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Fall / Winter | Double Issue | 2023

ARMY VETERINARY CORPS

Joint Mission: Readiness and Protection

CLINICAL - FOOD PROTECTION - RESEARCH - GLOBAL HEALTH ENGAGEMENT

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Note from the Borden Team

The 2023 fall/winter double issue is dedicated to military veterinary medicine. It encompasses all four areas of military veterinary medicine including clinical care, food safety, global health engagement, and pertinent research. This edition underscores the importance and impact of our Veterinary Corps from understanding history about the Veterinary Corps' role in the military to discovering breakthroughs in the treatment of animals. This double issue demonstrates the broad medical spectrum in which veterinarians serve and operate.

Is your agency or team involved in noteworthy research? Perhaps your unit has made some exciting or groundbreaking discoveries. Please consider sharing it with the military medical community. Contact us for more information and planning strategies at usarmy.jbsa.medical-coe.list.amedd-journal@army.mil. Submission guidelines as well as online archives may be found at https://medcoe.army.mil/the-medical-journal. If your office or agency is not receiving The Medical Journal, contact us to be added to the distribution list.

Special thanks to COL Steven Baty for his tireless efforts in support of this remarkable issue.

Introduction

COL Deborah Whitmer, Chief, Veterinary Corps

I am honored to serve as the 28th Chief of the Veterinary Corps and lead the diverse and talented people who comprise our US Army Veterinary Service. Army Veterinary Corps personnel are adaptable, highly educated professional and technical experts with the versatility to lead and foster healthy communities across the Joint Force while on military installations or deployed in austere, challenging environments around the globe.

Since our establishment in 1916, our mission has always been to adapt to meet the needs of the Warfighter. Initially, we served primarily to provide veterinary care for horses that transported the Army's soldiers and equipment and to inspect meat and other food sources to ensure the Army had safe food. Over the past 107 years, our mission has expanded exponentially. Today, we take care of people across the spectrum of Department of Defense (DOD) operations through sustained force health protection, veterinary health service support, and innovative medical research to enable readiness and conserve the fighting strength while supporting healthy families, animals, and environments.

This special edition of the Medical Journal is dedicated to all things related to the US Army Veterinary Corps. The Army Veterinary Corps is the world's premier, globally postured, expeditionary veterinary force, elevating Warfighter readiness and protection through unparalleled execution of our dynamic Veterinary Service mission across the Joint Force. Articles in this edition describe our current capabilities, challenges, and innovative approaches to ensure the readiness of our veterinary fighting force. The various topics in this edition's articles include military working dog casualty care, veterinary case reports, military working equids, food safety, veterinary global health engagement, research and development, resilience of veterinary personnel, animal-assisted interventions, and veterinary education and training programs that reflect the priorities for our diverse mission.

The Veterinary Corps is committed to providing our military working animals with the best care possible. The Defense Health Agency Veterinary Service (DHA VS) Division has made strides to advance and inform military working dog (MWD) casualty care through standardized care documentation, casualty care guidelines, an MWD trauma registry, a capabilities-based assessment, and blood and blood products support. Additionally, DHA VS has established a framework for a DOD Working Dog Research, Development, Test, and Evaluation Program. The Veterinary Corps has also explored the value of military-civilian partnerships to facilitate the readiness of veterinary providers to deliver combat casualty care in combat environments through the Veterinary Trauma Readiness and Operational Medicine Agility pilot program. Following the fatalities of military working equids in 2022, the Department of the Army directed the assessment of major factors affecting the health and herd management of military working equids on Army installations. As Veterinary Corps Chief, I led the task force in conducting assessments at 12 Army installations and provided recommendations to Army senior leaders. These recommendations are now driving enterprise-wide change to improve the management and care of Army military working equids.

The way we train for and conduct our food protection mission must evolve to remain relevant in the future as the battlefield changes. Our personnel are evaluating how Army Veterinary Services will complete the food protection mission with contested logistics in large scale combat operations against a near-peer adversary. Additionally, real-world events over the past couple of years offered new challenges to our current processes and yielded opportunities to improve. Lessons learned for food protection during the COVID-19 pandemic and while providing food protection support for Operation Allies Welcome are highlighted in this journal edition. The modernization of our processes for subsistence surveillance by instating a risk-based Comprehensive Active Surveillance Program to improve our detection of unacceptable food at destinations is also discussed.

The value of Army Veterinary Service support to combatant commanders through veterinary global health engagement continues to be in high demand in various theaters around the world. The contributions to medical research by our laboratory animal medicine officers, veterinary pathologists, and biomedical scientists are unmatched. Our expertise on the human-animal bond is frequently called upon as animal-assisted intervention programs expand and now include dogs embedded in military healthcare facilities and therapeutic support dogs attached to military units.

Though the US Army Veterinary Corps has experienced reform and reorganization, we remain ready to respond to tomorrow's challenges; we are more relevant today than ever.

Advancing Military Working Dog Casualty Care Capability: Defense Health Agency Veterinary Service Support to the Joint Force

COL (Ret.) Kevin W. Nemelka, DVM, DACLAM
LTC Sarah Cooper, DVM, MS, DACVIM (SAIM)

Abstract

The Department of Defense (DoD) trauma enterprise enables delivery and management of trauma care across the DoD, with the Joint Trauma System serving as the reference body for that trauma care. In collaboration with other Directorates within the Defense Health Agency, the Defense Health Agency Veterinary Service (DHA VS) Division aims to advance and inform military working dog (MWD) casualty care. Efforts have included standardized care documentation, casualty care guidelines, an MWD Trauma Registry, a capabilities-based assessment, and blood and blood products support. A coordinated, informed MWD casualty care system will improve MWD trauma outcomes and preserve the MWD team capability for the Joint Force commander.

Keywords: working dog, casualty care, trauma, Capability-based assessment

For the purposes of this article, the term *MWD* will include service MWDs and U.S. Special Operations Command Multipurpose Canines.

"The capability that military working dogs bring to the fight cannot be replicated by man or machine. By all measures of performance, their yield outperforms any asset we have in our inventory. Our Army would be remiss if we failed to invest more in this incredibly valuable resource."

Gen. David H. Petraeus, February 2008

Introduction

The Joint Trauma System (JTS) is the Department of Defense (DoD) Center of Excellence for trauma care and serves as the reference body for all trauma care provided across the DoD Trauma Enterprise.[1] The mission of the JTS is to improve trauma readiness and outcomes through evidence-driven performance improvement.[1] The JTS is the culmination of more than two decades of efforts to improve wartime medical capabilities and readiness.[2] The Joint Theater Trauma Registry was approved as a demonstration project in 2002 and over time evolved into the DoD Trauma Registry (DoD TR),[2] now a Congressional requirement.[3] The DoD TR documents demographic, injury, treatment, and outcomes data for all trauma patients admitted to any DoD military treatment facility, regardless of whether the injury occurred during ongoing military operations and is the largest military trauma data source in the world.[4] Similarly, the first Joint Theater Trauma System was deployed to U.S. Central Command in 2004,[2] and now, as the JTS, spans the entire continuum of care across the military health system. The JTS initiatives for data driven trauma system development and improvement, including the DoD TR and publication of evidence-based guidelines, have resulted in improved battlefield survival.[5]

In 2017, the U.S. Army Veterinary Corps Chief established a community of interest (COI) to address military working dog (MWD) trauma care gaps, some of which were outlined in the commentary by Orman et al.[6] Building off the successful path established by JTS, the COI identified the following four main efforts: 1) establish an MWD Trauma Registry[6]; 2) complete a DoD WD Capabilities-based Assessment; 3) provide a forum to update, inform, and bring together working dog stakeholders; and 4) establish a DoD working dog research, development, test and evaluation (RDT&E) program.[6] As the COI efforts transitioned to the Defense Health Agency Veterinary Service (DHA VS) Division the following five lines of effort were pursued in order to inform and support a global trauma care capability for MWDs: 1) develop canine combat casualty documentation, 2) formalize the COI into a committee, 3) establish an MWD Trauma Registry (MWDTR);, 4) complete a DoD MWD Capabilities-based Assessment, and 5) develop an enterprise MWD blood capability.

Military Working Dog Casualty Care Documentation

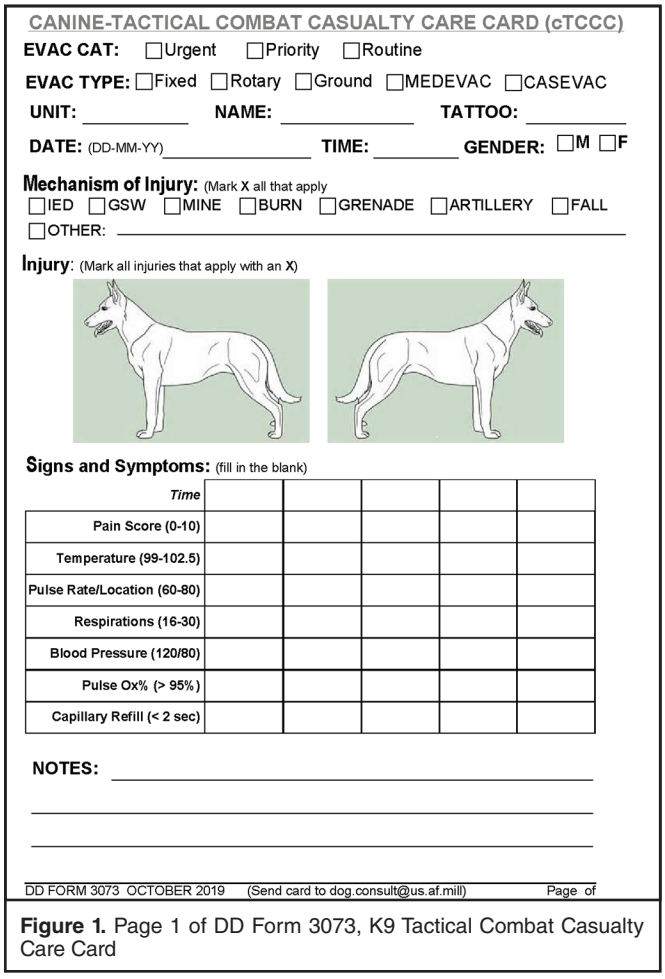
The COI recognized the need to standardize the documentation of medical care provided to MWDs in the operational environment.[6] Two forms were developed: DD (Defense Department) Form 3073, K9 Tactical Combat Casualty Care (K9

TCCC) Card (Figure 1), and DD Form 3074, Canine Treatment and Resuscitation Record (K9 TRR) (Figure 2). The K9 TCCC Card is completed at the point of injury and documents prehospital care provided to the MWD. Upon completion, the K9 TCCC Card is uploaded into the electronic Veterinary Health Record (eVHR). The form can also be directly submitted to DHA VS. The K9 TRR documents hospital care and is submitted as described above for the K9 TCCC Card. Guidance on responsibilities and use of the forms are published in Defense Health Agency-Procedural Instructions.[7,8] The K9 TCCC Card and K9 TRR provide standardized methods to document care provided throughout the continuum of care and provide invaluable data for MWD casualty care performance improvement.

K9 Combat Casualty Care Committee

The K9 Combat Casualty Care Committee (K9C4) was chartered in 2021 as an affiliate of the Defense Committee on Trauma (DCoT). Committee members are subject matter expert volunteers, either nominated or self-nominated, from across Army Veterinary Service organizations and include Veterinary Corps Officers (Areas of Concentration 64 series) and Animal Care Specialists (Military Occupational Specialty 68T). The mission of K9C4 is to develop best practice guidelines[9,10] for MWD combat casualty care and provide MWD combat casualty care subject matter expertise to the JTS to improve MWD casualty care readiness and outcomes.

Within K9C4, there are three subcommittees: Education and Training, Membership, and Technology. The Education and Training subcommittee develops evidence-based canine casualty care guidelines and training packages. The Membership subcommittee maintains memberships of the committee as described in the K9C4 and DCoT charters and by-laws. In addition, the K9C4 leverages existing and emerging technologies for canine operational medicine delivery and training through the efforts of the Technology subcommittee. The CPGs, as a committee responsibility, are evidence-based and developed with subject matter experts within the U.S. Army Veterinary Services to provide standards for MWD care in the operational environment. The CPGs are reviewed and updated, as needed, every 2 years by the K9C4. Finally, K9C4


CANINE-TACTICAL COMBAT CASUALTY CARE CARD (cTCCC)

EVAC CAT: ☐Urgent ☐Priority ☐Routine

EVAC TYPE: ☐Fixed ☐Rotary ☐Ground ☐MEDEVAC ☐CASEVAC

UNIT: _____ NAME: _____ TATTOO: _____

DATE: (DD-MM-YY)_____ TIME: _____ GENDER: ☐M ☐F

Mechanism of Injury: (Mark X all that apply

☐IED ☐GSW ☐MINE ☐BURN ☐GRENADE ☐ARTILLERY ☐FALL

☐OTHER: _____

Injury: (Mark all injuries that apply with an X)

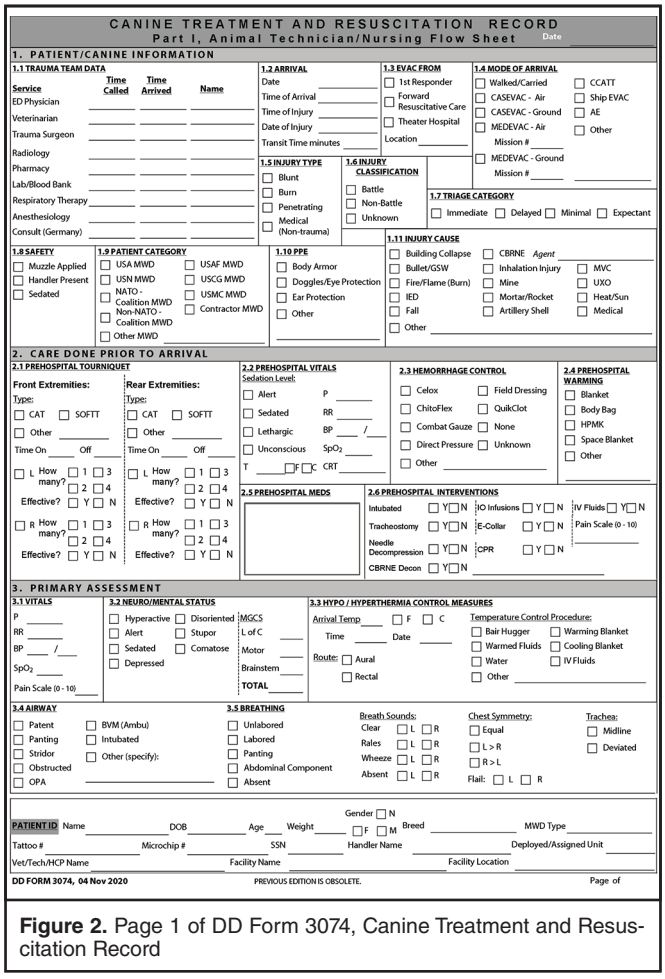
Signs and Symptoms: (fill in the blank)

Time					
Pain Score (0-10)					
Temperature (99-102.5)					
Pulse Rate/Location (60-80)					
Respirations (16-30)					
Blood Pressure (120/80)					
Pulse Ox% (> 95%)					
Capillary Refill (< 2 sec)					

NOTES: _____

DD FORM 3073 OCTOBER 2019 (Send card to dog.consult@us.af.mil) Page of

Figure 1. Page 1 of DD Form 3073, K9 Tactical Combat Casualty Care Card


CANINE TREATMENT AND RESUSCITATION RECORD

Part I, Animal Technician/Nursing Flow Sheet Date

1. PATIENT/CANINE INFORMATION

1.1 TRAUMA TEAM DATA

Service	Time Called	Time Arrived	Name
ED Physician			
Veterinarian			
Trauma Surgeon			
Radiology			
Pharmacy			
Lab/Blood Bank			
Respiratory Therapy			
Anesthesiology			
Consult (Germany)			

1.2 ARRIVAL: Date; Time of Arrival; Time of Injury; Date of Injury; Transit Time minutes; Location

1.3 EVAC FROM: ☐1st Responder ☐Forward Resuscitative Care ☐Theater Hospital

1.4 MODE OF ARRIVAL: ☐Walked/Carried ☐CCATT ☐CASEVAC - Air ☐Ship EVAC ☐CASEVAC - Ground ☐AE ☐MEDEVAC - Air ☐Other Mission # ☐MEDEVAC - Ground Mission #

1.5 INJURY TYPE: ☐Blunt ☐Burn ☐Penetrating ☐Medical (Non-trauma)

1.6 INJURY CLASSIFICATION: ☐Battle ☐Non-Battle ☐Unknown

1.7 TRIAGE CATEGORY: ☐Immediate ☐Delayed ☐Minimal ☐Expectant

1.8 SAFETY: ☐Muzzle Applied ☐Handler Present ☐Sedated

1.9 PATIENT CATEGORY: ☐USA MWD ☐USAF MWD ☐USN MWD ☐USCG MWD ☐NATO - Coalition MWD ☐USMC MWD ☐Non-NATO - Coalition MWD ☐Contractor MWD ☐Other MWD

1.10 PPE: ☐Body Armor ☐Doggles/Eye Protection ☐Ear Protection ☐Other

1.11 INJURY CAUSE: ☐Building Collapse ☐CBRNE Agent ☐Bullet/GSW ☐Inhalation Injury ☐MVC ☐Fire/Flame (Burn) ☐Mine ☐UXO ☐IED ☐Mortar/Rocket ☐Heat/Sun ☐Fall ☐Artillery Shell ☐Medical ☐Other

2. CARE DONE PRIOR TO ARRIVAL

2.1 PREHOSPITAL TOURNIQUET: Front Extremities: Type: ☐CAT ☐SOFTT ☐Other Time On Off ☐L How many? ☐1 ☐2 ☐3 ☐4 Effective? ☐Y ☐N ☐R How many? ☐1 ☐2 ☐3 ☐4 Effective? ☐Y ☐N; Rear Extremities: Type: ☐CAT ☐SOFTT ☐Other Time On Off ☐L How many? ☐1 ☐2 ☐3 ☐4 Effective? ☐Y ☐N ☐R How many? ☐1 ☐2 ☐3 ☐4 Effective? ☐Y ☐N

2.2 PREHOSPITAL VITALS: Sedation Level: ☐Alert ☐Sedated ☐Lethargic ☐Unconscious; P; RR; BP ___/___; SpO2; T ___ ☐F ☐C CRT

2.3 HEMORRHAGE CONTROL: ☐Celox ☐Field Dressing ☐ChitoFlex ☐QuikClot ☐Combat Gauze ☐None ☐Direct Pressure ☐Unknown ☐Other

2.4 PREHOSPITAL WARMING: ☐Blanket ☐Body Bag ☐HPMK ☐Space Blanket ☐Other

2.5 PREHOSPITAL MEDS

2.6 PREHOSPITAL INTERVENTIONS: Intubated ☐Y ☐N; IO Infusions ☐Y ☐N; IV Fluids ☐Y ☐N; Tracheostomy ☐Y ☐N; E-Collar ☐Y ☐N; Pain Scale (0 - 10); Needle Decompression ☐Y ☐N; CPR ☐Y ☐N; CBRNE Decon ☐Y ☐N

3. PRIMARY ASSESSMENT

3.1 VITALS: P; RR; BP ___/___; SpO2; Pain Scale (0 - 10)

3.2 NEURO/MENTAL STATUS: ☐Hyperactive ☐Disoriented ☐Alert ☐Stupor ☐Sedated ☐Comatose ☐Depressed; MGCS: L of C; Motor; Brainstem; TOTAL

3.3 HYPO / HYPERTHERMIA CONTROL MEASURES: Arrival Temp ☐F ☐C; Time; Date; Route: ☐Aural ☐Rectal; Temperature Control Procedure: ☐Bair Hugger ☐Warming Blanket ☐Warmed Fluids ☐Cooling Blanket ☐Water ☐IV Fluids ☐Other

3.4 AIRWAY: ☐Patent ☐Panting ☐Stridor ☐Obstructed ☐OPA ☐BVM (Ambu) ☐Intubated ☐Other (specify):

3.5 BREATHING: ☐Unlabored ☐Labored ☐Panting ☐Abdominal Component ☐Absent; Breath Sounds: Clear ☐L ☐R Rales ☐L ☐R Wheeze ☐L ☐R Absent ☐L ☐R; Chest Symmetry: ☐Equal ☐L > R ☐R > L Flail: ☐L ☐R; Trachea: ☐Midline ☐Deviated

PATIENT ID Name DOB Age Weight ☐F ☐M Gender ☐N Breed MWD Type

Tattoo # Microchip # SSN Handler Name Deployed/Assigned Unit

Vet/Tech/HCP Name Facility Name Facility Location

DD FORM 3074, 04 Nov 2020 PREVIOUS EDITION IS OBSOLETE. Page of

Figure 2. Page 1 of DD Form 3074, Canine Treatment and Resuscitation Record

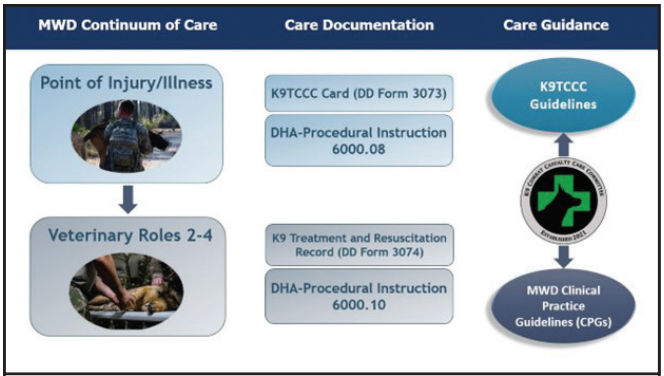


Figure 3. The military working dog continuum of care demonstrating the care documentation and care guidance aligning with each role of veterinary care.

informs the DoD medical RDT&E and acquisition enterprise on K9 combat casualty care research and performance capability gaps.

Published K9 TCCC Guidelines[9] provide standardized guidance for the management of canine battlefield injuries and include guidance for care under fire, tactical field care, and tactical evacuation care. The Education and Training subcommittee is developing accompanying training packages with lesson modules and speaker notes, learning objectives, skills lists, and patient scenarios to standardize K9 TCCC training to non-health care (eg, K9 team support members, K9 handlers, and combat lifesavers) and health care providers (eg, animal care specialists, veterinarians, combat medics, hospital corpsmen). The K9 TCCC training packages are tiered by skill level to ensure fundamental to advanced life-saving casualty management skills for first responders caring for injured MWDs. The first tier is expected to be published in Fiscal Year 2023 (FY23). The DHA VS Division will inform MWD operational medicine by developing standardized care documentation and standards for care in the operational environment (Figure 3).

Military Working Dog Trauma Registry

Utilizing the support and expertise of JTS, the COI began the development of a system called the MWDTR in 2018 to capture MWD trauma, disease, and nonbattle injury. The FY22 National Defense Authorization Act (NDAA)[11] updated verbiage from the FY17 NDAA[3] that expanded the requirement for the DoD to develop a comprehensive trauma care registry that would include military working dogs. The MWDTR became operational in January 2022 and is maintained by the JTS.

As part of its data collection efforts, the MWDTR maintains a registry of trauma, disease, and nonbattle injured canine patients and documents the demographics, injuries, treatments, and outcome data for all canine patients, regardless of whether the injury or illness occurred during ongoing military operations or in garrison. These MWDTR data can be analyzed to inform and advise performance improvement and the conduct of research for MWDs.[11] The JTS MWD abstractor utilizes DD Form 3073, DD Form 3074, veterinary health records, after action reports, and the U.S. Transportation Command (TRANSCOM) Regulating and Command & Control Evaluation System ($TRAC_2ES$) as data sources for input into the MWDTR.

Data from the MWDTR can be requested through a formal process[12] to inform research on the leading causes of morbidity and mortality of MWDs in combat. Subsequent data are used to inform performance improvement and enhance the care for MWDs. K9C4 collaborated with JTS to inform the development of the MWD Trauma Report, which provides current epidemiological snapshots from the MWDTR. The MWD Trauma Report is a dashboard supported by the DHA Program Management Office Enterprise Intelligence and Data Solutions Military Health Service Information Platform and managed by JTS. Data are compiled from the MWDTR weekly into the dashboard.

Documentation of care is vital to the success of the MWDTR and the ability to analyze its data to inform performance improvement. Diligence in documenting MWD care by healthcare providers is imperative. As described above, procedures for utilizing DD Forms 3073 and 3074 are published in DHA-Procedural Instructions.[7,8] Completion of the DD Form 3073 is a datafield in the MWD TR and can be used as a performance improvement metric. This quote from Col Shackelford, former Director of JTS, can be adapted to MWD casualty care:

> *"...if you save a guy's **[K9's]** life, good, you saved ONE life. If you document and submit to the JTS DoDTR **[MWDTR]**, then you have a part in saving the life of EVERY future **[K9]** casualty."*
>
> -Col Stacy Shackelford, 29 September 2020 (bolded words added for this article).

