82	0.68	
Handles live animals at least once a week	48	4.21	0.81	0.01	3.67	0.71	0.03
Handles live animals less than once a week	190	4.48	0.63		3.93	0.62	
Categories of animals handled							
Handles aquatic species >50% of time	16	3.66	1.1	0.002	3.43	0.71	0.06
Handles aquatic species ≤50% of time or not at all	222	4.83	0.60		3.91	0.56	
Handles terrestrial carnivores >50% of time	20	4.68	0.56	0.03	4.07	0.53	0.15
Handles terrestrial carnivores ≤50% of time or not at all	222	4.41	0.68		3.86	0.66	
Education or employer intervention							
Received zoonotic training in lifetime	90	4.47	0.60	0.68	3.99	0.63	0.03
No zoonotic training	131	4.39	0.73		3.79	0.65	
Read/reviewed NPS guidelines for safe work practices	84	4.54	0.58	0.003	4.07	0.58	<0.001
Did not read/review guidelines	106	4.25	0.75		3.66	0.66	
Zoonotic disease safety/PPE use included in EPAP	52	4.58	0.63	0.01	4.05	0.64	0.009
Zoonotic disease safety/PPE use not included in EPAP	115	4.32	0.68		3.80	0.66	
Job hazard analysis performed	88	4.52	0.61	0.06	4.00	0.61	0.03
No job hazard analysis in place	73	4.34	0.76		3.77	0.68	

<sup>a</sup> NPS = US National Park Service; PPE = personal protective equipment.

<sup>b</sup> Sex, education level, ever having contracted a zoonotic disease, length of time employed with NPS, being an employee supervisor, being employed as a biologist or biological technician, being a wildlife specialist, and NPS region were all examined and were revealed to have nonsignificant associations.

<sup>c</sup> Protection scores ranged from 1 to 5.

<sup>d</sup> Displayed *P* values were obtained by using Wilcoxon-ranked sums tests.

compliance with PPE use and additional protective measures. Managers and supervisors can encourage employees to read “NPS Safe Work Practices for Employees Handling Wildlife,” require employees to conduct a JHA (US Department of Labor, Occupational Safety and Health Administration, 2002) for handling wildlife species they manage, and incorporate measures for zoonotic disease safety or PPE use in EPAPs. Each of these interventions encourages individual risk assessment and planning, thereby enabling employees to

understand and mitigate zoonotic disease risks for their specific work environments. Further, facilitators for PPE use that were widely agreed upon by >90% of respondents (e.g., keeping PPE stocked and accessible and having portable and situation-specific PPE kits) are actions that can be promoted by supervisors and managers. Among other professions (e.g., automotive workers, grain farmers, or veterinarians), similar proactive supervisor engagement has been documented to increase compliance with work safety



measures (Torp and Moen, 2006; MacFarlane et al., 2007; Wright et al., 2008; Lombardi et al., 2009).

Another intervention that can be implemented for wildlife workers is developing a zoonotic disease continuing education curriculum and training program. A majority of respondents (62%) reported having no formal education on zoonotic diseases. Our data support the importance of developing and disseminating a curriculum for resource managers and field staff that emphasizes infection control principles, signs and symptoms of zoonotic diseases among wildlife and humans, and appropriate use of PPE. Because NPS biologists can be generalists (work with multiple species) or specialists (work primarily with one species), and also work in diverse ecosystems and habitats, zoonotic disease risks—and therefore training needs—can vary widely. Because of such professional diversity, a single curriculum is probably inadequate. Ongoing zoonotic disease training efforts can be more effective if they can be adapted to the needs of an individual park or employee and are available in multiple formats to provide maximum accessibility and value.

Surprisingly, activities that might result in zoonotic disease exposure were reported to be performed relatively infrequently among our respondents. High-risk activities evaluated during this study (e.g., handling live, sick, or dead animals; drawing blood from animals; and performing necropsies) occurred infrequently. Although reduced frequencies of exposures might reduce the likelihood of contracting a work-related zoonosis, our study revealed an inverse association between certain exposures and frequency of preventive behaviors. For example, our analysis indicated that respondents who handled live animals at least once a week had significantly lower hand protection and all protection scores when compared with those who handled animals less often. These results suggest a desensitizing or complacency effect where repeated

exposure might decrease perception of risk and reduce adherence to PPE use (Anderson Bosch et al., 2010). This finding should be interpreted with caution, however, because only a small proportion (20%) of our respondents reported handling animals once a week or more. Additional research is needed to verify this association, to understand its implications, and if needed, to determine appropriate mitigation efforts.

