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Injuries and Other Medical Problems Among Young Military Working Dogs (MWDs)

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14. ABSTRACT

Purpose: The goal of this project was to 1) quantify medical encounters among a population of Military Working Dogs (MWDs), 2) analyze risk factors for injuries and other common medical problems, and 3) to demonstrate the value of a centralized data repository for MWD demographic, deployment, and medical record data. **Methods:** This effort involved a partnership between the U.S. Army Public Health Center (APHC) Veterinary One Health and Injury Prevention Divisions. Medical encounters among young, active MWDs were categorized and combined with demographic information to analyze risk factors. **Results:** A total of 774 young dogs were included in the analysis. Most dogs were male (74%), German Shepherd (39%) or Belgian Malinois (31%) breeds, had a dark coat color (83%), and were certified in Explosive Detection (60%). The average age was 2.6 years (± 0.5 years). Ninety-seven percent of dogs had a medical encounter in their record. When surgical encounters were removed, the most common encounters were for dermatologic, alimentary, dental, soft-tissue injury, and musculoskeletal conditions. Risk factors for these conditions included German Shepherd or Belgian Malinois breed, Explosive Detection or Drug Detection certifications, intact spay/neuter status, and NORTHCOM or CENTCOM locations. **Conclusions and Recommendations:** Training and work conditions for the identified at-risk groups of MWDs should be assessed. The multiple sources which currently house MWD data should be merged with medical records in a central data repository for easier data cleaning and analysis. This will allow for future analyses like this to be conducted among larger cohorts and with more variables.

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1. SUMMARY

1.1 Purpose

The goal of this project was to 1) consolidate medical encounters among a population of Military Working Dogs (MWDs), 2) analyze risk factors for injuries and other common medical problems, and 3) demonstrate the value of a centralized data repository for MWD demographic, deployment, and medical record data.

1.2 Methods

This effort involved a partnership between the U.S. Army Public Health Center's (APHC) Veterinary One Health and Injury Prevention Divisions. Medical encounters among young, active MWDs were categorized and combined with demographic information to analyze risk factors.

1.3 Results

A total of 774 young dogs were included in the analysis. Most dogs were male (74%), German Shepherd (39%) or Belgian Malinois (31%) breeds, had a dark coat color (83%), and were certified in Explosive Detection (60%). The average age was 2.6 years (± 0.5 years).

Ninety-seven percent of dogs had a medical encounter in their record. When surgical encounters were removed from consideration, the most common encounters were for dermatologic, alimentary, dental, soft-tissue injury, and musculoskeletal conditions.

Risk factors for these conditions included German Shepherd or Belgian Malinois breed, Explosive Detection certification, intact spay/neuter status, and male sex.

1.4 Conclusions and Recommendations

Training and work conditions for the identified at-risk groups of MWDs should be assessed. The multiple sources which currently house MWD data should be merged with medical records in a central data repository for easier data cleaning and analysis. The repository will allow for future analyses of MWD data to be conducted among larger cohorts and with more variables. Data from an MWD post-deployment health assessment could also be included in the repository, which would allow for greater visibility and analysis of deployment-related medical concerns, including the use of MWDs as sentinels for human Service members.

2. REFERENCES

See Appendix A for a listing of the references cited within this report.

3. AUTHORITY

Army Regulation (AR) 40–905 (Departments of the Army the Navy and the Air Force, 2006) tasks the Army Veterinary Service to provide veterinary care to animals and collect medical records. AR 40–5, paragraph 2-19a (DA, 2007) tasks the APHC to provide "support of Army preventive medicine activities through consultations, program evaluations…in the areas of disease and injury prevention and control…health surveillance and epidemiology…"

4. BACKGROUND

Since World War I, Military Working Dogs (MWDs) have been used by the United States military in a variety of capacities, including explosive detection, drug detection, patrol/attack work, and special operations support (Giles III, 2016; Jennings Jr, 1991). The Pentagon spent billions of dollars investigating technological alternatives for detecting explosive devices and found that trained bomb-sniffing dogs are the most reliable option (Erwin, 2010).

German shepherds have historically been used as MWDs because of their intelligence and adaptability to a variety of situations (Jennings Jr, 1991; Leighton, Linn, Willham, & Castleberry, 1977). Belgian Malinois dogs have been used since the 1980s because they were found to be good detector dogs that have fewer health problems than German shepherds (Jennings Jr, 1991).

Department of Defense Directive (DODD) 5200.31E establishes procedures and assigns responsibilities for the MWD Program (DoD, 2011), which is implemented by Air Force Instruction 31-216/AR 800-81/OPNAVINIST 5585.2C/MCO 5585.6 (Departments of the Air Force the Army and the Navy, 2019). More specific Army responsibilities are outlined in Army Regulation 190–12 (DA, 2013b). The 341st Training Squadron (341TS) is tasked as accountable for maintaining the inventory of dogs, implementation of MWD training, and assigning dogs. Unique MWD identification numbers, a letter followed by 3 digits, are assigned by the 341TS and are tattooed on the inside of the dog's left ear (Departments of the Air Force the Army and the Navy, 2019). The letter portion of the identification number is assigned according to the fiscal year the dog was procured by the Government (Departments of the Air Force the Army and the Navy, 2019).

The 341TS also manages the DOD Puppy Program at Lackland Air Force Base (AFB), Texas (Cournoyer, 2003). Military veterinarians are responsible for the medical treatment of MWDs, as required by AR 40–905 (Departments of the Army the Navy and the Air Force, 2006) and AR 40–3 (DA, 2013a). U.S. Army Technical Bulletin, Medical (TB MED) 283 provides the necropsy protocol for MWDs (DA, 2001). The 2016 National Defense Authorization Act allocates Federal funding for MWDs' transportation home from combat (114th Congress, 2015).

There is little historical record of the demographics and medical conditions of MWDs. Medical history for MWDs is especially lacking, and most published studies have investigated prevalence of conditions in deployment settings only (J. Baker & Truesdale, 2008; J. L. Baker, Truesdale, & Schlanser, 2009; Takara & Harrell, 2014). As MWDs are a valuable military

resource, achieving a better understanding of their common medical conditions and associated risk factors is vital.

The current lack of a centralized database for military veterinary medical data introduces a barrier to future research. Therefore, the present analysis also served as a proof-of-concept prototype for the future merging of multiple databases that house MWD medical data. A series of post-deployment MDW handler surveys is also recommended to identify more detailed information about MWD injuries and illnesses during deployments.

5. Methods

5.1 Data Collection

The data collection for this survey involved the Remote Online Veterinary Record (ROVR), which provided MWD demographics, certification, location, and medical encounters. Demographics included date of birth, tattoo ID number, sex with neuter/spay status, breed, coat color, and occupational duty certification. Only young dogs with identification tattoos beginning with X and Y were included in this pilot, as all of their medical records were available in ROVR; access to archived paper records was not required. These dogs were procured by the U.S. Government 2014-2016.

To capture the MWDs with primarily military functions, MWDs at veterinary treatment facilities (VTFs; referred to as “kennels” in ROVR) more closely aligned with civilian police, Transportation Security Administration, or other working dog duties were excluded from the analyses. MWDs were assumed to be inactive and excluded if the ROVR record explicitly indicated “inactive,” or if the current location was identified as “RECORDS REPOSITORY.” Records in the repository are archived records of former MWDs that are now inactive and/or deceased.

5.2 Data Analysis

Data were exported from ROVR and analyzed with the Statistical Program for Social Sciences (SPSS®), Version 19.0. Descriptive statistics were calculated for general MWD demographics (e.g., breed, coat color, location, certification).

Age in years was calculated by subtracting the date of birth from the analysis date (31 July 2017). Age was not able to be calculated for 5 MWDs due to missing data of birth or medical record date. MWDs were defined by sex as either male, neutered male, female, or spayed female. Neuter/spay status was updated in the record if a reported intact male or female MWD had a medical encounter for neuter/spay. Breeds with 10 or more MWDs were kept as unique breed categories, and included German Shepherd, Belgian Malinois, Labrador Retriever, and German Shorthaired Pointer. Breeds with fewer than 10 MWDs were grouped into an “Other” breed category, including Chesapeake Bay Retriever, Dutch Shepherd, Flat-Coated Retriever, German Wirehaired Pointer, Golden Retriever, Jack Russell Terrier, Jagdterrier, Vizsla, Weimaraner, Wire Fox Terrier, Wirehair Pointing Griffon, mixed breed, and unknown breed. Dark coat color was defined as any of the following coat colors: black, black/tan, black/white, blue/fawn, brindle, brown/black, chocolate, grey, liver, and sable. Light coat color was defined

as any of the following coat colors: fawn, gold, red, tan, white, and yellow. MWDs categorized as Explosive Detection include those certified in Explosive Detection only, as well as those certified in both Patrol and Explosive Detection. “Drug Detection” MWDs represent those certified in Drug Detection only, as well as those certified in both Patrol and Drug Detection. Specialized Search MWDs include those certified in Mine Detection and in Specialized Search. MWDs categorized as Patrol are only certified to Patrol. MWDs were considered “not certified” if they did have a certification at the time data were retrieved.

Military branch was defined as the branch associated with the installation on which the MWD was located. Combatant command was based on the location of the MWD as reported in ROVR (U.S. Department of Defense, 2018). The location of the MWD within or outside the continental U.S. (CONUS or OCONUS, respectively) was also determined by the location of the MWD report in ROVR. For MWDs in the CONUS, U.S. Census Divisions and Regions were further distinguished (U.S. Census Bureau, 2013). See Appendix C for further information on Veterinary Treatment Facilities in each combatant command, CONUS and OCONUS, and U.S. Census Divisions and Regions.

According to a previously published methodology, all medical encounters for the population were categorized by veterinary subject matter experts (Takara & Harrell, 2014). These categories included alimentary, behavioral, cardiovascular, dental, dermatologic, heat injury/illness, infectious, mass lesion, multisystemic, musculoskeletal, neurological, ophthalmologic, soft tissue injury, surgical, urogenital, and other.

Deployment records included data on the following: start date, estimated deployment end date, end date (if applicable), location, and reason for deployment. MWDs may have deployed more than once during the timeframe, and all deployments were captured in the database. Length of deployment was calculated from start date and end date, or estimated end date if no exact end date was available. Deployment location was utilized to assign combatant commands while deployed, (U.S. Department of Defense, 2018), military branch while deployed, CONUS or OCONUS deployment, and for those in the CONUS, U.S. Census Divisions and Regions (U.S. Census Bureau, 2013). Reasons for deployment were grouped into four categories. Deployments for Operation Enduring Freedom (OEF) or OEF and Operation Iraqi Freedom (OIF), as well as any deployments to OEF/OIF-identified countries, were classified as OEF/OIF. Deployments related to Presidential or Secret Service duty were categorized as Presidential. Training deployments included all of the following:

- Certification,
- Training,
- Patrol Explosive Detector Dog course,
- Pre-deployment training,
- Pre-deployment, school,
- Training/certification,
- Training (ship), and
- Joint service training.

Other listed reasons for deployment included:

- Air Show,
- Temporary duty (TDY),
- Fleet Week,
- Mission,
- Regional Training Center en route to Kuwait,
- Special mission,
- Support of Incirlik AFB (Turkey),
- Hurricane relief,
- Joint Readiness Training Center,
- Marines Expeditionary Unit (ship), and
- Unknown/unspecified.

To determine if a death occurred, the terms “euthanized,” “died,” “death,” and “dead” were searched in pathology reports.

In preparation for multivariate risk factor analysis, the occurrence of at least one diagnosis in each of the top medical condition categories (soft-tissue injury, heat injury, musculoskeletal problems, dermatologic conditions, alimentary conditions, and dental conditions) or were coded as binary variables. If an MWD had diagnoses in more than one category, they were coded as “yes” for all applicable categories.

Univariate risk ratios and 95% confidence intervals (CIs) are reported for each risk factor variable. Variables were entered into a backward-stepping multivariate logistic regression analysis if they were found to be significant in univariate logistic regression assessments of injury risk ($p \leq 0.10$).

6. RESULTS

6.1 Active MWD Characteristics

On 31 July 2017, 4,805 medical encounters for 1,191 young MWDs with X and Y ID numbers were obtained from ROVR. Most of these MWDs were tattooed as MWDs in 2014-2016.

A total of 774 MWDs who were active as of 31 July 2017 were included in the analysis; Table 1 summarizes their characteristics. These MWDs had an average age of 2.6 years (± 0.50 years, range: 1–6 years), and 88% were either 2 or 3 years old at the time data were pulled on 31 July 2017. Almost three-quarters of the MWDs were males (74%); 21% of males were neutered, and 92% of females were spayed.

Appendix B shows photos of common MWD breeds. The predominant breeds for the young MWDs were German Shepherds (39%), Belgian Malinois (31%), and Labrador Retrievers (13%). Over one-third of young MWDs had sable coats (39%), followed by black coats (15%), and black/tan coats (13%). Overall, about 83% of MWDs had dark coats.

Thirty-six percent of the identified MWDs were certified to be Patrol & Explosive Detection dogs, 23% as Explosive Detection only, and 5% as Patrol & Drug Detection. More broadly, 60% were trained to be Explosive Detection dogs in some capacity, 8% as Drug Detection dogs in some capacity, 4% as Specialized Search dogs, 3% as Patrol dogs, and 25% were not certified at the time the data were pulled. Sixty-five percent of young MWDs were located on Air Force installations, 19% on Army installations, 8% on Naval bases, 6% on Marine Corps installations, and 2% on joint bases.

Table 1. Active MWD Demographics and Characteristics (n=774)

Variable Category		n (%)
Age (years) Mean: 2.64 years SD: 0.70 years)	1	18 (2.3)
	2	316 (40.9)
	3	368 (47.6)
	4	67 (8.7)
	5	3 (0.4)
	6	1 (0.1)
Above mean age	Yes	439 (56.8)
	No	334 (43.2)
Sex	Male	450 (58.2)
	Male, neutered	122 (15.8)
	Female	16 (2.1)
	Female, spayed	185 (23.9)
Breed	German Shepherd	299 (38.6)
	Belgian Malinois	240 (31.0)
	Labrador Retriever	103 (13.3)
	German Shorthaired Pointer	99 (12.8)
	Dutch Shepherd	12 (1.6)
	Flat-Coated Retriever	5 (0.6)
	German Wirehaired Pointer	4 (0.5)
	Vizsla	4 (0.5)
	Weimaraner	3 (0.4)
	Golden Retriever	2 (0.3)
	Jack Russell Terrier	1 (0.1)
	Jagdterrier	1 (0.1)
	Wirehaired Pointing Griffon	1 (0.1)
Coat Color	Sable	299 (38.6)
	Black	119 (15.4)
	Black/Tan	101 (13.0)
	Tan	70 (9.0)
	Liver	68 (8.8)
	Chocolate	32 (4.1)
	Red	29 (3.7)
	Yellow	27 (3.5)
	Black/White	11 (1.4)
	Brindle	9 (1.2)
	Grey	3 (0.4)

Variable Category		n (%)
	Blue/Fawn	2 (0.3)
	Fawn	2 (0.3)
	Gold	2 (0.3)
Certification	Patrol/Explosive Detection	274 (36.0)
	Explosive Detection	182 (23.9)
	Patrol/Drug Detection	36 (4.7)
	Patrol Only	24 (3.1)
	Drug Detection-large	19 (2.5)
	Specialized Search	17 (2.2)
	Mine	10 (1.3)
	Combat Tracker	6 (0.8)
	Drug Detection-small	2 (0.3)
	Not certified	192 (25.2)
	Missing	12 (1.6)
Military Branch	Air Force	501 (64.7)
	Army	144 (18.6)
	Navy	62 (8.0)
	Marines	47 (6.1)
	Joint	20 (2.6)

At the time of analysis, 87% of young MWDs were located in United States Northern Command (USNORTHCOM), followed by 8% in the United States Indo-Pacific Command (USINDOPACOM), and 4% in the United States European Command (USEUCOM, Table 2). Relatively few MWDs in this population (14%) were located in the United States Central Command (USCENTCOM) or the United States Southern Command (USSOUTHCOM). Eighty-seven percent of MWDs were located in the CONUS, with 77% of CONUS MWDs located in the South U.S. Census Region, 16% in the West U.S. Census Region, 6% in the Midwest U.S. Census Region, and 2% in the Northeast U.S. Census Region.

