



Canine Research

Handler training improves decontamination of working canines with oil-based exposure in field conditions using disposable kits



Ellie B. Powell^a, Gary A. Apgar^a, Eileen K. Jenkins^b, Stephen Y. Liang^c, Erin B. Perry^{a,*}

^a Department of Animal Science Food & Nutrition, Southern Illinois University, Carbondale, Illinois

^b First Year Graduate Veterinary Education Program, Public Health Activity – Fort Bragg, Fort Bragg, North Carolina

^c Divisions of Emergency Medicine and Infectious Diseases, Washington University School of Medicine, St. Louis, Missouri

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ABSTRACT

Exposure to contaminants in the field is a reality for deployed canines. To date, there are no data evaluating the benefits of training for handlers associated with canine decontamination efforts. The objective of our work was to investigate the impact of handler training on the reduction of oil-based contaminants in working canines. Canine teams ($n = 10$) were randomly assigned to either TRAINED or UNTRAINED groups. Each team (handler and dog) in the TRAINED group received 30-minutes of interactive training using an illustrated guide on proper utilization of equipment provided. Teams in the UNTRAINED group received the same equipment and illustrated guide but no interactive training. Decontamination efforts were measured using an oil-based pseudocontaminant (GloGerm[®], Moab, UT) topically applied to four anatomical locations: cranial neck, between the shoulder blades, left medial hindlimb, and left hind paw with pre- and post-washing images collected from a fixed distance of 20 inches. Visual assessment of contaminant reduction was scored as follows: 0 = <24% contaminant reduction; 1 = 25%–50% contaminant reduction; 2 = 51%–75% contaminant reduction; and 3 = >76% contaminant reduction. No score discrepancies >1 were reported between reviewers. Trained handlers were more effective at contamination reduction ($P = 0.0093$) as compared with their untrained counterparts. These results indicate that handlers, when properly trained, can achieve reduction of oil-based contaminants with a disposable decontamination kit and a garden hose.

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Introduction

Large-scale disasters can result in the dispersal of potentially toxic chemicals and hazardous materials into the environment (Murphy et al., 2003; Soric et al., 2008). Floods, volcanic eruptions, earthquakes, landslides, hurricanes, tornadoes, and man-made events (Binder and Sanderson, 1987; Otto et al., 2002) can release phenols, toxic petroleum products, asbestos-laden dust, heavy metals, and a wide range of volatile organic solvents and other compounds that may pose harm to animal and human health (Murphy et al., 2003; Soric et al., 2008).

Although some efforts have been made to identify methods associated with decontamination after disasters, few data have

identified effective techniques applicable to working canines deployed as part of a response team (Soric et al., 2008; Venable et al., 2017; Washington Department of Fish and Wildlife, 2009; Welte and Frink, 1991). Previous work has demonstrated current techniques are inadequate for complete removal of oil-based contaminants (Venable et al., 2017). By contrast, data from wildlife studies have reported complete contaminant removal, but suggest a protocol that is prohibitive due to the extensive amount of time required (Washington Department of Fish and Wildlife, 2009; Welte and Frink, 1991). These studies involve the use of a decontamination corridor (Figure 1) that is both labor intensive and unlikely to be available in the early hours of a disaster response.

Response time for effective decontamination is critical and should include efforts to reduce exposure, restrict absorption, and enhance elimination (Jones et al., 2004). The handler may better achieve each of these mandates through rapid decontamination in the field. To date, no data are available regarding the efficacy on contaminant reduction associated with handler decontamination in the field. Therefore, the objectives of our study were to assess the

* Address for reprint requests and correspondence: Erin B. Perry, Department of Animal Science Food & Nutrition, Southern Illinois University, Carbondale, IL 62901. Tel: (618) 453-1358; Fax: (618) 453-5231.

E-mail address: erin.perry@siu.edu (E.B. Perry).