Department of Defense Working Dog Capabilities-Based Assessment

The Office of the Assistant Secretary of Defense for Health Affairs (OASD [HA]) sponsored a DoD Working Dog Enterprise Capabilities-Based Assessment (CBA), which was funded through DHA's Deputy Assistant Director for Research & Engineering (DAD R&E). The Director of Security Forces, United States Air Force, who is the DoD's MWD Program Executive Agent, was a co-sponsor of the CBA, while DHA VS executed on behalf of OASD(HA) for veterinary programs. Beginning FY21, working dog Program Managers from among the DoD Agencies, Military Services, and combatant commands as well as U.S. Army Veterinary Services personnel from various organizations and other stakeholders

participated in five meetings over 8 months to perform a CBA inclusive of capability requirements development, gaps identification, and solutions development. This CBA led to the development of two documents: a Joint DOTmLPF-P Change Recommendation (DCR) for DoD Working Dog Enterprise Management[13] and an Initial Capabilities Document (ICD) for Joint Research Needs of the DoD Working Dog Enterprise.[14] The DCR and ICD were submitted into the Joint Capabilities Integration and Development System (JCIDS) in December 2021 for final approval by the Joint Requirements Oversight Council (JROC). Both documents were approved in JROC Memo 051-22, signed 15 August 2022.

While the DCR focused on how the DoD can best manage a federated approach to working dogs across many DoD components, the ICD focused on future R&D approaches to improve the products, clinical practice guidelines, and other capabilities MWDs and their teams use. The ICD identified multiple gaps that address the DoD's ability to prevent or mitigate and understand the outcomes from traumatic injuries to MWDs. Understanding the prevention or mitigation of traumatic injuries can drive materiel solutions, equipment, and protocols to protect MWDs while performing their mission as a force multiplier on the battlefield.[14] Data analysis of traumatic injury outcomes can be used to pursue funding for research to drive performance improvement or materiel solutions.

The DoD has conducted MWD RDT&E in a project-by-project manner across multiple DoD components. Using the validated research gaps in the ICD, DHA VS developed MWD Research Roadmaps that include a DoD Working Dog Combat Casualty Care Research Program (WDCCCRP). With the assistance of DHA DAD R&E, DHA VS is in the process of formalizing the WDCCCRP and developing processes to request and review proposals and award and track projects to completion.

The WDCCCRP has three task areas: 1) combat injuries; 2) blood and blood products; and 3) analgesia/anesthesia, with the goal to understand the optimal preventions, diagnostics, and treatments for point of injury care of MWDs. These task areas include topics such as shock, damage control resuscitation, advanced emergency medical monitoring, hemorrhage control, wound care, blood product usages, and management of injuries until the MWD is transferred to Veterinary Role 2 or higher echelon of care. To date, the program has received almost $1.03M from DHA for MWD combat casualty care research.

Military Working Dog Blood Capability

The DHA is the responsible component for the operational management and support of the Armed Services Blood Program (ASBP).[15] The ASBP is comprised of the integrated blood and blood product support system and operational elements of the DHA, Military Services, and the combatant commands.[15] A similar, enterprise system for MWDs does not exist. This gap has been recognized in several sources including validated gap number 203225 from a 2017/2018 Capabilities Needs Analysis and the ICD[14] described above. Specific research gaps in the ICD include understanding of and access to canine blood products, canine blood banking capabilities, and medical logistics capabilities related to canine blood products.[14] In addition, the DCR described above has two policy recommendations to mitigate identified MWD blood program gaps. The first recommendation is to review and revise DoD Directive 6400.04E, DoD Veterinary Public and Animal Health Services[16] to establish policy and assign responsibilities to program, develop, and maintain an enduring global trauma care capability for MWDs[13]. The second policy recommendation is to review and update DoD Instruction 6480.04, Armed Services Blood Program Operational Procedures,[15] to coordinate a blood program providing canine blood and blood products as requested by geographic combatant commands.[13] Additional policy solutions are being coordinated with ASBP Division (ASBPD) with the addition of MWD content in two ASBP Multi-Service Regulations (MSR) that are in the DHA publication process at the time of this writing. These MSRs will provide guidance for an MWD donor-screened walking blood bank equivalent capability as well as guidance and procedures for ASBP logistical support for canine blood products utilized by Army Veterinary Services. As noted by Lieutenant Commander Erika Nance, current Director, ASBPD (December 2022), "The ASBP has an established and reliable system to move blood across the globe to support combat casualty care. The integration of canine blood into the distribution system will leverage the existing ASBP capabilities to support the evolution of MWD trauma care."

In addition to policy solutions, the K9C4 developed a Clinical Practice Guideline (CPG) for MWD blood transfusions,[17] which was published by the JTS in 2019. The focus of the CPG is hemostatic resuscitation for the canine trauma patient in a deployed environment. This CPG provides an overview of available canine blood products, guidance for indications and administration of canine blood transfusions, and instructions for canine blood donation.

Other efforts currently underway include a DHA Joint Integrated Product Team (IPT) chartered in 2022. Program management responsibility for the Canine Blood Products Family of Systems Joint IPT is assigned to the U.S. Army Medical Materiel Development Activity (USAMMDA) and will serve to develop and acquire medical products for hemostatic resuscitation and treatment of hemostatic abnormalities in canines.[18] In addition, DHA J5 is leading an effort to develop a High Performance Team in order to draft a Capability Development Document for Canine Family of Systems - Blood Products. The combined efforts of these doctrine, organizational, material, and policy solutions will establish a DoD canine blood and blood products support system.

Conclusion

The DHA VS Division will continue to advocate for MWD casualty care by developing policy and guidance, providing subject matter expertise through the K9C4, and informing veterinary MWD RDT&E. The K9C4 will inform and advise JTS in management and utilization of data from the MWDTR and publication of MWD combat casualty care guidelines and training packages. In collaboration with DHA DAD R&E, MWD combat casualty care RDT&E will be informed by validated MWD combat casualty care needs, synchronized across the DoD via the JCIDS, and translated into best practice guidelines. The DHA VS Division has made great strides in the past 5 years with many more opportunities in the future to optimize MWD casualty care. An MWD global trauma care capability supported by the JTS will improve MWD trauma outcomes and ultimately maximize the MWD team capability within the Joint Force.

Acknowledgements

The DHA VS Division would like to thank all current and past K9C4 members for their willingness and hard work to see these first few years through. We appreciate the collaboration and willingness of the JTS staff in supporting these efforts.

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Defense Health Agency Veterinary Service: A Path to a Department of Defense Working Dog Veterinary Research, Development, Test, and Evaluation Program

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Abstract

The Defense Health Agency Veterinary Service (DHA VS) has advanced a strategic approach for maintaining Department of Defense Working Dog (DOD WD) team effectiveness in support of the National Security Strategy in current and future operating environments. DHA VS identified four lines of effort to establish a DOD WD veterinary research, development, test, and evaluation (RDT&E) program: 1) a Capabilities-based Assessment (CBA), 2) a business case analysis (BCA), 3) initiation of a DOD WD research portfolio, and 4) a WD Research Forum. The CBA resulted in the publication of an initial capabilities document (ICD) and a doctrine, organization, training, materiel, leadership, personnel, facilities, and policy (DOTmLPF-P) change recommendation (DCR). The BCA provided analytical information and a recommendation for decision makers on how to effectively manage DOD WD veterinary RDT&E activities, while the research forum shared relevant research and updates to inform the broad audience of WD stakeholders. This multiyear campaign, led by DHA VS, established the framework for a unified, informed DOD WD veterinary RDT&E program, which will enable the DOD to support the health, welfare, and performance of these force multipliers.

Introduction

Deliberate and strategic military medical research is required to answer the unique needs of the Military Health System, which has proven to be effective in driving operational medicine research questions and developing clinical practice guidelines.[1] Similarly, Orman et al identified the need for a specific military medical DOD WD research program.[2]

Historically, DOD WD veterinary research, development, test, and evaluation (RDT&E) has been decentralized and disjointed without strategic direction or oversight. Several organizations have recognized the gap in DOD WD veterinary RDT&E support and have pursued compartmentalized solutions ranging from completing singular projects to developing committees to identify and prioritize research gaps.[2] These uncoordinated efforts were brought to the attention of a US Army Veterinary Service community of interest.[2] The US Army Veterinary Service community of service concluded that support from military medical research programs is crucial for improving WD survivability on the battlefield.[2] Given these conclusions, DHA VS developed an action plan to further define and develop a DOD WD Veterinary Research Program. This action plan included the following: 1) completion of a CBA, 2) execution of a BCA on veterinary DOD WD RDT&E, 3) advocating for a DoD WD veterinary research program, and 4) hosting a working dog research forum.

Capabilities-Based Assessment

The Office of the Assistant Secretary of Defense for Health Affairs (OASD[HA]) sponsored a DOD WD Enterprise CBA, funded through DHA's Deputy Assistant Director for Research & Engineering (DHA DAD R&E). The Director of Security Forces, US Air Force, DOD MWD Program Executive Agent, co-sponsored the CBA. This co-led effort offered a unique and comprehensive evaluation of the DOD WD enterprise. The CBA's research-related efforts focused on the health, welfare, and performance of the DOD WD and were developed in collaboration with both the veterinary health care provider and operator—from tactical to strategic levels.

The CBA was conducted over an eight-month period with personnel support from the DOD WD operational and veterinary communities. This support included WD program managers from the DOD agencies, military services, combatant commands, DHA VS, US Army Veterinary Service subject-matter experts, and other stakeholders. The process included

capability requirements development, gaps identification, and solutions development. The CBA led to the publication of two critical documents: a Joint DCR for DOD WD Enterprise Management[3] and an Initial Capabilities Document (ICD) for joint research needs of the DOD WD Enterprise.[4] The DCR and ICD can be used by the Office of the Secretary of Defense, Joint Staff, military departments, defense agencies, combatant commands, and all other organizational entities within the DOD to drive DOTmLPF-P changes and align RDT&E funding to close the gaps identified against the requirements outlined during the CBA process. The DCR and ICD were submitted into the Joint Capabilities Integration and Development System in December 2021 for final approval by the Joint Requirements Oversight Council. Both documents were approved in JROC Memorandum 051-22, signed 15 August 2022.[5]

The future security environment will be characterized by varied terrain, evolving environmental conditions, and demanding operational tempos. This will require a complex and diverse DOD WD enterprise with the ability to efficiently procure, train, employ, and manage DOD WDs to effectively carry out all DOD WD Team mission sets.[5] Both the DCR and ICD identify recommendations to address these requirements. In particular, the ICD proposes research and development (R&D) activities that will lead to solutions to improve DOD's ability to manage DOD WD Enterprise RDT&E.[4] Scientists, researchers, and acquisition experts at joint and service organizations contributed to the ICD and identified 17 R&D areas of focus described in Table 1 with the following high-level recommendations[4]:

- Conduct research to understand how DOD can better detect, evaluate, and treat behavioral health problems in DOD WDs
- Conduct research to identify the biological (eg, genetic, physiological) basis of DOD WD success/performance and working life expectancy
- Conduct research to understand and provide guidance on optimal energy, nutrition, and hydration requirements—including timing and schedules—to optimize DOD WD performance and health in all environments
- Conduct research to understand the effects of the environment, including extreme environmental conditions and housing, on DOD WD health and performance
- Develop mechanisms to measure DOD WD fitness, performance, and other characteristics of success
- Develop training methods and aids that capitalize on the way DOD WDs detect and discriminate between target odors
- Develop methods of protection and equipment that reduce or prevent injury, yet do not compromise the operational effectiveness of DOD WDs
- Develop methods to prevent (or mitigate) and treat DOD WD injuries, including trauma-related injuries, environmental conditions, transport cases, and other causes.

Table 1. ICD R&D Areas of Focus

Analgesia	Handler/Dog Team Interaction
Behavior and Behavioral Health	Infectious Diseases
Blood and Blood Products	Injury
Breeding and Procurement	Musculoskeletal Conditions
Chemical, Biological, Radiological, and Nuclear	Nutrition
	Olfaction
Dental	Performance and Health
Dermal/Otological/Ocular	Physiology
Gastrointestinal	Protection

The complete list contains over 160 R&D solutions, including science and technology (S&T) research, knowledge translation, and acquisition solution statements.[4] These solution statements are intended to guide RDT&E efforts in closing identified capability gaps to maintain DOD WD health, welfare, and performance.

DOD WD Veterinary Research Management BCA

The Secretary of the Air Force is charged with managing and overseeing MWD RDT&E[6] with DOD Veterinary Services providing veterinary consultation. Within the context of this relationship, the DOD WD Veterinary Research Management BCA was conducted to identify and recommend the most cost-effective way to oversee and manage DOD WD veterinary RDT&E.[7] The BCA had five major objectives:

- Synchronizing DOD WD veterinary RDT&E responsibilities, requirements, and efforts across the enterprise
- Identifying and managing DOD RDT&E resources for veterinary DOD WD-specific projects
- Identifying a governance framework for DOD WD veterinary research management across the enterprise
- Aligning DOD WD veterinary and operational RDT&E program plans, needs, and priorities
- Identifying how to maximize scientific and technical information sharing and/or collaboration of industry, academia, DOD components, and other federal agencies.[7]

The BCA process included the development of a problem statement, a brief analysis of alternatives for identified courses of action (COAs), and a COA assessment process. A panel of 20 DOD veterinary and research experts evaluated and scored six COAs against six different factors through a working meeting, interviews, and a survey. Results were then used to select the COAs that ranked the highest in a decision model and were also determined to be suitable, feasible, and acceptable for further development and refinement. The DHA VS presented the final recommendation of the BCA to leaders within DHA Public Health, DHA DAD R&E, and OASD(HA) for review and determination for items to action.

DOD Working Dog Veterinary Research Program

In a parallel effort with the CBA and BCA, DHA VS endeavored to construct a DoD WD veterinary research program. Building on efforts from the Joint Service Military Working Dog Committee and the ICD, DHA VS started with the development of a WD Research Roadmap. This roadmap details a veterinary research program development strategy, moving from validated requirements to capabilities. Additionally, the roadmap was used to identify, prioritize, and submit DOD WD research projects to DHA DAD R&E for evaluation and funding. Since 2019, 19 projects have been funded and awarded to performers for execution for a total of $5.66 million. Project topics have included DOD WD combat casualty care; chemical, biological, radiological & nuclear protection; olfaction; infectious disease; vision; and fitness.

With the completion of the BCA in 2022, DHA DAD R&E and DHA VS will coordinate efforts to establish a formal DOD WD research portfolio, overseen by DHA DAD R&E, to provide funding and RDT&E execution oversight for DOD WD veterinary RDT&E. The DOD WD research portfolio will oversee four WD research programs: Combat Casualty Care, Operational Medicine, Modeling Simulation and Technology, and Chemical Biological Defense. Each program is divided into task areas (Table 2) as previously outlined in research roadmaps developed by DHA VS. DHA VS will look to leverage DOD research labs, academia, and industry to assist with the goals laid out for each task area.

DOD Working Dog Combat Casualty Care Research Program

The goal of the DOD WD Combat Casualty Care Research Program is to understand the optimal preventions, diagnostics, and treatments for combat casualty care of WDs and their effects on performance, blood product usages, and the management of injuries through veterinary echelons of care. The WD Combat Casualty Care Research Program has three task areas: 1) Combat Injuries, 2) Blood and Blood Products, and 3) Analgesia and Anesthesia.

Combat Injuries

The task area goals are to: 1) understand shock, damage control resuscitation, extremity trauma and regenerative medicine, sensory trauma (eyes/ears), and advanced emergency medical monitoring in WDs and how to improve outcomes in the operational environment; 2) understand and optimize treatment and protocols for point of injury/pre-hospital care to include hemorrhage control/respiratory emergencies; 3) understand combat-related wounds/burns in the WD; and 4) understand prolonged casualty care and how to improve outcomes in the operational environment.

Blood and Blood Products

The task area goal is to understand how to properly use and maintain the presence of canine blood and blood products in the deployed environment.

Analgesia and Anesthesia

The task area goal is to enhance canine analgesia and anesthesia in the operational environment.

DOD Working Dog Operational Medicine Research Program

The DOD WD Operational Medicine Research Program aims to understand optimal preventions, diagnostics, and treatments for injury, musculoskeletal, dental, dermal, otological, ocular, gastrointestinal, behavioral health, infectious disease, and environmental health and optimize performance. The WD Operational Medicine Research Program has four task areas: 1) injury prevention and reduction, 2) psychological health and resilience, 3) physiological health, and 4) environmental health and protection.

Injury Prevention and Reduction

The task area goals are to: 1) understand non-combat injuries in the WD, 2) understand musculoskeletal injuries and diseases in the WD, 3) understand dental trauma and diseases in the WD, 4) understand dermal/otological/ocular injuries and diseases in the WD, and 5) understand gastrointestinal injuries and diseases in the WD.

Psychological Health and Resilience

The task area goals are to: 1) understand WD behavior and 2) understand behavioral health care in the WD.

Physiological Health

The task area goals are to: 1) understand how to maximize the performance and health of WDs; 2) understand WD nutrition and how to optimize WD diets; 3) understand WD olfaction; and 4) understand the complex interaction of health, nutrition, and physiology on WD performance.

Table 2. DoD Working Dog Veterinary Research Program Structure

Research Program	Task Areas
Combat Casualty Care	Combat Injuries Blood and Blood Products Analgesia and Anesthesia
Operational Medicine	Injury Prevention and Reduction Psychological Health and Resilience Physiological Health Environmental Health and Protection
Modeling Simulation and Technology	Modeling and Simulation Technology
Chemical Biological Defense	Protection Treatment

Environmental Health and Protection

The task area goals are to: 1) understand antimicrobial drug resistance in the WD, 2) understand current and emerging infectious diseases in the WD, 3) develop and validate WD personal protective equipment, and 4) understand occupational hazards unique to WDs.

DOD Working Dog Modeling Simulation and Technology Research Program

The goal of the DOD WD Modeling Simulation and Technology Research Program is to understand how to optimize the confidence and competence/proficiency of first responders, WD handlers, and veterinary providers through realistic sustainment training using synthetic training environments. The goal is to understand and develop physiological monitoring systems and/or other wearable equipment to enhance WD performance and improve the quality of health care equipment to improve WD survivability. The WD Modeling Simulation and Technology Research Program has two task areas: 1) modeling and simulation and 2) technology.

Modeling and Simulation

The task area's goals are to: 1) develop validated training modalities for providers and handlers to improve health care outcomes for WDs, and 2) develop validated training modalities for handlers to improve the WD's team performance.

Technology

The task area's goal is to understand and develop technologies to improve WD care and performance.

DOD Working Dog Chemical Biological Defense Research Program

The DOD WD Medical Chemical Biological Defense Research Program aims to understand the Chemical, Biological, Radiological, Nuclear (CBRN) environment for WDs. These factors include environmental CBRN and logistics conditions, preventative/prophylactic and treatment protocols/medical countermeasures, effective decontamination strategies that decrease short- and long-term effects, and the development of equipment and devices that protect WDs from CBRN or detect it to decrease its effects on WD health, capability, and performance. The WD Medical Chemical Biological Defense Research Program has two task areas: 1) protection and 2) treatment.

Protection

The task area goals are to: 1) understand how to prevent exposure/illness from CBRN and how the prevention affects WD performance, and 2) understand how to detect CBRN exposures in the WD.

Treatment

The task area goals are to: 1) understand decontamination strategies, factors, and their effects on the WD; and 2) develop medical countermeasures for treating CBRN exposure and understand how the medical countermeasures affect WD performance.

Once the DOD WD research portfolio is developed and resourced, it will serve as a centralized and formalized program managed by DHA Research and Engineering. This initiative will improve efficiency, utilization of limited RDT&E resources, and ensure WD RDT&E efforts are aligned and executed in accordance with DOD policy.

Working Dog Research Forum

The fourth line of effort focuses on collaboration and knowledge sharing within the WD community. In April 2019, DHA VS hosted the first DOD WD Research Forum with the vision of bringing the DOD, federal agencies, industry, academia, private organizations, and international collaborators together to share, coordinate, and discuss how to optimize the health and performance of WDs. The first forum also facilitated the identification of prioritized WD research gaps from the community. Since the inaugural forum in 2019, annual

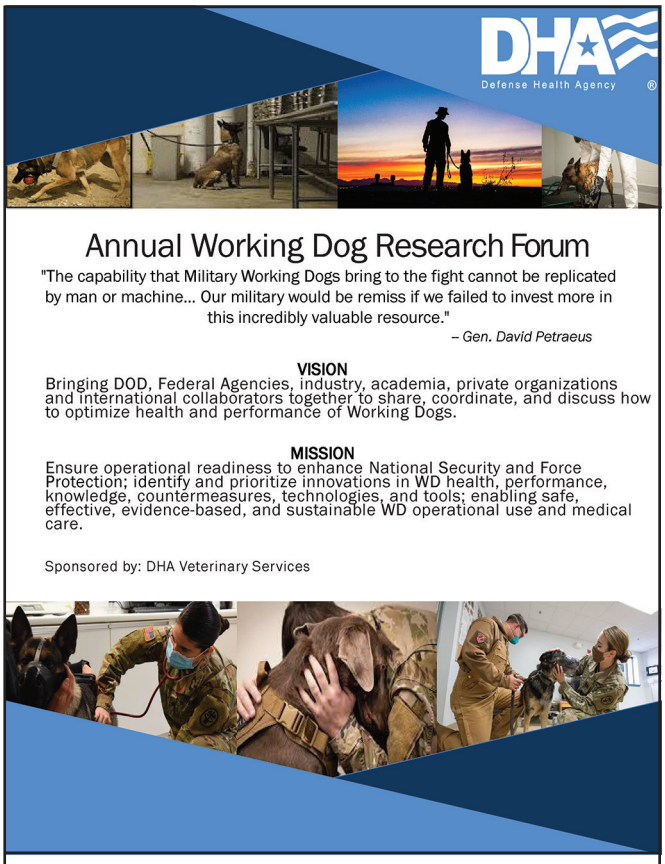

Figure 1. Annual Working Dog Research Forum Poster

attendance has more than tripled and includes participants from around the world. (Figure 1) Topics for the forum continue to evolve and have included the following: trauma care, nutrition, kennel design, fitness/performance, canine hearing, vision & olfaction, chemical, biological, radiological & nuclear, breeding, and procurement. The forum will continue to serve as the main avenue to share, coordinate, and discuss WD RDT&E.

Conclusion

DHA VS designed a multipronged approach to further efforts in developing a formal military medical research program for DOD WDs. This program is within the framework of responsibilities described in DOD policy and leverages efforts of both the DOD WD CBA and BCA. Collaboration across the WD enterprise, both internal and external to DOD, ensures the mutual benefit of a formalized DOD WD Research Program that is within an established governance framework with strategic guidance and oversight. This will allow RDT&E resources to best inform DOD WD health, welfare, and performance in support of these valuable resources.

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Implementation of the Veterinary Trauma Readiness and Operational Medicine Agility (Vet-TROMA) Military-Civilian Partnership Pilot Program

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Abstract

Military-civilian partnerships (MCPs) have come to the forefront within the Military Health System (MHS) as an enterprise-wide option to augment medical skills training and sustainment when existing military treatment facility frameworks lack adequate access to certain defined caseload objectives. Recent efforts to incorporate MCPs as a tool for MHS organizations to accomplish training objectives since passage of the 2017 National Defense Authorization Act have focused heavily on optimizing the readiness of healthcare providers to deliver effective combat casualty care in operational environments. The Defense Health Agency established a MCP Working Group to serve as a centralized repository for cataloguing and evaluating the effectiveness of these partnerships for maintaining trauma readiness. While MHS centralized military-civilian partnerships have maintained a multidisciplinary approach across medical specialties and skill levels to achieve objectives, consideration for veterinary medicine and support to Military Working Dogs (MWDs) is usually not included in initial program designs. The inclusion of MCPs as an option for maintaining the clinical readiness of nearly 1200 U.S. military veterinarians and animal care specialists could provide significant contributions toward optimizing the survivability of canine combat casualties and should be considered by senior MHS leaders. Establishment of the Veterinary Trauma Readiness and Operational Medicine Agility pilot program has provided valuable lessons learned and opportunities for future veterinary MCPs to further support MWDs in combat environments.

Introduction

U.S. Military Working Dogs (MWDs) and Multipurpose Canines (MPCs) are critical force multipliers and invaluable assets for combatant commanders due to their explosives and narcotics detection, specialized search, and security patrol or apprehension capabilities. Since the events of 9/11 and across the US Central Command (CENTCOM) operational landscape of the past two decades, MWDs/MPCs have successfully served alongside their handlers in some of the most challenging operating environments.[1] During that time, MWDs/MPCs suffered comparable combat injuries and trauma as their human counterparts and relied on US Army Veterinary Service (AVS) personnel for treatment.[2-4] In future operations, AVS personnel must be positioned and appropriately prepared to effectively treat complex canine emergency and trauma cases.[5-8] Initiatives focused on minimizing preventable canine deaths on the battlefield and optimizing canine combat casualty care (K9CCC) are vital when preparing AVS personnel to support all MWD/MPC casualties in large scale combat and multi-domain operations.[9-11]

Department of Defense (DoD) Directive 6400.04E: DoD Veterinary Public Health and Animal Health Services defines the US Army's responsibility to provide clinical veterinary services and comprehensive care of DoD-owned animals, including MWDs and MPCs.[12] While Public Health Activity (PHA) garrison veterinary treatment facilities (VTFs) provide Army Veterinary Corps Officers (VCOs) and Animal Care Specialists (68Ts) caseload exposure to develop proficiencies in general MWD/MPC medical and preventive care, opportunities to manage veterinary emergency medical or trauma cases that are needed to maintain certain additional clinical skills can be challenging.[13] On occasion, VCOs express a lack of confidence and competence performing certain emergency medical tasks, including some of the individual critical tasks (ICTs) for the Field Veterinary Service Officer Area of Concentration (AOC, 64A). Commanders will benefit from centralized Military Health System (MHS) and Army Medical Department (AMEDD) initiatives to develop standardized programs like human patient care models for medical skills sustainment that can augment unit-level clinical proficiencies for AVS personnel.[14]

Inconsistent access to relevant caseloads that prepare active-duty medical personnel for navigating the complex demands inherent in managing combat casualties is a challenge that exists across the spectrum for DoD human and veterinary medical healthcare providers (HCPs). The human patient sector has recently developed programs to increase exposure to relevant trauma cases.[15-17] These efforts include the establishment of military-civilian partnerships (MCPs) as defined in the 2017 National Defense Authorization Act. Many organizations within the MHS have established MCPs with civilian assets positioned to support objectives across a wide variety of medical AOCs.[18-20]

This paper describes the establishment and development of a novel, centralized and standardized veterinary MCP pilot program focused on exposure to veterinary emergency and trauma cases. The intent of this program is to increase the confidence and readiness of Army veterinarians and 68Ts to optimize the management and survivability of canine combat casualties in complex operational environments.