Table 2. Active MWD Locations (n=774)

Variable Category		n (%)
Combatant Command	USNORTHCOM	672 (86.8)
	USINDOPACOM	59 (7.6)
	USEUCOM	29 (3.7)
	USCENTCOM	12 (1.6)
	USSOUTHCOM	2 (0.3)
CONUS	No	102 (13.2)
	West South Central	392 (58.9)
	South Atlantic	105 (15.8)
	East South Central	13 (2.0)
	Mountain	32 (4.8)
	Pacific	75 (11.3)
	West North Central	30 (4.5)
	East North Central	7 (1.1)
	New England	5 (0.8)
	Middle Atlantic	7 (1.1)

Table 3 details MWD characteristics by sex and neuter/spay status. Female MWDs are more likely to be Belgian Malinois, and intact male MWDs are more likely to belong to VTFs in the West U.S. Census Region. Otherwise, the groups are comparable. Breed and certification were not found to have strong correlation.

Table 3. Active MWD Characteristics by Sex (n=774)

Variable category		Male n (Column %) [N=450]	Male Neutered n (Column %) [N=122]	Female n (Column %) [N=16]	Female Spayed n (Column %) [N=185]
Breed	German Shepherd	186 (41.3)	40 (32.8)	2 (12.5)	71 (38.4)
	Belgian Malinois	153 (34.0)	22 (18.0)	9 (56.3)	55 (29.7)
	German Shorthaired Pointer	50 (11.1)	19 (15.6)	0	30 (16.2)
	Labrador Retriever	45 (10.0)	30 (24.6)	5 (31.3)	23 (12.4)
	Other	16 (3.6)	11 (9.0)	0	6 (3.2)
Certification	Explosive Detection	284 (64.3)	55 (45.8)	9 (60.0)	108 (58.4)
	Drug Detection	36 (8.1)	9 (7.5)	0	12 (6.5)
	Specialized Search	24 (5.4)	2 (1.7)	1 (6.7)	6 (3.2)
	Patrol only	13 (2.9)	6 (5.0)	0	5 (2.7)
	Not certified	85 (19.2)	48 (40.0)	5 (33.3)	54 (29.2)
Military Branch	Air Force	263 (58.4)	89 (73.0)	14 (87.5)	135 (73.0)
	Army	95 (21.1)	18 (14.8)	0	30 (16.2)
	Navy	45 (10.0)	5 (4.1)	1 (6.3)	11 (5.9)
	Marines	32 (7.1)	7 (5.7)	1 (6.3)	7 (3.8)
	Joint	15 (3.3)	3 (2.5)	0	2 (1.1)
CONUS	No	65 (14.4)	12 (9.8)	1 (6.3)	23 (12.4)
	Yes	385 (85.6)	110 (90.2)	15 (93.8)	162 (87.6)
U.S. Census Regions for CONUS locations	South	271 (71.1)	92 (84.4)	15 (100)	132 (82.0)
	West	77 (20.2)	10 (9.2)	0	20 (12.4)
	Midwest	25 (6.6)	6 (5.5)	0	6 (3.7)
	Northeast	8 (2.1)	1 (0.9)	0	3 (1.9)

Tables 4 and 5 examine the average ages of MWDs by sex and neuter/spay status; Table 5 includes breed. There was no significant difference in average age by sex and neuter/spay status (p=0.31). Intact female Labrador Retrievers within that group were significantly older than other breeds (p=0.02).

Table 4. Average Age of Active MWDs by Sex (n=773)

Sex and Spay/Neuter Status	N	Mean age ± SD	Range	ANOVA p-value
Male	450	2.6 ± 0.7	1–5	0.31
Male, neutered	122	2.6 ± 0.7	1–6	
Female	16	2.9 ± 0.6	2–4	
Female, spayed	185	2.7 ± 0.7	1–5	

Table 5. Active MWD Average Ages by Breed and Sex (n=773)

Breed	Male		Female		Row p-value
	Not Neutered n Avg. Age (years) ± SD [range] (n=450)	**Neutered n Avg. Age (years) ± SD [range] (n=122)**	**Not Spayed n Avg. Age (years) ± SD [range] (n=16)**	**Spayed n Avg. Age (years) ± SD [range] (n=185)**	
German Shepherd	186 2.59 ± 0.65 [1-4]	40 2.75 ± 0.78 [2-6]	2 3.50 ± 0.71 [3-4]	71 2.70 ± 0.66 [1-4]	0.12
Belgian Malinois	153 2.63 ± 0.70 [1-5]	22 2.64 ± 0.58 [2-4]	9 2.56 ± 0.53 [2-3]	55 2.69 ± 0.84 [1-4]	0.94
Labrador Retriever	45 2.67 ± 0.77 [2-5]	30 2.43 ± 0.68 [1-4]	**5** **3.20 ± 0.45** **[3-4]**	23 2.83 ± 0.83 [2-4]	**0.02**
German Shorthaired Pointer	50 2.62 ± 0.57 [2-4]	19 2.53 ± 0.90 [1-4]	0	30 2.60 ± 0.77 [2-5]	0.89
Other	16 2.69 ± 0.60 [2-4]	11 2.73 ± 0.65 [2-4]	0	6 2.67 ± 0.52 [2-3]	0.98
Column p-value	0.93	0.44	**0.01**	0.87	

Appendix D provides comparisons of MWD characteristics by breed, age, and coat color. The demographic patterns of each of these groups were comparable to the entire population.

Appendix E shows characteristics of the small subset (9%) of young dogs that had been deployed. Most of these dogs had only been deployed once at the time of data collection. Most of the deployments were for training missions, and deployment length typically depended on deployment location (OCONUS missions were significantly longer than CONUS missions).

6.2 Medical Procedures and Concerns

Ninety-seven percent of active MWDs (n=440) had at least one reported medical encounter (Table 6). In total, there were 2,427 medical encounters among the active MWDs in the time period of interest. Eighty-one percent of MWDs experienced at least one dermatologic condition, 66% experienced at least one alimentary condition, and 50% experienced at least one dental condition. Twenty-six percent of medical encounters were for dermatologic conditions, 21% were for alimentary conditions, and 15% were for dental conditions. Frequently reported dermatologic conditions included dermatitis, demodicosis, and pyoderma. Leading diagnoses in the alimentary category included giardiasis, diarrhea, and underweight or overweight. Frequently reported dental conditions included fractured tooth, root canal, and extraction. Forty-three percent of MWDs experienced at least one injury during the timeframe, for a total of 276 medical encounters (Table 7). Ninety-eight percent of the injuries were acute. Frequently reported acute injuries included tail tip trauma, lacerations, and abrasions.

Table 6. Medical Encounters Among Active MWDs (n=440 dogs, n=2,427 medical encounters)

Medical Problem	Common Problem Descriptions	Active MWD n (%) [n=440]	Medical Encounters n (%) [n=2,427]	Average Medical Encounters per Active MWDs
Dermatologic	Scrotal dermatitis Otitis externa Pyoderma Demodicosis Pododermatitis	354 (80.5)	635 (26.2)	1.8
Alimentary	Giardiasis Diarrhea Underweight Overweight Colitis	292 (66.4)	515 (21.2)	1.8
Dental	Tooth extraction Fracture of tooth Root canal Periodontitis Dental prophylaxis	220 (50.0)	369 (15.2)	1.7
Soft Tissue-related Injury	Tail tip trauma Laceration Broken nail Muscle strain Abrasion	180 (40.9)	252 (10.4)	1.4
Musculoskeletal	Hindlimb lameness Panosteitis Forelimb lameness Hip dysplasia Fracture Lumbosacral stenosis	87 (19.8)	108 (4.4)	1.2
Urogenital	Cryptorchid Enlarged prostate Recessed vulva Urinary tract infection Scrotal ulcer	81 (18.4)	104 (4.3)	1.3
Other	FAVN failure Eosinophilia Allergy Leukopenia Leukocytosis w/neutrophilia	69 (15.7)	73 (3.0)	1.1
Heat injury/illness	Heat injury Overheating Heat exhaustion Heat stroke Exertional hyperthermia	65 (14.8)	91 (3.7)	1.4
Behavioral	Working bite quarantine Bite/scratch to human Aggression Territorial marking behavior	62 (14.1)	97 (4.0)	1.6

Medical Problem	Common Problem Descriptions	Active MWD n (%) [n=440]	Medical Encounters n (%) [n=2,427]	Average Medical Encounters per Active MWDs
	Anxiety			
Infectious	Babesia canis Lyme disease Ehrlichia canis Trypanosoma cruzi Rickettsia rickettsii	55 (12.5)	58 (2.4)	1.1
Ophthalmologic	Conjunctivitis Corneal deposit Entropion Ocular pannus Palpebral mass	43 (9.8)	51 (2.1)	1.2
Respiratory	Tracheobronchitis Cough Epistaxis Upper respiratory infection Elongated soft palate	23 (5.2)	27 (1.1)	1.2
Mass lesion	Carpal mass Lipoma Mammary mass Sternal mass Oral ulcers	17 (3.9)	20 (0.8)	1.2
Cardiovascular	Arrhythmia Heart murmur Premature ventricular contraction – opioid-induced Junctional premature complexes Mobitz 1a atrioventricular block	16 (3.6)	17 (0.7)	1.1
Neurologic	Hindlimb conscious proprioception deficit Lumbosacral stenosis Pelvic limb paresis Possible opiate hypersensitivity Possible seizure	7 (1.6)	7 (0.3)	1.0
Multisystemic	Nasal planum hyperkeratosis	2 (0.5)	2 (0.1)	1.0
Open	Collapse	1 (0.2)	1 (0.04)	1.0

Table 7. Injury Sub-categories Among Active MWDs (n=191 dogs, n=276 medical encounters for injury)

Injury	Active MWD n (%) [n=191]	Medical Encounters n (%) [n=276]
Acute	188 (98.4)	273 (98.9)
Chronic, overuse, arthritis	3 (1.6)	3 (1.1)

6.3 Factors Associated with Medical Problems

As injuries are the focus of this investigation, and potentially the outcome most easily affected by strategic interventions, this section presents risk factors for MWD injuries. Appendix F summarizes characteristics of MWDs that experienced the three other most common medical conditions among this population of MWDs (dermatologic, alimentary, and dental conditions), and Appendix G presents risk factors associated with those conditions.

6.3.1 Soft Tissue-Related Injuries

As shown in Table 8, soft tissue-related injuries were associated with sex, breed, military branch, and combatant command. Belgian Malinois and German Shepherd MWDs had the highest risk of a soft tissue-related injury when compared to Labrador Retrievers. Patrol MWDs had a higher risk of a soft tissue-related injury compared to noncertified MWDs. MWDs associated with the Navy had the highest risk of a soft tissue-related injury when compared to MWDs on joint bases. Note: analyses of risk factors for all acute injuries (soft tissue and musculoskeletal) are in Appendix G.

Table 8. Factors Associated with Soft Tissue-Related Injuries Among Active MWDs, Univariate (n=774)

Variable category		Total n	% injured	OR (95% CI)	p-value	Overall p-value
Sex	Male	450	24.0	1.14 (0.76–1.73)	0.52	0.91
	Male, neutered	122	22.1	1.03 (0.59–1.79)	0.92	
	Female	16	25.0	1.21 (0.37–3.95)	0.75	
	Female, spayed	185	21.6	1.00		
Breed	**German Shepherd**	**299**	**25.4**	**4.67 (2.08–10.51)**	**<0.01**	<0.01
	Belgian Malinois	**240**	**32.9**	**6.73 (2.98–15.18)**	**<0.01**	
	Labrador Retriever	103	6.8	1.00		
	German Shorthaired Pointer	99	10.1	1.54 (0.56–4.22)	0.40	
	Other	**33**	**21.2**	**3.69 (1.19–11.47)**	**0.02**	
Dark coat color	No	130	26.2	1.22 (0.79–1.88)	0.37	0.37
	Yes	644	22.5	1.00		
Certification	**Explosive Detection**	**456**	**28.1**	**2.87 (1.77–4.64)**	**<0.01**	<0.01
	Drug Detection	**57**	**28.1**	**2.87 (1.39–5.91)**	**<0.01**	
	Specialized Search	33	12.1	1.01 (0.33–3.15)	0.98	
	Patrol	**24**	**29.2**	**3.03 (1.13–8.08)**	**0.03**	

Variable category		**Total n**	**% injured**	**OR (95% CI)**	**p-value**	**Overall p-value**
	Not certified	192	12.0	1.00		
Military branch	*Air Force*	501	21.2	1.52 (0.44–5.29)	0.51	0.02
	Army	144	26.4	2.03 (0.56–7.32)	0.28	
	Navy	*62*	*38.7*	*3.58 (0.95–13.53)*	*0.06*	
	Marines	47	17.0	1.16 (0.27–4.93)	0.84	
	Joint	20	15.0	1.00		
Combatant Command	*USNORTHCOM*	672	22.6	1.43 (0.71–2.90)	0.32	0.07
	USCENTCOM	*12*	*41.7*	*3.50 (0.92–13.29)*	*0.07*	
	USEUCOM	**29**	**41.4**	**3.46 (1.27–9.44)**	**0.02**	
	USSOUTHCOM	2	0.0	–		
	USINDOPACOM	59	16.9	1.00		
CONUS	*No*	102	26.5	1.32 (0.77–1.98)	0.39	0.39
	Yes	672	22.6	1.00		
Deployed	*No*	703	22.3	1.00		0.10
	Yes	*71*	*21.0*	*1.56 (0.92–2.66)*	*0.10*	

Variable categories that are significantly associated with injury (p≤0.05) are bolded; those that are marginally associated (0.06≤p≤0.10) are italicized.

Factors that were statistically marginal or significant (p<0.10) in univariate analyses were included in multivariable logistic regression (Table 9). Multivariable regression revealed that German Shepherd or Belgian Malinois breeds were significantly associated with soft tissue-related injuries, as was Explosive Detection certification.

Table 9. Factors Associated with Soft Tissue-Related Injuries Among Active MWDs, Multivariable[1] (n=773)

Characteristic	Level	Total n	OR (95% CI)	p-value	Overall p-value
Breed	**German Shepherd**	**298**	**4.22 (1.81–9.83)**	**<0.01**	<0.01
	Belgian Malinois	**229**	**6.40 (2.75–14.93)**	**<0.01**	
	Labrador Retriever	103	1.00		
	German Shorthaired Pointer	99	1.42 (0.51–3.96)	0.51	
	Other	**33**	**3.21 (1.00–10.23)**	**0.05**	
Certification	**Explosive Detection**	**456**	**2.65 (1.58-4.45)**	**<0.01**	<0.01
	Drug Detection	**57**	**2.39 (1.09–5.24)**	**0.03**	
	Specialized Search	33	1.77 (0.51–6.19)	0.37	
	Patrol	*24*	*2.48 (0.89–6.95)*	*0.08*	
	Not certified	192	1.00		
Combatant Command	**USNORTHCOM**	**672**	**2.32 (1.11-4.83)**	**0.03**	0.12
	USCENTCOM	12	2.99 (0.73-12.25)	0.13	
	USEUCOM	**29**	**4.19 (1.40-12.52)**	**0.01**	
	USSOUTHCOM	2	N/A		
	USINDOPACOM	59	1.00		
Military branch	*Air Force*	*501*	*3.78 (0.96-14.85)*	*0.06*	0.15
	Army	144	2.89 (0.72-11.61)	0.13	
	Navy	**62**	**5.16 (1.25-21.39)**	**0.02**	
	Marines	47	2.40 (0.50-11.66)	0.28	
	Joint	20	1.00		

[1] Variables included in the multivariable model: breed, certification, military branch, combatant command, deployment yes/no

Variable categories that are significantly associated with injury (p≤0.05) are bolded; those that are marginally associated (0.06≤p≤0.10) are italicized.

