

Disaster Medicine

Injuries and illnesses among Federal Emergency Management Agency–certified search-and-recovery and search-and-rescue dogs deployed to Oso, Washington, following the March 22, 2014, State Route 530 landslide

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Objective—To establish types and rates of injuries and illnesses among search-and-recovery and search-and-rescue dogs deployed to Oso, Wash, following the March 22, 2014, State Route 530 landslide.

Design—Medical records review and cross-sectional survey.

Animals—25 Federal Emergency Management Agency–certified search dogs.

Procedures—On-site medical records and postdeployment laboratory test results were reviewed and an electronic survey was distributed to handlers within 8 days after demobilization.

Results—Dogs worked a total of 244 search shifts totaling 2,015 hours. Injuries and illnesses were reported in 21 (84%) dogs. Wounds (abrasions, pad wear, paw pad splits, and lacerations) were the most common injury, with an incidence rate of 28.3 wounds/1,000 hours worked. Dehydration was the most common illness, with an incidence rate of 10.4 cases of dehydration/1,000 hours worked. Total incidence rate for all health events was 66.5 events/1,000 hours worked. Two search dogs were removed from search operations for 2 days because of health issues. All others continued search operations while receiving treatment for their medical issues. All health issues were resolved during the deployment or within 2 weeks after demobilization.

Conclusions and Clinical Relevance—Results revealed that search dogs deployed to the Oso, Wash, landslide incurred injuries and illnesses similar to those reported following other disasters (dehydration, wounding, vomiting, and diarrhea) but also incurred medical issues not previously documented (acute caudal myopathy, cutaneous mass ruptures, and fever). The reported medical issues were minor; however, prompt veterinary care helped prevent them from developing into more serious conditions. (*J Am Vet Med Assoc* 2015;247:901–908)

Search dogs in the FEMA US&R system can be deployed within 4 to 6 hours after a terrorist attack (eg, the 1995 bombing of the Alfred P. Murrah Federal Building in Oklahoma City and the 2001 terrorist attack on the WTC in New York City) or natural disaster (eg, the 2010 earthquakes in Haiti; the tornados in Joplin, Mo, in 2011 and Moore, Okla, in 2013; hurricanes Katrina and Sandy in 2005 and 2012, respectively; and the flooding in Colorado in 2013). There is the potential for a wide range of environmental conditions

ABBREVIATIONS

FEMA	Federal Emergency Management Agency
IR ^{MIE}	Medical issue event incidence rate
IR ^{SDM}	Search dog morbidity incidence rate
US&R	Urban Search and Rescue
WSDA-RVC	Washington State Department of Agriculture Reserve Veterinary Corps
WTC	World Trade Center

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secondary to these events, including collapsed building rubble, running and still water, crushed rock, and forest terrain, with possible hazards ranging from physical to chemical, biological, radiologic, nuclear, and explosive concerns. In addition, dogs can be exposed to a range of climatic conditions, often without any opportunity for an acclimatization period.

Documentation of the illnesses and injuries experienced by US&R and other search dogs¹⁻⁷ serves several purposes. Data pooling serves to highlight ways to better prepare medical providers, identify supply and equipment needs, enhance training and preparedness, and institute preventive measures to mitigate the most common disease and trauma conditions that might be encountered. Preventive measures are important in maintaining dogs at their peak performance; swift and effective treatment is vital to allow ill or injured dogs to return to their duties in a safe and timely manner.

To date, there are no published reports of injuries and illnesses among FEMA US&R dogs deployed to a landslide event of large magnitude. Furthermore, to our knowledge, there are no published reports of injuries and illnesses among FEMA US&R dogs based on veterinary medical records maintained on-site throughout the deployment in addition to data gathered from postdeployment surveys of dog handlers and postdeployment laboratory test results. The purpose of the study reported here was to establish the types and rates of injuries and illnesses among search-and-recovery and search-and-rescue dogs deployed to Oso, Wash, following the March 22, 2014, State Route 530 landslide.

Materials and Methods

Description of the event—On Saturday, March 22, 2014, a massive landslide occurred 4 miles east of Oso, Wash, at the southeastern edge of Whitman Bench, a land terrace 240 m (800 feet) above the valley floor consisting of gravel and sand deposited during the most recent glaciation.⁸ The initial collapse began at 10:37 AM local time and lasted approximately 2.5 minutes. Additional events occurred over the next several hours. The collapse sent mud, rock, and debris across the North Fork of the Stillaguamish River, overrunning a rural neighborhood 4 miles east of Oso, engulfing 49 homes and other structures, covering an area 460 m (1,500 feet) long and 1,300 m (4,400 feet) wide, and depositing debris 9.1 to 21.3 m (30 to 70 feet) deep. The slide blocked the North Fork of the Stillaguamish River, leading to extensive flooding upstream, and blocked State Route 530, a main route through the area.

