Noncombat injury and illness prevalence and working score percentage quantify the impact on duty availability in US Army Special Operations military working dogs

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OBJECTIVE
This cross-sectional study determined the 2-year period prevalence and quantified the impact on working status of noncombat injury and illness by a working score percentage (WSP) based on the number of duty days lost (DDL).

ANIMALS
126 dogs from 9 US Army Special Operations kennels.

METHODS
Dog injury and illness events between May 1, 2021, and April 30, 2023, were recorded to determine period prevalence and calculate a WSP metric to quantify loss of duty status.

RESULTS
93 health events occurred in 62 of 126 (49.2%) dogs over a 24-month period resulting in 4,130 DDL. The period prevalence was 25 of 126 (19.8%) for dental injuries, 20 of 126 (15.9%) for musculoskeletal injuries, and 13 of 126 (10.3%) for gastrointestinal illnesses. Musculoskeletal conditions resulted in the highest total DDL at 1,472 (35.6%) in 20 dogs, followed by neurologic conditions at 950 (23%) in 4 dogs and heat injuries at 521 (12.6%) in 7 dogs. The total population 24-month mean WSP was 88.1% (95% CI, 86.6 to 89.5). The mean WSP for 43 dogs with acute events was 96.0% (95% CI, 95.0 to 97.0), and the mean WSP for 14 dogs with chronic events was 55.2% (95% CI, 47.8 to 62.5).

CLINICAL RELEVANCE
Quantifying the impact of noncombat illness and injury on the working status of military working dogs is the first step to identify risk factors, develop preventive strategies, resource veterinary care requirements, and improve these canine athletes’ health and welfare. The metrics developed in this study can be used to evaluate the population health of working, herding, and sport dogs.

Keywords: working dogs, military working dog, military working dog injury, injury prevalence, injury surveillance

The US Department of Defense (DoD) classifies noncombat injury and illness as disease and nonbattle injury (DNBI), which is defined as all illness and injury not resulting from hostile action, terrorist activity, or armed conflict. Disease and nonbattle injury have caused more morbidity and loss of human combat power than combat-related injuries throughout the history of armed conflict. The DoD has a robust injury- and disease-monitoring, surveillance system for human military service members, and data indicate that DNBI, specifically musculoskeletal and overuse injuries, account for 65% of duty days lost (DDL). Duty days lost is a metric used to evaluate the nonavailability of a military service-member to perform their job due to illness, injury, or other health factors. There is no policy requirement or mechanism to conduct equivalent quantitative health monitoring of US military working dogs (MWDs); therefore, the prevalence and incidence of DNBI in MWDs are unknown. Additionally, no previous studies have analyzed the impact of DNBI, or other health-related issues, on the availability of MWDs to perform their working capability, referred to as “medical readiness.”

Previous studies have primarily focused on identifying causes of combat-related injuries in MWDs. Mey et al and Takara and Harrell described DNBI
occurrence among dogs deployed to combat zones, and Schuh-Renner et al\textsuperscript{11} reported DNBI frequencies among young nondeployed MWDs. In non-US working dogs, Park et al\textsuperscript{12} and Suprovych et al\textsuperscript{13} indicated that gastrointestinal, general trauma, musculoskeletal, dental, and dermatological conditions were the most reported health conditions in non-US military canines. However, these studies did not quantify the impact on the dogs’ availability or medical readiness to perform their job. Caron-Lormier et al\textsuperscript{14} were the first to describe a metric for working dogs that quantified the impact and identified the conditions that negatively impacted the working career length in a population of UK service dogs.

The mandatory system used to monitor MWD medical readiness, category status, is an imprecise measure. Category status\textsuperscript{15} is a periodic metric and does not provide information on the number of days spent nondeployable or the nature of the injury or illness. The category status is updated once monthly in the MWD’s health record by the attending veterinarian. The dog is given a medical readiness status of category 1 to category 4, depending on the scope of injury or illness and the potential to return to duty, with category 1 signifying no medical constraints through category 4 indicating the need for medical retirement from military service. Monitoring DNBI prevalence in MWDs is challenging and labor-intensive due to the lack of efficient data categorization and data extraction capabilities using the category status metric. Developing health-monitoring metrics that assess the impact of DNBI on medical readiness for duty would be the first step toward a comprehensive working canine health surveillance system to identify risk factors and inform preventive programs. Such a streamlined, data-driven system could provide significant benefits in managing the population health of canine athletes in a variety of disciplines (eg., law enforcement, search and rescue, hunting, agility, herding) as well as other sport dogs.