6.3.2 Heat Injuries

Significant unadjusted risk factors for heat injuries were breed and certification (Table 10). Belgian Malinois had a higher risk of experiencing a heat-related injury compared to Labrador Retrievers, and MWDs certified as Patrol had a higher risk than MWDs certified for Drug Detection.

Table 10. Factors Associated with Heat Injuries Among Active MWDs, Univariate (n=774)

Variable category		Total n	% with heat injuries	OR (95% CI)	p-value	Overall p-value
Sex	Male	450	8.2	1.09 (0.85–2.08)	0.78	0.84
	Male, neutered	122	9.8	1.33 (0.59–2.99)	0.49	
	Female	16	12.5	1.74 (0.36–8.46)	0.49	
	Female, spayed	185	7.6	1.00		
Breed	German Shepherd	299	6.4	1.68 (0.56–5.06)	0.36	0.06
	Belgian Malinois	**240**	**12.5**	**3.54 (1.21–10.31)**	**0.02**	
	Labrador Retriever	103	3.9	1.00		
	German Shorthaired Pointer	99	9.1	2.47 (0.74–8.32)	0.14	
	Other	33	9.1	2.47 (0.52–11.68)	0.25	
Dark coat color	No	130	9.2	1.00		0.71
	Yes	644	8.2	0.88 (0.46–1.70)	0.71	
Certification	Explosive Detection	456	8.8	1.73 (0.52–5.79)	0.37	0.31
	Drug Detection	57	5.3	1.00		
	Specialized Search	33	0.0	–		
	Patrol	**24**	**20.8**	**4.74 (1.03–21.74)**	**0.05**	
	Not certified	192	8.9	1.75 (0.49–6.19)	0.39	
Military branch	Air Force	501	10.0	2.49 (0.59–10.59)	0.22	0.33
	Army	144	5.6	1.32 (0.27–6.46)	0.73	
	Navy	62	6.5	1.55 (0.27–8.85)	0.62	
	Marines	47	4.3	1.00		
	Joint	20	5.0	1.18 (0.10–13.86)	0.89	
Combatant command	USNORTHCOM	672	8.5	1.00 (0.38–2.60)	1.00	1.00
	USCENTCOM	12	0.0	–		
	USEUCOM	29	10.3	1.25 (0.28–5.62)	0.77	
	USSOUTHCOM	2	0.0	–		
	USINDOPACOM	59	8.5	1.00		
CONUS	No	102	7.8	1.00	0.83	0.83
	Yes	672	8.5	0.92 (0.42–1.99)		
Deployed	No	703	8.7	1.00		0.38
	Yes	71	5.6	0.63 (0.22–1.78)	0.38	

Variable categories that are significantly associated with injury (p≤0.05) are bolded.

Factors significantly or marginally ($p<0.10$) associated with heat injuries in univariate analyses were included in multivariable logistic regression (Table 11). Belgian Malinois breed was found to be significantly associated with heat injuries.

The odds of heat injury in Belgian Malinois were almost 4 times those for Labrador Retrievers (95% CI: 1.28–10.89, p=0.02).

Table 11. Factors Associated with Heat Injuries Among Active MWDs, Multivariable[1] (n=762)

Breed	Total n	OR (95% CI)	p-value	Overall p-value
German Shepherd	298	1.69 (0.56–5.08)	0.35	0.04
Belgian Malinois	**229**	**3.73 (1.28–10.89)**	**0.02**	
Labrador Retriever	103	1.00		
German Shorthaired Pointer	99	2.47 (0.74–8.32)	0.14	
Other	33	2.47 (0.52–11.68)	0.25	

[1] Variables included in the multivariable model: breed and certification
Variable categories that are significantly associated with injury ($p \leq 0.05$) are bolded.

6.3.3 Musculoskeletal Problems

While many common musculoskeletal problems in dogs are not injury-related, others may present as long-term effects of prior injury. In this population of MWDs, unadjusted risk factors for musculoskeletal problems were sex, breed, military branch, and combatant command (Table 12).

Table 12. Factors Associated with Musculoskeletal Problems Among Active MWDs, Univariate (n=774)

Variable category		Total n	% with musculoskeletal problems	OR (95% CI)	p-value	Overall p-value
Sex	**Male**	**450**	**13.3**	**3.60 (1.41–9.17)**	**0.01**	0.04
	Male, neutered	122	4.1	1.00		
	Female	**16**	**18.8**	**5.40 (1.16–25.23)**	**0.03**	
	Female, spayed	*185*	*10.3*	*2.68 (0.97–7.38)*	*0.06*	
Breed	**German Shepherd**	**299**	**13.4**	**7.80 (1.85–32.87)**	**0.01**	<0.01
	Belgian Malinois	**240**	**15.8**	**9.50 (2.25–40.17)**	**<0.01**	
	Labrador Retriever	103	1.9	1.00		
	German Shorthaired Pointer	99	3.0	1.58 (0.26–9.65)	0.62	
	Other	**33**	**12.1**	**6.97 (1.21–39.96)**	**0.03**	
Dark coat color	No	130	13.1	1.23 (0.70–2.17)	0.47	0.47
	Yes	644	10.9	1.00		
Certification	Explosive Detection	456	13.2	4.85 (0.65–36.14)	0.12	0.07
	Drug Detection	*57*	*17.5*	*6.81 (0.83–55.83)*	*0.07*	
	Specialized Search	33	3.0	1.00		
	Patrol only	24	4.2	1.39 (0.08–23.41)	0.82	
	Not certified	192	7.8	2.71 (0.35–21.26)	0.34	
Military branch	Air Force	501	9.0	2.22 (0.52–9.46)	0.28	0.01
	Army	**144**	**17.4**	**4.73 (1.08–20.78)**	**0.04**	
	Navy	**62**	**17.7**	**4.85 (1.02–23.07)**	**0.05**	
	Marines	47	4.3	1.00		
	Joint	*20*	*20.0*	*5.62 (0.94–33.71)*	*0.06*	
Combatant Command	USNORTHCOM	672	10.4	1.26 (0.49–3.24)	0.64	0.01
	USCENTCOM	**12**	**41.7**	**7.71 (1.78–33.50)**	**0.01**	
	USEUCOM	**29**	**24.1**	**3.44 (0.98–12.00)**	**0.05**	
	USSOUTHCOM	2	0.0	–		
	USINDOPACOM	59	8.5	1.00		
CONUS	*No*	*102*	*16.7*	*1.72 (0.97–3.06)*	*0.07*	0.07
	Yes	672	10.4	1.00		
Deployed	No	703	11.0	1.00		0.43
	Yes	71	14.1	1.33 (0.66–2.71)	0.43	

Variable categories that are significantly associated with injury ($p \leq 0.05$) are bolded; those that are marginally associated ($0.06 \leq p \leq 0.10$) are italicized.

When factors that were significantly or marginally associated with musculoskeletal problems in univariate analyses (p≤0.10) were included in multivariable logistic regression, it was observed that German Shepherd and Belgian Malinois breeds, MWDs located in USCENTCOM and USEUCOM, and intact males and females were significantly associated with musculoskeletal problems.

Table 13. Factors Associated with Musculoskeletal Problems Among Active MWDs, Multivariable[1] (n=773)

Variable category		Total n	OR (95% CI)	p-value	Overall p-value
Breed	**German Shepherd**	**299**	**6.81 (1.59–29.19)**	**0.01**	<0.01
	Belgian Malinois	**239**	**8.24 (1.92–35.30)**	**<0.01**	
	Labrador Retriever	103	1.00		
	German Shorthaired Pointer	99	1.54 (0.25–9.51)	0.64	
	Other	**33**	**7.51 (1.29–43.88)**	**0.03**	
Combatant Command	USNORTHCOM	672	1.64 (0.63–4.28)	0.31	0.04
	USCENTCOM	**12**	**7.44 (1.64-33.79)**	**<0.01**	
	USEUCOM	**29**	**3.55 (1.00-12.61)**	**0.05**	
	USSOUTHCOM	2	N/A		
	USINDOPACOM	59	1.00		
Sex	**Male**	**450**	**2.73 (1.04-7.16)**	**0.03**	0.11
	Male, neutered	122	1.00		
	Female	**16**	**5.77 (1.14-29.23)**	**0.03**	
	Female, spayed	185	2.38 (0.84-6.70)	0.10	

[1] Variables included in the multivariable model: sex, breed, certification, military branch, combatant command, and CONUS yes/no

Variable categories that are significantly associated with injury (p≤0.05) are bolded.

All factors associated with injuries or musculoskeletal problems among these young MWDs are summarized in Table 14.

Table 14. Summary of Factors Associated with Injuries and Musculoskeletal Problems Among Active MWDs (n=762)

	Soft tissue Injury	Heat Injury	Musculoskeletal Problems
Intact male			✓
Intact female			✓
German Shepherd breed	✓		✓
Belgian Malinois breed	✓	✓	✓
Other breed (not German Shepherd, Belgian Malinois, Lab, or German Shorthaired Pointer)	✓		✓
Explosives Detection certification	✓		
Drug Detection certification	✓		
Patrol certification	*		
NORTHCOM location	✓		
EUCOM location	✓		✓
CENTCOM location			✓
Navy	✓		
Air Force	*		

✓: statistically significantly associated ($p \leq 0.05$)
*: statistically marginally associated ($0.06 \leq p \leq 0.10$)

7. DISCUSSION

7.1 MWD Characteristics

7.1.1 Age

The studied population is a subset of young dogs (average 2.6 years ± 0.5). As with humans, it is expected that the likelihood of certain medical conditions will increase with age, and previous studies have indicated that the risk of injury increases around age 7 (Mey, 2009; Toffoli & Rolfe, 2006). However, age was not a risk factor for any of the leading medical conditions in this population of young MWDs.

7.1.2 Breed

Most of the young MWDs included in this study were German Shepherds (37.7%), Belgian Malinois (31.0%), Labrador Retrievers (13.3%), and German Shorthaired Pointers (13.2%). Breed is an important consideration for the prevalence of various MWD health outcomes. Belgian Malinois dogs have previously been reported to be at higher risk of dying or being euthanized due to neoplasms and malignant tumors, and at a younger age, than German

Shepherds (Peterson, Frommelt, & Dunn, 2000). Heat stroke has also been observed as more common among Belgian Malinois (Evans, Herbold, Bradshaw, & Moore, 2007). Prevalence of inherited disorders can also vary by breed, and in a study of the 50 most common UK Kennel Club breeds, German Shepherds were seen to have the highest number of predisposed combined inherited disorders (77 total conformation-related disorders, inherited disorders exacerbated by conformational traits, and nonconformational disorders) (Asher, Diesel, Summers, McGreevy, & Collins, 2009). Among over 43,000 Swedish dogs with health insurance, German Shepherds had higher-than-average risk of death overall, especially due to tumors, locomotor problems, neurological problems, and uncategorized ("other") diagnoses (Bonnett, Egenvall, Hedhammar, & Olson, 2005). In one study of search and rescue dogs (Duhaime, Norden, Corso, Mallonee, & Salman, 1998), German Shepherds were shown to have higher risk of injury. Breed influenced injury risk among one population of agility dogs (Cullen, Dickey, Bent, Thomason, & Moëns, 2013b), and a greater risk of certain inherited musculoskeletal conditions (Jennings Jr, 1991; Pogorevc, Lukanc, Seliškar, & Zorko, 2016; Popovitch, Smith, Gregor, & Shofer, 1995; Witsberger, Villamil, Schultz, Hahn, & Cook, 2008; Zink, 2013).

In this population, breed was found to be significantly associated all of the top medical problems among young MWDs, even when controlling for other risk factors. Even though they are the most common MWD breeds, German Shepherd and Belgian Malinois MWDs were observed to be at greater odds for experiencing these medical conditions than other MWD breeds.

7.1.3 Sex and Neuter/Spay Status

This population included predominantly male dogs (73%). Most male MWDs were intact (79%) and most females were spayed (92%). A previous study found that spayed and neutered dogs are at higher risk for musculoskeletal conditions like ruptured anterior cruciate ligament, and neutered females are at a higher risk for intervertebral disk disease (Belanger, Bellumori, Bannasch, Famula, & Oberbauer, 2017). On the contrary, the current results suggest that both intact males and intact females were at greater risk for musculoskeletal problems than those dogs that were spayed or neutered. Furthermore, all male dogs (both intact and neutered) were at statistically significantly higher risk for experiencing dermatologic conditions.

7.1.4 Coat Color

Eighty-three percent of dogs in this population had a dark coat color. It has been suggested that a darker coat color may increase risk of heat injury (Johnson, McMichael, & White, 2006). That was not the case in the current population.

7.1.5 Geographic Location and Combatant Command

Eighty-eight percent of the MWDs in this subpopulation were assigned to a location within the CONUS. Of those at CONUS locations, 54% were in the West South Central region. As most young MWDs will be training at the MWD Dog Center in Texas, this distribution of assignment locations was expected. Dogs who train in hot environments have been reported to be at greater risk for heat injuries and illnesses (Bruchim et al., 2014). Location was not associated with heat injuries in this population, but MWDs in NORTHCOM and EUCOM were are greater

risk for soft tissue injuries, and those in EUCOM and CENTCOM locations had increased odds of musculoskeletal problems.

7.1.6 Certification

Most of the young MWDs (57%) were certified for Explosive Detection. Twenty-seven percent were categorized as Untrained, likely because many of them are still undergoing training at the MWD Dog Center. MWDs certified in Patrol and Explosive Detection were at significantly increased odds of soft tissue injuries and dental conditions in the current study. MWDs with Drug Detection certifications were also at increased risk soft tissue injuries. Certification has not been previously identified as a risk factor for injuries, but the tasks performed by the MWDs certified in Patrol and Detection include bite work and high-low searches, which could explain their greater risks. Previous analyses have shown that more medical encounters for musculoskeletal issues were experienced by dogs in these certifications (Mey, 2009).

7.1.7 Military Branch

Two-thirds (67%) of the dogs included in the present population were affiliated with the Air Force, as many of the young dogs were still training at the MWD Dog Center at Lackland AFB. MWDs in the Navy were observed to be at greater risk of soft-tissue injuries in this population.

7.2 Medical Data

7.2.1 Medical Encounters

Previous studies have described common medical conditions among populations of MWDs (Evans et al., 2007; Mey, 2009; Moore, Burkman, Carter, & Peterson, 2001; Takara & Harrell, 2014). Behavioral issues, dermatologic problems, soft-tissue injuries, degenerative joint disease, and heat stroke have all been prevalent. Similarly, in this population of young MWDs, the five most common categories of medical encounters were dermatologic, alimentary, dental, soft-tissue injuries, and musculoskeletal conditions.

7.2.1.1 Injuries

In the current population, 41% of young MWDs experienced a soft-tissue injury, accounting for 10% of medical encounters. Belgian Malinois or German Shepherd breed and Explosive Detection certification increased the risk of injury in this population.

Similarly, Takara and Harrell (2014) found soft-tissue-related injuries to be the second most frequent cause of noncombat medical encounters, accounting for 21% of encounters. They found foot pad/paw injuries, other lacerations (not to the foot), tail tip trauma, and dog bite wounds to be the most common soft-tissue injuries. It has been suggested that handlers of athletic canines receive education about potential injuries and that injury surveillance systems be implemented (Cullen et al., 2013b).