Twenty FEMA-certified human-remains detection (ie, search-and-recovery) US&R Canine Search Teams, each consisting of 1 handler and 1 dog, were activated on April 2, eleven days after the initial incident, and began search operations the following day. Teams were from Arizona, California, Florida, Maryland, New York, Ohio, Texas, Utah, and Virginia. Two additional FEMA-certified human-remains detection US&R Canine Search Teams (from New York and Florida) were activated on April 20, twenty-nine days after the initial incident, and began search operations

the following day. In addition, 3 FEMA-certified live-find (ie, search-and-rescue) US&R dogs (2 of which were in training for human-remains detection also) were deployed by Washington State on April 2. An Incident Support Team Veterinary Officer (LEG) was activated on April 4, thirteen days after the initial event, locating the next day to the base of operations to begin providing on-site medical care for the search dogs that evening.

Medical records review—For the present study, medical records from April 3 through April 22, 2014, maintained by the WSDA-RVC and the FEMA Incident Support Team Veterinary Officer for the 25 FEMA US&R dogs deployed to the landslide were reviewed for information on signalment, body weight, and any physical examination findings and treatments provided. Postdeployment medical records and results of laboratory testing performed by the dogs' primary care veterinarians following demobilization were also reviewed.

Postdeployment survey—Eight days after the last search dog was demobilized, a survey was distributed via electronic mail to handlers of the 25 search dogs. Data collection included questions on duration of deployment, number and duration of search operations shifts, number of dog-specific hazard briefings, frequency and timing of examinations (premission, pre-shift, shift, postshift, demobilization, and postmission), and decontamination procedures.

Postdeployment testing—Postdeployment medical records were reviewed for information on postdeployment clinicopathologic testing, including results of CBCs, serum biochemical analyses, urinalyses, fecal testing, and an ELISA for *Giardia* infection. Follow-up information on any illness or injury acquired during deployment or that developed or was discovered after deployment was also obtained.

Statistical analysis—Summary statistics (mean, median, mode, and range) were calculated. The IR^{MIE} and IR^{SDM} were calculated on the basis of 1,000 hours worked.

Results

Data collection—On-site and postdeployment medical records were obtained for all 25 FEMA US&R dogs deployed to the landslide. In addition, handlers for all 25 dogs completed the postdeployment survey.

Search dog signalment—The 25 dogs consisted of 12 (48%) Labrador Retrievers, 5 (20%) German Shepherd Dogs, 2 (8%) Belgian Malinois, 2 (8%) Golden Retrievers, 2 (8%) Border Collie mixes, 1 (4%) Australian Shepherd, and 1 (4%) Border Collie. There were 14 (56%) neutered males, 6 (24%) sexually intact males, 4 (16%) spayed females, and 1 (4%) sexually intact female. Age at the time of deployment ranged from 1.7 to 10.1 years; 5 dogs were 1 to < 4 years old, 12 were 4 to < 6 years, 6 were 6 to < 8 years, 1 was 8 to < 10 years, and 1 was ≥ 10 years old (mean, 5.0 years; median, 4.7 years; mode, 4.7 years). Body weight ranged from 18 to

41 kg (40 to 90 lb; mean, 28 kg [62 lb]; median, 28 kg; mode, 32 kg [70 lb]). Most (19 [72%]) dogs weighed between 23 and 36 kg (51 and 80 lb).

Search operations history—Duration of deployment ranged from 5 to 21 days (mean, 15 days; median, 16 days; mode, 16 days), with individual search teams performing search operations for 2 to 18 days (mean, median, and mode, 12 days). Search operations were conducted during daylight hours, with a full shift typically being 10 hours (ie, 7 AM to 5 PM) and a half-shift typically being 5 hours (ie, 7 AM to 12 PM or 12 PM to 5 PM). Search teams worked a total of 244 shifts (range, 2 to 18 shifts; mean, 10 shifts; median, 9 shifts; mode, 7 shifts). Of these 244 shifts, 159 were full shifts (total, 1,590 hours) and 85 were half-shifts (total, 425 hours), for a total of 2,015 hours.