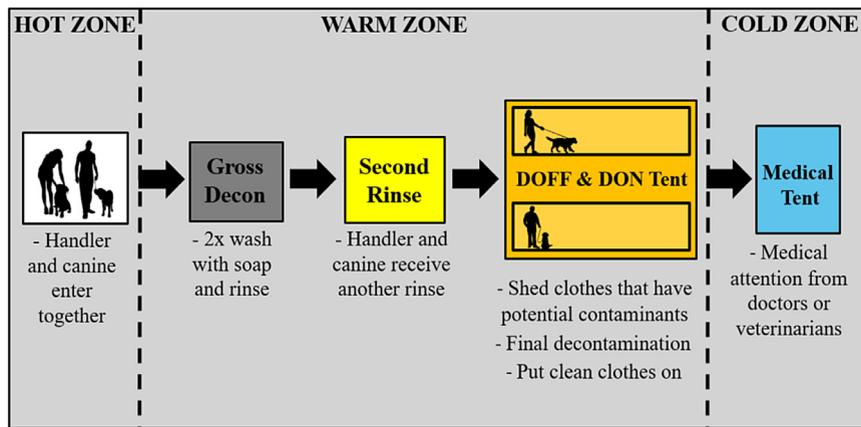


Figure 1. Illustration of typical decontamination corridor setup in the triage zone¹. ¹Zones: Hot, contaminant present; Warm, decontamination procedure; Cold, no contaminant present and medical checks performed.

contaminant reduction potential of handlers using disposable field kits for canine decontamination under field conditions and investigate the impact of training on handler decontamination effectiveness.

Materials and methods

Animals

This research was approved by the Southern Illinois University Institutional Animal Care and Use Committee (Protocol 15-032). Canine teams ($n = 10$) from the National Disaster Search Dog Foundation (Santa Paula, California) were randomly assigned to TRAINED or UNTRAINED groups for participation in a 2-day study. Breeds included German shepherds ($n = 2$), Labrador retrievers ($n = 5$), Belgian malinois ($n = 1$), and mixed breeds ($n = 2$). Each team (handler and dog) in the TRAINED group received 30 minutes of interactive instructions using an illustrated guide on proper utilization of equipment provided. Teams in the UNTRAINED group received the same equipment and illustrated guide but no interactive instructions. No handler had any knowledge or use of the decontamination field kit before the study.

Field kit

Both groups received identical field decontamination kits (Figure 2A), designed by the researchers for the purpose of this study. Each field decontamination kit contained a rubber grooming brush (ZoomGroom®, Salisbury, UK), two disposable nylon leashes, disposable towels for drying, Johnson & Johnson's Head-To-Toe-Baby Wash (Procter & Gamble, Cincinnati, OH), cotton balls, a package of baby wipes (Huggies®, Neenah, WI), disposable gloves and an illustrated guide (Figure 2B) with step-by-step procedures for decontamination. Instructions for use of the field decontamination kit and illustrated guide (Figure 3) were developed according to researchers' recommendation.

Procedure

An oil-based contaminant (GloGerm®, Moab, Utah) was topically applied to each canine at four anatomic sites: 1) cranial neck; 2) between the shoulder blades; 3) left medial hindlimb; and 4) left hind paw (Figure 4). Equal pressure was applied during application to maximize consistency of contaminant contact. Images

were collected before (Figure 5A) and after decontamination efforts (Figure 5B) with a Nikon D3400 DSLR camera with 18–55 mm VR lens and a UV flashlight provided by GloGerm® at a fixed position of 20 inches. Care was taken to ensure that room lighting and camera distance remained the same for all images.

Photos were analyzed using two methods: 1) assignment of visual score; 2) measurement of fluorescent reduction. Scores were assigned on visual inspection of each of the four anatomic sites, using two blinded reviewers with a >80% agreement as previously described with no score discrepancies of >1 between reviewers (Venable et al., 2017). Visual score assignments were allotted as follows: 0 = <24% contaminant reduction; 1 = 25%–50% contaminant reduction; 2 = 51%–75% contaminant reduction; and 3 = >76% contaminant reduction adapted from prior work (Lee and Lee, 2014). In addition, contaminant reduction was measured quantitatively at each site using the software program, ImageJ (NIH, Bethesda, MD) and by calculating the percent change in fluorescence using the equation $\left(\frac{PRE-POST}{PRE} \times 100\right) = \Delta\%$.