Methods

Program Initiation

Dialogue initiated in late 2019 between senior U.S. Army Veterinary Corps leadership and US Army Medical Command (MEDCOM) helped identify civilian veterinary specialty hospitals or networks able to support a veterinary MCP structure, which was inspired by the AMEDD Medical Skills Sustainment Program (AMSSP) Strategic Medical Asset Readiness Training (SMART) model.[21-23] In support of Army objectives, leadership used staffing, clinical capabilities, patient caseload, location, and a dedication to hour officer educational programs to evaluate potential veterinary civilian partners. Three prominent U.S. civilian specialty veterinary hospitals or networks were initially considered, and one was later identified as being the strongest candidate for partnership. Follow-on collaboration between AVS, US Army Medical Command and partner network executives helped establish a military training agreement (MTA) between the US Army through the Office of the Surgeon General (OTSG) and BluePearl Management, LLC ("BluePearl") in April 2020 (M8K04-20-MTA-0029). The pilot program was termed Veterinary Trauma Readiness and Operational Medicine Agility, or Vet-TROMA (see Figure 1). AVS principles and BluePearl (BP) personnel collaborated closely thereafter to develop the concept of operations and execution strategy for the Vet-TROMA pilot program.

Figure 1. A Vet-TROMA graphic was originally developed through the U.S. Army Public Health Center Visual Information Division and has been used to identify the program in presentations and relevant documents.

Pilot Program Design

The Vet-TROMA pilot program design is organized into three phases of participation. Phase 1 (Preparation) includes four to 12 weeks of self-paced distance learning modules that cover a variety of veterinary emergency and trauma care concepts; it also provides approved Continuing Education (CE) credits to AVS personnel. Participants complete two self-assessment surveys and are assigned to a BP hospital and mentor before arriving onsite for their immersion rotation. Phase 2 (Immersion) includes a 21-day temporary duty (TDY) assignment to the assigned BP hospital for immersion into primary case management of emergency and critical care veterinary patients alongside a BP mentor. The participant maintains a standardized clinical tasks objectives list and patient case log that is verified by the mentor before the conclusion of Phase 2. Phase 3 (Assessment) includes completion of an after-action review (AAR), completion of a final self-assessment survey, and submission of the clinical tasks objective list and patient case log turn-in to the Vet-TROMA program manager (PM) for data capture and analysis. A clinical competency assessment summary report is also submitted to the participant's commander.

Implementation of Phase 1

The intent of the distance learning modules is to establish uniform baseline clinical knowledge for Vet-TROMA participants that prepares them for successful integration into

Phase 2 regardless of prior veterinary emergency medicine experience. The Phase 1 distance learning modules were developed to include relevant clinical training content aligned with the program's objectives and organized on a digital platform capable of hosting and tracking participant progression. BluePearl's internal "EmERge" employee training program includes an initial four-week boot camp. The training provides didactic and hands-on clinical skills sessions by board-certified veterinary specialists for its new veterinary school graduate employees, or veterinarians who have not had significant experience in emergency medicine.[24] In June 2020, those boot camp training sessions were held virtually due to COVID-19 restrictions and were recorded. The BP Senior Director for Clinical Affairs made the recorded content available for AVS principles to review and incorporate in the Vet-TROMA modules. The resulting curriculum was organized into 14 modules grouped by topic or major organ system. Veterinary Clinical Medicine Officers (AOC 64F) were recruited to further screen the recorded lectures and provide any feedback on their relevance and benefit to AVS mission readiness. The recruited 64Fs were also asked to develop test questions for each session with approval by the American

Survey Area of Focus	Survey Question	Survey Clinical Skills
Therapeutic Procedures	Rate your current level of preparedness to properly conduct each procedure unassisted in a hospital setting.	- Thoracocentesis - Chest tube placement (low profile or trocar) - Venous cut down - Central venous catheter placement - Urethral catheter placement - Abdominocentesis - Gastric decompression - Blood donor collection and fresh whole blood transfusion
Therapeutic Interventions	Rate your current level of preparedness to properly conduct each procedure unassisted in a hospital setting. syndromes	- Cardiopulmonary resuscitation - Point of Care Ultrasound (POCUS) – including AFAST, TFAST - Formulation of a fluid prescription plan and treatment of shock - Choosing empiric antibiotic therapy - Management of polytrauma - Identification and treatment of malignant cardiac arrhythmias - Splinting a fractured tibia with an overlying soft tissue wound - Formulation of a sedation, analgesia, and anesthesia plan for a critical or traumatized patient
Communication and Leadership Skills	Rate your current level of preparedness to effectively conduct these communication and leadership skills unassisted in a hospital setting.	- Directing and delegating responsibilities amongst your team members - Providing feedback to and participating in the training of Animal Care Specialists/technicians on your team - Proficiency in time management during an ER shift (and/or duty day) - Discussing euthanasia with clients/handlers - Discussing tiered treatment options according to availability of roles/levels of care, client/handler comfort level, and operational expectations of patient (e.g., if patient is a service animal)
Common Emergency Room Conditions	Rate your current level of preparedness to effectively handle these common ER conditions, from diagnosis through treatment, unassisted in a hospital setting.	- Canine Polytrauma, including hemorrhage control, fracture stabilization, and wound care - Emergent blood transfusion post-Hit By Car in a dog - Acute rodenticide toxicity in a dog - Canine Gastric Dilatation-Volvulus - Canine mesenteric torsion - Canine splenic torsion - Congestive heart failure in a cat - Respiratory distress due to aspiration pneumonia in a dog - Acute onset vomiting and/or diarrhea in a dog - Urethral obstruction in a cat - Oliguric acute kidney injury in a dog - Status epilepticus in a dog - Canine Immune Mediated Hemolytic Anemia - Feline Diabetic Ketoacidosis - Induction choices for emergent intubation (e.g., airway obstruction) in a dog - Toxin ingestion

Figure 2. Self-Assessment Survey #1-3 questions for Vet-TROMA participants. Answers were based on a scale of 1-7 with 1 representing "Not Prepared at All" to 7 for "Extremely Prepared"

Association of Veterinary State Boards (AAVSB); this would enable the module to qualify for receiving Registry of Approved Continuing Education (RACE®) CE credits.

The final approved lectures were organized into their sequential modules on BluePearl University (BPU), a BP internal digital platform for sharing educational materials. Vet-TROMA participants were provided user accounts to access the material and post-session CE assessments. BPU provided each participant with an official RACE® CE certificate (65.75 veterinarian and 59.75 veterinary technician RACE® CE credits) to submit to the Vet-TROMA pilot program manager after successfully completing of the modules and test questions.

Two self-assessment participant surveys were also incorporated into Phase 1. The BP Marketing Support Team and Vet-TROMA coordinators developed a web-based survey asking participants to rate their current level of preparedness for eight types of therapeutic procedures, eight types of therapeutic interventions, five types of communication and leadership tasks, and management of 16 common ER conditions using a scale of 1 (Not Prepared at All) to 7 (Extremely Prepared) (see Figure 2). Participants were required to complete the pre-participation survey (Survey #1) before starting the BPU modules and the pre-arrival survey (Survey #2) at the completion of the modules and prior to moving onto Phase 2. Questions and free text options were developed to capture measures of confidence and competence from each participant. Raw and cumulative scores from participants were made available to the Vet-TROMA pilot PM to review and gauge participant progress.

Implementation of Phase 2

Phase 2 involved intensive participant immersion in an approved BP hospital alongside a BP mentor. Factors considered when approving BP facilities to host Phase 2 immersion rotations included hospital staffing, resources, location, and caseload. BP hospitals in close geographic proximity to military installations with deployable Medical Detachment Veterinary Services Support (MDVSS) units or First Year Graduate Veterinary Education (FYGVE) programs were preferred. The BP Senior Director of Clinical Affairs provided further information regarding the feasibility of an identified BP hospital to support the Vet-TROMA program. Legal requirements for state veterinary licensure were also considered to determine if military veterinarians or veterinary technicians in official command approved TDY status would be exempt from requiring a license in the state in which the BP hospital is located.

An objective Vet-TROMA facility criteria checklist was developed by AVS small animal emergency and critical care (ECC) 64Fs. It combines elements from facility certification guidelines from the Veterinary Emergency and Critical Care Society (VECCS) and veterinary trauma center verification guidelines from the American College of Veterinary Emergency and Critical Care (ACVECC) Veterinary Committee on Trauma (VetCOT).[25-26] Ultimately, two BP hospitals were identified to host the Vet-TROMA pilot program: Lakewood, Washington, within six miles of Joint Base Lewis-McChord and Cary, North Carolina, within 65 miles of Fort Liberty.

Phase 2 Vet-TROMA participants followed a 21-day rotation schedule that included twelve, 12-hour shifts. Participants were paired with a BP veterinarian for each shift and progressed through shadow, supervised, and primary case responsibilities. Participants spent 75% of their rotation in the hospital emergency room receiving service and 25% of their time in the intensive care unit. Participants completed day, swing, and overnight shifts on weekdays and weeknights to ensure access to targeted after-hours veterinary emergency or trauma caseload.[27-28]

A clinical tasks objective list spreadsheet, similar in substance to knowledge, skills and abilities (KSAs), was developed for Vet-TROMA participants and BP mentors to track patient caseload and emphasize the types of encounters that align with the program intent (See Figure 3).[18, 21] ECC and other supporting 64Fs developed a list of 27 veterinary emergency

1	Perform Management and Stabilization of the Canine Trauma Patient
2	Perform Hemorrhage Control
3	Perform Tracheostomy Placement and Management
4	Perform Chest Tube Placement and Management
5	Perform Canine Blood Product Transfusion
6	Perform Management of Acute Abdomen
7	Perform Splenectomy
8	Perform Intestinal Resection and Anastomosis
9	Perform Cardiopulmonary Resuscitation
10	Perform Pericardiocentesis
11	Perform Thoracentesis
12	Perform Intraosseous Catheter Placement
13	Perform Administration of Oxygen Therapy Support
14	Perform Point of Care Ultrasound: Focused Assessment with Sonography for Trauma (FAST scan; Abdominal and Thoracic)
15	Perform Clinical Laboratory Interpretation
16	Perform Analgesia and Anesthesia of the Emergency Canine Patient
17	Perform Urinary Catheter Placement and Management
18	Placement of Nasoesophageal or Nasogastric Tube
19	Perform In-patient Management of Hospitalized Patient
20	Perform Management of Wounds
21	Perform Management of Heat Stroke
22	Perform Management of Burns
23	Perform Management of Envenomation
24	Perform Management of Acute Intoxications
25	Perform Interpretation of Thoracic Radiographs
26	Perform Interpretation of Abdominal Radiographs
27	Perform Interpretation of Extremity Radiographs

Figure 3. Vet-TROMA Phase 2 Clinical Task Objectives List

medicine and trauma clinical tasks for the program. Each task was assigned a minimal mode of completion: direct patient care, observation/indirect patient care, case/resident rounds, or online module. The clinical task objective list was paired with a patient case log and provided to Vet-TROMA pilot participants into a combined Microsoft Excel® workbook (Redmond, Washington) at the start of their Phase 2 rotation for tracking task exposures. A single patient could count toward achieving multiple separate clinical task exposures depending on their clinical status and treatment plan.

Implementation of Phase 3

The final phase of Vet-TROMA involved completing the post-participation self-assessment (Survey #3), an AAR form, and completing and submitting the clinical task objectives list with patient log to the pilot PM. A final report and relevant feedback are provided to the commanders and other participants outlining the accomplishments of the Vet-TROMA program.

Statistics

Vet-TROMA participants were sent a survey invitation via e-mail with an authentication process so only the intended recipient could respond. The survey link contained a unique identifier within the URL string that assigns it to the recipient's email address. This authentication process is a survey best-practice methodology and helps maintain data integrity by ensuring only those intended to receive the survey can complete it. The response data was downloaded directly from the InMoment® survey platform (South Jordan, Utah) which houses all the survey information on its secure servers. The downloaded data was then put into Microsoft Excel® (Redmond, Washington) for analysis and graphing. Response frequencies were reported, and mean scores computed.

Results

Clinical Tasks Objectives

At the time of this writing, the Vet-TROMA pilot program has four VCOs who completed Phases 1-3, two VCOs who have completed Phase 1, and 23 VCOs and five 68Ts enrolled in Phase 1. The four VCOs who completed Phases 1-3 were all general practice Captain (O-3) Field Veterinary Service Officers (AOC 64A) from the 218th MDVSS at Joint Base Lewis-McChord. Their Phase 2 rotations were accomplished as a no-cost TDY between July 11, 2021 and March 17, 2022 at the Lakewood, Washington BP hospital. These Vet-TROMA participants were exposed to a cumulative 339 veterinary emergency or critical care patients during their 21-day rotations with an average of 84.75 patient exposures per participant (range 68-105).

Figure 4 illustrates the top 10 overall clinical task objectives accomplished, and the average number of times participants met them during their Phase 2 rotations. *Perform Clinical Laboratory Interpretation* (n=99, mean 24.75), *Perform Point of Care Ultrasound* (POCUS) (n=80, mean 20), and *Perform Analgesia and Anesthesia of the Emergency Canine Patient* (n=68, mean 17) were the three most common Vet-TROMA clinical task objectives exposures for participants. *Perform Clinical Laboratory Interpretation* was the most common exposure for three of the four participants. The most common 64A or 64F ICTs accomplished that provided at least one clinical case for all participants during the Phase 2 rotations (Figure 5) were *Perform POCUS: Focused Assessment with Sonography for Trauma* (FAST) (n=80, mean 20), *Perform In-Patient Management of a Hospitalized Patient* (n=56, mean 14), *Perform Urinary Catheter Placement and Management* (n=11, mean 2.75), and *Perform Thoracocentesis* (n=7, mean 1.75).

Participants achieved a total of 21 exposures for the clinical task objectives of *Perform Management and Stabilization of the Canine Trauma Patient* with a range of four to seven patients per rotation. The most common type of trauma exposure reported by participants were hit by car (n=7), and bite wounds (n=6), followed by two each of fall, polytrauma or "other". One gunshot wound patient was seen by VCO 001 on the final shift of the rotation. A *Perform Hemorrhage Control* exposure was recorded three times by VCO 004. *Perform Canine Blood Product Transfusion* was recorded seven times by three VCOs that included one patient receiving three separate

Number	Vet-TROMA Clinical Task Objectives	Avg Times per Rotation
1	Perform Clinical Laboratory Interpretation	24.75
2	Perform Point of Care Ultrasound: FAST	20
3	Perform Analgesia and Anesthesia of the Emergency Canine Patient	17
4	Perform In-Patient Management of a Hospitalized Patient	14
5	Perform Management of Acute Abdomen	12.5
6	Perform Administration of Oxygen Therapy Support	10
7	Perform Interpretation of Abdominal Radiographs	7.5
8	Perform Interpretation of Thoracic Radiographs	7.25
9	Perform Management and Stabilization of the Canine Trauma Patient	5.25
10	Perform Interpretation of Extremity Radiographs	3.75

Figure 4. The top 10 Vet-TROMA Phase 2 clinical skills objectives accomplished for participants during Phase 2 immersion rotations (n=4).

transfusions during its hospital stay. Clinical task objective exposures that were not accomplished by any participant included *Perform Chest Tube Placement and Management*, *Perform Intestinal Resection and Anastomosis*, *Perform Intraosseous Catheter Placement*, *Perform Management of Heat Stroke*, *Perform Management of Burns*, and *Perform Management of Envenomation*.

Self-Assessment Surveys

Survey #1 results from a total of 28 VCO participants enrolled in Phase 1 were available for baseline training knowledge analysis. Sixteen participants reported they were not currently serving in a VTF, eight reported they were currently serving in a VTF and four reported they were new graduates. When asked to rate their current level of preparedness on a scale of 1 (Not at All Prepared) to 7 (Extremely Prepared) to properly conduct each of the eight listed therapeutic procedures unassisted in a hospital setting, the mean score for all 28 was 3.7 and 2.8 for the four VCOs who completed Phases 1-3. The mean score for rating their current level of preparedness for eight listed therapeutic interventions was 3.9 for all respondents (n=28) and 3.3 for the Phase 1-3 VCO subset (n=4), 5.0 and 5.1 for five listed Communication and Leadership skills, and 3.6 and 3.0 for managing 16 listed common ER conditions respectively.

When asked to describe their prior experience with operational canine medicine in Survey #1, all 28 participants responded. Five VCOs indicated they were previously deployed, 21 stated their most common exposure to canine emergency medicine was conducting canine tactical combat casualty care (K9TCCC) training with canine handlers or HCPs, three VCOs stated they had ER experience before joining the Army and six VCOs stated they had experience treating or managing at least one MWD emergency case during their Army career.

Survey #2 and #3 results to compare to baseline training Survey #1 are only available for the four VCOs who completed Phases 1-3 with mean scores listed in Figure 6. Participants showed a progressive increase in their perceived preparedness to perform expected procedures, interventions or treatments from Survey #1 to Survey #3 with a slight decrease in communication in leadership preparedness between Surveys #1 and #2.

Discussion

To the author's knowledge, Vet-TROMA is the first centralized AMEDD veterinary MCP program for Army VCOs and 68Ts capable of augmenting command training programs to improve AVS operational readiness and canine combat casualty survivability. The U.S. Army Veterinary Corps Chief and OTSG endorse the pilot program and it has been well received by commanders. Development and execution of the Vet-TROMA pilot program relied on volunteer AVS personnel at both the strategic and tactical level for the program design, coordination with BP to establish the content and training platforms, and command support to launch VCO participation in Phases 1-3.

Establishing the Phase 1 distance learning modules focused on participants receiving exposure to a standardized curriculum, regardless of clinical background or experience, to ensure baseline preparedness before starting a Phase 2 rotation. Feedback from participants in Survey #1 indicated only 11% of VCOs (n=3) had any significant prior emergency medicine experience outside of clinical rotations in veterinary school. Exposure to veterinary emergency medicine for veterinary students is usually limited to didactic courses within the first two to three years of veterinary school and a two-to-three-week clinical rotation during their third or fourth year. Survey and AAR comments indicate the Phase 1 modules were a good refresher for participants and that an appropriate amount of time should be afforded by commanders to allow the participants to focus on their completion. Based on the authors' recommendations, participants should be allotted a minimum time of 30 days prior to any scheduled start of Phase 2 in order to complete all the learning modules. Participants also requested that lecture notes or slides be provided for reference when navigating over 65 hours of clinical topics. The opportunity to gain 65.75 RACE® CE credits at no personal or unit cost provides an incentive for commanders to

Number	Vet-TROMA Clinical Task ICT Objectives	Average per Rotation	Relevant ICT Number	AOC
1	Perform Point of Care Ultrasound: FAST	20*	081-000-2735	64A/64F
2	Perform In-patient Management of a Hospitalized Patient	14*#	081-64F-2004	64F
3	Perform Urinary Catheter Placement and Management	2.75*	081-000-2898	64A/64F
4	Perform Thoracocentesis	1.75*	081-000-2897	64A/64F
5	Perform Cardiopulmonary Resuscitation	1.75	081-000-2899	64A/64F
6	Perform Canine Blood Product Transfusion	1.75	081-000-2896	64A/64F
7	Perform Tracheostomy Placement and Management	0.25	081-000-2895	64A/64F
8	Perform Intestinal Resection and Anastomosis	0.25	081-000-2734	64A

Figure 5. Clinical Individual Critical Tasks (ICTs) for 64A and 64F AOCs accomplished during Vet-TROMA pilot program Phase 2 immersion rotations by participants (n=4) and the average number completed.
** Indicates every Vet-TROMA participant had at least 1 clinical case available to complete task.*
 # Indicates only completed by 64A participants.

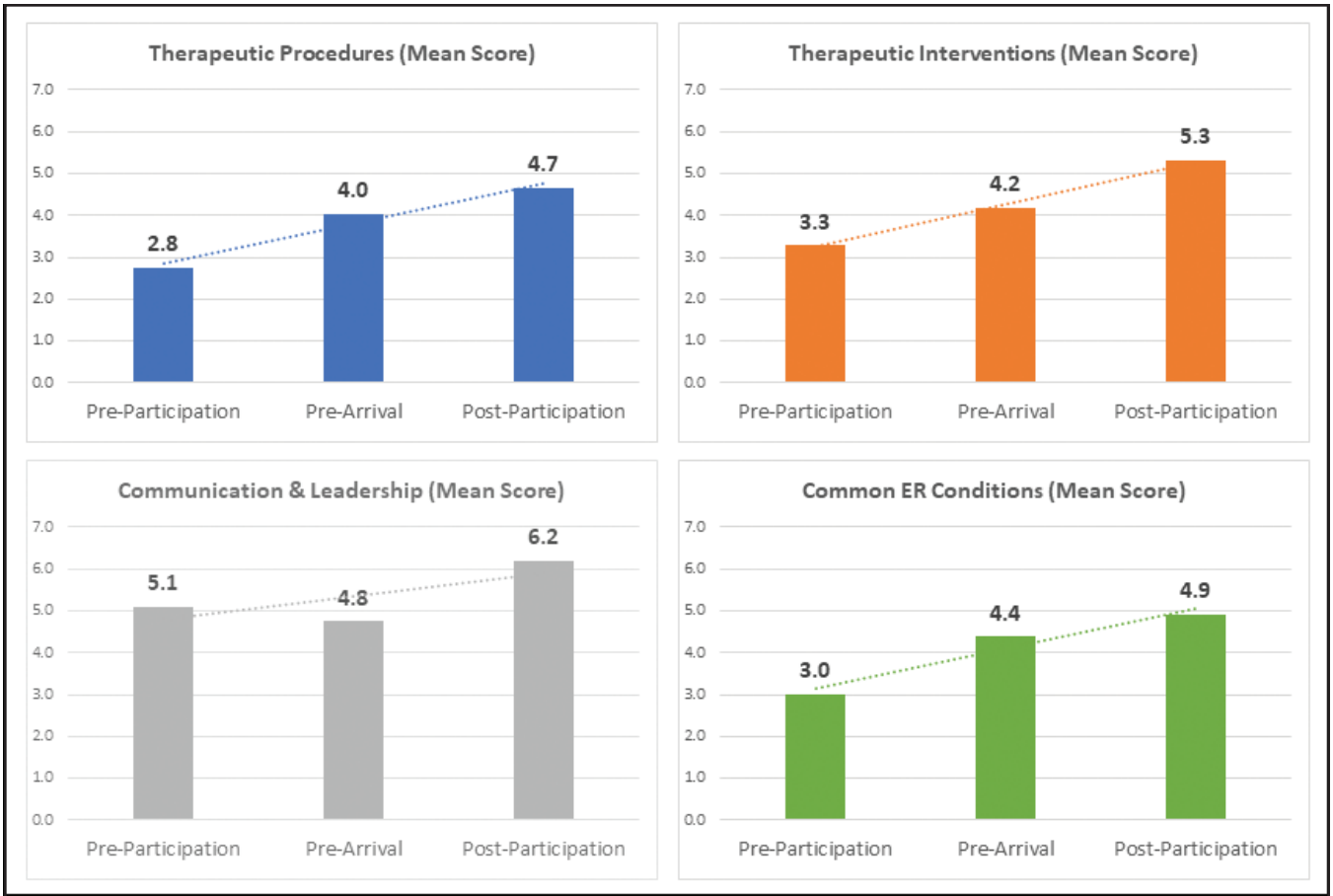

Figure 6. Mean scores across time for Phase 1-3 Vet-TROMA participants who completed Surveys #1-3 (n=4) depending on their status in the program: Pre-participation (Survey #1), Pre-Arrival (Survey #2), and Post-Participation (Survey #3)

encourage participation. Even if a Phase 1 participant is unable to be scheduled for a Phase 2 rotation soon after completion, important knowledge and confidence in emergency and critical care topics can be gained by completing the learning modules.

At the time of this writing, the recorded content for Phase 1 modules is over two years old and will need to be reassessed for any changes in clinical standards within the veterinary profession for treating trauma and emergency medicine cases. For example, advances in understanding the dynamics of resuscitation in canine hemorrhagic shock and the availability of new canine blood products will change how VCOs and 68Ts are expected to support future canine combat casualties.[29-33] Other medical training programs use blended learning models that include an online platform followed by an in-person option to successfully reinforce concepts.[34-36] Phase 1 of Vet-TROMA encourages 64Fs assigned to units with identified participants to spend time with them, reinforcing featured concepts face-to-face prior to Phase 2 in order to continue building confidence and competence of the individual. Currently, the Phase 1 online modules are geared towards veterinarians, but 68Ts are also allowed to progress through the training materials. Future iterations of the Vet-TROMA Phase 1 modules should include the option of veterinary technician level content focused specifically on the concepts and expectations relevant to 68Ts providing the nursing and technical support to canine combat casualties. BluePearl already has veterinary technician training programs online in BPU that are being evaluated for a 68T modified curriculum.