7.2.1.1.1 Cumulative Musculoskeletal Overuse Injuries

Muscle strains were among the most frequently reported injuries among these MWDs. Common diagnoses for musculoskeletal conditions included fracture injuries; lameness could also often be injury-related. Intact dogs and German Shepherds were at greater risk of experiencing musculoskeletal conditions; however, the medical encounter descriptions were often not detailed enough to discern between injury-related issues (e.g., strains) and other genetic degenerative musculoskeletal conditions (e.g., hip dysplasia). All musculoskeletal conditions accounted for 4% of medical encounters and affected 20% of dogs.

In populations of active humans (e.g., athletes, Soldiers), it is widely accepted that overuse injuries such as stress fractures, muscle strains, and joint pain result from micro-trauma due to frequent participation in physical training (Hauret, Jones, Bullock, Canham-Chervak, & Canada, 2010; Junge et al., 2009; Roos et al., 2015; U.S. Army Public Health Center, 2017). Unfortunately, musculoskeletal overuse-related injuries are likely underreported in animals because they are unable to communicate lower degrees of pain (Steiss, 2002). Therefore, it's only after a dog's condition has progressed enough to cause behavioral changes like vocalization or limping that a medical encounter will likely occur. Descriptions of behavioral changes from dog owners have been shown to be a reliable indicator of chronic pain (Hielm-Björkman et al., 2003; Wiseman, Nolan, Reid, & Scott, 2001). Musculoskeletal pain is often the result of repetitive strain and overuse related to inflammation, fibrosis, and tissue degradation, which can lead to difficulties transcending stairs, entering and exiting vehicles, and walking on slick flooring (Davies, 2014). Sprains and strains, especially to the hind quarters, have been reported as common in populations of sporting dogs (Baltzer, 2012), agility dogs (Cullen, Dickey, Bent, Thomason, & Moëns, 2013a; Gaudiano, 2006; Kerr, Fields, & Comstock, 2014; Levy, Hall, Trentacosta, & Percival, 2009), and competitive obedience dogs (Hopkins, 2015).

Training and work requirements for MWDs to frequently stand on their hind legs could lead to strain on the limbs and lumbosacral region (Takara & Harrell, 2014), and orthopedic injuries are often caused by chronic overload (Marcellin-Little, Levine, & Taylor, 2005) which may be common among MWDs in training. In one study, German Shepherd police dogs were significantly more likely to have emergency veterinary visits for orthopedic conditions than personally-owned German Shepherds (Parr & Otto, 2013). Like human athletes, it is recommended that active dogs participate in balanced training that includes a variety of strengthening, endurance, balance, and proprioception to achieve optimal fitness and conditioning (Marcellin-Little et al., 2005).

7.2.1.1.2 Heat Injuries

Heat injury and illness affected 15% of this MWD population and accounted for 4% of medical encounters. While not abundant, these injuries can be serious and are often preventable. Belgian Malinois dogs were at greater risk of heat injury than other breeds.

Besides behavioral reasons, heat stroke was the most common reason for discharge (8.2%) among one population of 85 U.S. MWDs under five years of age (Evans et al., 2007). Heat stroke was more common in Belgian Malinois (17%) than German shepherd dogs (7%) in that

study. In another study, heat stroke led to death or euthanasia in 0.6% of 927 MWDs from 1993 to 1996 (Moore et al., 2001).

Available clinical information about canine heat injuries is predominantly based on human medicine (Flournoy, Wohl, & Macintire, 2003), even though it is acknowledged that dogs are likely more prone to heat injuries than humans (Vogelsang, 2007). It is believed that fatality is possible at 43 degrees Celsius (ºC) (~109 degrees Fahrenheit (ºF)) (Flournoy, Macintire, & Wohl, 2003; Johnson et al., 2006), though brain damage can occur as low as 41º C (~106º F) (Flournoy, Macintire, et al., 2003). Stages of heat injury in dogs likely progress with time, in similar stages as humans: heat cramps, heat exhaustion, heat prostration, and heat stroke, with heat stroke being the most severe stage (Flournoy, Wohl, et al., 2003).

Most medical data available for heat injuries among MWDs and other canine athletes are for the occurrence of heat stroke because it is the most severe heat injury. Heat stroke is a medical emergency that results from extreme hyperthermia usually caused by exercise (exertional heat stroke, often due to lack of proper acclimatization to hot climates) or extended time spent in a confined area (environmental heat stroke) (Flournoy, Macintire, et al., 2003; Johnson et al., 2006). Exertional heat stroke, often more common in late spring or early summer, before proper acclimatization can occur (Flournoy, Wohl, et al., 2003), could be more prevalent in the U.S. MWD Training Center at Lackland AFB (Evans et al., 2007).

Heat stroke results when there are alterations in normal cooling functions leading to improper thermoregulation (Flournoy, Macintire, et al., 2003). Panting is the most common clinical sign in dogs (Flournoy, Macintire, et al., 2003; Flournoy, Wohl, et al., 2003; Johnson et al., 2006), but humidity may lessen its effectiveness (Flournoy, Wohl, et al., 2003). Other common signs include tachycardia, hyperemia, and dry mucous membranes (Flournoy, Macintire, et al., 2003; Flournoy, Wohl, et al., 2003; Johnson et al., 2006). Heat stroke has a high fatality rate in dogs, even when appropriate treatment is provided (Bruchim et al., 2006). Predisposing factors that decrease heat dissipation include confinement, lack of acclimatization, increased humidity, water deprivation, use of beta-blockers, obesity, cardiovascular disease, older age, darker coat color, or thicker coat (Johnson et al., 2006). Death was the outcome in one case study of a U.S. MWD with many of these risk factors (Andress & Goodnight, 2013).
In one study of 54 Israeli dogs with heat stroke (including 8 working dogs), 63% experienced exertional heat stroke (mean 58 minutes of exercise) and 37% experienced environmental heat stroke (Bruchim et al., 2006). Belgian Malinois dogs and Golden Retrievers were overrepresented. Higher environmental temperature (but not humidity) was associated with injury. Obesity, high serum creatinine after 24 hours, delayed admission, and seizures were risk factors for death; hypoglycemia, prolonged prothrombin time, or prolonged activated partial thromboplastin time at admission were associated with death. Another study of 40 personally-owned dogs with heat stroke in the U.S. showed that 48% were associated with exposure to a close or warm environment and 45% were exertional (some occurring after only 20–30 minutes of exercise) (Drobatz & Macintire, 1996). Panting, collapse, and vomiting were the top symptoms associated with heat stroke, and being comatose or having low blood sugar (hypoglycemia) were risk factors for death.

A study of 15 Belgian Malinois Israeli MWDs showed that cellular adaptive processes can be induced through combined exercise endurance training and heat acclimatization (Bruchim et al.,

2014). The primary treatment goal is to lower the dog's body temperature quickly through external cooling, intravenous volume replacement for cardiovascular support, and management of secondary complications (Flournoy, Macintire, et al., 2003; Johnson et al., 2006). Early recognition is key to effective treatment, and handlers should be educated about the dangers of confining their dogs or exercising them in hot environments (Bruchim et al., 2014; Flournoy, Macintire, et al., 2003), and the risk of using constrictive muzzles that prevent panting.

7.2.1.1.3 Foot Injuries

Broken nails and paw pad lacerations were commonly recorded soft-tissue injuries in this population. Takara and Harrell (2014) reported that foot pad/paw injures (lacerations) were the most common soft-tissue noncombat injury (32%) among MWDs in a combat zone, likely due to uneven terrain and/or hot surfaces experienced during patrol duties. Foot and paw pad injuries have also been reported as common among sporting dogs (Baltzer, 2012), search and rescue dogs (Duhaime et al., 1998; Gordon, 2012), and hunting dogs (Houlton, 2008). Better paw protection through booties or shoes has been suggested to reduce these injuries (Slensky, Drobatz, Downend, & Otto, 2004), and it is essential that such protection not impede performance (Duhaime et al., 1998).

7.2.1.1.4 Gunshot Injuries

No gunshot injuries were noted in the medical records for the current population, most likely because so few MWDs were deployed to theater. Although not typically a predominant cause of injuries to MWDs, gunshot injuries are severe when they do occur. In one study of MWDs deployed to Afghanistan and Iraq during OIF and OEF (2003–2009), 29 had gunshot wounds (38% survival rate), half of which were to the thorax (J. L. Baker, Havas, Miller, Lacy, & Schlanser, 2013). Among general populations of personally-owned dogs and hunting dogs, gunshot wounds are also not very common. During a 3-year period, 0.76% of dogs admitted to a veterinary center had projectile injuries (Capak, Bottegaro, Manojlovic, Smolec, & Vnuk, 2016), and gunshot wounds were not reported as a significant cause of injury among a population of gun dogs during two seasons (Houlton, 2008). Among a population of 82 personally-owned dogs with characteristics comparable to the current population (mostly young, sexually intact males), 122 gunshot wound injuries were seen at a veterinary hospital within a 9-year period, and common wound locations were the limbs, thorax, abdomen, head, neck, and vertebral column (Fullington & Otto, 1997). Injuries to the vertebral column or abdomen typically had more fatal prognoses in that population.

7.2.1.2 Non-Injury-Related Musculoskeletal Conditions

Of the 108 medical encounters for musculoskeletal conditions (Table 6), 39% (n=42) were for non-injury-related degenerative musculoskeletal conditions. It has been suggested that orthopedic injuries in athletic dogs may be exacerbated by pre-existing musculoskeletal conditions like hip or elbow dysplasia or patellar luxation (Marcellin-Little et al., 2005). In one survey of deployed search-and-rescue dog handlers (n=95, 32% German Shepherds, 29% Labradors), 27% of handlers reported that their dogs had musculoskeletal problems (Otto et al., 2010).

7.2.1.2.1 Hip Dysplasia and Hip Osteoarthritis

While only four of the musculoskeletal conditions observed in this population of young MWD were specifically noted as hip dysplasia, this is a fairly common condition among MWD breeds. Hip dysplasia (HD), an orthopedic disease that is common among medium- and large-breed dogs, affects German Shepherds disproportionately (Banfield, Bartels, Hudson, Wright, Hathcock, et al., 1996; Banfield, Bartels, Hudson, Wright, Montgomery, et al., 1996; Demko & McLaughlin, 2005; Edge-Hughes, 2007; Popovitch et al., 1995; Vince, 2007; Wahl, Herbst, Clark, Tsai, & Murphy, 2008; Witsberger et al., 2008). It is a skeletal defect resulting from a polygenic predisposition to joint laxity, leading to subluxation and poor soft tissue stabilization at the joint (Demko & McLaughlin, 2005; Hutt, 1967; Lotsikas et al., 2013). This often manifests as degenerative joint disease (G. K. Smith et al., 2001) that can cause chronic pain (Goldberg, 2017) and can have a significant negative impact on a dog's welfare (Collins, Asher, Summers, Diesel, & McGreevy, 2010). Besides medium or large breed, other risk factors for HD include neuter status (altered dogs are at greater risk) and age (younger dogs are at greater risk) (Witsberger et al., 2008). Especially when left untreated, joint degeneration associated with HD can lead to the development of hip osteoarthritis (OA) over time (Demko & McLaughlin, 2005). Compared to German Shepherds, Belgian Malinois dogs are at lower risk for HD and subsequent hip OA, presumably because the latter have less pelvic limb angulation (Pogorevc et al., 2016; Zink, 2013).

HD has been reported as the leading cause for medical rejection of dogs offered for sale or donation to the U.S. Military, and hip OA was a leading cause of premature disability of MWDs (Olson, 1971). In one retrospective study of 116 MWDs, radiographs for 50% of included MWDs were graded as some degree of dysplastic (Banfield, Bartels, Hudson, Wright, Hathcock, et al., 1996) and 15 dogs were euthanized for HD (Banfield, Bartels, Hudson, Wright, Montgomery, et al., 1996). In another investigation of 123 MWD deaths and euthanasias, 32% (n=39) of deceased dogs had degenerative OA of the coxofemoral joint, and HD-related lameness led to 98% of the euthanasias (Dutton & Moore, 1987). Likewise, radiographic evidence of HD was found in 27% of a population of over 1,000 German Shepherds (Leighton et al., 1977). Similarly, long-term surveillance showed that 44% of the working dogs who participated in search and rescue activities following the World Trade Center terrorist attacks (n=27, 78% German Shepherds) had lameness due to OA (Fox, Puschner, & Ebel, 2008).

Through selective breeding programs, the prevalence of HD, OA, and other undesirable genetic traits has been controlled successfully in a subset of the MWD population (Cournoyer, 2003). Because radiographic evidence of HD can be detected at 4–10 months (Demko & McLaughlin, 2005), pre-selection screening programs for musculoskeletal conditions have also been successful for other working dog populations, such as Slovenian police dogs (Zorko, Ivanuša, & Pelc, 2005). Clinical development of OA was reduced among Labrador Retrievers through a 25% dietary restriction, and the median age of onset was also increased through this intervention (G. K. Smith et al., 2006). After clinical signs of HD and OA are present, hip joints can benefit from physical therapy (Edge-Hughes, 2007) and, in one study, 59% of veterinarians reported referring dogs to rehabilitation clinics for OA (Alvarez, Fox, Van Dyke, & Grigsby, 2016). Surgeries that are recommended for various stages of HD and OA include juvenile pubic symphysiodesis, triple pelvic osteotomy, total hip arthroplasty, and femoral head and neck

excision (Demko & McLaughlin, 2005). In one case study, a successful total hip replacement to treat severe HD extended the pain-free career of a highly skilled U.S. MWD (Vince, 2007).

7.2.1.2.2 Degenerative Lumbosacral Stenosis

Degenerative lumbosacral stenosis (DLSS) is a progressive spinal condition in which developmental abnormalities cause disc degeneration, nerve compression, and dysfunction of the cauda equina within the vertebral canal (Chambers, 1989; De Risio, Thomas, & Sharp, 2000; Jeffery, Barker, & Harcourt-Brown, 2014; Ondreka et al., 2013; Worth, Thompson, & Hartman, 2009). Dogs with DLSS often present with decreased range of motion and/or ill-defined pelvic limb pain, and DLSS may be difficult to diagnose (De Risio et al., 2000; Jeffery et al., 2014). German Shepherds have an increased risk for developing DLSS (De Decker, Wawrzenski, & Volk, 2014; De Risio et al., 2000; Ness, 1994; Ondreka et al., 2013) because the morphology and morphometry of the lumbosacral joint is different from other large-breed dogs, and lumbosacral transitional vertebrae and sacral osteochondrosis are related conditions that may present along with cauda equine syndrome and/or DLSS (Morgan, Bahr, Franti, & Bailey, 1993; Ondreka et al., 2013; Worth et al., 2009). Dogs with high activity levels, such as sporting or working dogs, may be at higher risk due to deterioration of the lumbosacral disc caused by increased stress (Worth et al., 2009). In one study of 33 German Shepherd police dogs, 45% (n=15) were diagnosed with DLSS (Steffen, Hunold, Scharf, Roos, & Flückiger, 2007). In previous studies of MWDs, 19% of 927 MWDs that died or were euthanized in a 3-year period had a neurologic disease of the spinal cord or cauda equina (Moore et al., 2001), and 30% of 160 discharged MWDs ≥5 years old had a spinal cord disease (Evans et al., 2007). None of the MWDs in the present population had DLSS noted in their medical records.

DLSS can be treated surgically or through decompression and conservative pain management (De Decker et al., 2014; De Risio et al., 2000; Worth et al., 2009). In one study of 28 dogs of various breeds with DLSS, conservative pain management was successful in 50% of dogs with more mild symptoms, and surgery was effective in 81% of those needing more rigorous treatment (Ness, 1994).