Categorical data (visual scores) were analyzed as a chi square test using PROC FREQ (SAS, v 9.4). Numerical data ($\Delta\%$) were compared using a 1-way ANOVA. After calculations of both data sets, PROC REG was used to identify relatedness. The P value for all analysis was set at 0.05 and effective decontamination was defined as a reduction in fluorescence by at least 50% or a contaminant reduction score of ≥ 2 (Venable et al., 2017).

Cross-contamination was assessed visually in the kennel area for 5 canines and their handlers. Canine kennel areas were inspected 24-hours after decontamination, whereas the handlers were inspected immediately after field decontamination of their canines. Private kennel space was maintained for each dog to simulate kennel stations at a typical base of operations during deployments.

Results

Efficacy of decontamination

Training improved contaminant reduction compared with their untrained counterparts ($P = 0.0093$) as shown in Figure 6 as determined by visually assigned scores. Similarly, measured fluorescent reduction also indicated improved contaminant reduction associated with the TRAINED versus UNTRAINED group ($P = 0.0042$) (Figure 7).



Figure 2. (A) Disposable field kit designed to decontaminate canines in the field. (B) Illustrated guide with instructions on proper decontamination procedures.

Anatomic site also impacted contaminant reduction ($P = 0.0055$) as in Figure 8. The shoulder blades were most effectively decontaminated (i.e., greatest amount of reduction) at 50.3%, followed by the left hind paw at 40%. Both the paw and shoulder blades were more effectively decontaminated when compared with the cranial neck (29.2% reduction) and the left medial hindlimb (20.4% reduction).

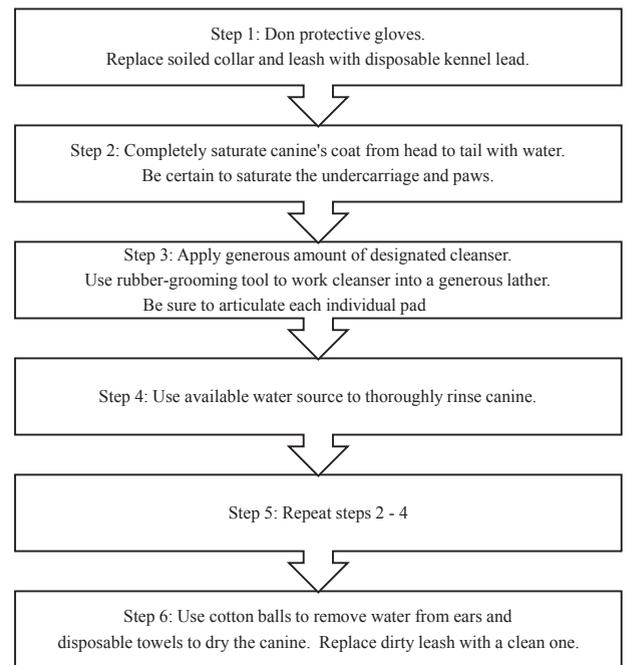


Figure 3. Instructions for use of the field decontamination kit, based on researcher's recommendations.

Cross-contamination

Cross-contamination was defined as the presence of contaminant on environmental surfaces and was assessed using an ultraviolet flashlight (The Bramton Company LLC, Dallas, TX). Of the 5 canine kennels surveyed, all showed evidence of residue transfer (Figure 9). Specific areas of contamination included 60% of the canines' water buckets and beds, 80% of the kennel floors and walls and 40% of the kennel doors handles. Handlers checked for cross-contamination had residue transfer to their boots, pants, belts, shirts, watches and hats, suggesting cross-contamination from canine to handler.

Comparison between categorical and measured fluorescent reduction data

A linear regression analysis was performed and indicated relatedness ($P = 0.0126$) between the visual scores and measured reduction. On further analysis, utilizing a Spearman's correlation, a weak relatedness ($r_s = 0.2476$) as determined between both sources of data. r_s is defined as:

$$r_s = 1 - \frac{6 \sum D^2}{n(n^2 - 1)}$$

where the Spearman rank correlation coefficient, D is the difference between each pair of ranks of corresponding values of the variables X and Y , and n is the number of pairs of values in the sample.