The opportunity to participate in Phase 2 was viewed as an overwhelming positive and beneficial experience for the four VCOs in the pilot program with all participants providing AAR comments that the 21 days should be expanded to at least five weeks or allow for the ability to return on a set schedule of shorter rotations for clinical skills sustainment. The pilot program participants received extensive exposure to necessary diagnostic tools and the follow-on interpretation of results which is required for developing sound treatment and case management plans for veterinary emergency and critical care patients. Veterinary Corps Officers in garrison VTFs

are primarily exposed to healthy MWD or privately-owned animal (POA) clinical laboratory results, or abnormal results that may not be associated with an emergent cause. Clinical laboratory interpretation of abnormal blood gases, complete blood counts, coagulation profiles and chemistry panels in veterinary emergency or trauma patients is a necessary skill for 64As serving in an MDVSS Veterinary Service Support Team (VSST) providing Veterinary Role 2 Medical Care.[37]

Vet-TROMA participants received increased exposure to patients requiring POCUS resulting in their mean score increasing from 4.0 to 6.0 between Surveys #1 and #3. This is important since most VTFs and all animal care teams within an MDVSS have ultrasound capability and FAST scans have proven to be an invaluable screening and diagnostic tool for veterinary emergency patients.[38-42] Prompt recognition of a potential pneumothorax, pleural effusion or abdominal fluid can drastically change treatment plans or prioritization within patient triage. VCOs should be expected to understand and execute FAST scan basics on a canine combat casualty.

Subjectively enthusiasm and support of the BP executives and hospital staff in supporting VCOs completing their Phase 2 rotations was very high throughout the four sponsored rotations. Staff members expressed satisfaction with the prospect of indirectly supporting the care of MWDs/MPCs by imparting their expertise to Vet-TROMA participants. A single individual within the Lakewood, WA facility was identified to develop the shift schedule for Vet-TROMA participants based on feedback from AVS principles as well as serve as the main mentor for the VCOs during their time at the facility. The VCOs rotated among different veterinarians, technicians and support staff members to enhance their experience and consistently expressed the BP staff were extremely welcoming and friendly. Further, the additional qualified veterinarian providers enhanced the workflow at the host BP hospital. VCOs were able to begin taking cases and dispensing care as an independent provider soon after the start of Phase 2 which allowed for increased hospital throughput and sharing of case load with the full-time staff. Introduction of the Vet-TROMA program comes at a pivotal time when emergency veterinarians and technicians across the U.S. are facing a high rate of burnout owing to increased caseloads, short staffing in part from increased number of sick employees and routine drug shortages.[43-45]

The Vet-TROMA clinical task objectives list was shared with the BP staff in advance to provide clarity on what types of patient encounters would best meet the Army objectives of the rotation. The BP staff included the VCOs, either directly or indirectly, whenever there was a patient in the facility that would count toward completion of a clinical task annotated on the list. This maximized overall exposure to the targeted clinical tasks and helped to summarize the case log at frequent intervals rather than at the end of the rotation. There was individual variability in how VCOs were providing details on the case log which resulted in pilot PM refinement of the log drop-down menu options in order to improve and standardize capture of hard data for analysis.

The focus of Vet-TROMA centers on the clinical readiness of VCOs and 68Ts to treat canine combat casualties, however participants did receive primary case management exposure to feline patients. Anatomic and physiologic differences do exist between canines and felines that warrant different approaches for interventions in trauma, sepsis or shock.[46-49] In veterinary general practice and small animal emergency and critical care, it is expected for practicing veterinarians to be able to transition from treating one species to the next. The Vet-TROMA participants gained overall confidence and competence in how to clinically approach a veterinary emergency or trauma patient regardless of species. Future iterations of Phase 2 should continue to allow access to feline patients despite the overall intent of improving survivability of canine combat casualties.

Challenges to implementing the Vet-TROMA pilot program include lack of a dedicated PM with sole responsibility to coordinate development and participation, and centralized funding to sponsor Phase 2 rotation TDYs. Development of Vet-TROMA was performed by volunteer AVS commissioned officers assigned to units outside of OTSG with primary duties and responsibilities not related to MCPs. The support of the OTSG was invaluable for establishing the MTA with BP and endorsing Vet-TROMA overall, but there are no VCOs or staff with veterinary experience in the AMSSP office to take the lead on establishing a program to meet AVS needs. For continued success and sustainability of the program moving forward, a position within AMEDD must be identified that can include Vet-TROMA program manager in the duty description and allow that individual the necessary time to devote to its administration. With the lack of centralized funding to support Phase 2 rotation TDYs, unit commanders must be willing and able to bear the financial burden for VCOs and 68Ts to participate. As such, the appeal must be great enough for commanders to risk three weeks of non-availability of their Soldiers amid competing mission priorities and allocate available funds for their veterinary personnel over other non-veterinary providers in their formation who also can also participate in similar MCPs. The original intent was to recruit 10 VCOs in the pilot program for the necessary participation and data analysis needed to determine if Vet-TROMA could achieve the defined AVS objectives for further sponsorship. The results from the four VCOs completing the program so far justifies continuing to the fully intended 10 participants.

Commanders expressed concern during the pilot program that being limited to two MCP locations for TDY participation was not ideal. Veterinary specialty practices within closer proximity to their location, where a local MCP could

be established would be preferred. Historically, commanders have placed the burden of establishing local MCPs on the lone 64F assigned to an MDVSS or PHA for a clinical skills sustainment program. This results in duplication of effort already achieved by the Vet-TROMA program. By working at the centralized level between the OTSG and a veterinary specialty network executive office, many of the legal questions related to licensure, privileging, malpractice, sponsorship, and party responsibilities can be identified and addressed by the people most qualified to negotiate them. Also, with the standardized curriculum, commanders have greater assurance that all Soldiers across their formation have a better chance of receiving consistent and repeatable experiences. In its current form, the Vet-TROMA program only allows for one VCO to be at a BP hospital for Phase 2 rotations at a time. This allows the staff to be able to devote full attention to the VCO present and ensures they are not in competition with another VCO for emergency and trauma patient encounters. More hospitals could be approved for inclusion as options for Phase 2 rotations to increase VCO/68T throughput. Currently there are other BP locations being evaluated for suitability in hosting VCOs. Without a fulltime PM position, there remains a challenge in devoting time to coordinate with additional hospitals beyond the Lakewood and Cary locations.

In its current form, the Vet-TROMA program is mainly focused on 64A VCO participation. A broader vision for the program does include the desire to pair 64As with their assigned 68Ts for Phase 2 rotations in order to maintain animal care team integrity. The state licensing board challenges have been greater for 68T participation primarily due to how individual states define a veterinary technician and what they are authorized to do in support of veterinary medicine. While 68Ts learn many of the same skills as veterinary technicians during their 11-week Advanced Individual Training (AIT) program, it falls drastically short of an American Veterinary Medical Association-accredited standard two- or three-year civilian veterinary technician program with the ability to apply for licensure after completion. Some veterinary technicians do enter the military, become 68Ts and maintain their status as a licensed or registered veterinary technician, but the majority across the formation do not and instead would best fit criteria established to be a veterinary assistant in the civilian sector after AIT. Further efforts are needed to best identify and define how to incorporate 68Ts into the Phase 2 rotations that allow them to gain necessary exposure to veterinary emergency and trauma patients while remaining within the limits of each state's legally approved skills for non-veterinarians.

Further efforts are also needed to incorporate 64Fs into the Vet-TROMA program both as mentors to 64As or 68Ts before, during and after Phase 2 rotations, and as participants themselves with the ability to receive exposure to veterinary emergency or trauma cases at the clinical specialist level. A 64F is a residency-trained or boarded officer and a veterinary clinical specialist within the Army, but unlike Medical or Dental Corps Officers, this one AOC can include multiple types of specialists including surgeons, internists, radiologists, criticalists, behaviorists and veterinary practitioners. It can be just as challenging for 64Fs to maintain exposure to specialty level clinical cases as it is for 64As to get exposure to veterinary emergency and trauma cases. This is especially true while the individual is assigned to an MDVSS where there are no organic clinic responsibilities while in garrison. Yet while deployed, 64Fs are expected to serve as Officers-in-Charge (OICs) of the MDVSS Veterinary Medical and Surgical Team (VMST) that includes responsibilities for case consultation and providing Veterinary Role 3 Medical Care in theater.[37] The Vet-TROMA program may offer an opportunity for 64Fs to manage specialist level patients and simultaneously assist 64As during Phase 2 with their clinical skills development. As shown during the pilot program, the second most common ICT accomplished was *Develop MWD Inpatient Care Plan* (081-64F-2004). Other 64F ICTs are shared with the 64A clinical ICTs, likely allowing Vet-TROMA 64F participants to have the same opportunity to complete their ICTs.

Prioritization of 64A, 64F and 68T participation in Vet-TROMA must be established to determine who will benefit the most from this type of training for support of canine combat casualties. The original concept for Vet-TROMA focused on active and reserve component MDVSS personnel for either just-in-time training prior to deployment or those who are most likely to deploy within a reasonably expected timeframe. Beyond that, active component VCOs and 68Ts serving in PHA garrison VTFs or reserve component personnel who also support those VTFs could be considered. Public Health Activity VCOs who are part of the one-year FYGVE program seem to be the most likely candidates assigned to a VTF to fit the program design since they are generally 1) new veterinary school graduates, 2) remain in training status during FYGVE, and 3) do not have any of the administrative responsibilities at the section or branch level which would require backfill during a three-week absence for Phase 2. MDVSS personnel in the pilot program have thus far offered the most flexible options for being placed on a BP hospital rotation schedule for uninterrupted completion. Currently, no PHA personnel have completed Phase 1 to be scheduled for Phase 2 for comparison.

Finally, Vet-TROMA in its current design and pilot status does not thoroughly address veterinary emergency or trauma clinical skills sustainment longer term than through Phase 3. The authors recognize that a three-week rotation provides sound introduction to the patient exposures necessary to improve confidence and competence for treating canine combat casualties, but there is much more work to be done to incorporate touchpoints thereafter to continue reinforcing those concepts into proficiency.[14] Additional resources and efforts would be

required after completion of the pilot program to determine the best course of action for participant graduates to return to an immersive environment that challenges VCOs to stretch their clinical assessment and treatment skills. Efforts within MEDCOM and AVS to modify the current VTF patient preventive medicine model for increasing exposure to veterinary urgent care cases could be pursued and analysis is ongoing by senior leadership for relevant courses of action. AVS provides comprehensive medical, dental and surgical care to MWDs/MPCs within PHA VTFs but those case exposures are primarily related to scheduled or non-emergent treatment of healthy dogs. The POA population available to the VTFs from authorized Department of Defense beneficiaries on a Nonappropriated Funds pay-for-service basis provides the greatest opportunity for expanding young VCOs and 68Ts' clinical exposure to urgent or emergent cases. Opportunities to better utilize these existing clinics to increase exposure to urgent and emergent cases should be explored.

Conclusion

The Vet-TROMA pilot program has thus far demonstrated a centralized AMEDD veterinary MCP can improve the confidence and competence of Army VCOs for managing the type of veterinary emergency and trauma cases to be expected from canine combat casualties. It has also demonstrated that exposure to veterinary ICTs can be accomplished in a mentor-focused environment with real world application for reinforcement. The program benefits most when centralized support from AMSSP, a designated program manager, a committed civilian partner, and willing commanders all come into alignment and coordinate the resources available for VCO and 68T participation success. Further efforts are needed to complete the pilot program and perform the final data analysis necessary for determining the long-term feasibility and sustainability of this MCP program.

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Factors Associated with Military Working Dog Global Electronic Veterinary Health Record Master Problem List Entries, 2018-2022

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Abstract

Understanding the commonly recorded medical problems among the military working dog (MWD) population is crucial to inform how these dogs are cared for and to maintain operational readiness. Previous studies have evaluated medical problems among young MWDs, others have specifically evaluated non-combat injuries among a cohort of deployed MWDs, while others have evaluated deployment-related injury and death. The goal of this project was to use veterinary provider-entered master problem list (MPL) entries in a global electronic veterinary health record (eVHR) system to describe documented medical problems among the active population of MWDs (regardless of deployment status) and identify factors associated with the most common recorded medical conditions. A total of 12,606 MPL entries from 1,666 individual MWDs were retrieved from the Defense Health Agency's Veterinary Services Systems Management (VSSM) and manually categorized using the same categories reported in previous studies. Descriptive analysis identified dental, dermatologic, surgical, soft tissue-related injury, alimentary and musculoskeletal MPL entries as the leading recorded conditions affecting a global population of MWDs from 1 January 2018 through 31 December 2021. Multi-variable logistic regression determined factors associated with each of the conditions varied, but included MWD age, sex, breed, duty certification, military branch of service, and location (continental US versus outside of continental US). These data reveal multiple areas where efforts can be made to improve training considerations for VCOs, veterinary medical personnel, MWD handlers, and kennel staff, and preventive medicine/routine care of MWDs to enhance overall health.

Keywords: Military Working Dog, MWD, MWD medical problems, MWD readiness, Veterinary Treatment Facility, Veterinary Corps Officer Readiness

Introduction

Military working dogs (MWDs) are an important asset to the US military, serving as force multipliers on the battlefield and in the garrison environment.[1–3] These highly trained canines have specialized capability in drug detection, explosives detection, patrol/attack, and special operations support.[2] The US Army Veterinary Services is responsible for the comprehensive medical and surgical care of MWDs across the Joint Force.[4] Understanding the commonly recorded medical problems among the MWD population is crucial to inform how these dogs are cared for and to maintain operational readiness.[5] Previous studies have evaluated medical problems among young MWDs,[5] others have specifically evaluated non-combat injuries among a cohort of deployed MWDs,[6] while others have evaluated specifically deployment-related injury and death.[1,7] The goal of this project was to use veterinary provider-entered MPL entries in a global electronic veterinary health record (eVHR) system to describe documented medical problems among the active population of MWDs regardless of deployed status and identify factors associated with the most common recorded medical conditions. To our knowledge, this is the first study with the aim of evaluating MPL entries and associated risk factors from all active MWD records over a multi-year period. These data can be used to inform Veterinary Corps Officer (VCO) medical skills training, MWD handler medical skills training, medical equipment acquisition, and overall MWD preventive care and husbandry guidelines.

Methods

When an MWD is presented to a US military Veterinary Treatment Facility (VTF) for evaluation, any identified medical conditions are annotated in the Defense Health Agency's Veterinary Services Systems Management (VSSM). VSSM is the eVHR for animals, including Department of Defense (DOD)-owned MWDs, presented to VTFs on military installations or in deployed environments for care. MWD MPL entries input between 1 January 2018 and 31 December 2021 were downloaded using an MPL central report from VSSM. The study period was chosen to capture MPL entries input over a four-year period. Basic demographic characteristics of interest included in the MPL report were age and end of study period (calculated from date of birth and the last date included in the study, 31 December 2021), sex (male/female), unique ID control number, tattoo number, military branch of service (determined by owning unit), and location (categorized as continental United States, [CONUS], or outside the continental United States [OCONUS]). In addition, MWD duty certifications were retrieved from the Working Dog Management System (WDMS) and matched to the respective MWD from the MPL central report. A total of 19,746 MPL entries input between 1 January 2018 and 31 December 2021 were retrieved. The MPL entries included 2,736 MWDs presented to 133 VTFs operating globally. VSSM records archived to the records repository (n=6,144) for deceased or adopted MWDs or those that indicated inactivity (n=996) during the study time frame were excluded from analysis. A total of 12,606 MPL entries from 1,666 individual MWDs were included and were subsequently manually categorized using the same categories reported in previous studies.[6,8] These categories included: alimentary, behavioral, cardiovascular, dental, dermatologic, endocrine, infectious, mass lesion, multisystemic, musculoskeletal, neurological, open, ophthalmologic, other, respiratory, soft tissue related injury, surgical, toxicosis-related, and urogenital. The MPL entries were further categorized into 721 subcategories to identify more specific problems. Information for MWDs without an MPL entry was not included due to lack of availability. This study was reviewed by the DOD Military Working Dog Veterinary Service (MWDVS) LTC Daniel E. Holland Military Working Dog Hospital Institutional Animal Care and Use Committee (IACUC) and determined to be except from full IACUC review as it does not involve use of live animals (13 September 2021). The use of MWD records for this study was approved by the DODM-WDVS on 15 September 2021.

Data Analysis

Descriptive statistics for MWD demographic characteristics included frequency, percentages and relative 95% CI. Differences in proportion were assessed by the χ^2 test. The continuous variable age at end of study period was described by the histogram, median, and range. Age was subsequently categorized into five age groups, ≤3 yrs, >3 yrs to ≤6 yrs, >6 yrs to ≤9yrs, and >9 yrs, and analyzed as a categorical variable in the univariable and multivariable analysis.

Factors associated with the top six MPL entries were analyzed using multivariable logistic regression. Full models included all variables with P-value <0.25 from the univariable analysis. Variables were removed in a stepwise fashion, starting with the highest P-value, until all variables with P-value >0.05 were removed. Independent variables were assessed for confounding by checking for a change in model coefficients of ≥10% as variables were removed or added to the model. Independent variables were assessed for interaction by adding interaction terms back into the model and assessing for significance. The final model fit was assessed using the Pearson's χ^2 goodness of fit and deviance test, or the Hosmer Lemeshow Goodness of Fit Test as applicable, with a P-value ≥ 0.05 indicating goodness of fit. Collinearity was assessed by analyzing point estimates, tolerance, and variance inflation. Descriptive statistics, univariable, and multivariable analysis were performed using SAS® On Demand for Academics (2021).

Results

Demographic characteristics of the 1,666 MWDs with MPL entries are listed in Table 1.

The age at the end of the study period (31 December 2021) ranged from 1.3 years to 15.6 years, with a median of 5.3 years. The majority of included MWDs were greater than three years old and less than or equal to 6 years of age (47.6%). Only 9.6% of dogs were 3 years old or less. The majority of MWDs in this study are male (76.5%), Air Force (39.1%), Belgian Malinois (49.2%), explosives detection (73.4%) dogs housed in the continental US (CONUS) (75%). We compared age, sex, breed, military branch of service, and location (CONUS vs. Outside the CONUS) in the study population to active MWD population data extracted from VSSM. We found the demographic characteristics for sex, breed, and location to be similar. For age, dogs ≤3 years, and dogs >9 years are underrepresented in this study, while dogs >3 and ≤9 are overrepresented. Air Force-owned dogs are underrepresented in this study, while Army, Marine Corps, and Navy dogs are overrepresented. Table 2 summarizes the 19 MPL entry categories listed by the number of MWDs affected by each problem, the total number of MPL entries, and the average number of recorded MPL entries for each problem per MWD (number of MPL entries divided by number of affected MWDs). The median number of MPL entries per MWD was 6 (range 1-38). The most common subcategories (problem descriptions) for each MPL category are also

Table 1. Demographics and Characteristics (n = 1666 active MWDs).

Variable Category		n (%)
Age at Study End[a] Median: 5.3 yrs Range: 1.3 yr-15.6yrs	≤3 yrs >3 yrs to ≤6 yrs >6 yrs to ≤9yrs >9 yrs	160 (9.6) 793 (47.6) 519 (31.2) 194 (11.6)
Sex	Male Female	1274 (76.5) 392 (23.5)
Breed	Belgian Malinois Dutch Shepherd German Shepherd Labrador Retriever Other[b]	820 (49.2) 56 (3.4) 696 (41.8) 78 (4.7) 16 (1.0)
Occupational Duty Certification[c]	Drug Detection Explosives Detection Patrol Only Specialized Search Not certified	364 (21.9) 1223 (73.4) 25 (1.5) 36 (2.2) 18 (1.1)
Military Branch	Air Force Army Marine Corps Navy	651 (39.1) 624 (37.5) 138 (8.3) 253 (15.2)
Location	CONUS OCONUS	1250 (75.0) (25.0)

[a] Age entry was calculated by subtracting each MWD date of birth from the last date of the study period (31 December 2021)
[b]Other breeds are all breeds with fewer than 10 MWDs: Jagdterrier, German Shorthaired Pointer, Golden Retriever, Mixed Breed, and Jack Russell Terrier.
[c]Duty certifications were categorized as: Drug Detection includes Drug Detection only and Patrol and Drug Detection certified dogs. Explosives Detection includes Explosives Detection only and Patrol and Explosive Detection certified dogs. Patrol only are Patrol certified only, no additional certifications. Specialized search includes Mine Detection, Combat Tracker, and Specialized Search certified dogs. Not certified did not have a certification at the time of data retrieval.

included in Table 2. The top MPL categories when considering the percent of individual MWDs with an MPL entry in the category included dental (51.9%), dermatologic (51.2%), surgical (44.2%), soft tissue-related injury (42.7%), alimentary (39.6%), and musculoskeletal (38.4%). The top MPL categories when considering the percent of all MWD MPL entries by category includes dermatologic (14.9%), dental (14.5%), soft tissue-related injury (9.4%), musculoskeletal (9.4%), alimentary (9.3%) and surgical (8.5%). These six categories account for 66% of all active MWD MPL entries.

Univariable logistic regression results for the top 6 MPL categories are displayed in Table 3. Factors associated with dental conditions included age, certification, and location. Factors associated with dermatological conditions included age, sex, and military service branch. The factors associated with surgical conditions included age and military service branch. Age and breed were factors associated with soft tissue-related injuries. Age and duty certification were factors associated with alimentary conditions. Age, sex, breed, and military service branch were associated with musculoskeletal conditions. The results of the multivariable analysis for the top 6 MPL categories are displayed in Table 4. Significant ($p \leq 0.05$) ORs and 95% CIs are reported. Variables associated with dental conditions included age (>3 years), certification (specialized search), and location (OCONUS). Variables associated with dermatologic conditions included age (>3 yrs), sex (male), and military service branch (Air Force, Army). Factors associated with surgical conditions included age (9 years of age and younger), and branch (Marine Corps). For soft tissue-related injuries, the significant variables included age (>3 yrs) and breed (Belgian Malinois). The significant variables for alimentary conditions were age (>3 yrs) and certification (specialized search). Factors associated with musculoskeletal conditions included age (>3 yrs), sex (male) and breed (Belgian Malinois, Dutch Shepherd, German Shepherd). Final model assessment showed good model fit. ORs with wide CI are representative of small sample sizes and should be interpreted with caution. No evidence of multicollinearity was present among the assessed variables.

Discussion

This study is the first to analyze master problem list entries across all active MWDs presenting to VTFs globally within a designated time frame and to capture all categories of MPL entries. These data compliment previous efforts to describe medical problems among young MWDs[5], diagnoses among deployed MWDs[6,7,9] , and random sample of MWD encounters.[8]input of senior veterinary subject matter experts, and feedback from the field. To date, no data have been published describing the cases presented to DOD-owned Veterinary Treatment Facilities (VTFs This report describing the top MWD medical problems and associated risk factors is important to enhance the medical care and husbandry of MWDs. Understanding the most frequent medical problems among MWDs can also identify measures to prevent medical illness or injury of the MWD. Comparing these results to studies of non-military owned canines presented to civilian veterinary facilities can also assist in identifying problems that may be unique or occur more frequently among MWDs.