7.2.1.3 MWDs as Sentinels for Human Medical Conditions

Since the 1870s, it has been suggested that animals can potentially act as sentinel hosts for human diseases (Van der Schalie et al., 1999) and exposure outcomes (Bischoff, Priest, & Mount-Long, 2010). Due to their popularity as pets, dogs in particular have been recommended for public health surveillance purposes in western regions (Cleaveland, Meslin, & Breiman, 2006; Resnick et al., 2008; Salb et al., 2008; Tenney, Curtis-Robles, Snowden, & Hamer, 2014). Development of certain conditions in dogs related to lead exposure (Bischoff et al., 2010), chemical exposure (Van der Schalie et al., 1999), pathogen exposure (Cleaveland et al., 2006), environmental contamination (Backer, Grindem, Corbett, Cullins, & Hunter, 2001), Lyme disease (Goossens, Van Den Bogaard, & Nohlmans, 2001; F. D. Smith, Ballantyne, Morgan, & Wall, 2012), cancers (Hayes, Tarone, Casey, & Huxsoll, 1990), viruses (Nichols, Bigler, Lassing, & Hoff, 1975; Resnick et al., 2008), and infections (Tenney et al., 2014) could warn of potential development of the same conditions among humans who experienced the same exposures. It has specifically been proposed that MWDs may be good sentinels for Soldier exposures, especially during deployments (Hayes et al., 1990; Nichols et al., 1975). Because

the seropositivity for infection may be shorter in dogs, one study found that Lyme disease prevalence among military pet dogs provided an indicator of human Soldier prevalence as well (Evans, 2014). Another study detected West Nile virus in dogs 6 weeks earlier than in humans (Resnick et al., 2008).

The potential use of MWD medical encounters to monitor public health trends and detect outbreaks more quickly than in the human population is a key reason to enhance the collection and surveillance of MWD medical data. Collecting exposure and health outcome data through MWD post-deployment health assessment may also allow MWDs to be analyzed as health sentinels for human Service members deployed to the same theater of operations. A newly developed central military disease surveillance system, the Government and Privately-owned Animal Worldwide Surveillance System (GPAWSS), could also be enhanced to include sentinel monitoring.

7.2.1.4 Treatment of MWDs During Deployment

Human providers may need to treat MWDs in clinics or hospitals due to lack of veterinary facilities, especially in combat theater and/or during overseas deployments (Galer, Magid, & Folio, 2009; Giles III, 2016; Vogelsang, 2007). Clinical Practice Guidelines state that nonveterinary health care providers can treat MWDs when life, limb, or eyesight is at risk (Joint Theater Trauma System Clinical Practice Guideline, 2012), but it is unknown how frequently this type of treatment is required (Giles III, 2016). While dogs can be treated similarly to humans for some emergent conditions, such as shock, dogs have different vital signs. Providers should also be cautious of MWDs that may be trained to attack unknown humans (Vogelsang, 2007).

Because veterinary care may not always be possible during deployments (Toffoli & Rolfe, 2006), handler information about deployment injuries, illnesses, and the availability of medicine and protective equipment is needed to evaluate future initiatives for MWD care. It is suggested that MWD handlers complete an MWD post-deployment health assessment (PDHA) in conjunction with the PDHA that all U.S. Military personnel complete upon their return from deployment. A MWD PDHA would employ similar methodologies as other studies that surveyed handlers of search and rescue dogs regarding the dogs' health status following a mission (Duhaime et al., 1998; Gordon, 2012).

7.2.1.5 Centralized MWD Medical Database

Currently, MWD data are stored in multiple databases that are outdated and are not connected to each another. Therefore, the only way to answer pertinent questions is to collect and merge MWD data from multiple sources. Because human error is introduced when multiple data sources are combined, as was done to build the current database, it would be beneficial for future systems to hold all pertinent aspects of MWD data. When MWD PDHAs are implemented, their results should be available within the same database.

7.2.1.6 Handler Injuries

Though such data were not obtained for this study, handler injuries and exposures resulting from work with MWDs should be considered in future work. Previous studies have identified

upper extremity musculoskeletal injuries related to restraining MWDs (Schermann et al., 2018) and lower extremity sprains and strains (Kerr et al., 2014). Risk factors for injuries among handlers include obesity (Kerr et al., 2014).

8. CONCLUSIONS AND RECOMMENDATIONS

8.1 Conclusions

This is one of the first studies to investigate risk factors for medical conditions among non-deployed MWDs. Ninety-seven percent of young MWDs had medical encounters. Soft-tissue injuries affected 41% of dogs, and 20% of dogs were seen for a musculoskeletal condition (some of which may be injury-related). Risk factors for injuries and musculoskeletal conditions included German Shepherd or Belgian Malinois breed, Explosive Detection certification, and intact spay/neuter status. These two breeds were also risk factors for other common medical conditions, and male sex was a risk factor for dermatologic conditions.

8.2 Recommendations

Training and work conditions for the identified at-risk groups of MWDs should be assessed; for example, tasks for those dogs with Explosive Detection certifications should be analyzed for any unnecessary exposures to injury hazards. As canine athletes, MWDs should train and maintain fitness appropriate to their required tasks, while avoiding overtraining. When injury details can be captured via future MWD PDHAs, specific prevention strategies may emerge.

The multiple sources that currently house MWD data should be merged with MWD medical records in a central data repository for easier data cleaning and analysis. This will allow for future analyses of MWD data to be conducted among larger cohorts and with more variables. The repository could also include data from an MWD PDHA.

9. POINT OF CONTACT

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APPENDIX A

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APPENDIX B

PHOTOS OF COMMON MWD BREEDS

Note: all photos were obtained from the Defense Visual Information Distribution Service.

Figure B-1. German Shepherd

Figure B-1. Belgian Malinois

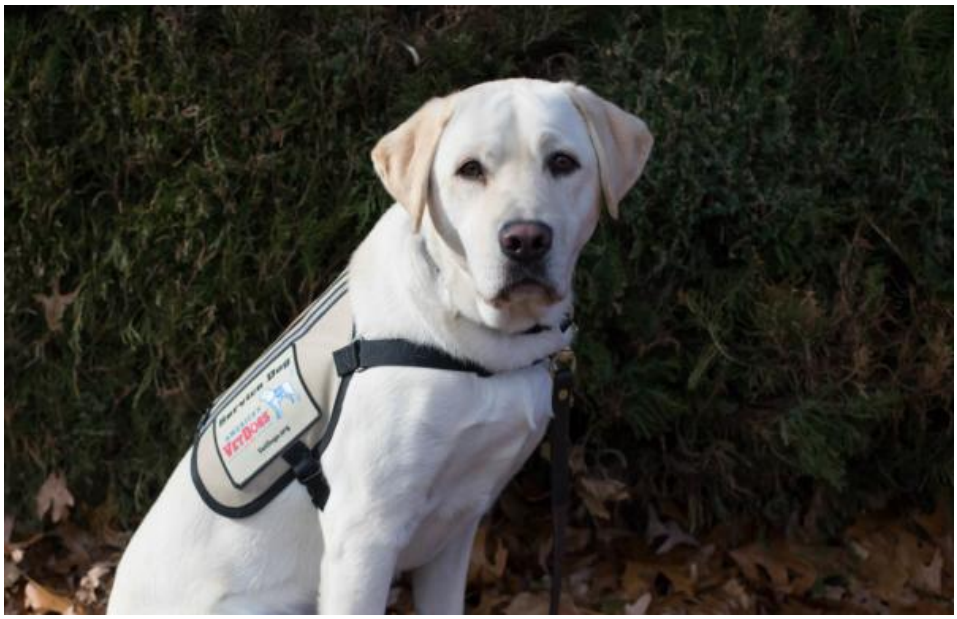

Figure B-3. Labrador Retriever

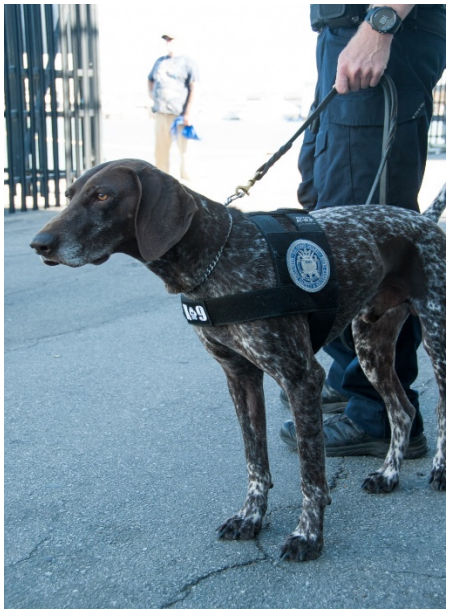

Figure B-4. German Shorthaired Pointer

APPENDIX C

MWD VETERINARY TREATMENT FACILITIES

Table C-1. MWD Veterinary Treatment Facilities (VTFs) by Military Branch

Army	Navy	Air Force	Marines	Joint
FORT LEONARD WOOD VS	NB NORFOLK VS	DOD MILITARY WORKING DOG VS	MCB CAMP LEJEUNE VS	KAISERSLAUTERN MILCOMMUNITY VS
FORT CARSON VS	BAHRAIN VS	KADENA AB VS	MCB CAMP PENDLETON VS	JBLM-MCCHORD AFB VS
FORT RICHARDSON VS	NSB KINGS BAY VS	MOODY AFB VS	MCAS MIRAMAR VS	JBMDL-FORT DIX VS
FORT BELVOIR VS	NAS SIGONELLA VS	ANDREWS AFB VS	MCB QUANTICO VS	JBSA-FORT SAM HOUSTON VS
CAMP HUMPHREYS VS	NB KITSAP-BANGOR VS	OSAN AFB VS	MCBH KANEOHE BAY VS	
FORT CAMPBELL VS	NBVC PORT HUENEME VS	KIRTLAND AFB VS	MCRD PARRIS ISLAND VS	
FORT HOOD VS	NSB NEW LONDON VS	ANDERSEN AFB VS	MCAGCC TWENTYNINE PALMS VS	
FORT WAINWRIGHT VS	NAS LEMOORE	HICKAM AFB VS	MCAS CHERRY POINT VS	
FORT BENNING VS	NAS WHIDBEY ISLAND VS	HILL AFB VS	MCAS IWAKUNI VS	
FORT BRAGG VS	NB SASEBO VS	INCIRLIK AB VS		
FORT SILL VS	NAS CORPUS CHRISTI VS	PATRICK AFB VS		
CAMP WALKER VS	NAS JACKSONVILLE VS	WHITEMAN AFB VS		
FORT BLISS VS	NAS PENSACOLA VS	AVIANO AB VS		
FORT HUACHUCA VS	NAS/JRB FORT WORTH VS	BEALE AFB VS		
FORT DRUM VS	NB GUANTANAMO BAY CUBA VS	DAVIS-MONTHAN AFB VS		
FORT IRWIN VS	NS ROTA VS	EGLIN AFB VS		
FORT LEE VS	NTC GREAT LAKES VS	FE WARREN AFB VS		
FORT RILEY VS	NAPLES VS	MINOT AFB VS		
FORT STEWART VS	NAS JRB FORT WORTH	MISAWA AFB VS		
KUWAIT VET DET	NAS NEW ORLEANS	RAF FELTWELL VS		
SCHOFIELD BARRACKS VS	NB GUAM VS	ROBINS AFB VS		
YONGSAN VS	NB YOKOSUKA VS	SCOTT AFB VS		
ANSBACH MIL COMMUNITY VS	NS MAYPORT	TINKER AFB VS		
FORT JACKSON VS				

Army	Navy	Air Force	Marines	Joint
FORT LEAVENWORTH VS		TRAVIS AFB VS		
FORT MEADE VS		BARKSDALE AFB VS		
FORT POLK VS		DOVER AFB VS		
REDSTONE ARSENAL VS		ELLSWORTH AFB VS		
ABERDEEN PROVING GROUND VS		FAIRCHILD AFB VS		
CAMP RED CLOUD VS		KEESLER AFB VS		
CAMP ZAMA VS		MOUNTAIN HOME AFB		
FORT EUSTIS VS		OFFUTT AFB VS		
FORT GORDON VS		SEYMOUR JOHNSON AFB		
FORT KNOX VS		SPANGDAHELM AB VS		
FORT MYER VS		TYNDALL AFB VS		
HOHENFELS MIL COMMUNITY VS		VANDENBERG AFB VS		
KOSOVO VET DET		WRIGHT-PATTERSON AFB VS		
STUTTGART MIL COMMUNITY VS		CHARLESTON AFB VS		
VILSECK MIL COMMUNITY VS		EDWARDS AFB VS		
		HANSCOM AFB VS		
		HOLLOMAN AFB VS		
		MACDILL AFB VS		
		MAXWELL AFB VS		
		MCCONNELL AFB VS		
		NELLIS AFB VS		
		SHAW AFB VS		
		U.S. AIRFORCE ACADEMY VS		
		YOKOTA AFB VS		

Table C-2. MWD VTFs by Combatant Command

USNORTHCOM			
DOD MILITARY WORKING DOG VS	BEALE AFB VS	NAS JACKSONVILLE VS	SHAW AFB VS
FORT LEONARD WOOD VS	DAVIS-MONTHAN AFB VS	NAS PENSACOLA VS	U.S. AIRFORCE ACADEMY VS
MCB CAMP LEJEUNE VS	EGLIN AFB VS	NAS/JRB FORT WORTH VS	
MCB CAMP PENDLETON VS	FE WARREN AFB VS	NTC GREAT LAKES VS	
MCAS MIRAMAR VS	FORT DRUM VS	OFFUTT AFB VS	
MOODY AFB VS	FORT IRWIN VS	REDSTONE ARSENAL VS	
ANDREWS AFB VS	FORT LEE VS	SEYMOUR JOHNSON AFB	
FORT CARSON VS	FORT RILEY VS	TYNDALL AFB VS	
FORT RICHARDSON VS	FORT STEWART VS	VANDENBERG AFB VS	
FORT BELVOIR VS	MINOT AFB VS	WRIGHT-PATTERSON AFB VS	
NB NORFOLK VS	NAS LEMOORE	ABERDEEN PROVING GROUND VS	
FORT CAMPBELL VS	NAS WHIDBEY ISLAND VS	CHARLESTON AFB VS	
FORT HOOD VS	ROBINS AFB VS	EDWARDS AFB VS	
JBLM-MCCHORD AFB VS	SCOTT AFB VS	FORT EUSTIS VS	
FORT WAINWRIGHT VS	TINKER AFB VS	FORT GORDON VS	
FORT BENNING VS	TRAVIS AFB VS	FORT KNOX VS	
FORT BRAGG VS	BARKSDALE AFB VS	FORT MYER VS	
FORT SILL VS	DOVER AFB VS	HANSCOM AFB VS	
KIRTLAND AFB VS	ELLSWORTH AFB VS	HOLLOMAN AFB VS	
NSB KINGS BAY VS	FAIRCHILD AFB VS	JBSA-FORT SAM HOUSTON VS	
FORT BLISS VS	FORT JACKSON VS	MACDILL AFB VS	
FORT HUACHUCA VS	FORT LEAVENWORTH VS	MAXWELL AFB VS	
HILL AFB VS	FORT MEADE VS	MCAGCC TWENTYNINE PALMS VS	
JBMDL-FORT DIX VS	FORT POLK VS	MCAS CHERRY POINT VS	
NB KITSAP-BANGOR VS	KEESLER AFB VS	MCCONNELL AFB VS	
NBVC PORT HUENEME VS	MCB QUANTICO VS	NAS JRB FORT WORTH	
NSB NEW LONDON VS	MCRD PARRIS ISLAND VS	NAS NEW ORLEANS	
PATRICK AFB VS	MOUNTAIN HOME AFB	NELLIS AFB VS	
WHITEMAN AFB VS	NAS CORPUS CHRISTI VS	NS MAYPORT	