Safety and hazards briefings—All 25 handlers received safety and hazards briefings in the morning before search operations or during the evening debriefing after search operations were completed for the day. Briefings were conducted by the Search Team Manager, Incident Support Team Veterinary Officer, or both. During these briefings, information was provided regarding weather-related thermoregulation, particularly in regard to preventing hyperthermia and hypothermia; sharp debris, both visible and buried in mud, that could cause lacerations and abrasions; dust hazards potentially causing eye irritation; water pools and mud containing gasoline, oil, antifreeze, other chemicals, protozoal and bacterial organisms (eg, *Giardia* sp, *Leptospira* spp, and coliform bacteria), and human remains; heavy equipment operations; poisonous and dangerous plants (eg, poison oak, poison sumac, and blackberry thorns);

potential salmon poisoning disease (neorickettsiosis) secondary to ingestion of raw salmon containing *Nanophyetus salmincola* carrying the causative organism (*Neorickettsia helminthoeca*); snakes (nonvenomous); and local free-roaming dogs in the search areas. The Washington State Department of Ecology monitored water from an inundated portion of the Stillaguamish River and from 2 areas downstream for chemicals and coliform bacteria throughout the time of deployment.^{a,b} Volatile chemicals that were detected were consistent with compounds occurring in gasoline, household paints and solvents, and refrigerants; concentrations did not exceed the national standards for primary drinking water. Three of 11 water samples contained fecal coliform bacteria at concentrations higher than the class AA freshwater criterion of 100 colony-forming units/100 mL.

Medical examinations—Search dogs received premission, preshift, shift, postshift, demobilization, and postmission examinations. Premission examinations were performed at their home base on 19 of the 25 (76%) dogs. For 18 dogs, premission examinations were performed by the dogs' primary care veterinarian; for the remaining dog, the premission examination was performed by the handler. Preshift examinations were performed at the base of operations or on-site on 24 (96%) dogs. All 25 dogs had examinations performed during their shifts and following their shifts at the base of operations. A combination of WSDA-RVC veterinarians and veterinary technicians, task force medics, the Incident Support Team Veterinary Officer, and the handlers conducted these examinations. Demobilization examinations were performed at the base of operations on 24 (96%) dogs. Postmission examinations and tests

Table 1—Morbidity and incidence rates for FEMA-certified search-and-recovery and search-and-rescue dogs (n = 25) deployed to Oso, Wash, following the March 22, 2014, State Route 530 landslide.

Medical condition	No. (%) of dogs affected	IR ^{SDM} *	No. of medical events	IR ^{MIE} †
Wounds	12 (48)	6.0	57	28.3
Abrasions	8 (32)	4.0	23	11.4
Lacerations	5 (20)	2.5	6	3.0
Split or cracked pad	3 (12)	1.5	12	6.0
Worn pad‡	1 (4)	0.5	16	7.9
Dehydration	10 (40)	5.0	21	10.4
Dietary indiscretion	7 (28)	3.5	7	3.5
Weight loss	5 (20)	2.5	5	2.5
Dermatitis	5 (20)	2.5	9	4.5
Diarrhea	4 (16)	2.0	4	2.0
Exhaustion or lethargy	4 (16)	2.0	6	3.0
Shivering	4 (16)	2.0	6	3.0
Lameness	3 (12)	1.5	3	1.5
Stiffness	3 (12)	1.5	3	1.5
Cutaneous mass	3 (12)	1.5	3	1.5
Acute caudal myopathy	2 (8)	1.0	2	1.0
Attitude change	2 (8)	1.0	2	1.0
Vomiting	1 (4)	0.5	3	1.5
Fever	1 (4)	0.5	1	0.5
Ear infection	1 (4)	0.5	1	0.5
Ocular discharge	1 (4)	0.5	1	0.5
Total	21 (84)	10.4	134	66.5

*IR^{SDM} = Total number of dogs affected/1,000 hours worked. †IR^{MIE} = Number of medical issue events/1,000 h worked. ‡Severe pad wear causing lameness.

were done on all 25 dogs by their primary care veterinarian at home.

A total of 253 documented medical examinations were conducted during the deployment. Additional consultations and examinations were performed during search operations by the Incident Support Team Veterinary Officer but were not documented in writing. Typically, 2 to 8 such consultations and examinations were performed during each shift.

Veterinary care—Two veterinary treatment areas were established at the base of operations, which was located 16 miles from search operations, and 4 forward operations sites with warming tents and veterinary treatment areas were established along the mile-long search area. Forward operations sites were staffed by at least 1 veterinarian and 1 veterinary technician during all search shifts. A local private veterinary clinic that was open 24 h/d every day was available for further diagnostic testing and treatment as needed, with an estimated drive time from the search area to the clinic of 1 hour and an estimated helicopter evacuation lift time of 10 minutes.

Injuries, illnesses, and treatments—Twenty-one of the 25 (84%) search dogs incurred an injury or illness during their deployment, for an IR^{SDM} of 10.4 dogs/1,000 hours worked. Fifteen (60%) dogs had multiple medical issues. A total of 134 medical issues were recorded (77 injuries and 57 illnesses), for an IR^{MIE} of 66.5 injuries and illnesses/1,000 hours worked (Table 1).