Dental Conditions

Dental conditions affected more than half of the MWDs in this study. The most common dental problem identified in this study was dental fracture (Table 2). Dental prophylaxis is the second most common dental MPL item followed by gingival disorder, dental extraction, and dental calculus (Table 2). We initially excluded dental prophylaxis from the study because prophylaxis is not medical problem. Even when this routine procedure item was excluded from analysis, 51.1% of these active MWDs still had a dental MPL entry other than prophylaxis. Dental prophylaxis was ultimately not excluded

Table 2. Master problem list (MPL) entries among Active military working dogs (MWD) (n=1666 dogs, n=12606 master problem list entries)

Master Problem List Entry Categories	Active MWD n(%) [n=1666]		MPL Entries n(%) [n=12606]		Avg MPL Category entries per Active MWD
Dental *Common problem descriptions*: dental fracture, dental prophylaxis, gingival disorder, dental extraction, dental calculus	864	(51.9)	1824	(14.5)	2.1
Dermatologic: *Common problem descriptions:* otitis externa, dermatitis, scrotal dermatitis, hygroma, aural hematoma	854	(51.3)	1884	(14.9)	2.2
Surgical *Common problem descriptions:* gastropexy, ovariectomy, incisional dehiscence, caudectomy, ovariohysterectomy	737	(44.2)	1070	(8.5)	1.5
Soft Tissue-related Injury *Common problem descriptions:* laceration, tail tip trauma, abrasion, cutaneous wound, toenail fracture	711	(42.7)	1185	(9.4)	1.7
Alimentary *Common problem descriptions:* diarrhea, vomiting, enteritis, gastroenteritis, colitis	659	(39.6)	1175	(9.3)	1.8
Musculoskeletal *Common problem descriptions*: lameness hindlimb, lameness forelimb, lameness, joint swelling, Spondylosis	640	(38.4)	1188	(9.4)	1.9
Open *Common problem descriptions:* overweight, weight loss, thrombocytopenia, underweight, staph hypersensitivity	524	(31.5)	797	(6.3)	1.5
Other *Common problem descriptions:* blood type notes, notes, ALT increased, FAVN failure, healthy	493	(29.6)	610	(4.8)	1.2
Infectious *Common problem descriptions:* Giardiasis, Rickettsiosis, Ehrlichiosis, *Borrelia*, *Babesia canis*	390	(23.4)	548	(4.3)	1.4
Behavioral *Common problem descriptions:* bite quarantine, behavior abnormal, anxiety, aggression, self-injury	358	(21.5)	565	(4.5)	1.6
Urogenital *Common problem descriptions:* prostatomegaly, hematuria, azotemia, proteinuria, BPH	344	(20.6)	552	(4.4)	1.6
Mass lesion *Common problem descriptions:* cutaneous mass, mass (unspecified), subcutaneous mass, palpebral mass, prostatic mass	266	(16.0)	372	(2.95)	1.4
Ophthalmologic *Common problem descriptions:* conjunctivitis, pannus, cataract, corneal pigmentation, nuclear sclerosis	213	(12.8)	279	(2.2)	1.3
Multisystemic *Common problem descriptions:* heat injury, lymphadenopathy, lethargy, allergy, dehydration	162	(9.7)	207	(1.6)	1.3
Cardiovascular *Common problem descriptions:* hypertension, arrhythmia, cardiac murmur, heartworm disease, valvular abnormality	89	(5.3)	108	(0.86)	1.2
Neurological *Common problem descriptions:* CP deficit, ataxia, seizure, gait abnormal, reflex delayed	83	(5.0)	111	(0.88)	1.4
Respiratory *Common problem descriptions:* epistaxis, cough, respiratory distress, tonsilitis, rhinitis	83	(5.0)	105	(0.83)	1.3
Endocrine *Common problem descriptions:* hypothyroidism, hyperadrenocorticism, discoid lupus	14	(0.8)	14	(0.11)	1.0
Toxicosis-related *Common problem descriptions:* toxin ingestion, toxicity, C4 ingestion, medication ingestion, toxin exposure	11	(0.7)	12	(0.1)	1.1

Table 3. Summary of statistically significant univariable risk factors associated with the top six master problem list entries (n=1666 active MWDs)

Variable Category		Dental Conditions n=864 affected MWDs OR	(95%CI)	Dermatologic Conditions n=853 affected MWDs OR	(95%CI)	Surgical Conditions n=737 affected MWDs OR	(95%CI)	Soft Tissue-related Injury Conditions n=711 affected MWDs OR	(95%CI)	Alimentary Conditions n=659 affected MWDs OR	(95%CI)	Musculoskeletal Conditions n=640 affected MWDs OR	(95%CI)
Age	≤3 yrs	REF		REF		**6.60**	**(3.36-12.25)**	REF		REF		REF	
	>3 yrs to ≤6 yrs	**2.55**	**(1.78-3.67)**	**3.18**	**(2.17-4.67)**	**37.1**	**(21.38-64.38)**	**3.44**	**(2.27-5.22)**	**1.9**	**(1.33-2.84)**	**3.52**	**(2.05-6.04)**
	>6 yrs to ≤9yrs	**3.54**	**(2.42-5.19)**	**4.18**	**(2.81-6.22)**	1.71	(0.95-3.07)	**3.99**	**(2.60-6.12)**	**2.1**	**(1.39-3.04)**	**10.4**	**(6.02-17.9)**
	>9 yrs	**1.98**	**(1.27-3.07)**	**3.40**	**(2.15-5.36)**	REF		**2.20**	**(1.34-3.59)**	**1.7**	**(1.10-2.73)**	**15.6**	**(8.6-28.2)**
Sex	Female	1.02	(0.82-1.28)	REF		1.25	(1.00-1.57)	1.05	(0.84-1.32)	REF		REF	
	Male	REF		**1.91**	**(1.51-2.40)**	REF		REF		1.06	(0.84-1.34)	**1.35**	**(1.06-1.71)**
Breed	Belgian Malinois	1.42	(0.52-3.84)	1.60	(0.57-4.43)	1.38	(0.50-3.82)	**1.54**	**(1.25-1.89)**	1.49	(0.51-4.33)	**3.10**	**(1.68-5.72)**
	Dutch Shepherd	1.71	(0.56-5.26)	1.44	(0.46-4.52	2.07	(0.66-6.47)	1.27	(0.73-2.21)	1.53	(0.47-5.01)	**2.78**	**(1.24-6.23)**
	German Shepherd	1.34	(0.49-3.63)	1.97	(0.71-5.48)	1.19	0.43-3.31)	REF		1.43	(0.49-4.16)	**3.59**	**(1.94-6.64)**
	Labrador Retriever	1.35	(0.46-4.00)	2.05	(0.68-6.19)	1.67	(0.55-5.03)	1.18	(0.73-1.90)	1.10	(0.35-3.50)	REF	
	Other	REF		REF		REF		1.32	(0.49-3.59	REF			
Certification	Explosives Detection	**1.28**	**(1.02-1.62)**	1.40	(0.63-3.11)	2.07	(0.86-4.98)	2.04	(0.85-4.92)	1.19	(0.94-1.52)	1.03	(0.81-1.31)
	Patrol	1.47	(0.65-3.32)	REF		REF		REF		1.90	(0.84-4.29)	0.76	(0.32-1.81)
	Specialized Search	**7.15**	**(2.72-18.79)**	1.27	(0.46-3.55)	2.06	(0.69-6.13)	1.29	(0.42-3.92)	**2.20**	**(1.10-4.39)**	1.45	(0.73-2.88)
	Not Certified	0.58	(0.21-1.57)	0.36	(0.09-1.42)	2.57	(0.72-9.16)	0.32	(0.06-1.78)	-	-	-	-
	Drug Detection	REF		1.23	(0.55-2.79)	2.02	(0.82-4.94)	1.78	(0.73-4.37)	REF		REF	
Military Branch	Air Force	1.24	(0.93-1.65)	**1.52**	**(1.14-2.04)**	REF		1.06	(0.79-1.41)	1.04	(0.77-1.40)	**1.51**	**(1.11-2.06)**
	Army	1.11	(0.83-1.48)	**1.35**	**(1.01-1.81)**	0.98	(0.78-1.22)	0.95	(0.71-1.28)	1.04	(0.77-1.40)	1.34	(0.98-1.82)
	Marine Corps	1.12	(0.74-1.70)	1.50	(0.99-2.28)	**1.81**	**(1.25-2.62)**	0.80	(0.52-1.22)	0.86	(0.55-1.32)	1.10	(0.71-1.70)
	Navy	REF			(0.26-3.79)	1.20	(0.90-1.61)	REF		REF		REF	(0.56-2.21)
Location	OCONUS	**1.47**	**(1.18-1.84)**	1.13	(0.91-1.42)	1.07	(0.86-1.34)	1.21	(0.97-1.52)	1.19	(0.95-1.49)	1.04	(0.83-1.30)
	CONUS	REF		REF		REF		REF		REF		REF	

REF=regression reference level; OR=Odds Ratio; CI=Confidence Interval; CONUS: Continental US; OCONUS: Outside continental US. Bold values are statistically significant (p≤0.05)

from analysis to maintain a full picture of what items veterinary providers are placing on the MPL. We compared these data to studies addressing non-military owned canines presenting to civilian veterinary facilities.[10,11] In one study that examined private veterinary practices in the United States, dental problems was listed as the highest prevalence among canines.[10] Dental calculus and gingivitis were the most commonly reported dental disorders.[11] In another study, skin (dermatologic), non-specific, gastrointestinal (alimentary), musculoskeletal, and dental were the most common categories of problems addressed among canines during direct observation of veterinary encounters.[11] The most common dental clinical sign reported in the study was dental calculus.[11]

A previous study of MWDs revealed that dogs certified in patrol and explosives detection were at increased risk of dental conditions.[5] In the present study analysis showed dogs older than 3 years, certified in specialized search, and located OCONUS were more likely to have a dental condition listed on their MPL during the study period. Further epidemiologic study to identify the specific cause of tooth fracture among military working dogs is warranted. This can help determine treatment requirements as well as possible prevention strategies to reduce the number of tooth traumas requiring treatment.

One possible explanation for MWDs potentially having greater predisposition to dental fractures and extractions when compared to non-MWDs is housing and training requirements. The literature reports that traumatic dental disease can occur due to dog behavior in the kennel.[12] Some dogs tend to chew on metal pans, fencing, and other materials to alleviate boredom, which can result in dental fractures that require endodontic treatment.[12] Though one study stated that bite training rarely results in tooth fractures[12], another included bite training as a risk factor.[5]

Dermatologic Conditions

Dermatologic conditions also affected more than half of the MWDs in this study (Table 2). Two studies of problems encountered in private civilian practice identified dermatologic problems as the most common observed.[11,13] Another study had dermatologic conditions

Table 4. Statistically significant multivariable risk factors associated with the top five master problem list entries (n=1666 MWDs)

Variable	Category	Dental Conditions n=864 affected MWDs OR	(95%CI)	Dermatologic Conditions n=854 affected MWDs OR	(95%CI)	Surgical Conditions n=737 affected MWDs OR	(95%CI)	Soft Tissue-related Injury Conditions n=711 affected MWDs OR	(95%CI)	Alimentary Conditions n=659 affected MWDs OR	(95%CI)	Musculoskeletal Conditions n=640 affected MWDs OR	(95%CI)
Age	≤3 yrs	REF		REF		**6.78**	**(3.65-12.61)**	REF		REF		REF	
	>3 yrs to ≤6 yrs	**2.70**	**(1.84-3.96)**	**3.20**	**(2.17-4.72)**	**36.8**	**(21.2-64.0)**	**3.59**	**(2.36-5.46)**	**1.80**	**(1.22-2.65)**	**3.51**	**(2.04-6.03)**
	>6 yrs to ≤9yrs	**3.56**	**(2.39-5.31)**	**4.09**	**(2.73-6.11)**	**1.67**	**(0.93-3.00)**	**4.46**	**(2.89-6.88)**	**1.82**	**(1.22-2.71)**	**10.3**	**(5.95-17.8)**
	>9 yrs	**2.14**	**(1.35-3.38)**	**3.33**	**(2.10-5.27)**	REF		**2.35**	**(1.43-3.85)**	**1.61**	**(1.01-2.56)**	**15.1**	**(8.33-27.42)**
Sex	Male	*		**1.90**	**(1.50-2.40)**	*		*		*		**1.33**	**(1.03-1.72)**
	Female	*		REF		*		*		*		REF	
Breed	Belgian Malinois	*		*		*		**1.67**	**(1.35-2.07)**	*		**3.01**	**(1.60-5.68)**
	Dutch Shepherd	*		*		*		1.28	(0.73-2.25)	*		**3.09**	**(1.33-7.16)**
	German Shepherd	*		*		*		REF		*		**2.85**	**(1.51-5.38)**
	Labrador Retriever	*		*		*		1.22	(0.75-1.99)	*		REF	
	Other	*		*		*		1.43	(0.52-3.98)	*		0.73	(0.14-3.78)
Certification	Drug Detection	REF		*		*		*		REF		*	
	Explosives Detection	1.23	(0.97-1.57)	*		*		*		1.19	(0.94-1.53)	*	
	Patrol	1.06	(0.45-2.50)	*		*		*		1.95	(0.86-4.42)	*	
	Specialized Search	**7.82**	**(2.90-21.1)**	*		*		*		**2.30**	**(1.14-4.63)**	*	
	Untrained	1.24	(0.43-3.57)	*		*		*		*		*	
Military Branch	Air Force	*		**1.58**	**(1.17-2.14)**	1.17	(0.88-1.56)	*		*		*	
	Army	*		**1.40**	**(1.04-1.90)**	REF		*		*		*	
	Marine Corps	*		1.49	(0.97-2.27)	**1.85**	**(1.14-3.01)**	*		*		*	
	Navy	*		REF		1.02	(0.70-1.47)	*		*		*	
Location	OCONUS	**1.43**	**(1.13-1.81)**	*		*		*		*		*	
	CONUS	REF		*		*		*		*		*	

REF=regression reference level; OR=Odds Ratio; CI=Confidence Interval; CONUS: Continental US; OCONUS: Outside continental US. Bold values are statistically significant (p≤0.05).
*Variable not included in stepwise logistic regression risk factor model/no statistically significant associations with any variable level.

in the top five, but multiple dermatologic conditions were listed separately among all problems, making direct comparison difficult.[10] The most common dermatologic issues in the present study included otitis, dermatitis, scrotal dermatitis, hygroma, and aural hematoma (Table 2). Otitis, dermatitis, and aural hematoma were also reported as common dermatologic issues among canines presented to civilian veterinary clinics.[10,11,13] These data suggest scrotal dermatitis and hygroma diagnoses may be more common entries on the MWD MPL. Both scrotal dermatitis and hygroma were noted as prevalent conditions of MWDs in a previous study.[12]

In the present study, age, sex, and military service branch were identified as risk factors for dermatologic conditions. Though these conditions can develop at any age, these data suggest the conditions are more likely to develop once an MWD is older than 3 years. Dermatologic conditions were also noted to be more common among males and among all branches except the Navy. A possible explanation for the increased risk among male dogs is scrotal dermatitis due to being housed on concrete kennel floors[5,6,12] Other factors that could contribute to dermatologic conditions include kennel humidity, moisture exposure, geographic location, and MWD husbandry. Scrotal dermatitis was also reported in previous studies of MWDs.[5,6] Why risk for dermatologic disease is decreased among Navy-owned MWDs is unknown. Further epidemiologic investigation into causes of dermatologic conditions as well as housing and preventive care of Navy-owned MWDs to identify possible explanations for these findings is warranted. Further analysis of husbandry and geographic location could also help identify the cause and prevention of these conditions. In addition, continuing education or training events emphasizing these disorders for both VCOs and veterinary support personnel could advance the diagnosis and treatment of these disorders.

Surgical Conditions

The most common surgical conditions identified in this study were gastropexy, ovariectomy, incisional dehiscence,

caudectomy, and ovariohysterectomy (Table 2). In one study of private clinical practice, castration and ovariohysterectomy were the top two surgical procedures performed.[14] Risk factors for surgical conditions included age and branch of service (Marine Corps). Routine surgeries such as spay, neuter, and gastropexy are more often performed on younger dogs, which likely explains this trend. This was one reason surgical entries were excluded in a study of young MWDs.[5] Further analysis is necessary to determine why Marine Corps MWDs were more likely to have a surgical condition MPL entries during the study period, even when controlling for age. Incisional dehiscence could be attributed to the behavior of MWDs and difficulty keeping them from licking, biting, and chewing surgical incisions. Further work to identify best practices for post-surgical care of MWDs, along with training of MWD handlers is warranted. The use of a bucket in place of the commercially available Elizabethan collar has had success in preventing MWDs from self-trauma.[12] It is not surprising that caudectomy is high on the list of surgical conditions. We identified tail tip trauma as the second leading soft tissue-related injury, which in chronic cases, is often treated by surgical removal of the tail (caudectomy). Possible causes of tail tip trauma are identified in the next section.

Soft Tissue-Related Injury Conditions

The most common soft tissue-related injury conditions included laceration, tail tip trauma, abrasions, cutaneous wound, and toenail fracture. Many of these conditions can occur due to kennel behavior and kennel conditions.[12] Tail tip trauma can occur when MWDs develop the habit of spinning in their kennels, causing repeat trauma to the tip of their tail when it hits the kennel wall.[6,12] These chronic spinners often need to have their tails amputated (caudectomy) to prevent continued trauma. Consideration of less invasive, nonsurgical intervention such as behavior modification through enrichment activities, altered work-rest cycles, or alternate kennel construction to prevent kennel-related injury is warranted. A previous study revealed MWDs certified in patrol and explosives detection or drug detection were more likely to experience soft tissue-related injuries.[5] We did not find an association between duty certification and soft tissue-related injury, but did note the Belgian Malinois breed and ages 3 years and older were risk factors. Further research to investigate root cause of these injuries in warranted to prevent the conditions.

Alimentary conditions

The most common alimentary condition MPL entries included diarrhea, vomiting, enteritis, gastroenteritis, and colitis (Table 2). Frequency of gastrointestinal illness also ranked highly among dogs presented to civilian veterinary facilities.[10,11,13,15] Risk factors for alimentary conditions among MWDs included age (>3 yrs) and duty certification (specialized search). These results differ from a study of young MWDs, where breed, sex, military branch, and duty certification were identified as risk factors for alimentary conditions.[5] The top alimentary conditions in that study included giardia, and over or underweight, which may account for the differences we see when compared to our study of older MWDs.[5] Based on these data, it appears as though MWDs are not unique from non-military canines with respect to alimentary conditions. Further studies to determine underlying causes of these non-specific gastrointestinal illness clinical symptoms is warranted. The results could assist veterinary teams to be more prepared to diagnose and treat underlying causes of these conditions.

Musculoskeletal Conditions

The most common musculoskeletal conditions included hindlimb lameness, forelimb lameness, lameness (location not specified), joint swelling, and spondylosis. Musculoskeletal problems also ranked highly among dogs presented to private clinical practice, with lameness also commonly reported.[10,11,13,15] In a study of young dogs (average age 2.6 years), it was noted that musculoskeletal conditions were not as frequent as expected (13.6%).[5] The authors concluded this may be due the young population of dogs in their study not yet being diagnosed with a condition that may develop chronically.[5] In the present study which includes dogs of all ages, we noted that the percentage of musculoskeletal injuries was higher (38.4%), as expected. The median age of the population in the current study was 5.3 years, versus 2.6 years in the study of young dogs.[5] Other factors, associated with musculoskeletal injuries in this study were breed, sex, and military branch. Male dogs older than 3 years old were more likely to experience musculoskeletal conditions than those less than 3 years and female. This trend is not unexpected as the most common musculoskeletal injuries (lameness and joint swelling) tend to occur as dogs age and work more.[7]demographic and medical data were collected for 794 MWDs from the U.S. Army, Air Force, Navy, and Marine Corps that deployed to Iraq between March 20, 2003 and December 31, 2007. Sixty-two percent (n = 490 The literature also shows that sex can increase canine risk for musculoskeletal injuries.[7,16,17]demographic and medical data were collected for 794 MWDs from the U.S. Army, Air Force, Navy, and Marine Corps that deployed to Iraq between March 20, 2003 and December 31, 2007. Sixty-two percent (n = 490 Similar to alimentary conditions, further investigation into the root causes of musculoskeletal conditions is warranted.

The present study and comparison studies all report dermatologic, soft tissue-related injury, alimentary, and musculoskeletal illness/injury among the top six illness/injury categories. This information can inform MWD husbandry, handler training, and medical training of veterinarians and veterinary support staff. Placing training priorities on diagnosis and treatment of these common medical problems, in addition to the previously discussed dental and surgical problems (one or

both of which were excluded from comparison studies) will account for 66.0% of the MWD medical problems VCOs can expect to observe in MWD patients, even when considering previous studies of deployed MWDs.[6,8]

Limitations

Though these data expand and complement existing data on MWD medical conditions, there are some limitations. MPL entries require manual entry by veterinary medical personnel. If the MPL is not updated at each veterinary medical encounter, it can lead to inaccuracies in the data set. In addition, MPL entry may vary from provider to provider, with some providers only placing more severe conditions on the MPL, which could lead to under representation of minor conditions.[5] MPL entries can either be selected from a drop down menu or entered as free text, and many of the same conditions have different MPL descriptions. Because of this, all MPL entries had to be categorized by hand. It is possible some incorrect categorization occurred due to human error. In the present study, spay/neuter status of the MWDs was not known. Other studies did identify associations between spay or neuter status and health outcomes.[5,18] The ability to export an accurate spay or neuter status from VSSM along with MPL entries could expand this study to include factors associated with spay or neuter status. Another identified limitation is VSSM does not allow for the easy export of categorized veterinary encounter data. The requirement to categorize MPL entries by hand is a laborious and inefficient process.[8]input of senior veterinary subject matter experts, and feedback from the field. To date, no data have been published describing the cases presented to DOD-owned Veterinary Treatment Facilities (VTFs The VSSM must be improved to allow for processes to easily code encounter data so analysis can be conducted in a more accurate and timely manner. Many of the MPL entries are clinical signs, not specific diagnoses. More specific prevention strategies and training packages could be developed if there were an exportable, specific diagnosis entry capability in VSSM.

Conclusion

We identified dental, dermatologic, surgical, soft tissue-related injury, alimentary, and musculoskeletal MPL entries as the leading recorded conditions affecting a global population of MWDs from 1 January 2018 through 31 December 2021. The factors associated with each of the conditions varied, but included MWD age, sex, breed, duty certification, military branch of service, and location (CONUS versus OCONUS). These data reveal multiple areas where efforts can be made to improve training considerations for VCOs, veterinary medical personnel, MWD handlers, and kennel staff, and preventive medicine and routine care of MWDs to enhance overall health. Continued efforts to increase efficiency of retrieving and analyzing categorized data from VSSM will improve timeliness and accuracy of future studies, allowing for more rapid and informed decision making.

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Diagnosis, Treatment, and Rehabilitation of a SOF Multi-Purpose Canine (MPC) with Sacral Osteochondrosis Causing Degenerative Lumbosacral Stenosis

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Abstract

A 7th Special Forces Group (SFG) (Airborne) Multi-Purpose Canine (MPC) with an intervertebral calcified sacral osteochondritis dissecans (OCD) causing lumbosacral disease clinical signs successfully returned to duty following dorsal laminectomy and focused rehabilitation. Keys to this case included early anatomic diagnosis and tailored surgical intervention followed by dedicated rehabilitation performed by the handler and overseen by attending Group Veterinarian. A 4-year-old, male-castrated, Belgian Malinois was presented for an approximately 6-week history of decreased drive and pain on spinal extension. No neurological abnormalities were identified on focused exam. Computed tomography (CT) findings demonstrated extradural compressive radiculopathy due to intervertebral disk protrusion and sacral osteochondrosis. The patient underwent a dorsal laminectomy centered over L7-S1 nine days after the report. A rehabilitation plan was instituted immediately following surgery. Rehabilitation equipment was crafted utilizing found materials and the existing obstacle course. The patient was returned to duty with no restrictions seven months after surgery. To the best of the authors' knowledge, this is the first reported case of an MPC returning to duty following dorsal laminectomy. Previous retrospective studies suggest a return-to-duty rate for military working dogs undergoing dorsal laminectomy between 41-75%. Cost analysis of this case indicates that the replacement cost for a MPC significantly exceeds the cost of performing surgery and rehabilitation. Future research is required to determine the efficacy of rehabilitation conducted at home station and the true return-to-duty rate for dogs who have undergone dorsal laminectomy.

Keywords: Canine lumbosacral disease, canine rehabilitation, military working dog, sacral osteochondritis dissecans, dorsal laminectomy

Introduction

Degenerative lumbosacral stenosis (DLSS) is a multifactorial degenerative disorder caused by a variety of anatomical abnormalities at the lumbosacral junction. While the condition is considered one disease, there are various anatomic causes for the clinical signs. Separate treatments may be recommended based on the anatomical cause. Recognized causes include intervertebral disc herniation, transitional vertebra, congenital osseous stenosis of the vertebral canal or intervertebral foramina, sacral osteochondrosis, proliferation of the joint capsules or ligaments, osteophytosis of the articular processes, epidural fibrosis, and instability or malalignment of the L7-S1 vertebral articulation. These changes can occur individually or in combination. The presence of these anatomic alterations causes physical deformation or compression of the nerve roots directly or through altered biomechanics leading to proliferation and hypertrophy of the soft tissues.[1] These nerve roots, as part of the cauda equina, are much less susceptible to compression than the spinal cord itself. As a result, the prevailing physical exam finding associated with the disorder is lower back pain. Pain may worsen with exercise then subside after a period of rest. Neurological abnormalities of the sciatic, perineal, and pelvic nerves can occur leading to decreased withdrawal, perineal reflex, or anal tone. When DLSS is suspected, advanced imaging is necessary for diagnosis, treatment, and prognosis.[2]

DLSS has long been suspected as a significant source of morbidity amongst Military Working Dogs (MWDs). Multi-Purpose Canines (MPCs) are specialized working dogs for Special Operations Forces. To the best of the authors' knowledge,

there is no published data on the prevalence of DLSS in these dogs nor is the disease broken out by anatomic cause(s). Retrospective studies performed on U.S. MWDs and New Zealand police canines suggest approximately 16-30% of dogs were retired from service due to spinal cord disease and/or back pain. [3-5] Imaging is needed to differentiate causes of the pain to best understand prevalence. Military veterinarians should endeavor to create an open dialogue between radiologists, surgeons, and the attending veterinarian to develop the best treatment plan for an affected dog.

While both conservative and surgical treatments have been described for DLSS, there is limited literature to suggest the most efficacious regimen and the true return-to-duty rate for working dogs largely because the condition is grouped as one diagnosis and not broken down by anatomic causes.[2] In 2000, Jones *et. al*. reported 8 of 12 MWDs successfully returned to duty following surgical intervention. The study followed the dogs for six months and there was no mention of a targeted rehabilitation program.[6] In 2003, Linn *et. al.* published a study of 29 MWDs who underwent surgical intervention following diagnosis of DLSS. Twelve (41%) returned to normal function, eleven (38%) improved, and six (20%) never returned to active duty. Eight of the twenty-three dogs who returned to duty experienced a recurrence of clinical signs within twenty-one months. Unsurprisingly, younger dogs and those with mild clinical signs at the time of surgery were more likely to return to work. Two key factors may have contributed to the lower return to duty rates in the literature. First, the anatomic cause for DLSS was not described. Second, there was no mention of a rehabilitation protocol.[7]

The utilization of rehabilitation with DLSS in MWDs has been published. In 2014, Henderson evaluated the effects of a core conditioning program in MWDs, eight of which had evidence of lumbosacral pain and eight who appeared to be pain free. Results suggested that a core conditioning program could yield observable improvement in typical tasks required of MWDs when evaluated by an objective functional test. Additionally, the study was able to demonstrate an increase in the cross-sectional area, symmetry, and density of the paraspinal muscles associated with the lumbosacral region.[8]

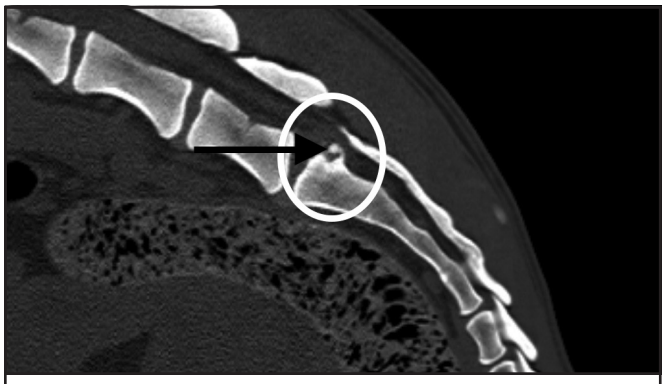

Figure 1. Extended lumbosacral CT-image demonstrates the 3.0 x 5.0 mm rounded lucent defect within the right dorsal aspect of the cranial vertebral endplate of S1 (black arrow). Defect was interpreted as sacral osteochondrosis. Lesion presumed as inciting component for DLSS signs in this dog. Secondary changes also present in image (white circle), including intervertebral disc protrusion. Considerable amount of fibrous material protruding into the spinal canal during surgery. Image courtesy of LTC T. Kimbrell.