USSOUTHCOM	USEUCOM	USCENTCOM	USINDOPACOM
NB GUANTANAMO BAY CUBA VS	KAISERSLAUTERN MILCOMMUNITY VS NAS SIGONELLA VS AVIANO AB VS RAF FELTWELL VS ANSBACH MIL COMMUNITY VS NS ROTA VS SPANGDAHELM AB VS HOHENFELS MIL COMMUNITY VS KOSOVO VET DET NAPLES VS STUTTGART MIL COMMUNITY VS VILSECK MIL COMMUNITY VS	BAHRAIN VS INCIRLIK AB VS KUWAIT VET DET	KADENA AB VS OSAN AFB VS CAMP HUMPHREYS VS ANDERSEN AFB VS CAMP WALKER VS HICKAM AFB VS MISAWA AFB VS NB SASEBO VS SCHOFIELD BARRACKS VS YONGSAN VS MCBH KANEOHE BAY VS CAMP RED CLOUD VS CAMP ZAMA VS MCAS IWAKUNI VS NB GUAM VS NB YOKOSUKA VS YOKOTA AFB VS

Table C-3. MWD VTFs by U.S. Census Region

Northeast	South		Midwest	West
JBMDL-FORT DIX VS	DOD MILITARY WORKING DOG VS	NAS JACKSONVILLE VS	FORT LEONARD WOOD VS	MCB CAMP PENDLETON VS
NSB NEW LONDON VS	MCB CAMP LEJEUNE VS	NAS PENSACOLA VS	WHITEMAN AFB VS	MCAS MIRAMAR VS
FORT DRUM VS	MOODY AFB VS	NAS/JRB FORT WORTH VS	MINOT AFB VS	FORT CARSON VS
HANSCOM AFB VS	ANDREWS AFB VS	REDSTONE ARSENAL VS	SCOTT AFB VS	FORT RICHARDSON VS
	FORT BELVOIR VS	SEYMOUR JOHNSON AFB	ELLSWORTH AFB VS	JBLM-MCCHORD AFB VS
	NB NORFOLK VS	TYNDALL AFB VS	NTC GREAT LAKES VS	FORT WAINWRIGHT VS
	FORT CAMPBELL VS	ABERDEEN PROVING GROUND VS	OFFUTT AFB VS	KIRTLAND AFB VS
	FORT HOOD VS	CHARLESTON AFB VS	WRIGHT-PATTERSON AFB VS	FORT HUACHUCA VS
	FORT BENNING VS	FORT EUSTIS VS	NELLIS AFB VS	HILL AFB VS
	FORT BRAGG VS	FORT GORDON VS		NB KITSAP-BANGOR VS
	FORT SILL VS	FORT KNOX VS		NBVC PORT HUENEME VS
	NSB KINGS BAY VS	FORT MYER VS		BEALE AFB VS
	FORT BLISS VS	JBSA-FORT SAM HOUSTON VS		DAVIS-MONTHAN AFB VS
	PATRICK AFB VS	MACDILL AFB VS		FE WARREN AFB VS
	EGLIN AFB VS	MAXWELL AFB VS		FORT IRWIN VS
	FORT LEE VS	MCAS CHERRY POINT VS		NAS LEMOORE
	FORT STEWART VS	NAS JRB FORT WORTH		NAS WHIDBEY ISLAND VS
	ROBINS AFB VS	NAS NEW ORLEANS		TRAVIS AFB VS
	TINKER AFB VS	NS MAYPORT		FAIRCHILD AFB VS
	BARKSDALE AFB VS	SHAW AFB VS		MOUNTAIN HOME AFB
	DOVER AFB VS			VANDENBERG AFB VS
	FORT JACKSON VS			EDWARDS AFB VS
	FORT MEADE VS			HOLLOMAN AFB VS
	FORT POLK VS			MCAGCC TWENTYNINE PALMS VS
	KEESLER AFB VS			U.S. AIRFORCE ACADEMY VS
	MCB QUANTICO VS			
	MCRD PARRIS ISLAND VS			
	NAS CORPUS CHRISTI VS			

Table C-4. MWD VTFs by U.S. Census Division

New England	Middle Atlantic	South Atlantic		East North Central	East South Central	West North Central	West South Central	Mountain	Pacific
NSB NEW LONDON VS HANSCOM AFB VS	JBMDL-FORT DIX VS FORT DRUM VS	MCB CAMP LEJEUNE VS MOODY AFB VS ANDREWS AFB VS FORT BELVOIR VS NB NORFOLK VS FORT BENNING VS FORT BRAGG VS NSB KINGS BAY VS PATRICK AFB VS EGLIN AFB VS FORT LEE VS FORT STEWART VS ROBINS AFB VS DOVER AFB VS FORT JACKSON VS FORT MEADE VS MCB QUANTICO VS MCRD PARRIS ISLAND VS NAS JACKSONVILLE VS NAS PENSACOLA VS SEYMOUR JOHNSON AFB TYNDALL AFB VS	ABERDEEN PROVING GROUND VS CHARLESTON AFB VS FORT EUSTIS VS FORT GORDON VS FORT MYER VS MACDILL AFB VS MCAS CHERRY POINT VS NS MAYPORT SHAW AFB VS	SCOTT AFB VS NTC GREAT LAKES VS WRIGHT-PATTERSON AFB VS	FORT CAMPBELL VS KEESLER AFB VS REDSTONE ARSENAL VS FORT KNOX VS MAXWELL AFB VS	FORT LEONARD WOOD VS WHITEMAN AFB VS MINOT AFB VS ELLSWORTH AFB VS OFFUTT AFB VS NELLIS AFB VS	DOD MILITARY WORKING DOG VS FORT HOOD VS FORT SILL VS FORT BLISS VS TINKER AFB VS BARKSDALE AFB VS FORT POLK VS NAS CORPUS CHRISTI VS NAS/JRB FORT WORTH VS JBSA-FORT SAM HOUSTON VS NAS JRB FORT WORTH NAS NEW ORLEANS	FORT CARSON VS KIRTLAND AFB VS FORT HUACHUCA VS HILL AFB VS DAVIS-MONTHAN AFB VS FE WARREN AFB VS MOUNTAIN HOME AFB HOLLOMAN AFB VS U.S. AIRFORCE ACADEMY VS	MCB CAMP PENDLETON VS MCAS MIRAMAR VS FORT RICHARDSON VS JBLM-MCCHORD AFB VS FORT WAINWRIGHT VS NB KITSAP-BANGOR VS NBVC PORT HUENEME VS BEALE AFB VS FORT IRWIN VS NAS LEMOORE NAS WHIDBEY ISLAND VS TRAVIS AFB VS FAIRCHILD AFB VS VANDENBERG AFB VS EDWARDS AFB VS MCAGCC TWENTYNINE PALMS VS

APPENDIX D

ADDITIONAL MWD CHARACTERISTICS

D-1. MWD Characteristics by Demographics

Table D-1 displays characteristics of active MWDs by breed. The average ages for all breeds was 2.6–2.7 years. Intact male MWDs with dark coat colors comprised the majority of each breed. The majority of dogs in each breed were certified in Explosive Detection jobs; German Shorthaired Pointers were certified in Explosive Detection only.

Table D-1. Characteristics of Active MWDs by Breed (n=774)

Characteristics	Level	German Shepherd N (Column %) [N=299]	Belgian Malinois N (Column %) [N=240]	Labrador Retriever N (Column %) [N=103]	German Shorthaired Pointer N (Column %) [N=99]	Other N (Column %) [N=33]
Age (years)	1	6 (2.0)	9 (3.8)	1 (1.0)	2 (2.00	0
	2	119 (39.8)	91 (38.1)	49 (47.6)	45 (45.5)	12 (36.4)
	3	151 (50.5)	116 (48.5)	38 (36.9)	44 (44.4)	19 (57.6)
	4	22 (7.4)	22 (9.2)	14 (13.6)	7 (7.1)	2 (6.1)
	5	0	1 (0.4)	1 (1.0)	0	0
	6	1 (0.3)	0	0	0	0
Avg. Age (years) ± SD		2.65 ± 0.68	2.64 ± 0.72	2.66 ± 0.76	2.60 ± 0.70	2.70 ± 0.59
Sex	Male	186 (62.2)	153 (64.0)	45 (43.7)	50 (50.5)	16 (48.5)
	Male, neutered	40 (13.4)	22 (9.2)	30 (29.1)	19 (19.2)	11 (33.3)
	Female	2 (0.7)	9 (3.8)	5 (4.9)	0	0
	Female, spayed	71 (23.7)	44 (23.0)	23 (22.3)	30 (30.3)	6 (18.2)
Dark coat color	No	1 (0.3)	95 (39.6)	27 (26.2)	1 (1.0)	6 (18.2)
	Yes	298 (99.7)	145 (60.4)	76 (73.8)	98 (99.0)	27 (81.8)
Certification	Explosive Detection	182 (61.1)	151 (65.9)	46 (44.7)	58 (58.6)	19 (57.6)
	Drug Detection	38 (12.8)	17 (7.4)	0	0	2 (6.1)
	Specialized Search	10 (3.4)	5 (2.2)	18 (17.5)	0	0
	Patrol	8 (2.7)	14 (6.1)	0	0	2 (6.1)
	Not certified	60 (20.1)	42 (18.3)	39 (37.9)	41 (41.4)	10 (30.3)
Military branch	Air Force	156 (52.2)	135 (56.3)	90 (87.4)	93 (93.9)	27 (81.8)
	Army	79 (26.4)	58 (24.2)	1 (1.0)	2 (2.0)	4 (12.1)
	Navy	35 (11.7)	22 (9.2)	2 (1.9)	1 (1.0)	2 (6.1)
	Marines	20 (6.7)	17 (7.1)	10 (9.7)	0	0
	Joint	9 (3.0)	8 (3.3)	0	3 (3.0)	0

Characteristics	Level	German Shepherd N (Column %) [N=299]	Belgian Malinois N (Column %) [N=240]	Labrador Retriever N (Column %) [N=103]	German Shorthaired Pointer N (Column %) [N=99]	Other N (Column %) [N=33]
Combatant Command	USNORTHCOM	247 (82.6)	198 (82.5)	98 (95.1)	99 (100)	30 (90.9)
	USINDOPACOM	27 (9.0)	25 (10.4)	5 (4.9)	0	2 (6.1)
	USEUCOM	18 (6.0)	10 (4.2)	0	0	1 (3.0)
	USCENTCOM	5 (1.7)	7 (2.9)	0	0	
	USSOUTHCOM	2 (0.7)	0	0	0	
CONUS	No	52 (17.4)	42 (17.5)	5 (4.9)	0	3 (9.1)
	Yes	247 (82.6)	198 (82.5)	98 (95.1)	99 (100)	30 (90.9)
U.S. Census Regions for CONUS locations	South	174 (71.6)	125 (63.8)	90 (91.8)	94 (94.9)	27 (90.0)
	West	43 (17.7)	51 (26.0)	6 (6.1)	5 (5.1)	2 (6.7)
	Midwest	19 (7.8)	16 (8.2)	1 (1.0)	0	1 (3.3)
	Northeast	7 (2.9)	4 (2.0)	1 (1.0)	0	0
U.S. Census Divisions for CONUS locations	West South Central	112 (46.1)	79 (40.3)	85 (86.7)	92 (92.9)	24 (80.0)
	South Atlantic	53 (21.8)	42 (21.4)	5 (5.1)	2 (2.0)	3 (10.0)
	Pacific	30 (12.3)	33 (16.8)	6 (6.1)	5 (5.1)	1 (3.3)
	West North Central	15 (6.2)	13 (6.6)	1 (1.0)	0	1 (3.3)
	Mountain	13 (5.3)	18 (9.2)	0	0	1 (3.3)
	East South Central	9 (3.7)	4 (2.0)	0	0	0
	Middle Atlantic	5 (2.1)	2 (1.0)	0	0	0
	East North Central	4 (1.6)	3 (1.5)	0	0	0
	New England	2 (0.8)	2 (1.0)	1 (1.0)	0	0

Table D-2 displays characteristics of active MWD by average age. MWDs younger and older than the average age were comparable across sex and neuter/spay status, breeds, military branch, and U.S. Census Regions. Seventy-five percent of older MWDs were certified in Explosive Detection, compared to 41% of younger MWDs. Seventeen percent of older MWDs were located OCONUS, compared with 8% of younger MWDs.

Table D-2. Characteristics of Active MWDs by Age (n=773)

Characteristics	Level	Younger than 2.6 years n (Column %) [n=334]	Older than 2.6 years n (Column %) [n=439]
Sex	Male	195 (58.4)	255 (58.1)
	Male, neutered	56 (16.8)	66 (15.0)
	Female	4 (1.2)	12 (2.7)
	Female, spayed	79 (23.7)	106 (24.1)
Breed	German Shepherd	125 (37.4)	174 (39.6)
	Belgian Malinois	100 (29.9)	139 (31.7)
	Labrador Retriever	50 (15.0)	53 (12.1)
	German Shorthaired Pointer	47 (14.1)	52 (11.8)
	Other	12 (3.6)	21 (4.8)
Certification	Explosive Detection	135 (40.5)	321 (74.8)
	Drug Detection	36 (10.8)	21 (4.9)
	Specialized Search	17 (5.1)	16 (3.7)
	Patrol	4 (1.2)	20 (4.7)
	Not certified	141 (42.3)	51 (11.9)
Military Branch	Air Force	224 (67.1)	277 (63.1)
	Army	58 (17.4)	85 (19.4)
	Navy	27 (8.1)	35 (8.0)
	Marines	15 (4.5)	32 (7.3)
	Joint	10 (3.0)	10 (2.3)
CONUS	Yes	306 (91.6)	366 (83.4)
	No	28 (8.4)	73 (16.6)
U.S. Census Regions for CONUS locations	South	235 (77.8)	275 (75.5)
	West	43 (14.2)	64 (17.6)
	Midwest	21 (7.0)	16 (4.4)
	Northeast	3 (1.0)	9 (2.5)

Table D-3 displays characteristics of active MWDs by light or dark coat color. Seventy-three percent of MWDs with light coat colors were Belgian Malinois, compared to only 23% of MWDs with dark coat colors. MWDs with light or dark coat colors were similar with regard to certification, military branch, CONUS location, and U.S. Census Region.

Table D-3. Characteristics of Active MWDs by Coat Color (n=774)

Characteristics	Level	Light Coat Color n (Column %) [n=130]	Dark Coat Color n (Column %) [n=644]
Breed	German Shepherd	1 (0.8)	298 (46.3)
	Belgian Malinois	95 (73.1)	145 (22.5)
	German Shorthaired Pointer	1 (0.8)	98 (15.2)
	Labrador Retriever	27 (20.8)	76 (11.8)
	Dutch Shepherd	0	12 (1.9)
	Flat-Coated Retriever	0	5 (0.8)
	German Wirehaired Pointer	0	4 (0.6)
	Weimaraner	0	3 (0.5)
	Jagdterrier	0	1 (0.2)
	Jack Russell Terrier	0	1 (0.2)
	Wirehaired Pointing Griffon	0	1 (0.2)
	Vizsla	4 (3.1)	0
	Golden Retriever	2 (1.5)	0
Certification	Explosive Detection	75 (59.5)	381 (59.9)
	Drug Detection	8 (6.3)	49 (7.7)
	Specialized Search	7 (5.6)	26 (4.1)
	Patrol	4 (3.2)	20 (3.1)
	Not certified	32 (25.4)	160 (25.2)
Military Branch	Air Force	85 (65.4)	416 (64.6)
	Army	25 (19.2)	119 (18.5)
	Navy	7 (5.4)	55 (8.5)
	Marines	10 (7.7)	37 (5.7)
	Joint	3 (2.3)	17 (2.6)
CONUS	Yes	115 (88.5)	557 (86.5)
	No	15 (11.5)	87 (13.5)
U.S. Census Regions for CONUS locations	South	86 (74.8)	424 (77.0)
	West	23 (20.0)	84 (15.2)
	Midwest	6 (5.2)	31 (5.6)
	Northeast	0	12 (2.2)

Table D-4 presents the characteristics of active versus inactive MWDs.