Overall, 19 of the 25 (76%) dogs incurred injuries, with a total of 77 injuries documented (IR^{MIE}, 38.2 injuries/1,000 hours worked). Wounds (abrasions, pad wear, paw pad splits or cracks, and lacerations) were the most common injury, with an incidence rate of 28.3 wounds/1,000 hours worked (Figure 1). One dog had all 16 digital pads worn thin. Other injuries included inflamed skin (erythematous irritation), lameness, rupture or swelling of a cutaneous mass, stiff gait, superficial dermatitis, and acute caudal myopathy. Treatment included various topical medications (ie, antimicrobial solutions and ointments, corticosteroid ointments and powders, and lanolin-based ointment), systemic medications (ie,

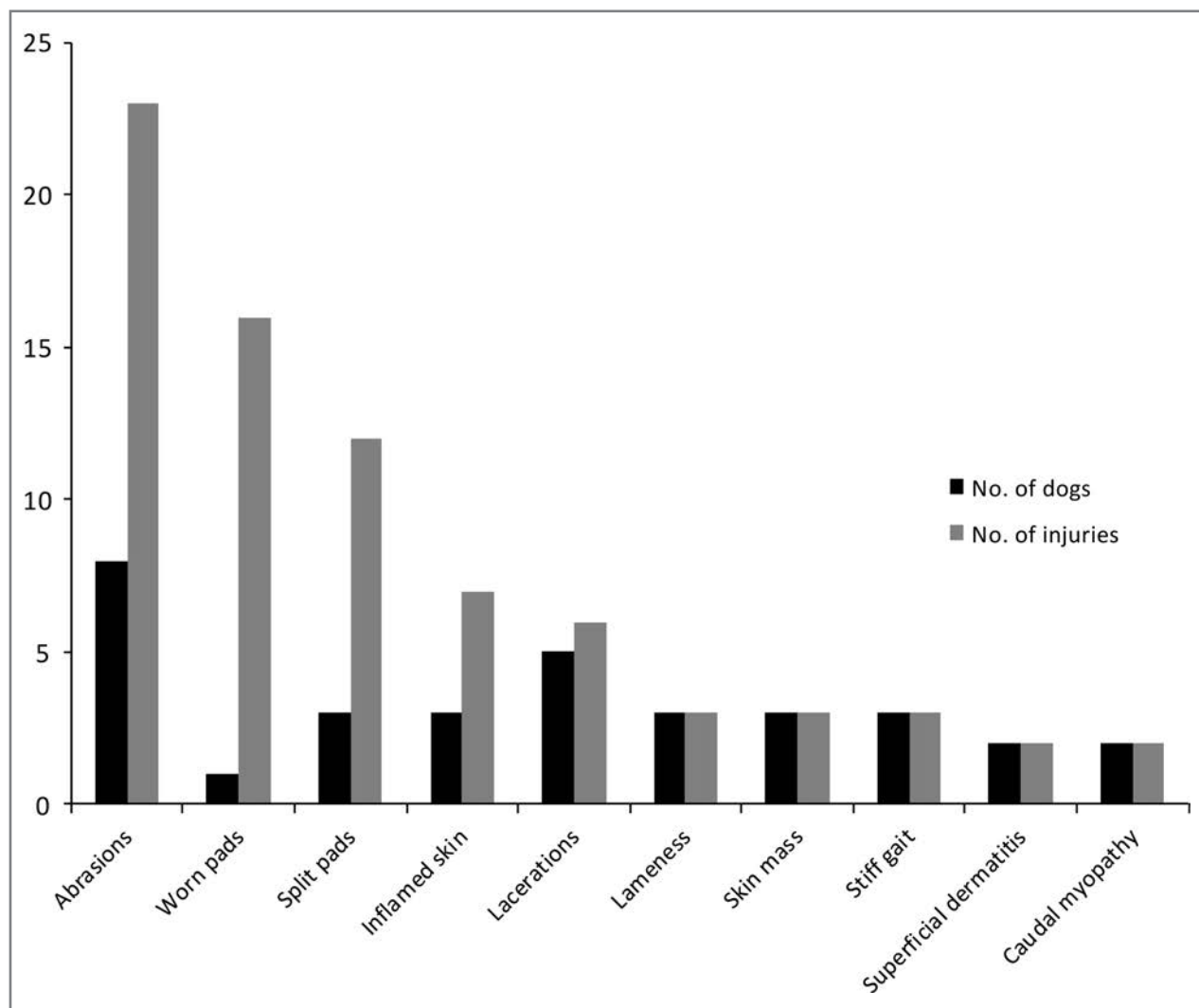


Figure 1—Numbers of injuries, classified by type, experienced by FEMA-certified search-and-recovery and search-and-rescue dogs (n = 25) deployed to Oso, Wash, following the March 22, 2014, State Route 530 landslide. Overall, 19 of the 25 (76%) dogs incurred injuries, with a total of 77 injuries documented.

antimicrobials, corticosteroids, NSAIDs, probiotics, and narcotics), and bandaging. Several types of bandages were used to protect the paws during search operations. The bandaging protocol found to be best for withstanding a 10-hour shift in wet, muddy conditions while avoiding bandage complications consisted of cloth tape stirrups,^c wound ointment and gauze pads, cast padding, 3- or 4-inch stretch gauze, stretch bandage tape,^{d-f} elastic tape,^a and duct tape. Eight (32%) dogs had bandages applied to their paws for 1 to 14 days.