While all referenced studies had limitations, they suggest that there is the potential for consistently successful return-to-duty for working dogs suffering from DLSS. This case report attempts to provide further evidence that some anatomic causes for DLSS can be treated successfully with early diagnosis, tailored surgical planning, and a dedicated, team rehabilitation approach. This study also discusses the cost of veterinary treatment for DLSS to include surgery, official travel, and rehabilitation within Army Veterinary Services in comparison to the acquisition cost of a new dog.

Case Report

On May 13, 2021, a 4-year-old, male-intact, Belgian Malinois presented for an approximately 2-week history of decreased drive, pain in lumbar extension, and intermittent hematuria. Radiographic and sonographic imaging demonstrated prostatomegaly and prostatic cysts. The patient was diagnosed with prostatitis. He was placed on enrofloxacin and gabapentin with a plan to castrate in 60 days.

On June 03, 2021, the patient was re-evaluated by a visiting clinical specialist. Diminished work effort was partially resolved, but the patient demonstrated persistent pain associated with lumbar extension. A computed tomography scan of the lumbar and caudal spine demonstrated multiple findings associated with the lumbosacral joint. There was a 5.0 mm diameter rounded lucent defect approximately 3.0 mm deep within the right dorsal aspect of the cranial vertebral endplate of S1 (Figure 1). There was also a 3.0 x 4.0 x 3.0 mm angular mineral attenuating structure present within the vertebral canal immediately adjacent to this lucent defect. When the hindlimbs were placed in extension, the L7-S1 intervertebral disc was noted to extend dorsally into the vertebral canal, compressing the cauda equina. When the hindlimbs were placed in flexion, the cauda equina compression largely resolved but displacement persisted on the right side adjacent to the previously described mineral structure within the canal. These changes were interpreted as dynamic L7-S1 ventral extradural compressive radiculopathy due to intervertebral disc protrusion and sacral osteochondrosis (OCD). After consultation with a board-certified veterinary surgeon, the patient was considered a candidate for decompressive surgery based on the OCD cause for compression.

The patient underwent a dorsal laminectomy on June 25, 2021. Gross findings were consistent with radiographic findings (Figure 2). There were grossly apparent bony changes

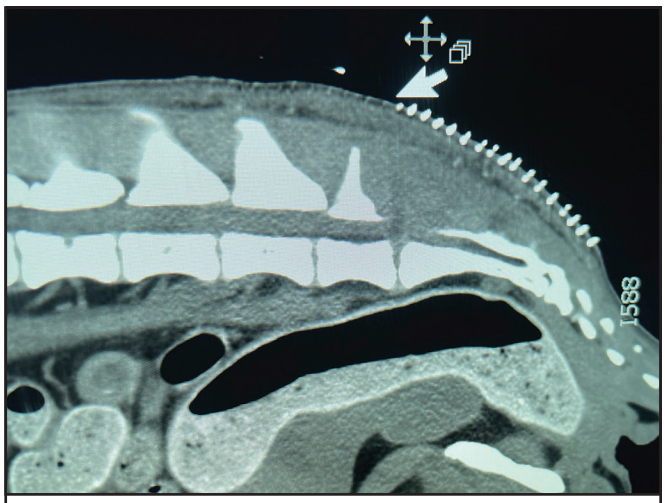

Figure 2. Post-op CT-image demonstrates resolution of the OCD lesion. OCD lesion behaved like a "rock in a shoe" in LS space. Removal was necessary to eliminate chronic inflammation/irritation from cauda equina compression. Image courtesy of LTC T. Kimbrell.

surrounding the right vertebral foramen. There was significant ventral fibrotic protrusion into the spinal canal in the area of the disc space. The right side of the spinal cord and the right L7-S1 nerve root were grossly light red. These changes were considered most likely secondary to chronic inflammation. The mineralized OCD lesion was removed prior to closure and there were no significant surgical or anesthetic concerns.

Rehabilitation principles were instituted immediately postoperatively.

The patient's rehabilitative plan was conceptually broken into three broad phases based upon tissue healing: the inflammatory phase, the repair phase, and the maturation phase. Modifications to the rehab plan were made by the attending Group Veterinarian based upon the patient's progression and available resources. After the patient successfully completed the protocol, he transitioned into a reconditioning program administered by the Group Veterinarian and his handler. Reconditioning was defined as a shift in focus away from the tissues of the affected segment to a focus on the entire body to address any biomechanical abnormalities that may affect the canine athlete.[9] Generally, the patient progressed as expected post-operatively. The progression was not always linear, and each phase presented its own unique challenges. A transcribed version of the patient's rehabilitation plan may be found at:

https://medcoe.army.mil/the-medical-journal-archive/

Please note that the included plan is representative of rehabilitative sessions completed by the Group Veterinarian and the handler. It is not meant to serve as a protocol for future clinical requirements.

The inflammatory phase was expected to peak 72-hours postoperatively and was expected to last for ten to fourteen days. Goals during this phase were prioritized as appropriate application of supportive care, pain management, and safe, controlled mobility. The patient was able to voluntarily urinate and defecate immediately following surgery. Initially, his pain was managed by injectable narcotics. He transitioned to oral pain relievers within thirty-six hours. At that time, the patient was willingly sitting sternally and consistently attempting to rise to a standing position. The primary rehabilitative modalities utilized were therapeutic massage, cold-packing of the incision site, passive range-of-motion exercises, and gradual introduction of therapeutic exercise. After surgery, the patient was restricted to walking on a flat surface with good traction for no more than five minutes at a time. At the conclusion of this phase, the patient had graduated to walking on an inclined surface for 10-15 minutes. The patient was continuously supervised by the handler. When he could not be supervised, the patient was kept in a crate. A key piece of equipment that was required for this phase was a two-part harness borrowed from the Fort Belvoir VETCEN (Figure 3). Therapeutic exercise during this phase consisted of slow, controlled walks progressing in duration and incline as the patient tolerated. Towards the end of this phase, the patient was taught to "place" front paws and rear paws on a raised platform. This training paid dividends as more advanced therapeutic exercise was used in the next phase.

The repair phase followed the inflammatory phase and was expected to be complete between 4-6 weeks post-operatively. Goals for this phase included improving the patient's mobility; conditioning the active stabilizers of the spinal column; and a gradual, progressive return to low impact working tasks.

Figure 3. The patient was voluntarily walking only a few hours after surgery. Here he is being shown while supported by the surgeon and his handler using a two-part harness. The patient remained in this harness for approximately two weeks. Image courtesy of CPT B. Von Schaumburg.

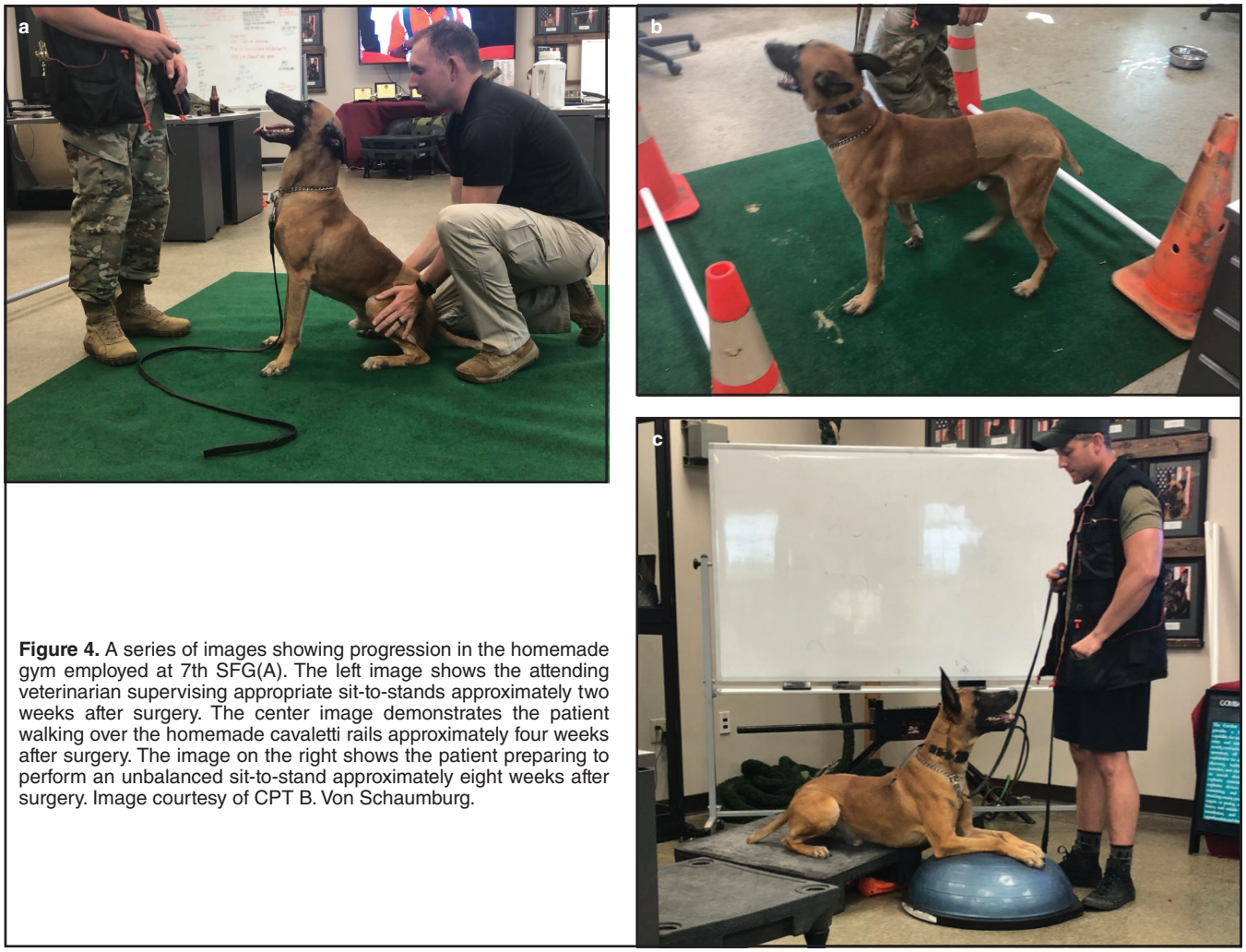

Figure 4. A series of images showing progression in the homemade gym employed at 7th SFG(A). The left image shows the attending veterinarian supervising appropriate sit-to-stands approximately two weeks after surgery. The center image demonstrates the patient walking over the homemade cavaletti rails approximately four weeks after surgery. The image on the right shows the patient preparing to perform an unbalanced sit-to-stand approximately eight weeks after surgery. Image courtesy of CPT B. Von Schaumburg.

The patient remained on oral carprofen and gabapentin to control his pain. The patient underwent daily physical therapy sessions with the primary focus being on therapeutic exercise. Initially, the attending Group Veterinarian conducted each session. Within two weeks, that frequency had diminished to three times a week. These sessions commonly took place in an open space of the 7th SFG(A) handlers' office. The attending veterinarian and the patient's handler constructed a gym to enable the recommended exercises.

The kennel facility (see Figure 4) already possessed a treadmill and agility training platforms. A 12' x 12' section of astro-turf was repurposed to provide a non-skid surface. Tall traffic cones were procured from the Group engineers. They were utilized as weave poles and later as standards to support cavaletti rails. Plastic bumpers, the type commonly used to train retrievers, were re-purposed to provide instability underneath a platform. A half-ball and exercise bands were procured from the physical therapy department. These tools provided the basis for the patient's therapeutic exercise program. The patient was taught sit-to-stands, weaves, and to walk over cavaletti rails. The patient was started at a very basic level for all three exercises. Sit-to-stands were taught from a level surface. The patient had to be encouraged to engage both hind limbs to perform the exercise correctly. Progression started with an unbalanced sit-to-stand on the forelimbs, proceeded to an unbalanced sit-to-stand on the hindlimbs, and eventually to an unbalanced sit-to-stand on all four limbs. For weaves, the patient was encouraged to take very wide circles with cones spaced widely apart. Eventually, he progressed to traditional weaves amongst narrow poles. The patient started with cavaletti rails on the ground. As the patient progressed both the height of the rails and the number of repetitions were increased. Food reward and an obedient heel were critical components to ensure the patient slowly walked over the rails. Accessory exercises such as swimming, walking upstairs, and pushing a desk chair with forelimbs elevated were incorporated as the patient progressed towards the final phase.

Figure 5. The patient waits to move up the ladder 16 weeks after surgery. He was able to wait in this fully extended position with no apparent discomfort. Once released, he was able to climb the A-frame with speed and power. Image courtesy of CPT B. Von Schaumburg.

The maturation phase is never expected to be complete. The passive structures affected by the surgery were expected to be healed by eight to twelve weeks.[10] Given that DLSS is a dynamic disease, it's expected that the patient will benefit from veterinarian-directed sports medicine with an emphasis on the active structures in the lumbosacral region. The goal of this phase was to transition the patient to a reconditioning program. Early in this phase, the standard obstacle course was utilized heavily (Figure 5). The patient was gradually re-introduced to tasks typically asked of an MPC. He was asked to climb stairs, starting with the large steps, and progressing to a ladder. He was asked to low-crawl underneath obstacles and through tunnels. He was asked to navigate cat walks and jump over obstacles. As the patient progressed, the number of obstacles, the complexity of the course, and the number of repetitions were increased. Accessory exercises such as endurance walks (simulating an overland movement) and swimming became more prevalent. The patient was gradually re-introduced to explosives detection, tracking, and finally bite work in that order. By January 2022 - seven months after surgery - the patient was considered fit for duty and re-certified as a fully mission capable MPC. At the time of this writing, he had shown no clinical signs of recurrence.

Discussion

To the best of the authors' knowledge, this is the first published case report of an active-duty MPC who successfully returned to duty following a dorsal laminectomy and rehabilitation. There were several contributing factors to success in this case. First, the patient was young, well-conditioned prior to surgery, and his clinical signs were mild and early in disease progression. The anatomic cause for the compression was amenable to dorsal laminectomy as a treatment and included cauda equina compression that was alleviated by the surgery. Second, the handler and assigned Group Veterinarian demonstrated unwavering dedication throughout the rehab process. The handler remained committed to almost daily rehab sessions for eight weeks without fail and the veterinarian continuously tailored the rehabilitation plan based on performance. Third, the command was supportive of the special requirements and long convalescence required by the patient. It would be inappropriate to speculate on the relative impact of each of these factors, but the authors recommend they be examined in future case selection.

This case provides an interesting cost-analysis that may warrant further discussion amongst military clinicians and accountable unit commanders (AUC) responsible for MWDs. This patient was able to receive a dorsal laminectomy and post-op care at a military veterinary treatment facility (the Fort Belvoir VETCEN) for approximately $2,717.41. This includes the cost of official travel for 2 people, one veterinarian and one handler, to drive the dog to and from home station at Eglin Air Force Base. Once the patient returned to home station, the homemade gym cost $189.16. The owning unit invested seven months into convalescence for this patient. While procurement costs and replacement times vary across the enterprise, these figures suggest that there may be significant cost and time savings to the AUC given a successful return-to-duty.

The follow-up question is obvious – what is the true return-to-duty rate for active duty working dogs who undergo a surgical procedure for DLSS and subsequently undergo a rehabilitation protocol? Based on our review of the literature, there are currently no veterinary publications that address that question. Previous studies in military working dogs focus on return-to-duty following surgical decompression. Though dated, their results suggest a return-to-duty rate between 41-75%. Neither study documented a specific rehabilitation protocol and follow-up in Jones' study was limited to six months.[6-7] Studies from the civilian veterinary literature suggest between 79-85% of patients are "improved", "normal" or "resolved" following surgical decompression.[11-13] The 2000 study by Danielsonn, et.al. reported 78% of "very active/working dogs" returned to being very active / working at the time of follow-up. The 2008 study by Suwankong, et. al., did not specifically describe the outcome for working dogs though 10 were included. The 2012 study by Hankins, et. al. reported all four working dogs returned to full work in 14 months. The type of work was not delineated. Studies from the civilian veterinarian literature should be interpreted with caution as they typically rely upon owner feedback in a majority pet population.

This case demonstrates that decompressive surgery followed by a rehab program performed at home-station can be successful. This case suggests that this course of treatment may yield a cost benefit to the government. The authors assumed

that the rehabilitation protocol administered at home-station enhanced the success of this case and that the return-to-duty rates could be higher than published with a tailored surgery and rehabilitation approach. Future studies should focus on return-to-duty rates specific to the anatomic cause of DLSS following surgery combined with a dedicated team rehabilitation protocol.

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Possible Brown Recluse Spider (*Loxosceles reclusa*) Envenomation in a Military Working Dog

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Abstract

A four-year-old male intact German Shepherd Military Working Dog (MWD) presented to Eglin Air Force Base Veterinary Treatment Facility for acute onset right forelimb lameness and swelling. Initial physical exam findings included severe pain, edema, heat, and ecchymosis of the right elbow. No puncture wounds were noted on the shaved elbow, and there were no bony changes or foreign materials on the two-view elbow radiographs. In addition, the MWD showed signs of systemic illness meeting the diagnostic criteria for systemic inflammatory response syndrome. The abnormal findings of the elbow progressed, requiring extensive wound management and reconstructive surgery. Due to the severe local and systemic clinical signs and report of a spider in the MWD's environment, brown recluse spider envenomation (BRSE) was suspected. Reports of canine BRSE are uncommon, and the extreme local and systemic manifestations seen in this case were unanticipated. This MWD was in critical condition for over 72 hours, required 16 surgeries, and over 100 days of treatment before returning to duty without limitations. This case report highlights critical care interventions used in a canine BRSE with systemic manifestations and the successful wound management strategies in this MWD.

Keywords: canine loxoscelism, spider envenomation, dermonecrotic, systemic inflammatory response syndrome

Introduction

The Brown Recluse (*Loxosceles reclusa*) spider's (BRS) natural habitat within the continental United States ranges from central Texas, north to middle Indiana, and south and eastern to northwest Florida.[1] The BRS is typically between 8-13 mm in length with legs measuring 20-30 mm.[2] BRS tend to be brown but can vary between yellow-brown to gray-brown (Figure 1).[2] Although often known for the violin or fiddle-shaped marking on their back, the most accurate way to identify a BRS are the six eyes in a U-shaped pattern with space between each pair in combination with its coloration.[2]

BRS venom is a potent mixture of enzymes including sphingomyelinase D (SMase D), hyaluronidase, alkaline phosphatase, collagenase, esterase, ribonuclease, and deoxyribonuclease.[2] The complexity of the venom may account for the range of reported clinical signs – mild, local reaction to life-threatening manifestations.[2] SMase D activates matrix metalloproteinases, which in turn activate complement, alter transmembrane proteins, prevent activation of Protein C, and induce apoptosis, leading to the exuberant immune response and resulting dermonecrosis.[2]

In a 2009 comprehensive review, Pace and Vetter[2] describe the scarcity of companion animal BRSE research and literature as well as the difficulty in diagnostically confirming a BRSE. The authors know only one published case report of BRSE in a canine.[3] The patient, a four-year-old female poodle in Brazil, presented with two extensive, necrotic skin lesions along the dorsum that were painful on palpation.[3] Systemically, the patient had mild anemia and a neutrophilic leukocytosis with a left shift.[3] The patient had histopathology performed on the lesions, demonstrating extensive coagulation necrosis and interstitial inflammatory infiltrate. The patient was treated with wound care and systemic antibiotics and recovered two months after presentation.[3] The owners located a brown spider in their residence, but it could not be positively identified.[3]

While severe systemic involvement secondary to BRSE is unreported in veterinary literature, other canine wound management data could offer insight into possible sequelae. A retrospective case study from 2014 showed that among canine patients with bite wounds that required surgical intervention, 54.3% developed systemic inflammatory response syndrome (SIRS).[4] That case study defined SIRS as having two or more

Figure 1. Diagnostic Brown Recluse Spider Eye Pattern.
The brown recluse spider is the only spider in North America with 3 evenly spaced pairs of eyes in a U-shaped pattern with the yellow-brown to gray-brown body coloration.

of the following during the same day of hospitalization: (1) temperature <37.8°C (100.0°F) or >39.4°C (103.0°F), (2) heart rate >140 beats/min, (3) respiratory rate >20 breaths/min, (4) total white blood cell count <6.0 $\times 10^9$/L or >16.0 $\times 10^9$/L, and (5) band neutrophils >3%.[4] These patients with SIRS were 6.3 times more likely to die versus their counterparts.[4] This case report describes another possible BRSE in a canine that not only resulted in severe dermonecrotic lesions and systemic manifestations previously undescribed in canines.

Case Description

A four-year-old male intact German Shepherd MWD presented for acute onset right forelimb lameness and swelling to the Eglin Air Force Base Veterinary Treatment Facility (VTF). The MWD's history included working off-leash in the woods earlier in the day with no reported incidents. At the evening kennel checks, he was non-weight-bearing lame on the front right leg, and veterinary personnel were immediately contacted. On initial physical exam, he was tachycardic with a heart rate of 170 beats/ min, panting, and had a high-normal temperature of 102.3 °F. He was non-weight bearing on the right front leg and severely painful on gentle manipulation of the right elbow. The limb was warm and had moderate edema. The limb was clipped and revealed ecchymosis of the medial elbow measuring 32 cm in circumference. Baseline photographs were taken to monitor for size and color change (Figure 2). No puncture wounds were appreciated, and mediolateral and craniocaudal radiographs of the right elbow did not demonstrate any bony changes or metallic or bone density foreign bodies. As seen in Table 1, a complete blood count and serum chemistry revealed moderately elevated alkaline phosphatase (ALP) of 641 IU/L (reference range, 20 - 150 IU/L), severe elevation of alanine transaminase (ALT) of 1196 IU/L (reference range, 10-118 IU/L), and

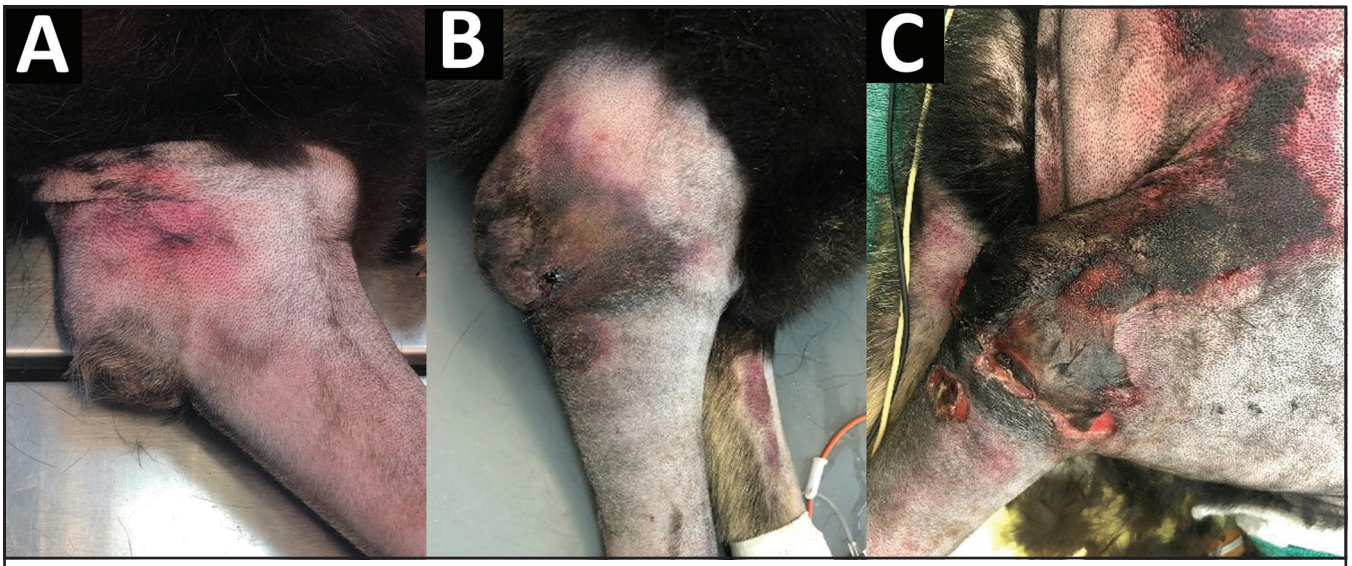

Figure 2. Early Progression of Dermal Lesions.
Ecchymosis and local erythema noted at presentation on day 1 (A). Progression of the ecchymosis, swelling, and discharge noted on day 2 (B). Development of dermonecrosis on day 3 at presentation to the Fort Benning Veterinary Center (C).