Table D-4. Characteristics of Active vs. Inactive MWDs (n=1,062)

Characteristic	Characteristic Level	Active n (Column %) [n=774]	Inactive n (Column %) [n=288]
Age (years)	1	18 (2.3)	4 (1.4)
	2	316 (40.8)	98 (34.0)
	3	368 (47.5)	147 (51.0)
	4	67 (8.7)	33 (11.5)
	5	3 (0.4)	6 (2.1)
	6	1 (0.1)	0
Mean age ± SD (years)		2.64 ± 0.70	2.79 ± 0.74
Sex	Male	450 (58.1)	58 (20.1)
	Male, neutered	122 (15.8)	123 (42.7)
	Female	16 (2.1)	9 (3.1)
	Female, spayed	185 (23.9)	98 (34.0)
Breed	German Shepherd	299 (38.6)	74 (25.7)
	Belgian Malinois	240 (31.0)	77 (26.7)
	Labrador Retriever	103 (13.3)	63 (21.9)
	German Shorthaired Pointer	99 (12.8)	48 (16.7)
	Other	33 (4.3)	26 (9.0)
Certification	Explosive Detection	456 (59.8)	15 (5.3)
	Drug Detection	57 (7.5)	0
	Specialized Search	33 (4.3)	2 (0.7)
	Patrol	24 (3.1)	2 (0.7)
	Not certified	192 (25.2)	263 (93.3)
CONUS	No	102 (13.2)	0
	Yes	672 (86.8)	288 (100)

APPENDIX E

DEPLOYED MWD CHARACTERISTICS AND DEPLOYMENT DETAILS

Seventy-one active MWDs in this population of 774 young dogs (9%) deployed at least once between February 2016 and June 2017.

E-1. Initial Deployment Characteristics

On their initial deployments, 61% of MWDs deployed to USNORTHCOM, followed by 32% to USCENTCOM, and 7% to USEUCOM (Table E-1). Twenty-eight percent of these deployments supported Operation Enduring Freedom/Operation Iraqi Freedom, 21% supported the President of the United States of America, and 18% of deployed MWDs were in training. MWDs deployed for an average of 63.4 days (SD: 97.8 days, range: 2–365 days) on their first deployment.

Table E-1. Characteristics of Initial MWD Deployments, February 2016–June 2017 (N=71)

Characteristic	Characteristic level	N (%)
Deployment Location by Combatant Command[1]	USNORTHCOM	43 (60.6)
	USCENTCOM	23 (32.4)
	USEUCOM	5 (7.0)
Deployment Reason	OEF/OIF	20 (28.2)
	Presidential	15 (21.1)
	Training	13 (18.3)
	Other[2]	23 (32.4)
Deployment Length Tertiles (days) (mean: 63.4, SD: 97.8)	≤ 6	20 (35.7)
	7–26	18 (32.1)
	≥ 27	18 (32.1)

Notes:
[1] USNORTHCOM: United States of America, U.S. Virgin Islands; USCENTCOM: Egypt, Saudi Arabia, Iraq, Israel, Jordan, Kuwait, Qatar, Turkey; USEUCOM: Germany, Italy, Switzerland
[2] Other reasons include Fleet Week, special mission, etc.

E-2. All Deployment Characteristics

Seventy-one MWDs completed 127 deployments between February 2016 and June 2017 (Table E-2). MWDs completed an average of 1.4 deployments (range: 1–8 deployments). Of the 71 MWDs who deployed, 49% were German Shepherds, 44% were Belgian Malinois, and 3% were Labrador Retrievers. Fifty-six percent of MWDs deployed once, and 25% deployed twice.

Sixty-six percent of deployments were to CONUS locations. Among those deployed in CONUS, 46% deployed to the South U.S. Census Region, followed by 23% to the Midwest, and 16% to the Northeast. Among those deployed to USCENTCOM countries, 28% deployed to Iraq, 16% deployed to Afghanistan, and 16% deployed to Kuwait.

The top three reasons for deployment were Training (29%), Presidential (28%), and OEF/OIF (28%). All Training deployments were in USNORTHCOM. Of the 36 deployments for Presidential missions, 92% were in USNORTHCOM. Of the 35 deployments for OEF/OIF, 74% were to USCENTCOM, and 14% were to USNORTHCOM. Ninety-one percent of MWDs deployed for OEF/OIF were certified as Patrol and Explosive Detection dogs.

The average deployment length was 45.7 days (SD: 81.2, range: 1–365 days). As shown in Table E-3, the average deployment length was significantly longer for OCONUS locations compared with CONUS locations (OCONUS: 118.8 days ± 117.9 days; CONUS: 22.9 days ± 46.1 days; $p<0.01$).

Table E-2. Deployment Characteristics for All MWD Deployments, February 2016–Jun 2017 (N=71 MWDs, 127 deployments)

Characteristic	Characteristic level	N (%)
Breed	German Shepherd	35 (49.3)
	Belgian Malinois	31 (43.7)
	Labrador Retriever	2 (2.8)
	German Shorthaired Pointer	0 (-)
	Other	3 (4.2)
Number of Deployments	1	40 (56.3)
	2	18 (25.4)
	3	9 (12.7)
	4	1 (1.4)
	6	2 (2.8)
	8	1 (1.4)
Deployment Location by Combatant Command	USNORTHCOM	85 (66.9)
	USCENTCOM	32 (25.2)
	USEUCOM	9 (7.1)
	USSOUTHCOM	1 (0.8)
OCONUS Country	Iraq	9 (28.1)
	Afghanistan	5 (15.6)
	Kuwait	5 (15.6)
	Jordan	3 (9.4)
	Qatar	3 (9.4)
	Saudi Arabia	3 (9.4)
	Bahrain	1 (3.1)
	Egypt	1 (3.1)
	Israel	1 (3.1)
	Turkey	1 (3.1)
CONUS Census Region	West South Central	13 (15.9)
	South Atlantic	21 (25.6)
	East South Central	4 (4.9)
	Mountain	9 (11.0)
	Pacific	3 (3.7)
	West North Central	9 (11.0)
	East North Central	10 (12.2)
	Middle Atlantic	13 (15.9)

Characteristic	Characteristic level	N (%)
Combatant Commands for Training Deployments	USNORTHCOM	37 (100)
Combatant Commands for Presidential Deployments	USNORTHCOM	33 (91.7)
	USCENTCOM	1 (2.8)
	USEUCOM	2 (5.6)
Combatant Commands for OEF/OIF Deployments	USNORTHCOM	5 (14.3)
	USCENTCOM	26 (74.3)
	USEUCOM	4 (11.4)
Combatant Commands for Other Deployments[1]	USNORTHCOM	10 (52.6)
	USCENTCOM	5 (26.3)
	USEUCOM	3 (15.8)
	USSOUTHCOM	1 (5.3)
Deployment Length tertiles (days) (mean: 45.7, SD: 81.2)	≤ 6	40 (39.2)
	7–19	28 (27.5)
	≥ 20	34 (33.3)

No[1] Other reasons include Air Show, Fleet Week, Special Mission, etc.

Table E-3. Average Deployment Length by CONUS Status (N=101 deployments with actual end dates)

Characteristic	Characteristic level	OCONUS N (%) [N=24]	CONUS N (%) [N=77]	p-value
Deployment Length tertiles (days)	≤ 6	4 (16.7)	35 (45.5)	
	7–19	7 (29.2)	21 (27.3)	
	≥ 20	13 (54.2)	21 (27.3)	
Avg. Deployment Length (days)		118.79 ± 117.87	22.94 ± 46.13	< 0.01

Table E-4 shows the characteristics of deployed MWDs by breed. Among German Shepherds, 34% of deployments were for Training, 28% were for Presidential missions, and 25% were for OEF/OIF. Among Belgian Malinois, 33% were deployed for OEF/OIF, 25% were for Presidential missions, and 23% were for training. All Labrador Retriever deployments were for training.

Table E-4. Characteristics of Deployed Active MWDs by Breed (N=127 deployments)

Characteristics	Level	German Shepherd N (%) [N=61]	Belgian Malinois N (%) [N=57]	Labrador Retriever N (%) [N=3]	Other N (%) [N=6]
Deployment Reason	Training	21 (34.4)	13 (22.8)	3 (100)	0 (-)
	Presidential	17 (27.9)	14 (24.6)	0 (-)	5 (83.3)
	OEF/OIF	15 (24.6)	19 (33.3)	0 (-)	1 (16.7)
	Other	8 (13.1)	11 (19.3)	0 (-)	0 (-)
CONUS	No	19 (31.7)	21 (36.8)	0 (-)	3 (50.0)
	Yes	41 (68.3)	36 (63.2)	3 (100)	3 (50.0)
Combatant Command	USNORTHCOM	43 (70.5)	36 (63.2)	3 (100)	3 (50.0)
	USCENTCOM	15 (24.6)	15 (26.3)	0 (-)	2 (33.3)
	USEUCOM	2 (3.3)	6 (10.5)	0 (-)	1 (16.7)
	USSOUTHCOM	1 (1.6)	0 (-)	0 (-)	0 (-)

APPENDIX F

CHARACTERISTICS OF MWDs WITH LEADING NONINJURY MEDICAL ENCOUNTERS

Table F-1 describes active MWDs that experienced dermatologic problems over the timeframe. Sixty-two percent of MWDs that experienced dermatologic conditions were male, and 42% were German Shepherds.

Table F-1. Characteristics of Active MWDs with Dermatologic Problems (n=354)

Characteristic	Level	n (%)
Sex	Male	221 (62.4)
	Male, neutered	62 (17.5)
	Female	7 (2.0)
	Female, spayed	64 (18.1)
Breed	German Shepherd	148 (41.8)
	Belgian Malinois	106 (29.9)
	Labrador Retriever	39 (11.0)
	German Shorthaired Pointer	50 (14.1)
	Other	11 (3.1)
Dark Coat Color	No	55 (15.5)
	Yes	299 (84.5)
Certification	Explosive Detection	226 (63.8)
	Drug Detection	25 (7.1)
	Specialized Search	11 (3.1)
	Patrol	14 (4.0)
	Not certified	78 (22.0)
Military Branch	Air Force	229 (64.7)
	Army	64 (18.1)
	Navy	33 99.3)
	Marines	17 (4.8)
	Joint	11 (3.1)
Combatant Command	USNORTHCOM	308 (87.0)
	USCENTCOM	5 (1.4)
	USEUCOM	16 (4.5)
	USSOUTHCOM	2 (0.6)
	USINDOPACOM	0

Table F-2 describes active MWDs that experienced alimentary problems over the timeframe. Sixty-three percent of MWDs that experienced alimentary conditions were male, and 43% were German Shepherds.

Table F-2. Characteristics of Active MWDs with Alimentary Problems (n=292)

Characteristic	Level	n (%)
Sex	Male	183 (62.7)
	Male, neutered	44 (15.1)
	Female	3 (1.0)
	Female, spayed	62 (21.2)
Breed	German Shepherd	124 (42.5)
	Belgian Malinois	109 (37.3)
	Labrador Retriever	18 (6.2)
	German Shorthaired Pointer	29 (9.9)
	Other	12 (4.1)
Dark Coat Color	No	48 (16.4)
	Yes	244 (83.6)
Certification	Explosive Detection	194 (66.4)
	Drug Detection	20 (6.8)
	Specialized Search	10 (3.4)
	Patrol	12 (4.1)
	Not certified	56 (19.2)
Military Branch	Air Force	181 (62.0)
	Army	61 (20.9)
	Navy	25 (8.6)
	Marines	17 (5.8)
	Joint	8 (2.7)
Combatant Command	USNORTHCOM	249 (85.3)
	USCENTCOM	5 (1.7)
	USEUCOM	14 (4.8)
	USSOUTHCOM	0
	USINDOPACOM	24 (8.2)

Table F-3 describes active MWDs that experienced dental problems over the timeframe of interest. Sixty-one percent of MWDs that experienced dental problems were male, and 46% were German Shepherds.

Table F-3. Characteristics of Active MWDs with Dental Problems (n=220)

Characteristic	Level	n (%)
Sex	Male	133 (60.5)
	Male, neutered	29 (13.2)
	Female	3 (1.4)
	Female, spayed	55 (25.0)
Breed	German Shepherd	102 (46.4)
	Belgian Malinois	82 (37.3)
	Labrador Retriever	18 (8.2)
	German Shorthaired Pointer	14 (6.4)
	Other	4 (1.8)
Dark Coat Color	No	39 (17.7)
	Yes	181 (82.3)
Certification	Explosive Detection	149 (68.0)
	Drug Detection	16 (7.3)
	Specialized Search	5 (2.3)
	Patrol	11 (5.0)
	Not certified	38 (17.4)
Military Branch	Air Force	137 (62.3)
	Army	48 (21.8)
	Navy	19 (8.6)
	Marines	12 (5.5)
	Joint	4 (1.8)
Combatant Command	USNORTHCOM	185 (84.1)
	USCENTCOM	3 (1.4)
	USEUCOM	7 (3.2)
	USSOUTHCOM	0
	USINDOPACOM	25 (11.4)

Table F-4 shows the characteristics of MWDs with acute injuries. Thirteen active MWDs (1.7%) had pathology reports during the timeframe, but no pathology reports indicated death or euthanasia.

Table F-4. Characteristics of Active MWDs with Acute Injuries (n=188)

Variable category		n (%)
Injury type	Soft tissue-related injury	168 (89.4)
	Musculoskeletal	20 (10.6)
Sex	Male	113 (60.1)
	Male, neutered	28 (14.9)
	Female	4 (2.1)
	Female, spayed	43 (22.9)
Breed	German Shepherd	80 (42.6)
	Belgian Malinois	83 (44.1)
	Labrador Retriever	9 (4.8)
	German Shorthaired Pointer	9 (4.8)
	Other	7 (3.7)
Dark coat color	No	35 (18.6)
	Yes	153 (81.4)
Certification	Explosive Detection	134 (71.7)
	Drug Detection	17 (9.1)
	Specialized Search	4 (2.1)
	Patrol	7 (3.7)
	Not certified	25 (13.4)
Military Branch	Air Force	114 (60.6)
	Army	39 (20.7)
	Navy	24 (12.8)
	Marines	8 (4.3)
	Joint	3 (1.6)
Combatant Command	USNORTHCOM	156 (83.0)
	USCENTCOM	6 (3.2)
	USEUCOM	13 (6.9)
	USSOUTHCOM	0
	USINDOPACOM	13 (6.9)

APPENDIX G

FACTORS ASSOCIATED WITH OTHER LEADING MEDICAL ENCOUNTERS AMONG YOUNG MWDs

Univariate analysis was conducted for the top three most frequent medical problems and acute injuries (Tables G1–G3).

As shown in Table G-1, statistically significant and marginal (p≤0.10) unadjusted risk factors for dermatologic conditions were sex, breed, certification, and military branch.