Our first objective was to determine the 2-year period prevalence of DNBI in a population of US Army Special Operations multipurpose canines (MPCs). Our second objective was to quantify the impact of DNBI on duty availability and medical readiness by developing a working score percentage (WSP) metric.

**Methods**

**Study design**

To determine the number and type of DNBI, we abstracted 24 months of non-combat-related injury and illness data from monthly health reports on 129 US Army Special Operations canines from 9 kennels between May 1, 2021, and April 30, 2023. The US Special Operations Command Veterinary Review Office approved the use of the animal health data. Attending veterinarians completed regularly required reports on a shared spreadsheet containing the month, kennel name, dog demographics, injury or illness classifications, number of DDL that month, and a free-text notes section (SharePoint; Microsoft Corp). The veterinarians submitted the previous month’s information during the first week of the subsequent month as part of the required monthly records review. The monthly information was sequentially merged on 1 master spreadsheet. All injury classifications were determined by the kennel’s attending veterinarian and approved by the supervising veterinarian (MGK). Medical and convalescent data for 129 dogs was compiled (n = 1,647 observations) on the merged spreadsheet. Dogs that entered the MPC program during the study period were included. Three dogs (n = 32 observations) were removed from the data set due to complex or obscure medical issues, which resulted in discharge from military service. A total of 1,615 month-observations from 126 dogs were included in the final data set.

**Classification of data**

Demographic data from the monthly reports were classified for descriptive analysis. Breed was a categorical variable with 3 levels: Belgian Malinois, Shepherds (German, Dutch, and Czech), and other (including Labradors and Terriers). Sex was a binary variable. Reproductive status was not included in the final variable list because it was highly correlated with sex. Military Working Dog Program requirements dictate that all female dogs be spayed and all male dogs remain intact unless medical necessity indicates the need for neutering. Age was formatted as a categorical variable with 4 levels: dogs < 1 year of age, dogs 1 to < 3 years of age, dogs 3 to < 5 years of age, and dogs ≥ 5 years of age. Body condition score (BCS) was an integer variable on a scale from 1 (severely underweight) to 9 (severely obese).

The attending veterinarian assigned 1 of 15 codes (Supplementary Table S1) that categorized the type of injury, illness, or reason for loss of duty status. For any DNBI that could be classified in more than 1 category, a decision was made to select only 1 category by the attending veterinarian in consultation with the supervising veterinarian (MGK). Total DDL per month was recorded for each dog, and DDL was defined as the number of days a dog was unavailable for duty each month due to an injury, illness, convalescence, or pending retirement from the MPC program. Multipurpose canines are expected to be mission-ready 7 days a week due to Special Operations units’ training and operational demand; therefore, the maximum duty days available each month were 28, 30, or 31.

The DDL was further categorized into preventive, acute, or chronic categories. Preventive DDL occurred from procedures or surgeries conducted to prevent future illness or as a routine component of veterinary care. These included spay, neuter, dental prophylaxis, and gastropexy. Acute DNBI resulting in DDL was defined as a trauma, injury, or illness caused by a single event that was resolved by medical or surgical therapy. Chronic DNBI resulting in DDL was defined as an ongoing or recurring illness or injury resulting from a previous event, irreversible disease, illness, or long-term injury-related effect.

If the DNBI incident spanned multiple, sequential months in a particular dog, a secondary numeric code,
injury number, was used to denote that the DDL was due to the same injury or illness. If a dog was available for all duty days in a month, the code NA was used to denote that no DDL was accrued. This study did not track injuries and illnesses that did not result in DDL (ie, the dog continued to work). Adapting the working life metric originally described by Caron-Lormier et al, we developed a WSP, calculated by subtracting DDL from the total days in the month, divided by the total days in the month, multiplied by 100:

\[ \text{WSP} = \left( \frac{\text{days in month} - \text{DDL}}{\text{days in month}} \right) \times 100 \]

For example, a dog with a WSP of 80% for November would be interpreted as follows: the dog was medically ready and available to work 80% (24/30) of the days in November. The dog was not medically ready to work for 6 days (6/30) due to an illness or injury. Calculation of mean WSP by kennel was incorporated into the shared spreadsheet (SharePoint; Microsoft Corp) to create a shared dashboard (Power BI; Microsoft Corp) to visualize dog medical readiness status and track WSP at the individual and kennel levels over time (Supplementary Figures S1 and S2).