Discussion

According to the Urban Search and Rescue Veterinary Group, canine decontamination is a recognized component of Federal Emergency Management Agency (FEMA) Urban Search-and-Rescue canine care and part of the expected setup to maintain a clean base of operations environment (FEMA, 2017). Although efforts toward

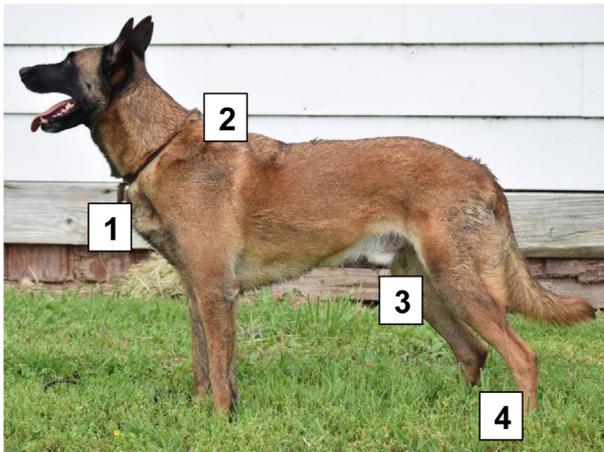


Figure 4. Anatomic sites for contaminant application: (1) cranial neck, (2) between the shoulder blades, (3) left medial hindlimb, and (4) left hind paw.

improved decontamination of working canines have been made, lack of available data and standardized protocols have inhibited opportunities for replication. Consequently, evidence-based guidelines are needed to protect canines and handlers when disasters strike.

Gordon (FEMA, 2012, 2017) reported attempted decontamination by federal teams deployed to hurricanes in 2012 and 2017. Decontamination stations were used with 63%–100% of canines decontaminated (FEMA 2012, 2017). However, procedures were inconsistent and lacked adequate detail. Various combinations of water temperatures (cold or warm), cleansers (soap or Simple Green®) and baby wipes were used to decontaminate the canines with some teams reporting the use of water alone.

Other reports have included greater detail but indicate a lack of evidence regarding cleanser selection. In 2010, after an earthquake in Haiti, 22 Urban Search-and-Rescue canines were deployed. Twenty-one of the canines underwent decontamination on all search days, whereas the remaining canine only received decontamination on half of the search days (FEMA, 2012). However, no corridor was set up for decontamination. Eighteen canines were decontaminated with soap and water, 2 canines had a combination

of soap, water, moist wipes, and eye flush, whereas the remaining 2 canines were decontaminated with water alone (FEMA, 2012). After a 2014 landslide in Oso, Washington, the Washington National Guard established 2 mass decontamination units, and Washington Task Force 1 established a decontamination corridor to decontaminate the 25 canines deployed (Gordon, 2015). Decontamination was provided for canines after every shift. Water and dish soap were used, but veterinary medical stations also provided additional water, wipes, and towels to further decontaminate the canines as needed (Gordon, 2015). Veterinary assessments revealed that the dish soap used caused dermatological issues, leading to scratching and skin damage. Therefore, an oatmeal-based shampoo formulated for canines was acquired and used for the remaining duration of the deployment to mitigate skin drying (Gordon, 2015). This report seems to suggest that repetitive decontamination, as is often necessary under deployment conditions, may require investigation so as to provide evidence-based recommendations for cleansers that are effective and safe.

Decontamination protocols for oil-based contaminant exposure exist for sea otters and waterfowl (Washington Department of Fish and Wildlife, 2009; Welte and Frink, 1991). Both utilize Dawn® (Procter & Gamble, Cincinnati, OH) due to degreasing properties. In sea otters, multiple applications of diluted 5% solution were applied at washing tables. (Washington Department of Fish and Wildlife, 2009). Each wash table required 4 to 6 people to decontaminate the sea otters, as the detergent was massaged into the oiled fur and then rinsed off under moderate pressure (30–40 psi) with a spray nozzle (Washington Department of Fish and Wildlife, 2009). This procedure was repeated until all of the oil was lifted and removed from the otter's fur, requiring 40–60 minutes to complete (Washington Department of Fish and Wildlife, 2009). After the wash procedure, a final rinse lasted an additional 40–60 minutes. Although this method has been deemed effective for wildlife, the length of time required for implementation makes this approach impractical for working canines in the field.