Table 1. Clinicopathologic data during initial hospitalization.

	Reference Range	Day 1 VTF	Day 2 VTF	Day 3 VTF	Day 3 VETCEN	Day 4 VETCEN	Day 5 VETCEN
White Blood Cells	6.00 - 17.00 (10^9/L)	6.8	8.0	8.2	13.2	27.7	14.1
Neutrophils	3.00 - 12.00 (10^9/L	5.9	7.0	7.6	12.4	26.2	12.6
Platelets	165-500 (10^9 cells/L)	63.0	95.0	105.0	97.0	39.0	46.0
Albumin	2.5-4.4 (g/dL)	2.0	1.7	1.5	1.6	1.0	1.0
Alkaline phosphatase	20-150 (IU/L)	641	810	736	730	665	636
Alanine aminotransferase	10-118 (IU/L)	1196	856	758	790	671	577
Total bilirubin	0.1-0.6 (mg/dL)	0.4	0.6	1.3	1.0	1.4	0.7
Prothrombin time	14-19 seconds	17.9	20.5	21.0	-	-	-
Activated partial thromboplastin time	75-105 seconds	90.6	122.4	133.4	-	-	-
Calcium	8.6 - 11.8 mg/dL	4.6	9.2	8.1	9.2	8.6	8.4
Potassium	3.7 - 5.8 mmol/L	6.2	6.2	5.3	5.9	4.0	3.0

MWD's biochemical parameters over the first days of hospitalization. Day 1 was the initial presentation for right forelimb lameness. The patient was medically evacuated from the Eglin Air Force Base Veterinary Treatment Facility (VTF) to the Fort Benning Veterinary Center (VETCEN) on Day 3.

severe thrombocytopenia of 63 × 10^3 cells/μL (reference range, 165-500 × 10^9 cells/L). At presentation, the problem list included severe right forelimb lameness (localized to the elbow with concurrent moderate to severe swelling, ecchymosis, and pain), tachycardia, tachypnea, hyperthermia, thrombocytopenia, and hepatopathy. The combination of severe clinical signs localized to the right elbow and systemic signs consistent with SIRS raised the concern for sepsis or non-infectious insult with the right elbow as the probable source. Specific differential diagnoses included septic or sterile arthropathy, and snake or spider envenomation. The patient was hospitalized overnight for supportive care, including pain management with buprenorphine (0.01 mg/kg IV), crystalloid IV fluid administration, and monitoring.

Over the next 24 hours, the patient continued to deteriorate. He remained tachycardic and was minimally responsive to opioid pain management. His temperature ranged between 102.5- 104.1 °F. The ecchymosis was expanding and becoming circumferential around the right elbow, with the caudal aspect darkening to green – purple. The edema also expanded distally (Figure 2). Biochemically, ALP and ALT remained elevated at 810 IU/L and 856 IU/L respectively. The patient developed mild bilirubinemia at 0.6 mg/dL (reference range, 0.1- 0.6 mg/dL) and mildly prolonged clotting times (prothrombin [PT] at 20.5 s [reference range, 14- 19 s]) and activated partial thromboplastin (aPTT) at 122.4 s (reference range, 75- 105 s). The thrombocytopenia slightly improved at 95 × 10^9 cells/L. Intravenous antibiotics (ampicillin sodium with sulbactam sodium, 15 mg/kg/ 8 h) were started for potential septicemia, and multimodal analgesia was initiated utilizing hydromorphone (0.1 mg/kg IV/ 8- 12 h) in addition to a lidocaine constant rate infusion (CRI) (50 mcg/kg/min). Maropitant (1 mg/kg) was given subcutaneously every 24 hours following an episode of vomiting. At this point, the systemic clinical signs had expanded to include vomiting, hyperbilirubinemia, and indicators concerning for disseminated intravascular coagulation (eg, thrombocytopenia, prolonged PT, and prolonged aPTT). A sterile arthrocentesis for cytology and culture revealed a hazy, viscous fluid with numerous red blood cells and a broadly antimicrobial-susceptible beta streptococcus.

On day 3, the patient continued to decline. He became depressed and remained intermittently febrile. Despite the current analgesic plan, the right elbow became severely swollen and increasingly painful. A serous discharge developed, and areas on the caudal aspect of the elbow displayed necrosis (see Figure 2). Systemic inflammation was also worsening with development of a moderate hypoalbuminemia at 1.5 g/dL (reference range, 2.5- 4.4 g/dL) and mild hyperbilirubinemia at 1.3 mg/dL, which is highlighted in Table 1. Given the worsening clinical signs and need for advanced care, the patient was medically evacuated to a Role 3 veterinary center (VETCEN) at Fort Moore (formerly Fort Benning), Georgia. While the patient was en route to the VETCEN on the morning of day 2, a brown spider was found in the patient's run at Eglin Air Force Base. Since Eglin Air Force Base lies just on the eastern border of the reported BRS range, this find increased suspicion of a spider envenomation as the underlying etiology of the patient's clinical signs.

Once received and triaged, the patient was sedated for a computed tomography scan, which identified swelling of the right elbow with subcutaneous gas pockets. The stomach was severely distended with food despite 48 hours of fasting. The patient was anesthetized at the VETCEN for jugular intravenous catheter placement, and samples were taken for blood culture (positive for beta streptococcus G). A joint aspirate for cytologic evaluation was red and hazy with abundant

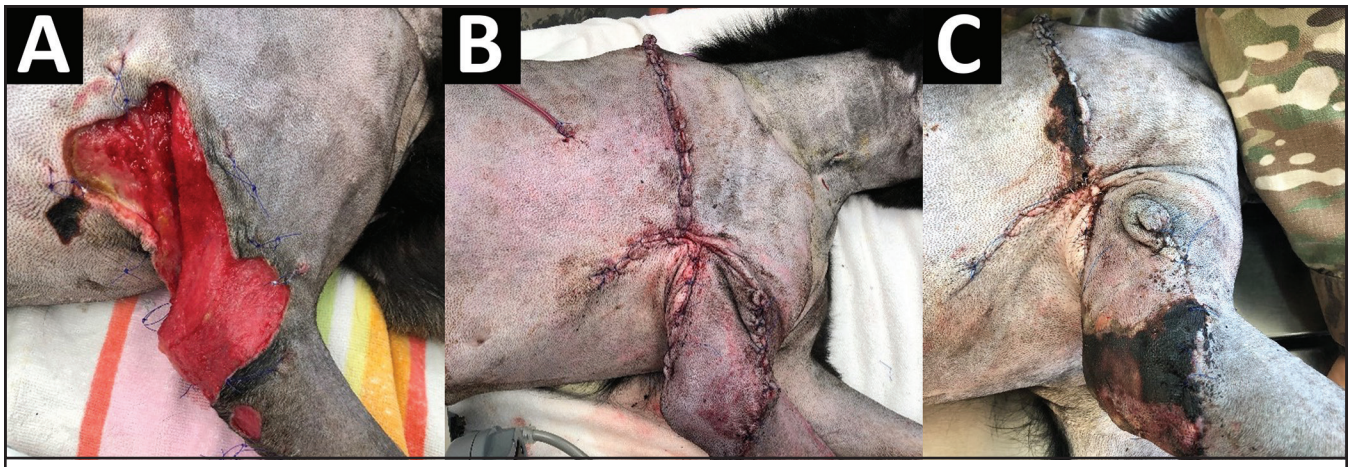

Figure 3. Surgical Treatment of the Right Elbow Wound
Initial surgical debridement on Day 4 (A). Thoracodorsal axial pattern flap performed on day 15 (B). Failure of the flap on day 22 after returning to home station (C).

non-degenerate neutrophils and few foamy macrophages. Specific gravity and total protein were not measured due to insufficient volume, but findings were consistent with an inflammatory arthropathy. Supportive care was continued with crystalloid intravenous fluids, lidocaine CRI, hydromorphone boluses, and ampicillin sodium with sulbactam sodium. The systemic clinical signs and hepatopathy improved throughout the next 48 hours of hospitalization, as noted in Table 1, and the pain was controlled. The right elbow wound became more necrotic requiring more extensive wound management.

The patient was placed under general anesthesia for wound management on day five. The wound was surgically debrided (Figure 3) and flushed with a sterile lactated Ringer solution. A wet-to-dry debridement bandage was placed with hypertonic saline-soaked laparotomy pads and covered in a modified Robert-Jones bandage. Samples of the skin and tissues were submitted for bacterial culture and susceptibility as well as histopathology. Bacterial culture grew primarily susceptible isolates of *Proteus mirabilis*, *Pseudomonas aeruginosa*, and *Staphylococcus hominis hominis*. Histopathologic results showed a necrosuppurative cellulitis consistent with bacterial infection with or without concurrent toxin (including venom) exposure. A complete blood count revealed an inflammatory leukogram with persistent thrombocytopenia. Blood chemistries, shown in Table 1, revealed persistent elevated hepatic enzymes (ALP and ALT), hypocalcemia, and hypokalemia. Wound management with wet-to-dry bandaging continued for several days as necrotic tissue continued to declare. Exudate in the bandage on day 10 was concerning for *Pseudomonas* infection, which was confirmed on culture. A silver-impregnated gauze was placed to help with topical control of possible multidrug-resistant bacteria and left in place for 72 hours. During this period, the MWD was monitored as an outpatient, and the hypocalcemia, hypoalbuminemia, inflammatory leukogram, and thrombocytopenia resolved.

On day 13, the MWD was placed under general anesthesia for vacuum-assisted closure (VAC) and was hospitalized for the following 48 hours for negative pressure wound therapy (NPWT) and monitoring. On blood chemistries, the hypokalemia resolved, and the hepatic enzymes continued to improve. Wound bacterial culture and susceptibility taken during surgery and returned during this time revealed the growth of *Escherichia coli* and *Proteus* organisms, both susceptible to current antibiotics.

Initial wound closure was performed on day 15. A thoracodorsal axial pattern flap was created and transposed into the wound. An active suction drain was placed to decrease pocketing at the donor site (see Figure 3). The limb was bandaged to protect the flap and to provide immobilization. The drain was removed 72 hours later. On day 21, blood chemistry abnormalities had completely resolved, and the MWD had a final bandage change under deep sedation at the VETCEN. He was discharged to his home station for daily bandage changes.

The tip of the flap began to necrose over the next several days (see Figure 3). The wound started producing green sweet-smelling discharge on day 22, and sterile samples were obtained from under the flap and submitted for bacterial culture and susceptibility. The patient was referred to the VETCEN on day 27 for additional care.

On examination, the flap had completely failed (see Figure 3), and the wound culture was positive for *Pseudomonas* organisms. Given the failure of the first flap and the ongoing infection concerns, attending clinicians faced a significant decision point. Amputate the right forelimb or continue with

wound management. Given all factors, it was decided to continue with a limb-salvaging course of treatment. The wound was completely opened (including the donor bed) for three days, and managed with daily surgical debridement, flushing, and hypertonic saline wet-to-dry bandage. On day 30, silver-impregnated gauze was placed in the wound, and NPWT was again used for 72 hours.

The NPWT bandage was removed on day 35, and the wound was deemed suitable for primary closure. Given the lack of skin, a right axillary hinge flap was performed (Figure 4). The patient was started on intravenous gentamicin (6 mg/kg every 24 hours) based on culture results for resistant *Pseudomonas*, *Proteus*, and *Staphylococcus* species. Daily urine sediment exams were conducted to evaluate for renal damage. A bandage was placed to immobilize the limb and prevent weight bearing. The MWD was discharged for outpatient care on day 37 with bandage management via outpatient visits as needed.

On day 49, the MWD returned to the VETCEN to release the flap and close the elbow wound. The wound was significantly improved, and bacterial cultures only yielded *Enterococcus*. Gentamicin was continued for another seven days before being discontinued. On day 51, the MWD was released to his home station for follow-up every two to three days for wound evaluation.

On day 57, an area of tissue necrosis developed at the caudal point of the elbow measuring roughly 1 cm in diameter, which was sterilely sampled and submitted for bacterial culture and susceptibility. On day 62, the MWD was rechecked at the VETCEN. The necrotic eschar had fully declared itself and fallen off (Figure 5), and the culture results indicated resistant *Pseudomonas* organisms. Surgical debridement, wet-to-dry bandages, and gentamycin with daily urine sediment checks were initiated. A VAC device was placed on the wound on day 66 and maintained for 72 hours.

On day 70, the MWD was placed under general anesthesia, and the wound on the caudal elbow was closed. The leg was splinted post-operatively to decrease movement. Bacterial culture grew both multidrug-resistant *Pseudomonas* organisms and drug resistant *Enterobacter aerogenes*. Gentamicin was continued, and enrofloxacin was added. The bandage was checked and changed daily until day 72 when he was released back to his home station. Bandage changes then occurred every three to four days or as needed.

On day 79, the MWD presented to the VETCEN for reevaluation. The front right leg had slight weight-bearing lameness, but he could ambulate well. The wound was healing appropriately. Gentamycin was discontinued, and enrofloxacin was continued until day 81. Video gait analysis was obtained and submitted to a canine rehabilitation specialist for a rehabilitation plan. On day 87, the MWD returned to the VETCEN for a wound recheck and neurologic and orthopedic exams

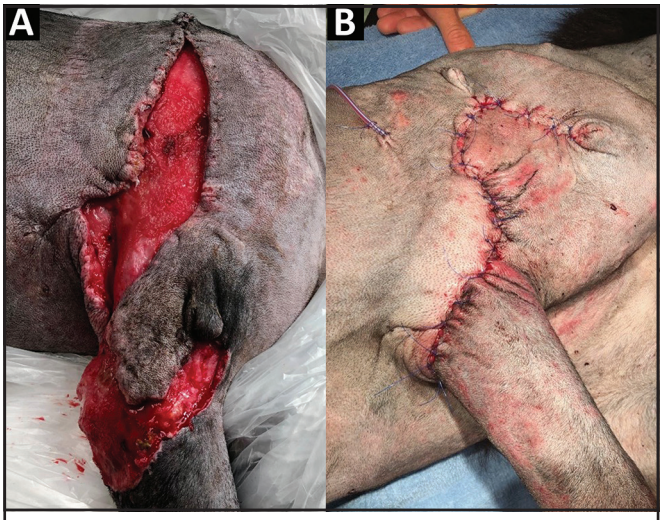

Figure 4. Failure of First Flap and Completion of Second Flap. Wound after tissue debridement following flap failure on day 27 (A). Completion of the right axillary hinge flap on day 35 (B).

focused on the right forelimb. A small superficial wound was noted on the elbow, but granulation tissue was present, and other tissues were healthy. A mild weight-bearing lameness was noted with decreased range of motion in extension of the right shoulder joint. On day 101, the MWD returned to the VETCEN for his final follow-up. All wounds had completely healed, and fur had regrown to cover the limb except for one scar measuring roughly 0.5 cm wide by 7 cm long mid-way down the chest on the right side (see Figure 5). The only remaining physical exam abnormalities were decreased range of motion of the right shoulder joint (mainly decreased extension) and decreased elbow abduction, likely secondary to scarring from the skin grafts. He was able to return to full work with no limitations to his deployability.

Discussion

This case report illustrates the potential for severe systemic and local effects of a possible BRSE in a canine. In humans, most BRSE cases have no clinical signs or are limited to local irritation.[2] A small percentage of cases will have more severe local effects, and they rarely progress to systemic signs, although these can include death.[2] Clinical manifestations in canines are poorly described, and definitive diagnosis is challenging.[2] Nearly all of the current companion animal BRSE epidemiologic information and treatment recommendations are extrapolated from human literature.[2] The risk in only referencing human responses to BRSE is that there is significant variation in mammalian tissue reactions to spider envenomation.[2] For example, Isbister et al[5] chronicled humans and dogs envenomated by spiders of the family Theraphosidae in Australia. While the clinical signs in humans were mild, all seven canines died.[5] As an example for *Loxosceles* envenomation, rats and mice do not develop dermonecrotic lesions,

Figure 5. Final Stages of Wound Healing.
Focal area of tissue necrosis on day 62 (A). Wound on day 101 after completing all treatments. Note the only remaining disfigurement being the caudally running scar (white arrow) at mid-right-thorax (B).

while guinea pigs and rabbits can.[2] Interestingly, Schenone et al[6] described two dogs that succumbed when >17 venom glands of *L. laeta* were injected intradermally, while four dogs that had <15 glands showed no effects. The severity of the case presented in this report, combined with the lack of clearly documented epidemiology of BRSE in canines, emphasizes the need for further understanding of this toxicity.

Pace and Vetter[2] also describe the difficulty in diagnostically confirming a BRSE, as there is currently no commercially available diagnostic test. They proposed criteria for grouping envenomations: proven, probable, and possible envenomations.[2] For a proven envenomation, the spider must be recovered immediately and close to the clinical reaction, and an arachnologist must provide positive identification.[2] For a probable envenomation, a positively identified spider must be nearby, in a region where they are known to occur, and with a typical lesion verified by clinical experts.[2] For a possible envenomation, the lesion must be typical of BRSE and in an area considered endemic to the species.[2] Based on these proposed criteria, the case report from Brazil[3] and this case report are categorized as possible envenomations since the spiders found in the animal's habitats were not positively identified.

Pace and Vetter[2] call for caution when considering BRSE as a diagnosis, and the authors agree. Numerous differentials must be considered. MWDs in the Department of Defense have a robust preventive healthcare plan, which includes semiannual examinations with laboratory diagnostic testing to monitor health status and screen for infectious diseases. This thorough medical management contrasts with many privately owned dogs where vaccination status, preventive parasiticide use, and husbandry are often incompletely known. The baseline of health in this patient, known history, controlled husbandry, lack of an identified infectious etiology, and report of

a spider around the time of the incident support a diagnosis of BRSE. While there was a positive bacterial culture early in the course of the disease, the acuteness of the presentation, severe pain and systemic inflammation on presentation, histopathologic results suggestive of toxin exposure, and subsequent severe dermonecrosis are more consistent with envenomation. The MWD had been working with no lameness or evidence of clinical disease earlier that same day.

This case demonstrated several important findings. The VTF, a Role 2 veterinary medical facility that treated and stabilized the MWD during the first 48 hours of care, was staffed by one Veterinary Corps officer and one animal care specialist. To provide the required 24-hour patient-oriented care the critical MWD required, the officer-in-charge declared a mass casualty (MASCAL) event. During these events, all efforts are redirected to patient care and stabilization while nonessential services are temporarily curtailed.

This case also benefitted from early, frequent, and clear communication. Two different veterinary clinical medicine officers (area of concentration 64F) specializing in small animal internal medicine and small animal veterinary surgery consulted from the beginning. They researched and formulated the best patient care plan possible with the many moving clinical problems. The electronic veterinary medical records clearly delineated what care was given on what day, for what problem(s), and what the plans were moving forward. These efforts synchronized the care across three locations, in three states, with five different veterinarians.

One or two handlers were required to accompany the MWD during treatment at the VETCEN, resulting in their absence for more than 30 days from their home station. For a unit of only five MWD handlers, this caused a significant logistical challenge to continue their home station mission while caring for the MWD. Their temporary relocation was also a fiscal burden to their command. Frequent communication to discuss treatment plans, prognosis, and timelines was crucial to achieving shared understanding and trust.

The resultant wounds from the suspected envenomation led to significant long-term morbidity in this case. The wound care plan required frequent adjustments and creative changes due to the concurrent impediments to wound healing. Most notably, frequent multidrug-resistant wound bed infections occurred and were mitigated by a multimodal antibiotic plan. NPWT created aerobic environments to combat some infectious organisms. Different gauze and bandaging techniques delivered high concentrations of antimicrobials and assisted in the delayed primary closure. These techniques, as well as the oral and injectable antibiotics, were selected based on frequent culture and susceptibility testing. As is typical with many wounds in the shoulder and elbow, tension and high mobility required tension-relieving techniques and skin grafting.

This case of a suspected BRSE nearly jeopardized the life and limb of the MWD and resulted in over 100 days of recovery and extensive wound management. With dedicated care, clear provider communication, and the generous partnership and support of the MWD-owning unit, this MWD returned to duty. The unusual clinical presentation demonstrates the need for more research in canine BRSE and the adoption of standardized diagnostic criteria to understand BRSE in canines better. Clinicians should cautiously consider BRSE in endemic areas while attempting to exclude other causes of dermal necrosis.

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A Suspected Infectious Disease Outbreak in a Military Working Dog Kennel in Japan: A Case Series

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Abstract

Introduction: Infectious diseases are often important contributors to morbidity and mortality in dogs. In kennel environments, dog density, herd immunity, cleaning practices, dog to dog contact, and environmental factors can significantly influence infectious disease transmission rates. Dogs can easily transmit infectious diseases to one another, leading to increased morbidity and mortality in a population.

Background: Leptospirosis is a systemic disease in dogs caused by *Leptospira* bacteria. Susceptible canines typically acquire a leptospirosis infection from direct or indirect contact with urine or tissues of an infected animal. Leptospirosis serovars differ between the United States and Japan and can cause subclinical infections to severe systemic disease and death.

Case Series: This paper examines a population of eight military working dogs located in the Kanto Region of Japan that showed similar clinical signs of an infectious disease, from August to December 2021. Differential diagnoses considered for the suspected infectious disease outbreak included leptospirosis, brucellosis, and mycoplasmosis. Isolation protocols were implemented, including the use of an alternate kennel facility. All dogs received antibiotics to limit suspected *Leptospira* urine shedding and shorten the duration of clinical signs.

Discussion: Only one dog had a positive leptospirosis urine PCR test. Limited positive test results may have resulted from various serovars, a dog's vaccination status, and limited testing modalities used on this population. It could have also been a result of a different, undiagnosed, infectious disease outbreak that was not originally considered.

Conclusion: All dogs were treated successfully and returned to duty. Strict isolation protocols were followed, preventing spread of the suspected infection to one dog.

Keywords: leptospirosis, military working dog, infectious disease, outbreak, kennel, Japan

Introduction

Infectious disease is an important cause of morbidity and mortality in dogs. In dogs, hundreds of infectious pathogens, some of which are zoonotic, have been described and identified and more continue to emerge in canine populations.[1,2] Transmission of infectious diseases can be increased when dogs are located in a shared environment, such as a kennel or hospital.[3,4] Infectious agents vary in environmental stability, transmission modes, infectivity, virulence, and pathogenicity.[5] Individual canine factors that can influence disease transmission include age, health status, acquired immunity from previous infection or vaccination, preventative care, and hygiene of dog handlers and caretakers.[5] Within a kennel environment, dog density, herd immunity, cleaning practices, and the amount of dog to dog contact can influence transmission rates. Environmental factors such as weather and proximity to wildlife influence exposure to infectious agents due to their impact on disease vectors and potential to contaminate water sources.[5] Kennels and other shared housing facilities must strive to prevent or reduce the transmission of infectious diseases via direct contact, aerosol and fomite spread. This process is influenced by many factors including kennel design, population density, and vaccination status.