**Statistical analysis**

All data were analyzed using standard statistical software (Studio, version 3.8; SAS Institute Inc). The Shapiro-Wilk test for normality was used, and the null hypothesis for normality was rejected \((P < .0001)\). Skewness of continuous parameters was \(-2.4\), and kurtosis was 4.1, indicating the need for nonparametric testing. Bivariate descriptive statistics were performed on categorical variables via the Fisher exact test with Monte Carlo simulation to optimize accuracy given the small sample size. Nonparametric 1-way ANOVA was used to compare group means; the \(\alpha\) level was set at 0.05, and CIs were set at 95%.

**Results**

Of the 126 dogs included in the study, Belgian Malinois were 92 (73.0%) of the MPCs, and there were 26 (20.6%) Shepherds, with the remaining 8 (6.4%) being various other breeds (Table 1). There were 64 (50.8%) dogs 1 to < 3 years of age and 38 (30.2%) dogs between 3 and < 5 years of age. Breed did not differ significantly between kennels (fixed-effects \(P = .16\)), and neither did the age of the dog (fixed-effects \(P = .73\)). Most dogs were male (\(n = 111 \ [88.1\%]\)), and sex distribution did differ significantly between kennels (fixed-effects \(P = .002\)). Mean BCS was 4.31 (95% CI, 4.28 to 4.33), with a minimum of 3 and a maximum of 6. Mean BCS varied significantly between kennels \((P < .0001)\).

Of the 1,615 observation months in the final data set, 1,335 (82.7%) were coded NA, indicating that the dog did not sustain any DNBI resulting in lost duty days. A total of 143 DDL-producing incidents from a population of 126 dogs resulted in 5,828 DDL over 24 months. Of the 143 events, 93 (65.0%) were injuries and illnesses resulting in 4,130 (70.9%) DDL (Table 2); 34 (23.8%) were preventive procedures and resulted in 349 (6.0%) DDL; and 16 (11.2%) were dogs awaiting nonmedical discharge from service and resulted in 1,349 (23.1%) DDL. Dental injuries had the highest

### Table 1—Demographic characteristics of 126 US Army Special Operations multipurpose canines (MPCs) by kennel (K) between May 1, 2021, and April 30, 2023.

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>K1</th>
<th>K2</th>
<th>K3</th>
<th>K4</th>
<th>K5</th>
<th>K6</th>
<th>K7</th>
<th>K8</th>
<th>K9</th>
<th>n (%)</th>
<th>FE P value</th>
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<tbody>
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<td>Breed</td>
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<tr>
<td>Malinois</td>
<td>6</td>
<td>17</td>
<td>11</td>
<td>14</td>
<td>12</td>
<td>8</td>
<td>10</td>
<td>12</td>
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<td>92 (73.0%)</td>
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<td>3</td>
<td>3</td>
<td>4</td>
<td>2</td>
<td>7</td>
<td>2</td>
<td>3</td>
<td>0</td>
<td>26 (20.6%)</td>
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<tr>
<td>Other</td>
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<td>1</td>
<td>0</td>
<td>0</td>
<td>2</td>
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<td>0</td>
<td>1</td>
<td>8 (6.4%)</td>
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<td>Sex*</td>
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<tr>
<td>Male</td>
<td>9</td>
<td>14</td>
<td>12</td>
<td>16</td>
<td>14</td>
<td>17</td>
<td>13</td>
<td>15</td>
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<td>111 (88.1%)</td>
<td>.74</td>
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<tr>
<td>Female</td>
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<td>6</td>
<td>3</td>
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<td>2</td>
<td>15 (11.9%)</td>
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<td>Age</td>
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<td>3 (2.4%)</td>
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<td>1 to &lt; 3 y</td>
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<td>13</td>
<td>8</td>
<td>9</td>
<td>5</td>
<td>9</td>
<td>8</td>
<td>6</td>
<td>1</td>
<td>64 (50.8%)</td>
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<td>3 to &lt; 5 y</td>
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<td>4</td>
<td>6</td>
<td>8</td>
<td>4</td>
<td>4</td>
<td>3</td>
<td>5</td>
<td>2</td>
<td>38 (30.2%)</td>
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<tr>
<td>≥ 5 y</td>
<td>3</td>
<td>3</td>
<td>1</td>
<td>1</td>
<td>4</td>
<td>3</td>
<td>2</td>
<td>4</td>
<td>0</td>
<td>21 (16.7%)</td>
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</table>

Data are number of dogs (age on April 30, 2023, or the dog’s age when discharged from military service).