In addition to sea otter decontamination, the Washington Department of Fish and Wildlife also has protocols in place for waterfowl exposed to oil-based contaminants. Warm water (104°F) and Dawn® solution (2%–15%) are used in conjunction with 10-gallon tubs to wash oil from feathers. Once again, the cleaning effort takes approximately 60 minutes (Welte and Frink, 1991). Clearly, these methods, although potentially effective, are not

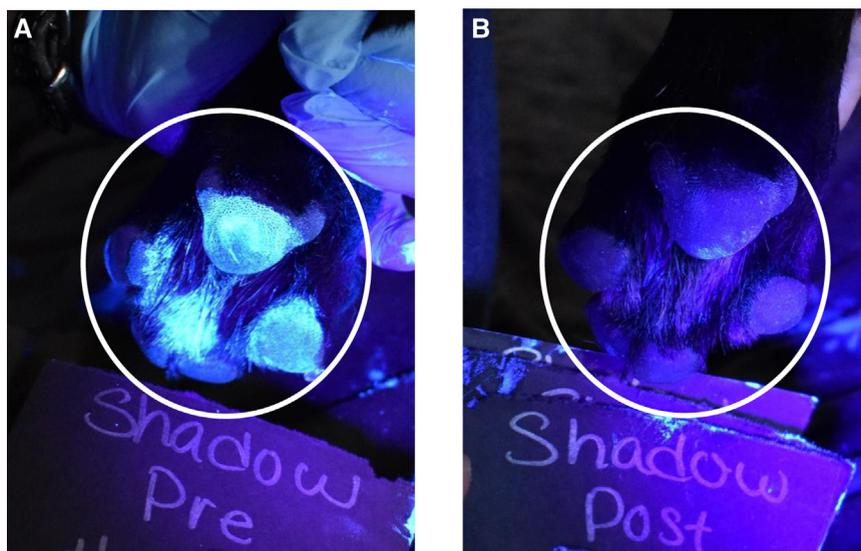


Figure 5. (A and B) Images representing pre- and post-washing levels of fluorescent residue. Image depicts a score of 3 (>75% reduction in contamination).

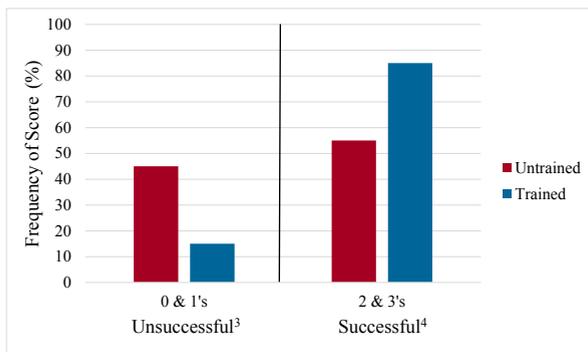


Figure 6. Effect of training¹ on frequency of contaminant reduction score² visually assigned across all anatomic sites ($P = 0.0093$). ¹Training: trained handlers—30-minute formal presentation on field kit and use. Untrained handlers—no formal presentation on field kit and use. ²Frequency of score was used to determine percent occurrence. ³Unsuccessful—contaminant reduction score of 0-1. ⁴Successful—contaminant reduction score of 2-3.

plausible for use in the field where warm water may be unavailable and lengthy decontamination procedures are prohibitive. Decontamination procedures must proceed efficiently and rapidly to accommodate the influx of teams returning to base.

Some decontamination efforts have utilized Dawn[®] and Simple Green[®] as cleansers despite the lack of data for safety and efficacy in the canine. The use of Simple Green[®] to decontaminate canines is alarming. Simple Green[®] is a product approved for use on inert surfaces, not on animals. Soaps and detergents, also known as surface active agents, work as emulsifiers to surround and lift organic matter from hair, which can then be rinsed away with water (Soric et al., 2008). Although that chemical characteristic provides a sound theory for the use of dish soap, when Dawn[®] was compared with baby shampoo in a recent study, baby shampoo (Johnson & Johnson Head-To-Toe Baby Wash, Procter & Gamble, Cincinnati, OH) was found to be more effective at reducing oil-based contaminants than Dawn[®] (Venable et al., 2017). These pilot data are the first to suggest that dish soap may be ineffective at oil-based contaminant reduction using standard decontamination techniques in working canines.