Table G-1. Factors Associated with Dermatologic Conditions Among Active MWDs, Univariate (n=774)

Characteristic	Level	Total n	% affected	OR (95% CI)	p-value	Overall p-value
Sex	**Male**	**450**	**49.1**	**1.82 (1.28-2.60)**	**<0.01**	0.01
	Male, neutered	**122**	**50.8**	**1.95 (1.23-3.12)**	**<0.01**	
	Female	16	43.8	1.47 (0.52-4.13)	0.46	
	Female, spayed	182	34.6	1.00		
Breed	**German Shepherd**	**299**	**49.5**	**1.61 (1.02-2.54)**	**0.04**	0.12
	Belgian Malinois	240	44.2	1.30 (0.81-2.08)	0.28	
	Labrador Retriever	103	37.9	1.00		
	German Shorthaired Pointer	*99*	*50.5*	*1.67 (0.96-2.93)*	*0.07*	
	Other	33	33.3	0.82 (0.36-1.87)	0.64	
Dark Coat Color	No	130	42.3	1.00		0.39
	Yes	644	46.4	1.18 (0.81-1.73)	0.39	
Certification	*Explosive Detection*	*456*	*49.6*	*1.97 (0.93-4.15)*	*0.08*	0.09
	Drug Detection	57	43.9	1.56 (0.64-3.82)	0.33	
	Specialized Search	33	33.3	1.00		
	Patrol	*24*	*58.3*	*2.80 (0.94-8.31)*	*0.06*	
	Not certified	192	40.6	1.37 (0.63-2.98)	0.43	
Military Branch	Air Force	501	45.7	1.41 (0.72-2.79)	0.32	0.42
	Army	*144*	*44.4*	*2.01 (0.92-4.37)*	*0.08*	
	Navy	62	53.2	1.49 (0.80-2.76)	0.21	
	Marines	47	36.2	1.00		
	Joint	20	55.0	2.16 (0.74-6.24)	0.16	
Combatant Command	USNORTHCOM	672	45.8	1.32 (0.77-2.28)	0.31	0.70
	USCENTCOM	12	41.7	1.12 (0.32-3.95)	0.86	
	USEUCOM	29	55.2	1.93 (0.78-4.74)	0.15	
	USSOUTHCOM	2	100	-		
	USINDOPACOM	59	39.0	1.00		
CONUS	No	102	45.1	1.00		0.89
	Yes	672	45.8	1.03 (0.68-1.57)	0.89	
Deployed	No	703	45.1	1.00		0.26
	Yes	71	52.1	1.33 (0.81-2.16)	0.26	

Variable categories that are significantly associated with injury (p≤0.05) are bolded; those that are marginally associated (0.06≤p≤0.10) are italicized.

Factors significantly associated with dermatologic conditions in univariate analyses were included in multivariable logistic regression (Table G-2). Male sex (both intact and neutered) and German Shephered and German Shorthaired Pointer breeds were significantly associated with dermatologic conditions.

Table G-2. Factors Associated with Dermatologic Conditions Among Active MWDs, Multivariable[1] (n=762)

Characteristic	Level	Total n	OR (95% CI)	p-value	Overall p-value
Sex	**Male**	**442**	**1.90 (1.33-2.72)**	**<0.01**	<0.01
	Male, neutered	**120**	**2.24 (1.39-3.62)**	**<0.01**	
	Female	15	1.89 (0.65-5.53)	0.25	
	Female, spayed	185	1.00		
Breed	**German Shepherd**	**299**	**1.70 (1.06-2.71)**	**0.03**	0.08
	Belgian Malinois	240	1.49 (0.91-2.43)	0.11	
	Labrador Retriever	103	1.00		
	German Shorthaired Pointer	**99**	**1.81 (1.02-3.21)**	**0.04**	
	Other	33	0.79 (0.34-1.82)	0.58	

[1] Variables included in the multivariable model: sex, breed, certification, and military branch
Variable categories that are significantly associated with injury (p≤0.05) are bolded.

Univariate risk factors for alimentary conditions included sex, breed, certification, and deployment status (Table G-3).

Table G-3. Factors Associated with Alimentary Conditions Among Active MWDs, Univariate (n=774)

Characteristic	Level	Total n	% affected	OR (95% CI)	p-value	Overall p-value
Sex	*Male*	*450*	*40.7*	*2.97 (0.83-10.57)*	*0.09*	0.14
	Male, neutered	122	36.1	2.44 (0.66-9.05)	0.18	
	Female	16	18.8	1.00		
	Female, spayed	185	33.5	2.18 (0.60-7.95)	0.24	
Breed	**German Shepherd**	**299**	**41.5**	**3.35 (1.91-5.85)**	**<0.01**	<0.01
	Belgian Malinois	**240**	**45.4**	**3.93 (2.23-6.94)**	**<0.01**	
	Labrador Retriever	103	17.5	1.00		
	German Shorthaired Pointer	**99**	**29.3**	**1.96 (1.00-3.81)**	**0.05**	
	Other	**33**	**36.4**	**2.70 (1.13-6.46)**	**0.03**	
Dark Coat Color	No	130	36.9	1.00		0.84
	Yes	644	37.9	1.04 (0.71-1.54)	0.84	
Certification	**Explosive Detection**	**456**	**42.5**	**1.80 (1.25-2.58)**	**<0.01**	0.01
	Drug Detection	57	35.1	1.31 (0.70-2.46)	0.39	
	Specialized Search	33	30.3	1.06 (0.47-2.36)	0.89	
	Patrol	**24**	**50.0**	**2.43 (1.03-5.73)**	**0.04**	
	Not certified	192	29.2	1.00		
Military Branch	Air Force	501	36.1	1.00		0.71
	Army	144	42.4	1.30 (0.89-1.90)	0.17	
	Navy	62	40.3	1.19 (0.70-2.05)	0.52	
	Marines	47	36.2	1.00 (0.54-1.87)	1.00	
	Joint	20	40.0	1.18 (0.47-2.94)	0.72	
Combatant Command	USNORTHCOM	672	37.1	1.00		0.78
	USCENTCOM	12	41.7	1.21 (0.38-3.86)	0.74	
	USEUCOM	29	48.3	1.59 (0.75-3.34)	0.23	
	USSOUTHCOM	2	0	-		
	USINDOPACOM	59	40.7	1.16 (0.68-2.00)	0.58	
CONUS	No	102	42.2	1.24 (0.81-1.89)	0.32	0.32
	Yes	672	37.1	1.00		
Deployed	No	703	36.6	1.00		0.04
	Yes	**71**	**49.3**	**1.69 (1.03-2.75)**	**0.04**	

Variable categories that are significantly associated with injury (p≤0.05) are bolded; those that are marginally associated (0.06≤p≤0.10) are italicized.

When factors that were significantly or marginally associated with alimentary problems in univariate analyses were included in multivariable logistic regression (Table G-4), MWDs of all other breeds were at significantly increased odds of alimentary problems when compared to Labrador Retrievers.

Table G-4. Factors Associated with Alimentary Problems Among Active MWDs, Multivariable[1] (n=762)

Characteristic	Level	Total n	OR (95% CI)	p-value	Overall p-value
Breed	**German Shepherd**	**298**	**3.37 (1.93-5.88)**	**<0.01**	<0.01
	Belgian Malinois	**229**	**4.29 (2.42-7.59)**	**<0.01**	
	Labrador Retriever	103	1.00		
	German Shorthaired Pointer	**99**	**1.96 (1.00-3.81)**	**0.05**	
	Other	**33**	**2.70 (1.13-6.46)**	**0.03**	

[1] Variables included in the multivariable model: sex, breed, certification, deployment yes/no
Variable categories that are significantly associated with injury (p≤0.05) are bolded.

Dental conditions were associated with breed, certification, and deployment status (Table G-5).

Table G-5. Factors Associated with Dental Conditions Among Active MWDs, Univariate (n=774)

Characteristic	Level	Total n	% affected	OR (95% CI)	p-value	Overall p-value
Sex	Male	450	29.6	1.82 (0.51-6.48)	0.36	0.49
	Male, neutered	122	23.8	1.35 (0.36-5.07)	0.66	
	Female	16	18.8	1.00		
	Female, spayed	185	29.7	1.83 (0.50-6.69)	0.36	
Breed	**German Shepherd**	**299**	**34.1**	**3.14 (1.70-5.81)**	**<0.01**	<0.01
	Belgian Malinois	**240**	**34.2**	**3.15 (1.69-5.89)**	**<0.01**	
	Labrador Retriever	103	17.5	1.29 (0.60-2.75)	0.52	
	German Shorthaired Pointer	99	14.1	1.00		
	Other	33	12.1	0.84 (0.26-2.75)	0.77	
Dark coat color	No	130	30.0	1.10 (0.73-1.66)	0.66	0.66
	Yes	644	28.1	1.00		
Certification	**Explosive Detection**	**456**	**32.7**	**2.72 (1.03-7.18)**	**0.04**	<0.01
	Drug Detection	57	28.1	2.19 (0.72-6.65)	0.17	
	Specialized Search	33	15.2	1.00		
	Patrol	**24**	**45.8**	**4.74 (1.36-16.46)**	**0.01**	
	Not certified	192	19.8	1.38 (0.50-3.82)	0.53	
Military branch	Air Force	501	27.3	1.51 (0.49-4.57)	0.47	0.56
	Army	144	33.3	2.00 (0.63-6.31)	0.24	
	Navy	62	30.6	1.77 (0.52-6.00)	0.36	
	Marines	47	25.5	1.37 (0.38-4.92)	0.63	
	Joint	20	20.0	1.00		
Combatant Command	USNORTHCOM	672	27.5	1.19 (0.50-2.84)	0.69	0.20
	USCENTCOM	12	25.0	1.05 (0.22-4.98)	0.95	
	USEUCOM	29	24.1	1.00		
	USSOUTHCOM	2	0	-		
	USINDOPACOM	*59*	*42.4*	*2.31 (0.85-6.25)*	*0.10*	
CONUS	No	102	34.3	1.38 (0.88-2.14)	0.16	0.16
	Yes	672	27.5	1.00		
Deployed	No	703	27.2	1.00		0.02
	Yes	**71**	**40.8**	**1.85 (1.12-3.06)**	**0.02**	

Variable categories that are significantly associated with injury ($p \leq 0.05$) are bolded; those that are marginally associated ($0.06 \leq p \leq 0.10$) are italicized.

Factors significantly associated with dental conditions in univariate analyses were included in multivariable logistic regression (Table G-6). German Shepherd and Belgian Malinois breeds and Patrol certification were significantly associated with dental conditions. Explosive Detection certification was marginally associated (p=0.09).

Table G-6. Factors Associated with Dental Conditions Among Active MWDs, Multivariable[1] (n=762)

Characteristic	Level	Total n	OR (95% CI)	p-value	Overall p-value
Breed	**German Shepherd**	**298**	**3.02 (1.62-5.64)**	**<0.01**	<0.01
	Belgian Malinois	**229**	**3.11 (1.65-5.88)**	**<0.01**	
	Labrador Retriever	103	1.45 (0.67-3.14)	0.35	
	German Shorthaired Pointer	99	1.00		
	Other	33	0.79 (0.24-2.60)	0.69	
Certification	*Explosive Detection*	*456*	*2.39 (0.88-6.48)*	*0.09*	0.03
	Drug Detection	57	1.58 (0.50-4.97)	0.43	
	Specialized Search	33	1.00		
	Patrol	**24**	**3.62 (1.00-13.07)**	**0.05**	
	Not certified	192	1.41 (0.50-3.99)	0.51	

[1] Variables included in the multivariable model: breed, certification, combatant command, and deployment yes/no, Variable categories that are significantly associated with injury (p≤0.05) are bolded; those that are marginally associated (0.06≤p≤0.10) are italicized.

All factors associated with dermatologic, alimentary, or dental conditions among these young MWDs are summarized in Table G-7.

Table G-7. Summary of Factors Associated with Dermatologic, Alimentary, and Dental Conditions Among Active MWDs (n=762)

	Dermatologic Conditions	Alimentary Problems	Dental Conditions
Intact male	✓		
Neutered male	✓		
Intact female			
German Shepherd	✓	✓	✓
Belgian Malinois		✓	✓
German Shorthaired Pointer	✓	✓	
Patrol Certification			✓
Explosives Detection Certification			*

✓: statistically significantly associated (p≤0.05)
*: statistically marginally associated (0.06≤p≤0.10)

Since eighty-nine percent of acute injuries were soft tissue-related injuries, risk factors for acute injuries are expected to be similar to those for soft-tissue injuries (see 6.3.1). Sixty percent of MWDs that experienced acute injuries were male and 43% were German Shepherds. As shown in Table G-8, acute injuries were associated with breed, certification, military branch, and combatant command.

Table G-8. Factors Associated with Acute Injuries Among Active MWDs, Univariate (n=774)

Characteristic	Level	Total n	% affected	OR (95% CI)	p-value	Overall p-value
Sex	Male	450	25.1	1.13 (0.70-1.81)	0.62	0.94
	Male, neutered	122	23.0	1.00		
	Female	16	25.0	1.12 (0.33-3.74)	0.86	
	Female, spayed	185	23.2	1.02 (0.59-1.75)	0.95	
Breed	**German Shepherd**	**299**	**26.8**	**3.82 (1.84-7.82)**	**<0.01**	<0.01
	Belgian Malinois	**240**	**34.6**	**5.52 (2.65-11.50)**	**<0.01**	
	Labrador Retriever	103	8.7	1.00		
	German Shorthaired Pointer	99	9.1	1.04 (0.40-2.75)	0.93	
	Other	*33*	*21.2*	*2.81 (0.96-8.27)*	*0.06*	
Dark Coat Color	No	130	26.9	1.18 (0.77-1.81)	0.44	0.44
	Yes	644	23.8	1.00		
Certification	**Explosive Detection**	**456**	**29.4**	**3.02 (1.04-8.75)**	**0.04**	<0.01
	Drug Detection	*57*	*29.8*	*3.08 (0.94-10.12)*	*0.06*	
	Specialized Search	33	12.1	1.00		
	Patrol	24	29.2	2.99 (0.76-11.71)	0.12	
	Not certified	192	13.0	1.09 (0.35-3.35)	0.89	
Military Branch	Air Force	501	22.8	1.67 (0.48-5.82)	0.42	0.04
	Army	144	27.1	2.10 (0.58-7.58)	0.25	
	Navy	*62*	*38.7*	*3.58 (0.95-13.53)*	*0.06*	
	Marines	47	17.0	1.16 (0.27-4.93)	0.84	
	Joint	20	15.0	1.00		
Combatant Command	USNORTHCOM	672	23.2	1.07 (0.56-2.03)	0.84	0.03
	USCENTCOM	**12**	**50.0**	**3.54 (0.98-12.83)**	**0.05**	
	USEUCOM	**29**	**44.8**	**2.88 (1.10-7.48)**	**0.03**	
	USSOUTHCOM	2	0	-		
	USINDOPACOM	59	22.0	1.00		
CONUS	*No*	*102*	*31.4*	*1.51 (0.96-2.38)*	*0.07*	0.07
	Yes	672	23.2	1.00		
Deployed	No	703	24.0	1.00		0.61
	Yes	71	26.8	1.15 (0.66-2.01)	0.61	

Variable categories that are significantly associated with injury ($p \leq 0.05$) are bolded; those that are marginally associated ($0.06 \leq p \leq 0.10$) are italicized.

Factors significantly associated with acute injury in univariate analyses were included in multivariable logistic regression (Table G-9). German Shepherd and Belgian Malinois breeds, affiliation with Navy or Air Force military branches, and USEUCOM combatant command was significantly associated with acute injury.

Table G-9. Factors Associated with Acute Injuries Among Active MWDs, Multivariable[1] (n=762)

Characteristic	Level	Total n	OR (95% CI)	p-value	Overall p-value
Breed	**German Shepherd**	**298**	**3.47 (1.61-7.48)**	**<0.01**	<0.01
	Belgian Malinois	**229**	**5.27 (2.44-11.39)**	**<0.01**	
	Labrador Retriever	103	1.00		
	German Shorthaired Pointer	99	0.95 (0.36-2.55)	0.92	
	Other	33	2.42 (0.80-7.33)	0.12	
Military Branch	**Air Force**	**499**	**4.56 (1.14-18.21)**	**0.03**	0.08
	Army	139	3.18 (0.78-12.95)	0.11	
	Navy	**62**	**5.27 (1.25-22.15)**	**0.02**	
	Marines	42	2.59 (0.53-12.74)	0.24	
	Joint	20	1.00		
Combatant Command	USNORTHCOM	672	1.67 (0.85-3.28)	0.11	0.16
	USCENTCOM	*12*	*3.16 (0.79-12.55)*	*0.10*	
	USEUCOM	**29**	**3.60 (1.25-10.35)**	**0.02**	
	USSOUTHCOM	2	N/A		
	USINDOPACOM	59	1.00		

[1] Variables included in the multivariable model: breed, certification, military branch, combatant command, and CONUS yes/no

Variable categories that are significantly associated with injury (p≤0.05) are bolded; those that are marginally associated (0.06≤p≤0.10) are italicized.