Nineteen dogs developed various illnesses, with a total of 57 illnesses documented (IR^{MIE}, 28.3 illnesses/1,000 hours worked). The most common illness was dehydration (5% to 8%), which was documented in 10 dogs on 21 occasions (IR^{MIE}, 10.4 cases of dehydration/1,000 hours worked; Figure 2). Other illnesses included dietary indiscretion (ie, ingestion of contaminated water, dead fish, human remains, an unknown bag of dog food, and a 2-week-old raw chicken), weight loss ranging from 3% to 13% of body weight, uncontrollable shivering, extreme exhaustion, diarrhea, an attitude change (ie, agitation or depression), vomiting (3 times over a 12-hour period), fever, bilateral ear infection, and bilateral ocular irritation. Treatment included IV or SC administration of fluids, oral administration of dextrose, injectable and oral administration of antimicrobials, and oral administrations of antiemetics, emetics, vitamin supplements, antidiarrheal medications, and probiotics.

Two search dogs were removed from search operations for 2 days because of health issues. All others continued search operations while receiving treatment for their medical issues. All health issues were resolved during the deployment or within 2 weeks after demobilization.

Decontamination—The Washington National Guard established 2 mass decontamination units, and Washington Task Force 1 established a decontamination corridor. All veterinary medical stations had additional water, moist towelettes and wipes,

and towels to decontaminate dogs as needed during search operations. Only cold water was available the first 2 days, but warm water was available by the third day. Dish soap was used for the first 3 days, but dog shampoo was subsequently acquired to mitigate skin drying that could have led to scratching and compromise of the skin. Towels were used for drying, and dogs were then transported in a heated van to the base of operations and, typically, into a heated tent. All 25 search dogs were decontaminated after every shift.

Weather conditions—From April 3 to 22, 2014, mean daytime high temperature was 14.4°C (58°F; range, 10.6° to 21.7°C [51° to 71°F]).⁹ Mean nighttime low temperature was 4.4°C (40°F; range, 0°C to 7.8°C [32° to 46°F]). Rain fell 7 of those 20 days (rainfall total, 1.15 inches). Mean wind speed was 8 km/h (5 mph; range, 0 to 42 km/h [0 to 26 mph]).

Postmission examinations—Handlers were advised to have a postmission examination performed by their dogs' primary care veterinary within 7 to 14 days after they arrived home, including a complete physical examination, CBC, serum biochemical profile, urinalysis, fecal testing for parasites, and an ELISA for *Giardia* infection. Handlers were also advised to monitor their dogs for any signs of illness, particularly leptospirosis and salmon poisoning disease.

All 25 dogs underwent the recommended post-mortem examination within 2 to 19 days after arriving home. Results were normal for 15 of the 25 (60%) dogs and were abnormal for 10 (40%). Four dogs had abnormal urinalysis findings (3 with crystalluria and proteinuria; 1 with crystalluria), 2 had positive ELISA results for *Giardia* antigen but were negative for fecal cysts, 1 had positive ELISA results for *Giardia* antigen and fecal cysts, 1 had hypercalcemia, 1 had signs of urinary tract infection (hematuria, pyuria, and proteinuria) and was positive for hookworms, and 1 had eosinophilia, high serum creatinine concentration, and proteinuria.