In a study conducted by the Sea World Research Institute, a decontamination protocol for otters was developed, utilizing diluted Dawn[®] solution (1:16 in water). The researchers designed a protocol that required a 40-minute wash, followed by a 40-minute rinse once there was no indication of oil residue on the fur of the otters (Davis et al., 1988). However, gas chromatography performed on fur samples taken from the abdomen (unooled) or the sternum

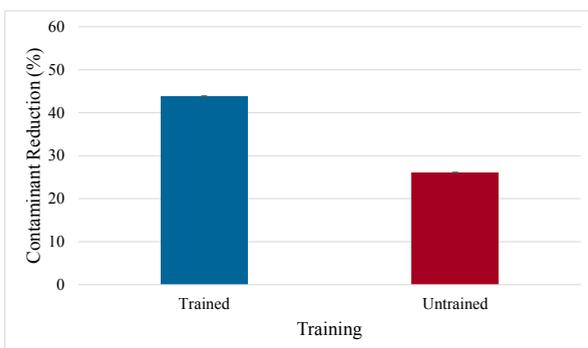


Figure 7. Effect of training¹ on contaminant reduction measured across all anatomic sites ($P = 0.0042$). ¹Training: trained handlers—30-minute formal presentation on field kit and use; untrained handlers—no formal presentation on field kit and use.

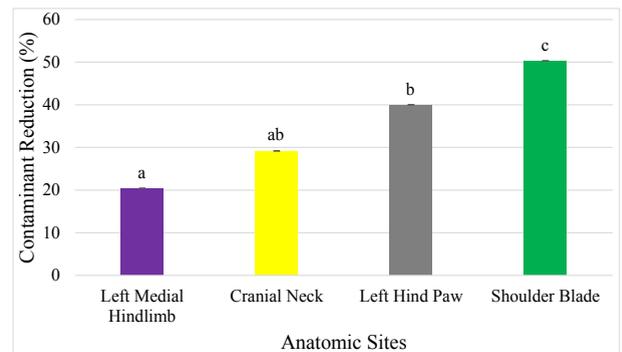


Figure 8. Effect of anatomical site on measured contaminant reduction after field decontamination ($P = 0.0055$). ^{a,b,c} Means with different superscripts differ ($P < 0.05$).

(oiled) of otters revealed changes in squalene concentrations after use of Dawn[®] (Davis et al., 1988). Squalene is important in maintaining the water-repellent and insulating qualities of otter fur. Squalene was not restored in the oiled and cleaned fur after 7 days (Davis et al., 1988) suggesting adverse dermatological effects associated with the use of dish soap.

The impact of decontamination on canine skin is dependent on the type and frequency of cleanser used, as well as the health and composition of the skin to which the cleanser is applied. The use of surfactants in cleansers facilitates removal of dirt and soil. Unfortunately, the interaction of surfactant with proteins and lipids in mammalian skin can be detrimental to dermatologic health (Ananthapadmanabhan et al., 2004). Anionic surfactants, which typically have an alkaline pH, are notably more irritating to skin than cationic surfactants, which typically have a neutral to slightly acidic pH (Ananthapadmanabhan et al., 2004). Differences in cleanser structural properties and skin pH influence the amount and type of damage inflicted by surfactants interacting with



Figure 9. Evidence of cross-contamination of an untrained handler's canine's kennel, after field decontamination.

proteins and lipids within the stratum corneum (Beranda et al., 2002; Ananthapadmanabhan et al., 2004).

To maximize effectiveness and minimize irritation, the pH of the cleanser should resemble the pH of the skin. Most products currently used for canine decontamination are shampoos formulated for human skin and hair, or dishwashing soap formulated to protect human skin. The pH of canine skin is slightly acidic to neutral, varies by body region and is influenced by excitement, but is not influenced by male or female sex (Meyer and Neurand, 1991). While human skin typically has a pH of 5.5–6.5 (Chan et al., 2012), the mean pH of canine skin can range from 5.86 to 7.42 in the unexcited state and 7.15 to 8.03 in the excited state (Meyer and Neurand, 1991). Thus, the use of cleansers formulated for human skin may not be the most effective or safe product for decontamination of canine skin.