The findings from our study are subject to limitations. First, use of self-reported data introduces the possibility of respondent bias. Second, a majority of our respondents were generalists who worked with at least four terrestrial species and who reported handling live animals infrequently. Some of our findings and recommendations might not be applicable to all field biologists, particularly those who work with nonmammalian species (e.g., aquatic species, amphibians, insects, and reptiles), those who are specialists, or those who handle live animals more often than our study population. Additional surveys targeting different populations of wildlife workers (outside of NPS) would help to assess the representativeness and validity of our data. Finally, because our survey instrument was designed to assess prevention practices under general situations, we cannot assess if specific exposures reported by respondents warranted standard or higher levels of protection (e.g., depending on the level of involvement or species being studied, necropsies might or might not warrant the use of masks and face shields).

As next steps, the NPS plans to review the findings from this survey with senior managers and develop a multitiered strategy that will encourage positive behavior change among wildlife workers. This strategy will likely include interventions at the policy level (e.g., defining minimum standards for PPE caches in parks), supervisor level (e.g., EPAPs), and the individual level (e.g., education/training). All guidance materials will be developed

in collaboration with the NPS Office of Public Health, Office of Risk Management, Biological Resource Management Division, regional offices, and individual park units. Current servicewide NPS resources for employees include the safe work practice guidelines and in-person trainings on wildlife diseases (including zoonotic diseases), which are offered every 18 mo to approximately 40 biologists and other resource managers. The development of more frequent continuing-education programs is being considered. As these and additional interventions are improved or implemented, future surveys can be conducted to assess the influence of such interventions in improving PPE practices over time.

Ultimately, achieving sustainable improvements in zoonotic disease prevention practices among biologists will likely require a culture change within the profession, akin to modifications in infection control practices that occurred among health care professionals after the onset of the human immunodeficiency virus/acquired immune deficiency syndrome (HIV/AIDS) epidemic (Patterson, 2004). As initial steps, universities should emphasize PPE use and worker safety among biology students and trainees. The concept of standard precautions (Siegel et al., 2007, NPS, 2008; CDC, 2011)—basic infection control principles that are utilized at all times (e.g., hand washing; wearing gloves when handling animal tissues or blood)—should be developed or adapted for wildlife professionals (NPS, 2008). Such guidelines could then be promoted by professional associations (e.g., The Wildlife Society; Wildlife Disease Association), who could serve as advocates for cultural change across the profession. Lastly, during necropsies or other potentially high-risk activities, additional safety measures should be encouraged, including the use of facial and eye protection, when indicated (NASPHV, 2010). Although this baseline survey provides a snapshot of prevention practices among a national sample of biologists and

other wildlife workers, further study and evaluation is needed to determine how best to translate these findings into effective interventions and control measures.

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#### LITERATURE CITED

- American Veterinary Medical Association. 2010. *Disease Precautions for Hunters*. [http://www.avma.org/public\\_health/zoonotic\\_risks/hunters\\_precautions.pdf](http://www.avma.org/public_health/zoonotic_risks/hunters_precautions.pdf) Accessed June 2012.
- Anderson Bosch S, Leong K, Musgrave K, Powers J, Wong D. 2010. Zoonotic disease risk perceptions and use of personal protective measures among wildlife biologists: An application of the health belief model. *Hum Dimens Wildl* 15:221–228.
- Baker WS, Gray GC. 2009. A review of published reports regarding zoonotic pathogen infection in veterinarians. *J Am Vet Med Assoc* 243:1271–1278.
- Centers for Disease Control and Prevention (CDC). 2002. Hantavirus pulmonary syndrome—United States: Updated recommendations for risk reduction. *Morb Mortal Wkly Rep* 51 (RR-9): 1–12.
- Centers for Disease Control and Prevention (CDC). 2008. Human rabies prevention—United States, 2008: Recommendations of the Advisory Committee on Immunization Practices. *Morb Mortal Wkly Rep* 57 (RR-3): 26–28.
- Centers for Disease Control and Prevention. 2011. *Guide to Infection Prevention for Outpatient Settings: Minimum Expectations for Safe Care*. <http://www.cdc.gov/HAI/pdfs/guidelines/standards-of-ambulatory-care-7-2011.pdf>. Accessed June 2012.
- Goldmann DA. 1991. The role of barrier precautions in infection control. *J Hosp Infect* 18 (suppl A): 515–523.
- Hugh-Jones ME, Hubbert TW, Hagstad HV. 1995. *Zoonoses: Recognition, control, and prevention*. Iowa State University Press, Ames, Iowa, 369 pp.