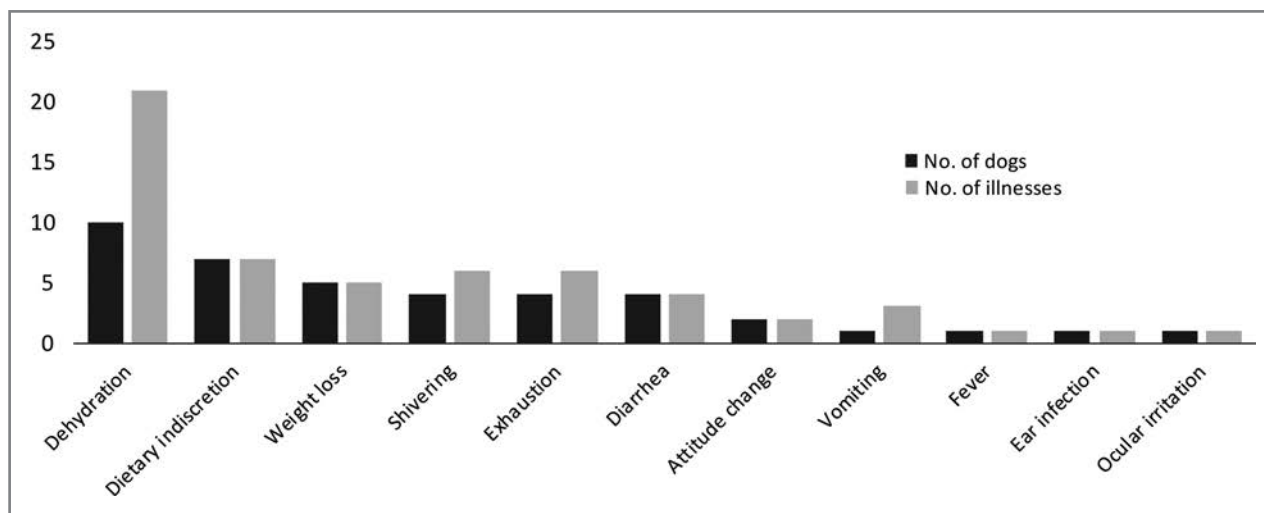


Figure 2—Numbers of illnesses experienced by dogs in Figure 1. Overall, 19 of the 25 (76%) dogs experienced illnesses, with a total of 57 illnesses documented.

Discussion

In the present study, search dogs deployed to the Oso, Wash, landslide were found to have incurred injuries and illnesses similar to those reported following other disasters (dehydration, wounding, vomiting, and diarrhea) but also incurred medical issues not previously documented (acute caudal myopathy, cutaneous mass ruptures, and fever). None of the reported medical issues were life threatening, but prompt veterinary care helped prevent minor issues from developing into more serious conditions.

Three unique aspects mark the Oso, Wash, landslide and response: the geological nature of the disaster, the first deployment of an Incident Support Team Veterinary Officer, and the first modular deployment of FEMA human-remains detection Canine Search Teams.

More than 50 major landslides have occurred in the United States since 1900,^{10,11} but the Oso, Wash, State Route 530 landslide resulted in the largest loss of human lives. Because this was the first landslide disaster event to which FEMA US&R has deployed resources since its inception, the nature of the search area was unique to the dogs. Historically, dogs most often train in and have been deployed to collapsed structures, mangled vehicles, and wide-area plains. Training in mud, especially the depth and amount of mud that characterized the Oso landslide, is rare. Thus, the geological nature of the disaster and the resulting search conditions presented unique challenges for human and canine responders.

The Oso landslide represented the first deployment of an Incident Support Team Veterinary Officer for FEMA US&R. The intent was to provide veterinary care for the search dogs through an individual trained to operate safely and effectively in a disaster environment who had experience working with search dogs and could provide continuity of care during the deployment. Additional support for medical care of the search dogs was provided by veterinarians and veterinary technicians from the WSDA-RVC, the local authority on the scene. The continued presence of WSDA-RVC personnel beyond the initial 2-week deployment of local wilderness canine search teams was a tremendous asset in providing care for the FEMA search dogs. The size of the debris field meant that operations were spread out over an area that was 1,300 m (4,400 feet) wide,⁸ making it challenging for the Incident Support Team Veterinary Officer to be available for all dogs at all sites at all times. The WSDA-RVC veterinarians and veterinary technicians provided continuous on-site care and logistic support for veterinary supplies, equipment, and medications. The WSDA-RVC veterinarians who assisted on-site consisted of small animal, large animal, and equine practitioners and state veterinarians. They did not necessarily have experience treating working dogs and were not certified in emergency response safety, hazardous materials, or bloodborne pathogen procedures. The Incident Support Team Veterinary Officer was able to provide just-in-time training and consultations to help local support team members operating safely in the disaster environment and with search dogs and handlers.

During an emergency response, FEMA deploys US&R Task Forces as a Type I 80-person unit with a

minimum of 4 certified search-and-rescue dogs. Less common is the deployment of a modular mission, designed to deploy trained individuals from 1 team or several teams for a specific mission assignment (ie, a water rescue team). Federal Emergency Management Agency approval for Human Remains Detection Canine Search Teams⁸ was very recent, in May 2013, with certification standards approved in August 2013, just 8 months prior to this deployment. The Oso, Wash, landslide was the first US&R modular deployment for canine search teams FEMA-certified for human-remains detection; on this deployment, 25 handlers from 10 different teams, which had never deployed together, worked as a cohesive and effective unit.

Most of the search dogs deployed to the Oso landslide were Labrador Retrievers or German Shepherd Dogs. This reflected the fact that of the 34 FEMA-certified human-remains detection dogs at the time, 13 were Labrador Retrievers and 6 were German Shepherd Dogs.^h Information on search dog signalment can be useful in response training and preparation, as it can provide information regarding breed-specific problems (eg, laryngeal paralysis, cruciate ligament trauma, and stress colitis) that could potentially be encountered.