Regardless of the cleansing product used, repeated washing of skin can have deleterious effects. With repeated use, surfactants can cause a decrease in skin hydration and viscoelasticity, cause denaturation of skin proteins, and can alter skin lipid biosynthetic pathways (Ananthapadmanabhan et al., 2004). Repeated washing with dish soap caused increased epidermal irritation in search and rescue canines bathed daily (Gordon, 2015). The serial use of Dawn dish soap for canine decontamination resulted in mild to moderate epidermal irritation starting at a mean of 4.9 days (Mabry, 2015). The serial use of DermaLyte soap, a product marketed specifically for dogs, also resulted in mild to moderate epidermal irritation starting at a mean of 5.8 days (Mabry, 2015). More research is needed to determine the most effective and least irritating products to use for serial decontamination of canine skin. The ideal cleanser will rapidly and effectively remove a wide variety of contaminating substances, will not enhance cutaneous absorption or penetration of the contaminant, is readily rinsed or removed after use, does not damage skin, and is affordable and readily available (Chan et al., 2012).

One objective of this study was to determine the effect of training on contaminant reduction, using a field kit. Handlers receiving no training failed to remove soiled collars from the canine's neck, thus the collar acted as a vector for reintroduction of contaminants. This is similar to prior work demonstrating a failure to remove soiled collars from canines during decontamination procedures (Venable et al., 2017). In addition, training also had an impact on the amount of contaminant reduction on the canine's paw. The paws are likely to have the highest amount of contamination. This is especially concerning as floodwaters may contain potentially dangerous chemicals and pathogens. This is particularly worrisome as canines groom themselves in areas where accumulated contaminants are likely to occur: their paws, the area immediately around the sides of the mouth, along their limbs and the areas of short hair, such as the anogenital area (Beaver, 2009). This behavior provides a pathway for oral exposure (Fitzgerald et al., 2008) and requires further investigation to better understand oral ingestion of contaminants and gastrointestinal complications frequently observed in dogs during deployment (Gordon 2010, 2015; Otto et al., 2002; Murphy et al., 2003).

The benefits of training associated with decontamination have been studied extensively in hospital settings. Formal education programs significantly improve physician and nurse hand hygiene compliance. However, improvements are usually short-lived; without ongoing reinforcement, compliance tends to return to baseline over a period (Lam et al., 2004). Therefore, it seems reasonable to assume that improvements in canine decontamination efforts as a result of formal training are also perishable and will require regular reinforcement.

Another objective of this study was to examine the efficacy of a portable field decontamination kit. Based on the results, the kit

provided an effective in-field decontamination option for handlers. This is particularly important when timely intervention is critical and a decontamination corridor is not available.

The observations of cross-contamination noted in this study are particularly worrisome. Researchers noted fluorescent residue transfer to the kennels and handlers. During a disaster, contaminated water, particularly in the setting of poor or compromised sanitation, has the potential to harbor pathogens that could be detrimental to working dog and/or human health. Working dogs exposed to contaminated water can become infected with certain pathogens (e.g., *Leptospira*, *Giardia*), develop illness, and transmit disease to humans. They could also serve as unwitting carriers of enteric pathogens on their fur coat that pose a threat primarily to humans (e.g., *Escherichia coli*, *Vibrio*, enteroviruses) during large-scale disasters. Close contact between working dogs and humans combined with poor hand hygiene practices could lead to human oral ingestion of pathogens and subsequent infection.

Conclusion

Training was shown to have a positive effect on contaminant reduction in this study. Further study is recommended to analyze this effect across different breeds with varying coat types. Effects related to coat type should be examined with particular attention given to type of cleanser and repetitive cleansing. In addition, the impact of the cleanser on the skin needs to be evaluated more thoroughly. Currently there is insufficient evidence available to determine which cleansers are safest for canine skin. Improved training and further investigation into the safety and efficacy of existing cleansers are needed to protect the health of our canine partners in the field. Future work should also assess likely areas of contamination on the canine so as to maximize decontamination efforts and improve results.

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The findings and conclusions in this article represent the opinion of the authors and do not necessarily represent those of the U.S. Department of Homeland Security or the Federal Emergency Management Agency.

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