- Jones KE, Patel NG, Levy MA, Storeygard A, Balk D, Gittleman JL, Daszak P. 2008. Global trends in emerging infectious diseases. *Nature* 451:990–994.
- Kruskal WH, Wallis WA. 1952. Use of ranks in one-criterion analysis of variance. *J Am Stat Assoc* 47:583–624. [Errata. 1953. *J Am Stat Assoc* 48:907–911.]
- Lombardi DA, Verma SK, Brennan MJ, Perry MJ. 2009. Factors influencing worker use of personal protective eyewear. *Accid Anal Prev* 41:775–762.
- MacFarlane E, Chapman A, Benke G, Meaklim J, Sim M, McNeil J. 2007. Training and other predictors of personal protective equipment use in Australian grain farmers using pesticides. *Occup Environ Med* 65:141–146.
- Mann JH, Rollag OJ, Hull HF, Montes JM. 1984. Animal bites as an occupational hazard among animal control officers. *Am J Public Health* 74:255–256.
- Mills JN, Carroll DS, Revelez MA, Amman R, Gage KL, Henry S, Regnery RL. 2007. Minimizing infectious disease risks in the field. *Wildl Prof* (Winter 2007):30–35.
- National Association of State Public Health Veterinarians. (NASPHV). 2010. Compendium of veterinary standard precautions for zoonotic disease prevention in veterinary personnel. *J Am Vet Med Assoc* 237 (12): 1403–1422.
- Patterson JE. 2004. Isolation of patients with communicable diseases. In: *Hospital epidemiology and infection control*, 3rd ed., Mayhall CG editor. Lippincott, Williams & Wilkins, Philadelphia, Pennsylvania, pp. 1703–1725.
- Siegel JD, Rhinehart E, Jackson M, Chiarello L, the Healthcare Infection Control Practices Advisory Committee. 2007. *Guideline for Isolation Precautions: Preventing Transmission of Infectious Agents in Healthcare Settings*. <http://www.cdc.gov/hicpac/pdf/isolation/Isolation2007.pdf>. Accessed June 2012.
- Taylor LH, Latham SM, Woolhouse MEJ. 2001. Risk factors for human disease emergence. *Philos Trans R Soc London Ser B* 356:983–989.
- Torp S, Moen BE. 2006. The effects of occupational health and safety management on work and environment and health: A prospective study. *Appl Ergon* 37:775–783.
- US Department of Labor, Occupational Safety and Health Administration. 2002. *Job Hazard Analysis Guide*. <http://www.osha.gov/Publications/osh3071.pdf>. Accessed June 2012.
- US National Park Service Office of Policy. 2008. *Director's Orders and Related Documents*. Reference manual 50B—occupational safety and health program. Section 4—occupational health. 4.15 Safe work practices for employees handling wildlife, <http://www.nps.gov/policy/RM50Bsection4.pdf>. Accessed June 2012.
- Wilcoxon F. 1945. Individual comparisons by ranking methods. *Biometrics* 1:80–83.
- Wong D, Wild MA, Walburger MA, Higgins CL, Callahan M, Czarniecki LA, Lawaczek EW, Craig E, Levy J, Patterson G, et al. 2009. Primary pneumonic plague contracted from a mountain lion carcass. *Clin Infect Dis* 49:e33–38.
- Wright JG, Jung S, Holman RC, Marano MN, McQuiston JH. 2008. Infection control practices and zoonotic disease risks among veterinarians in the United States. *J Am Vet Med Assoc* 232:1863–1872.

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