For the Oso landslide response, search shifts were typically 10 hours, and search operations were conducted only during the day. Briefings and debriefings were conducted before and after search operations to allow for the transfer of new information and emphasize important safety issues. Search dogs received multiple physical examinations and on-site care for injuries and illnesses, allowing for timely care of conditions before they became worse or prevented dogs from working.

Twenty-one of the 25 (84%) search dogs incurred an injury or illness while deployed to the landslide area, with 15 (60%) of them incurring multiple medical issues. Morbidity rate for dogs in the present study was similar to that reported for dogs that responded following the WTC terrorist attack (81% and 68%)^{2,6} but was higher than that reported for dogs that responded following the Haiti earthquake (43%)⁷ or the Oklahoma City bombing (49%).¹ The IR^{SDM} in the present study (10.4 dogs/1,000 hours worked) was nearly twice that reported following the Haiti earthquakes (5.6 dogs/1,000 hours worked)⁷ but was within the range of rates reported following the WTC attacks (6.0 and 17.5 dogs/1,000 hours worked).^{2,6} The IR^{MIE} (66.5 injuries and illnesses/1,000 hours worked) was more than 5 times the rate following the Haiti earthquake (12.6 injuries and illnesses/1,000 hours worked) but again was within the range reported following the WTC attacks (47.6 and 92.8 injuries and illnesses/1,000 hours worked).^{2,6} Differences in search area hazards, weather conditions, shift hours, work-rest cycles, search dog signalment, preexisting conditions, duration of deployment, and study design (interviews, surveys, and medical records) likely account for these differences in morbidity and incidence rates between studies. Despite these differences, however, medical issues encountered at the Oso landslide were generally similar to those reported following these other deployments.

As was the case for previous disaster response deployments,^{1,2,6,7} wounds (abrasions, pad wear, paw pad

splits or cracks, and lacerations) were the most common injuries in the present study. However, dogs responding to the Oso landslide incurred wounds at a rate 3 times that reported following the WTC attacks^{2,6} and 7 times the rate reported following the Haiti earthquake.⁷ Pad injuries comprised 18 of the 20 injuries documented in search dogs following the Oklahoma City bombing, but an incidence rate was not reported.¹ Search dogs do not typically wear personal protective equipment (eg, boots, helmets, and masks), so their bodies are exposed to a variety of debris during search operations. In Oso, the deep mud hid many sharp objects, was irritating to the skin, and dried out pads, eventually leading to cracks that became deeper with time. The higher abrasion rate at the landslide may have been due to the abrasive nature of the mud that the dogs were stepping in throughout their search work.

Acute caudal myopathy has not been previously reported among dogs responding to a disaster event.^{1-3,6,7} However, both of the dogs in the present study that developed acute caudal myopathy were Labrador Retrievers, one of the breeds reportedly predisposed to this condition,¹² and both had had extensive exposure to cold, wet conditions during their first week of deployment. Thus, it seems likely that the acute caudal myopathy was not strictly due to deployment to the Oso landslide.

The 3 dogs in the present study with rupture or swelling of a cutaneous mass did not have any complications associated with the masses. In 1 dog, the mass would swell and then shrink, raising concerns that it was a mast cell tumor. The possibility of anaphylactic complications secondary to rupture of the mass was discussed with the handler, who was directed to avoid touching or rubbing the area. In addition, diphenhydramine was kept nearby. The skin masses in these 3 dogs were likely preexisting conditions, and it is unknown whether search work exacerbated the condition.

Dehydration was the most common illness among dogs responding to the Oso landslide. The IR^{MIE} was similar to that encountered among New York City Police Department dogs responding to the WTC terrorist attack,⁶ but twice the rate reported in a second study² of dogs responding to the WTC attack and 2.5 times the rate reported following the Haiti earthquake.⁷ Subjectively, encouraging oral rehydration by adding canned dog food to the dogs' drinking water was often successful in resolving the dehydration. However, because the dogs were intermittently working high-intensity searches for 10 hours, if they did not drink much or still appeared dehydrated after a rest period, warmed fluids were administered SC.

Dietary indiscretion was the second most common illness in the present study. Human and dog food, pools of contaminated water, and dead fish were all found in the search fields. Only one of the dogs observed to have eaten food from the field or drunk from water in the field vomited, and none of these dogs developed diarrhea. Eating anything or drinking from any pool of liquid in a search area is discouraged throughout training, and this is constantly reinforced throughout the dogs' search career. This training is especially important because FEMA US&R dogs are encouraged and

expected to search out of sight of and independently from the handler. Thus, there may be a high potential to ingest hazards.