*Values are significantly \((P < .05)\) different.

FE = Fisher’s Exact.
period prevalence (n = 25/126 [19.8%]), followed by musculoskeletal injury (20/126 [15.9%]) and gastrointestinal illness (13/126 [10.3%]). Musculoskeletal injuries accrued the highest DDL (n = 1,472), followed by neurologic injuries (950) and heat injuries (521).

The 24-month mean WSP across all dogs in all kennels was 88.1% (95% CI, 86.6 to 89.5). The mean WSP by kennel ranged from 81.9% to 100%, and the variance in means was statistically significant (P < .0001). Dogs ≥ 5 years of age had the lowest mean WSP at 80.3% (95% CI, 76.4 to 84.2), followed by dogs 3 to < 5 years old at 88.5% (95% CI, 86.2 to 90.7). The variance in WSP means between age groups was statistically significant (P < .0001). The mean WSPs for Malinois (87.9%) and Shepherds (87.2%) were not statistically different (P = .21).

A total of 62 of 126 (49.2%) dogs recorded 1 or more DNBI during the 24-month period. Dogs sustaining only acute injuries (n = 43) had a 24-month mean WSP of 96.0% (95% CI, 95.0 to 97.0); dogs sustaining only chronic injuries (14) had a 24-month mean WSP of 55.2% (95% CI, 47.8 to 62.5), a difference of 40.8%. Dogs sustaining a combination of acute and chronic injuries (n = 5) had a 24-month mean WSP of 68.8% (95% CI, 60.2 to 77.3), a difference of 27.2% from acute only and 13.6% from chronic only. The mean DDL and mean WSP for each DNBI type were further categorized by acute or chronic status (Table 3). Seventy-three (78.5%) of the DNBI cases were coded acute and generated 1,066 DDL (24.4%); 20 DNBI cases (21.5%) were coded chronic and generated 3,124 DDL (75.6%). Further analysis comparing the means among the injury types were not completed at this time and will be conducted in future studies when more data has been collected.

### Discussion

This study reported DNBI period prevalence among US Army Special Operations MPCS and, to our knowledge, is the first to quantify the impact of DNBI on MWD medical readiness. In addition to developing the WSP metric, we designed a new management tool to provide kennel and veterinary personnel with near-real-time monthly and retrospective data on the population health of their dogs (Supplementary Figures S1 and S2).

The 3 most prevalent DNBI categories over this 24-month period in this population were dental injuries, musculoskeletal injuries, and gastrointestinal illnesses. The 3 DNBI categories resulting in the most DDL were musculoskeletal, neurologic, and heat injuries. A retrospective analysis by Schuh-Renner et al. showed 639 of 774 (83%) nondeployed US MWDs had at least 1 nonsurgical medical problem; 54% of the dogs recorded a dermatologic problem, 46% recorded an alimentary problem, 34% recorded a dental problem, 28% recorded a soft-tissue-related injury, and 14% recorded a musculoskeletal injury. However, Schuh-Renner et al. included all medical problems in the electronic medical record, even if the condition did not result in loss of duty status. Minor dermatologic and alimentary conditions may not result in loss of duty status for an MPC. Takara and Harrell reported that of 1,350 injured or ill combat-deployed MWDs, 25% of DNBI were dermatologic, 21% were soft tissue trauma, 17.1% were alimentary, and 14.3% were musculoskeletal, while dental accounted for only 2.5% of DNBI in deployment settings. The Takara and Harrell report did not distinguish whether the DNBI caused loss of duty status; as stated previously, many minor dermatologic conditions do not warrant loss of duty status, which may account for the differences in study findings. Adjusting our data collection to include conditions that do not cause loss of duty status would likely increase the number of other conditions.

The prevalence of dental injuries in our report (19.8%) was lower than a recent study by Bilyard et al. on dental trauma in a population of US MWDs, which found that the 1-year prevalence of traumatic dental injury was 43.6% (n = 596). However, our study included only dental injuries that resulted in lost duty days and thus was not a comprehensive measure of all dental issues. This likely resulted in a lower respective prevalence of dental injuries. The prevalence of dental injuries indicates the need for further research on possible risk factors associated with dental injury, including bite training methods and frequency, husbandry, and working environment.