Weight loss ranging from 3% to 13% of body weight was documented in 5 (20%) dogs in the present study; none of these dogs were reported to have had a decrease in appetite. This differed from findings for previous disaster responses. For instance, weight loss was reported for 9 (33%) New York City Police Department dogs responding to the WTC attacks, of which 8 reportedly had decreased appetites,⁶ and was reported for 22 (23%) of the FEMA and local law enforcement search-and-rescue dogs at the WTC site, of which 19 reportedly had decreased appetites.² Weight loss among the Oso search dogs occurred even though handlers increased the amount of food offered and the number of feedings per day, provided nutritional supplements, and fed high-calorie foods. These findings highlight the increased demands placed on working dogs during a deployment and the need to increase caloric consumption as a result.

The 6 shivering events reported in the present study all occurred on days that were subjectively colder and wetter. Neoprene vests and emergency blankets were purchased to decrease the incidence of shivering episodes by decreasing exposure to the rain and insulating the body. The vests were easily trimmed to fit the dogs, especially in the axillary and groin areas, and additionally served as protection from sharp debris. None of the handlers reported observing the vests interfere with their dogs' ability to search among the debris.

Respiratory abnormalities and urinary tract abnormalities were not identified among dogs deployed to the Oso landslide, unlike the case for dogs deployed following the Oklahoma City bombing and WTC attacks.^{1,2,6} This may have been due, at least in part, to the lack of smoke from burning fires, aerosolized debris from explosive events, and dust from structure collapses. Most of the search area consisted of fields, rather than an urban setting.

Although it is recommended that FEMA search dogs work without any body equipment, neoprene vests, which provided protection from the weather and debris, and foot bandages, which protected the pads, were used by dogs throughout the response to the Oso landslide. Subjectively, these vests and bandages did not interfere with the dogs' ability to search.

All dogs in the present study underwent decontamination procedures following every search shift. Volatile chemicals and coliform bacteria were identified during water testing,^{a,b} and dogs are particularly susceptible to environmental toxins through respiratory, dermal, ocular, and oral pathways.⁶ Decontamination was performed as a precaution against possible exposure to environmental toxins and to remove caked-on mud, which may have hidden wounds. Warm water was used in an effort to decrease the potential for hypothermia. Initially, dish soap was used, but this was found to dry the dogs' skin, resulting in scratching. Therefore, an oatmeal-based shampoo formulated for dogs was acquired and used for the duration of the deployment.

A method for decontaminating animals exposed to flood waters was published in 2008,¹³ with the au-

thors stating that decontamination is an important component of responsible emergency management. Decontamination of human team members has been a foundation of the FEMA emergency response program, but decontamination protocols for search dogs were not officially adopted until 2008.ⁱ These guidelines are important because search dogs do not typically wear protective gear. Also, hazardous materials and bacterial contaminants (eg, leptospires in standing water) may not readily be apparent during search operations and, following completion of search operations, dogs could potentially transport hazardous materials and biological contaminants back to vehicles, bases of operation, and tents where other task force members and other agency personnel are housed and fed. Locally based search dogs return to their handlers' vehicles and homes, where family members, including children, may be exposed. An inexpensive, lightweight, easy-to-assemble canine decontamination system has been developed by Massachusetts Task Force 1 and approved by FEMA. This system has a small cargo footprint and takes no more personnel to operate than does a human decontamination system.

For dogs in the present study, postmission examination with clinicopathologic testing was recommended on the basis of the environmental conditions at the landslide and concerns regarding potential infectious diseases dogs might have acquired, including leptospirosis, giardiasis, and salmon poisoning disease. None of the 6 dogs with abnormal postmission urinalysis results had signs of urinary tract disease during deployment, and only 1 of the 4 dogs with abnormal postmission fecal test results had diarrhea.

All medical issues documented in the present study resolved during the deployment or within 2 weeks after demobilization. The mass that seemed to change size several times was excised, and the histopathologic diagnosis was mast cell tumor.

Importantly, although multiple illnesses and injuries were documented, no serious medical issues occurred. Mild to moderate abrasions, lacerations, and dehydration were the most common health issues. Wounding was also the most common injury in 4 similar studies^{1,2,6,7} of 3 prior deployments. Dehydration was also the most common illness in a similar study⁷ and ranked third most common in 2 others,^{2,6} whereas exhaustion, ocular discharge, and weight loss occurred more frequently per 1,000 hours worked. Respiratory and urinary tract abnormalities did not occur and ocular problems were minimal, unlike in prior reports.^{1,2,6} These data emphasize health concerns responders should be aware of, but also reveal the need to be vigilant about all issues, including preexisting conditions and abnormalities not associated with search hazards, so that these issues do not become exacerbated and result in a dog being removed from search operations.

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