Musculoskeletal injuries are a common reported injury type across several working and sport dog disciplines. A comprehensive prospective study of 641 herding dogs in New Zealand showed that 43% had at least 1 musculoskeletal injury in a subsequent study of 323 dogs, 57% (n = 184) developed at least 1 musculoskeletal abnormality, and of these dogs available for follow-up, 68% developed a second musculoskeletal abnormality. Our study intended to determine the
impact of medical events on MWD operational readiness. Our results showed that musculoskeletal injuries resulted in the highest number of days lost; this aligns with human military service member DNBI analysis, which found that musculoskeletal injuries represent the leading cause of lost duty days. The high amount of lost duty due to musculoskeletal conditions, especially in chronic cases, underlines the importance of early detection, proactive monitoring, and early intervention in reducing the impact of these conditions on working dog availability.

The prevalence of musculoskeletal injuries in our study (15.9%) closely matched results from Schuh-Renner et al (14.0%) and Takara and Harrell (14.3%). These numbers were much lower than the incidence of musculoskeletal injury in New Zealand herding dogs and UK service dogs, likely because our population of dogs was quite young overall and the study period was relatively short. Additionally, our study showed there were multiple dogs that sustained more than 1 injury or illness during the period observed; however, we did not conduct further analysis on these multiple injuries.

Chronic injuries accounted for less than a quarter of total injuries in this study but resulted in more than three-quarters of lost duty days, whereas acute injuries accounted for more than three-quarters of total injuries but less than a quarter of lost duty days. Dogs sustaining chronic injuries also had the lowest 24-month mean WSP. These results suggested that chronic injuries significantly impact the availability of working dogs to perform the duties for which they have been trained. Therefore, identifying risk factors and preventing chronic injuries would improve working dog health, effectiveness, and working longevity. These findings also supported the idea that military veterinarians need to receive advanced training in veterinary dentistry, sports medicine, and rehabilitation to address common issues in working dogs effectively. These findings support the need for additional research on management strategies to minimize the risk of dental, musculoskeletal, neurologic disorders and heat injuries in canine athletes.

Another analysis of guide and service dogs showed that using selective breeding strategies incorporating health information as part of the breeding selection process decreased the proportion of health-related eliminations from the working program over subsequent generations. This suggests it is advantageous to incorporate health surveillance and working longevity into the breeding selection strategy for working dog populations, which emphasizes the need to develop a robust health surveillance system for all disciplines of working dogs.

Our analysis indicated that the sex distribution between kennels was significant. This is most likely due to the preference of the handler and trainer for choosing males for their respective programs. Body condition score differed significantly between kennels, as well. This score is an inherently subjective measurement, and additionally, some trainers may prefer to keep their dogs at a leaner body condition than others; both of these facts could confound condition score assessment.

The development and application of the WSP metric in this study represented an innovative approach to monitoring the medical readiness of individuals and groups of dogs over time. The dashboard system (Supplementary Figures S1 and S2) developed in conjunction with our data collection provided real-time, quantifiable injury and illness data of this population of MPCs and reflected more robust health monitoring than the current MWD medical readiness metric of category status.

Limitations of this study include a small sample size and a limited data collection period. Four of the 9 kennels had only 1 year of data for analysis. Our exclusion of any DNBI that did not cause loss of duty status may have resulted in an incomplete assessment of all health factors influencing MPC readiness. Additionally, DNBI categories may have been miscategorized; these categories were assigned based on the initial veterinary evaluation. Rest and recovery periods after specific injuries were not standardized; individual veterinary clinicians had varying recommendations for convalescent time, which may have resulted in differing days lost for similar injuries. Future studies should incorporate the DDL and WSP metrics over an expanded time among a larger population of canine athletes to better understand the mid- to long-term impacts of DNBI on medical readiness. Further exploring the WSP metric as a real-time, prospective tool would be valuable for working dog management.

The use of DDL and WSP metrics in a real-time and retrospective dashboard offers a proof of concept for adding a health-monitoring capability to current DoD MWD electronic veterinary health records systems. Further refinement of this capability would allow more precise surveillance to assist in identifying potential injury risk factors, which can inform targeted preventive measures and interventions. This addition to working dog epidemiologic resources will justify policy updates and provide additional financial, technical, and personnel resources needed to improve the health and welfare of MWDs. The WSP metric may help elucidate potential health, training, and environmental challenges for various working dogs and canine athletes at the population level. These efforts will assist in shaping the future of veterinary health data collection, identifying risk factors, developing preventive programs, and tailoring management decisions to improve the health and working longevity of canine athletes. Additionally, this information will serve as baseline data to gauge the potential effectiveness of intervention programs for canine athlete conditioning and injury rehabilitation.

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References

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