Background

Leptospirosis is a systemic disease of humans and domestic animals, including dogs, that is caused by spirochete bacteria in the genus *Leptospira*.[6] Most commonly diagnosed canine pathogenic serovars belong to the *Leptospira interrogans* species, with the exception that the serovar

Leptospira grippotyphosa is typically classified as a *Leptospira kirschneri* species.[7] Approximately six to eight *Leptospira* serovars (groups within a single species of microorganisms which share distinctive surface antigens) are thought to be pathogenic in the dog.[8] Historically, most cases of leptospirosis in dogs in North America were associated with infections caused by the serovar *Leptospira canicola*, with dogs serving as maintenance hosts, or by the serovar *Leptospira icterohemorrhagiae*.[9] These two serovars were found in the long-existing bivalent vaccines since they were considered most common.[7] Serologic evidence in North American dogs has shown an increase in predominant disease causing serovars to include *L. grippotyphosa*, *Leptospira pomona*, *Leptospira bratislava* and *Leptospira autumnalis*.[9] Vaccinations available in the United States today protect against *L. grippotyphosa, L. pomona, L. canicola*, and *L. icterohaemorrhagiae*.[10,11,12]

In Japan, studies have shown that the prominent serovar leading to high morbidity in dogs is *Leptospira hebdomadis*, followed by *Leptospira australis*, and *L. autumnalis*.[13,14] Other studies have reported that *L. icterohaemorrhagiae* is most common, followed by *L. autumnalis*, *L. canicola*, *L. hebdomadis*, and *L. australis*.[15] Vaccinations available in Japan include a bivalent vaccine that contains *L. icterohaemorrhagiae* and *L. canicola* and a trivalent vaccine that contains *L. copenhageni* (a closely related serovar to *L. icterohaemorrhagiae*), *L. canicola* and *L. hebdomadis*.[15] Currently, there is no vaccine available that contains *L. australis* or *L. autumnalis*; however, serology results do not always accurately predict the infecting serovar, and there is cross-reactivity between serovars.[7, 14]

Susceptible canines typically acquire a leptospirosis infection from direct or indirect contact with urine or tissues of an infected animal.[6] Transmission from indirect contact likely occurs in areas where infected urine persists in the environment. Mice are known to serve as a reservoir for *L. icterohaemorrhagiae* and rats are a known reservoir for *L. copenhageni*, harboring the bacteria in their kidneys and shedding it in their urine, often without signs of disease.[6,7] Cats have been shown to be seropositive for *L. pomona* and *L. bratislava*, but commonly do not show signs of clinical disease.[16] Stray cats are common in Japan and a study done on the island of Okinawa indicated that cats were seropositive for *Leptospira borgpetersenii* serogroup Javanica and also for *L. hebdomadis*, the latter which has been known to infect dogs.[17] It is possible that these, or different serogroups of *Leptospira*, may be present in the stray cat population in mainland Japan. Pigs, which are commonly farmed in Japan, may harbor *L. pomona* or *L. bratislava*.[18] In addition to these vectors of transmission, warm temperatures in combination with wet conditions favor organism survival and outbreaks are often seen following periods of rain.[7] Incidence of disease is significantly higher in warm-climate countries due to longer survival of the bacteria in warm, humid conditions.[18]

Clinical signs of leptospirosis in dogs are non-specific, and laboratory tests are required to obtain a definitive diagnosis. Signs vary from subclinical to mild clinical disease, to severe disease affecting the kidneys, liver or lungs.[7] Abdominal pain, anuria to polyuria, polydipsia, fever, icterus, vomiting, diarrhea, inappetence, lethargy, coagulation disorders, or a combination of these clinical signs may be noted.[6,19] In breeding populations, reproductive syndromes, including abortion, premature, or weak puppies may be seen.[6] At this time, there is weak evidence of any correlation between the infecting serovar with a dog's clinical presentation.[19]

Laboratory blood chemistry abnormalities often include azotemia, but literature may be biased as often only clinically ill dogs are tested, and in experimental infections, subclinical disease is common.[7] Electrolyte abnormalities may be noted with severe kidney dysfunction. Hepatic dysfunction may be noted by increases in serum alanine transaminase (ALT), aspartate aminotransferase (AST), alkaline phosphatase (ALP), and total bilirubin concentration.[19] On complete blood counts (CBC), thrombocytopenia is common and a mild to moderate non-regenerative anemia may be noted.[19] Urinalysis can show hematuria, bilirubinuria, glucosuria, proteinuria, pyuria, and isosthenuria or hyposthenuria.[19]

Current treatment for leptospirosis in dogs consists of antimicrobial therapy with doxycycline, at 5 milligrams per kilogram (mg/kg) orally or intravenously (IV) for two weeks.[19] For patients that do not tolerate treatment with doxycycline, ampicillin can be administered at 20 mg/kg IV every six hours until gastrointestinal distress has subsided, but is not recommended for definitive treatment.[19] Hemodialysis can be utilized in severely affected anuric patients.[19] To minimize risk of transmission in a hospital or kennel setting, affected patients should be kept away from high-traffic areas and only allowed to urinate in a designated, restricted area.[19] Personnel providing care should wear gloves, a disposable gown, protective eyewear or a face shield, and should wash hands before and after handling each patient.[19] Areas contaminated with infected urine should be cleaned with disinfectants such as a 10% bleach, accelerated hydrogen peroxide, or quaternary ammonium solutions.[19]

This paper aims to describe an infectious disease outbreak, where leptospirosis was a differential diagnosis, in a population of military working dogs in a kennel environment in the Kanto Region of Japan, the capabilities used to combat the outbreak, and the challenges with isolation and treatment of the outbreak.

Case Series

Canine Population and Presentation of Clinical Signs

The kennel population affected by the outbreak consisted of eight military working dogs at the time of the first presentation

Table 1. Military working dog demographics at the time of the outbreak, indicating sex, age, breed, and date of last leptospirosis vaccination.

	Sex	Age (Year, Month)	Breed	Date of Last Vaccination
Dog 1	Male	8 Y 3 M	German Shepherd Dog	17 JUN 2021
Dog 2	Male	4 Y 4 M	German Shepherd Dog	16 APR 2021
Dog 3	Male	5 Y 9 M	Belgian Malinois	03 NOV 2020
Dog 4	Female Spayed	4 Y 0 M	Belgian Malinois	12 AUG 2021
Dog 5	Male	3 Y 4 M	Belgian Malinois	10 MAY 2021
Dog 6	Male	4 Y 2 M	Belgian Malinois	17 MAY 2021
Dog 7	Male	4 Y 2 M	Belgian Malinois	18 MAY 2021
Dog 8	Male Neutered	11 Y 2 M	German Shepherd Dog	25 JUN 2021

of clinical signs (Table 1). All dogs were vaccinated annually for leptospirosis prior to the outbreak, with the most recent administered vaccination date shown in Table 1.[10]

On 28 August 2021, Dog 1 presented for a medical sick call with clinical signs of tenesmus, scooting and perianal swelling. On 31 August 2021, additional clinical signs were noted, including mucopurulent preputial discharge, and pain with palpation of the caudal abdomen and testicles. The handler also reported that the dog's drinking and urination habits had changed, with subjective signs of polyuria and polydipsia. Ultrasound exam of the prostate indicated prostatomegaly and small cysts throughout the parenchyma. By 2 September 2021, Dog 1 was anorexic.

On 3 September 2021, Dog 2 presented with similar clinical signs as Dog 1, consisting of tenesmus, hematuria, perianal swelling, mucopurulent preputial discharge, pain with palpation of the caudal abdomen and testicles, and prostatomegaly. This dog also developed stranguria by 15 September 2021. On 5 September 2021, Dog 3 presented with clinical signs of tenesmus, perianal swelling, mucopurulent preputial discharge, discomfort on rectal exam, and prostatomegaly. By 7 September 2021, Dog 3 also had caudal abdominal pain and scrotal pain with palpation. Urinary signs progressed to pollakiuria on 10 September 2021 and stranguria on 15 September 2021.

Dogs 4 through 7 showed similar clinical signs to the initial three cases, and the number of dogs affected by these clinical signs is summarized in Table 2. Dogs 4 through 7 presented for initial evaluations from 15 September 2021 to 23 November 2021 (Figure 1). Although initial clinical signs were similar for Dog 6 at initial presentation on 4 November 2021 when compared to all other affected dogs, this dog had a secondary set of clinical signs that presented on 25 December 2021. These clinical signs included regurgitation, dehydration, jaundice, and hepatomegaly which were concerning for acute hepatitis. Dog 8 did not develop clinical signs or symptoms at any point during the outbreak.

Differential Diagnoses

At the time of Dog 1's presentation, the primary differential diagnosis was acute prostatitis, due to the concentration of clinical signs surrounding the male reproductive tract and the ultrasonographic findings of the prostate. However, when similar clinical signs presented in Dog 2 and Dog 3, infectious etiologies were considered as more likely diagnoses, along with possible toxin exposure. Throughout the first few weeks of the suspected outbreak, multiple Veterinary Corps Officers (VCOs) were consulted from a variety of specialty fields, including surgery, internal medicine, theriogenology, and public health, to consider all possible underlying causes and to get input regarding additional diagnostics and treatment considerations. Initial consultation occurred with the local clinical specialist at the onset of clinical signs in Dog 1, and then outside consultation with additional specialists was performed after Dogs 2 and 3 showed similar clinical signs.

Brucellosis was initially considered as a differential diagnosis due to the intact status of the male dogs and recent travel history of two dogs (Okinawa, Japan and Diego Garcia, British

Table 2. Observed clinical signs in the military working dog population.

	Number of Dogs Affected	Percentage of Dogs Affected
Painful Scrotum and Testicles	6/8	75%
Tenesmus	6/8	75%
Mucopurulent Preputial Discharge	5/8	62.5%
Perianal Swelling	5/8	62.5%
Prostatomegaly	5/8	62.5%
Diarrhea	4/8	50%
Anorexia	3/8	37.5%
Lethargy	3/8	37.5%
Painful Caudal Abdomen	3/8	37.5%
Stranguria	3/8	37.5%

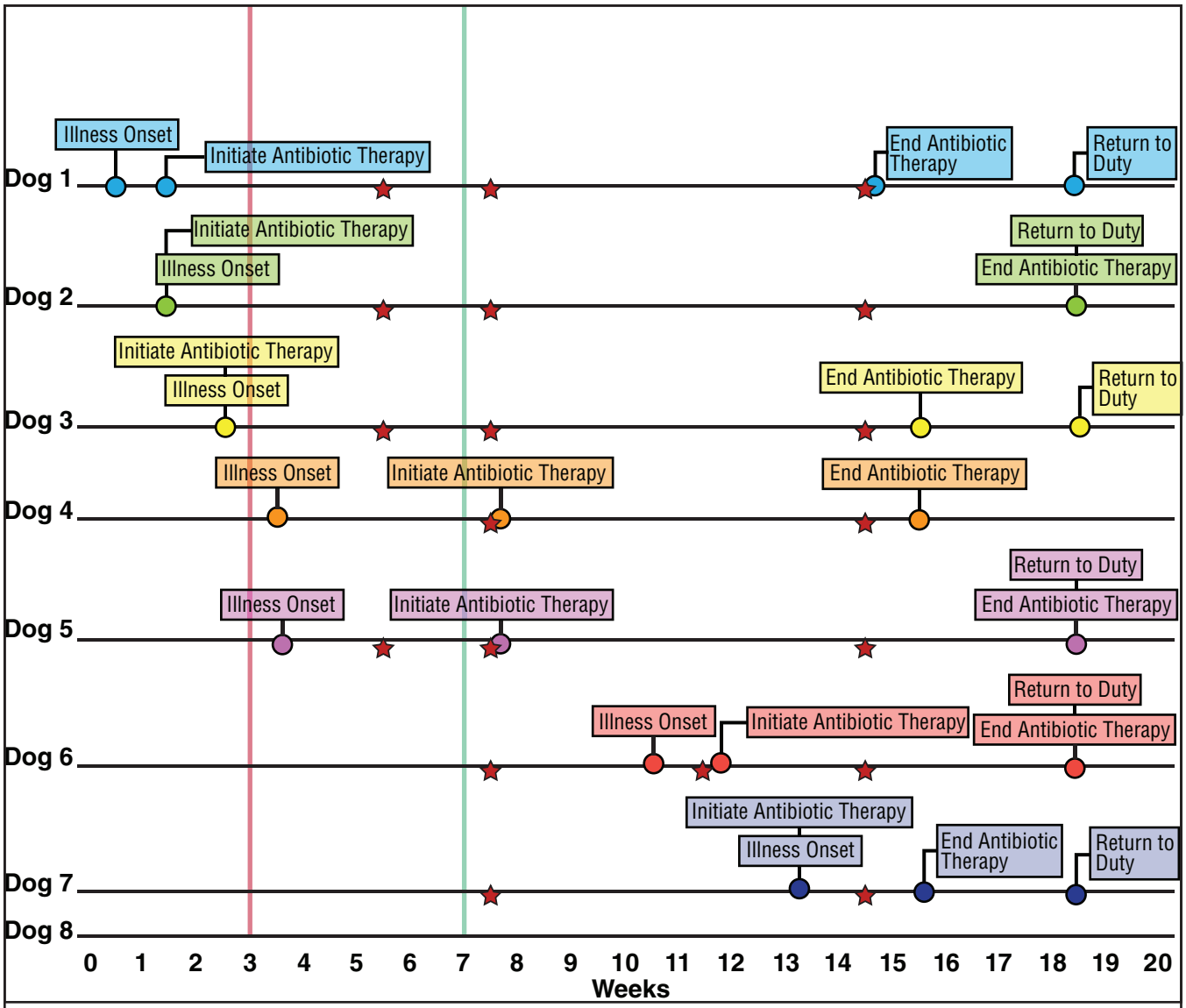

Figure 1. Chronological timeline of outbreak. Indicates illness onset, initiation of antibiotic therapy, end of antibiotic therapy, and return to duty for each military working dog. Dog 8 was not clinically affected. Vertical red line indicates initiation of isolation protocol within original kennel facility. Vertical green line indicates when remaining healthy dogs were moved to alternate location. Red stars indicate when leptospirosis testing was conducted.

Indian Ocean Territory). *Brucella canis* is known to target reproductive tissues including the prostate, testicles, and epididymides in males causing epididymitis, scrotal edema, and less frequently, orchitis.[20] However, these bacteria can also cause uveitis, discospondylitis, lymphadenitis and non-specific clinical signs such as fever, lethargy, decreased appetite, and weight loss.[20] Leptospirosis was another infectious etiology considered since it is a known worldwide zoonosis, especially prevalent in areas with higher annual rainfall and warm climates.[19] All dogs had the potential to be directly and indirectly exposed to leptospirosis through wildlife in the vicinity of the kennel or standing water due to the Kanto Region weather.

Although not considered as a differential diagnosis during the original outbreak, upon further review of the case series, *Mycoplasma canis* is another infectious disease that could have caused similar clinical signs. Clinical signs reported to occur in patients infected with *M. canis* include depression, anorexia, lethargy, dysuria, abdominal pain, and hematuria.[21] Some dogs have been shown to have prostatitis and epididymitis due to *M. canis* infection.[22] Mycoplasmas can be part of normal flora of canine mucous membranes, such as the urogenital tract, and can cause urinary tract infections by ascending from the lower urinary tract or genital tract.[21] It may be spread between dogs through contact with freshly voided urine.[22] *M. canis* can often be difficult to detect on

routine bacterial culture, but can be detected through urine PCR testing.[22, 23]

Isolation Protocols

At the time of the outbreak, all affected dogs were isolated from the remaining healthy dogs throughout the duration of the outbreak due to the top two differential diagnoses being infectious in nature. The kennel complex consisted of two rows of adjacent dog kennels, with a common access hallway in the center of the two rows of kennels. At the outset, Dog 1, Dog 2, and Dog 3 were moved to the far end of the kennel complex with two empty kennels between the affected dog kennels and the remaining healthy dog kennels. Dog 8, the oldest dog of the population, was moved to an individual isolation kennel in a separate part of the kennel facility to provide increased separation from any infected dog. Plastic sheeting was placed from ceiling to floor across the two rows of kennels and center hallway to separate the affected and healthy portions of the kennel, and separate care teams were designated to provide treatment to either the affected or unaffected population of dogs. Each population of dogs had a separate exit from the kennel to designated areas of the outdoor obstacle course yard, where they were not allowed to interact or use any shared space.

The care team treating the affected dogs wore personal protective equipment (PPE) consisting of disposable gowns, disposable nitrile gloves, disposable surgical masks, disposable surgical booties, and eye protection. When exiting the quarantine area, all disposable, single use PPE was placed into biohazard bags for disposal. Every dog had an individual thermometer, muzzle, and leash. Each dog also had an individual metal food and water pan that after being rinsed out, were cleaned with a bleach solution (1:10 dilution), followed by hot water and liquid dish soap, and then rinsed with water. All runs were cleaned twice daily with a cleaner and deodorant.[24]

Figure 2. Military working dog deployment kennels used to house remaining healthy dogs at an alternate location away from the primary kennel facility.

As the number of affected dogs increased, the three remaining healthy dogs (Dog 6, Dog 7, and Dog 8) were moved to an alternate location to try and prevent these dogs from becoming infected due to inadequate isolation space in the original kennel facility. The dogs were maintained in deployment kennels inside a building at the alternate location, as it was not a facility originally designed for animal use (Figure 2). At the alternate facility, a temporary obstacle course yard was constructed outside to continue the dogs' exercise regimen and obedience training. Dog 6 and Dog 7 eventually showed similar clinical signs of the infected kennel population and were then kept separate from the remaining healthy dog (Dog 8).

Diagnostic Testing

To try to rule in or out infection with *Brucella canis*, and due to the potential difficulty in diagnosing *Brucella canis*, more than one type of test was submitted to increase chances of detection since no single diagnostic test is completely satisfactory.[25] Serological testing was submitted through one laboratory for *Brucella canis*, and included a rapid slide agglutination (RSAT) test with 2-mercaptoethanol and an agar gel immunodiffusion test (AGID II).[26] *Brucella canis* antibody by IFA and *Brucella canis* PCR tests were submitted through a second laboratory.[27] Samples were submitted for testing approximately every two weeks for a period of three months, and then again in June 2022. All tests for *Brucella canis* in the infected dog population were negative.

Determine if leptospirosis was present in the canine population, leptospirosis enzyme-linked immunosorbent assay (ELISA) antibody testing was submitted, and upon initial testing, all affected dogs were positive except Dog 2; however, vaccinated dogs may have detectable antibodies on the assay.[27,28] Leptospirosis PCR testing was also completed on canine blood and urine.[26] Dog 1 tested positive for *Leptospira* on urine PCR on 2 October 2021, after receiving antibiotic therapy for approximately 10 to 14 days, and approximately one month after initial presentation of clinical signs. Dog 1 tested negative on *Leptospira* urine PCR in a subsequent sample sent two weeks later. All remaining dogs tested negative on both blood and urine samples submitted for PCR testing multiple times over a four-month period, with some samples being submitted before initiating antibiotic therapy and others while receiving antibiotic therapy (Figure 1).

Due to the clinical signs being atypical for leptospirosis, a canine vector-borne disease panel was submitted for Dogs 1, 2, and 3 to rule out any tick-borne infectious diseases, and all dogs tested negative.[27] Complete blood counts were completed for all affected dogs (Dogs 1 through 7) and there were no significant findings. Chemistry panels were completed for all dogs and five dogs had elevated liver enzymes, but all elevations were noted after starting doxycycline antibiotic therapy, which can cause an increase in liver enzymes.[29] Four of the

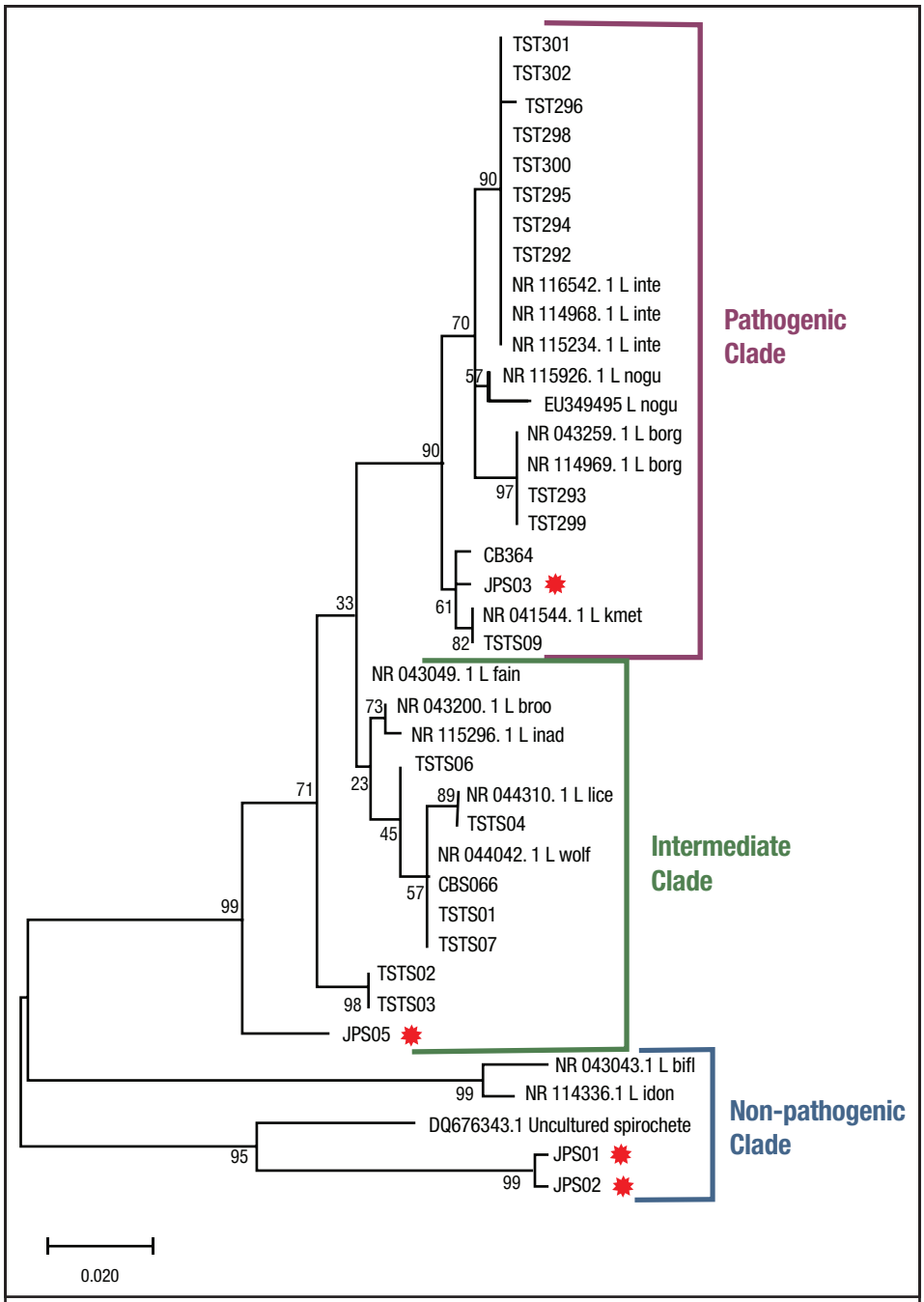

Figure 3. Phylogenetic tree of 16S rRNA gene of Leptospira spp. using the Maximum Composite Likelihood (MCL) method and Tamura-Nei model. The percentage of trees in which the associated taxa clustered together is shown next to the branches. The tree was generated automatically by applying the Neighbor-Join and BioNJ algorithms to a matrix of pairwise distances calculated using the MCL method, and then selecting the topology with the highest log likelihood value. The tree is to scale, with branch lengths measured in the number of substitutions per site. The red star indicates the positive samples gathered from soil testing.

dogs had a symmetric dimethylarginine (SDMA) test completed, and three of these dogs had mild elevations (15 to 17 micrograms per deciliter, with a normal reference interval of 0 to 14 micrograms per deciliter).[27] Dog 1 had a urine sample submitted for culture, prior to initiating antibiotic therapy, which indicated no growth. No other dogs had urine submitted for culture. A urinalysis was completed in all dogs, and abnormalities noted included hyposthenuria (Dog 3), proteinuria (Dog 1, 2, 5, 6), hematuria (Dog 1, 2, 7), and bilirubinuria (Dog 1, 4, 6, 7).

Samples of soil were obtained from the area surrounding the kennel and obstacle yard for DNA extraction. Four of the five soil samples were found to be positive for *Leptospira* using quantitative PCR (qPCR). Two samples were closely related to an uncultured spirochete *rrs* gene in a non-pathogenic *Leptospira* clade, one was associated with *Leptospira kmetyi* in a pathogenic *Leptospira* clade, and one was clustered in an intermediate clade (Figure 3).

Case Management

When Dog 1 presented as an individual case with a primary differential of prostatitis, antibiotic therapy was initiated with enrofloxacin at a dosage of 10 mg/kg IV every 24 hours. Amoxicillin and sulbactam was also prescribed at a dosage of 30 mg/kg IV every eight hours while urine culture and sensitivity results were pending following findings of hematuria, proteinuria, and struvite crystalluria. Dog 1 was also placed on carprofen at a dosage of 2.2 mg/kg orally every 12 hours. Oral enrofloxacin was started at a dosage of 10 mg/kg by 3 September 2021 and IV enrofloxacin therapy was discontinued. Supportive care for inappetence was administered with anti-nausea medications, including ondansetron at a dosage of 0.5 mg/kg IV every 12 hours, and maropitant citrate at a dosage of 1 mg/kg IV every 24 hours. Gastroprotectant medications were also administered (pantoprazole 1 mg/kg IV every 12 hours).

As additional dogs displayed clinical signs, and brucellosis and leptospirosis became the top two differential diagnoses, antibiotic treatment for each dog was initiated with doxycycline (10 mg/kg orally every 12 hours) and enrofloxacin (10 mg/kg orally every 24 hours) except for Dog 7, which only received doxycycline (Figure 1). Doxycycline was chosen as an antibiotic because it is noted to be effective in clearing leptospiremia, and *Brucella canis* isolated from dogs is usually susceptible to doxycycline.[24] Combination antibiotic therapy has been shown to be superior to single agent antibiotic therapy for *Brucella canis* and enrofloxacin has been shown to be beneficial when combined with doxycycline.[20] Some dogs also still had clinical signs concerning for mild prostatitis (prostatomegaly, prostatic cysts, pain on caudal abdominal palpation) and enrofloxacin is known to diffuse well into prostatic tissue.[30] Due to mild presenting clinical signs, Dog 4 and Dog 5 did not have antibiotic therapy started at the onset of clinical signs, in an attempt to collect and send out diagnostic blood and urine samples prior to initiating antibiotic therapy (Figure 1). All patients received carprofen as anti-inflammatory treatment (2.2 mg/kg orally every 12 hours), except if the dogs were anorexic, in which therapy was suspended until normal eating resumed.

To assist with quicker resolution of clinical signs of prostatomegaly and suspected prostatitis, orchitis, and epididymitis, all intact male dogs were castrated under general anesthesia. Tissues were sent for histopathological analysis to the Joint Pathology Center (Silver Spring, Maryland). All dogs had normal testes except Dog 1, where a sperm granuloma was noted in the left testis. Some dogs received trazodone (5 mg/kg oral dosage every eight to 12 hours as needed) to assist with keeping the dogs calm during the two-week post-operative recovery period.

Dogs 2, 3, 4, and 5 had the dosage of doxycycline decreased to 5 mg/kg orally every 12 hours at weeks 15, 12, 12, and 10, respectively. Dogs 1, 6, and 7 remained on the original dosage throughout the duration of treatment. The dosage was decreased in these four dogs due to development of mild inappetence and soft stools. These dogs were administered probiotic therapy to help restore normal fecal consistency. All antibiotic therapy was discontinued between weeks 15 and 19 based on the lack of clinical signs in each dog, except in Dog 6 in which antibiotic therapy was discontinued due to presentation of acute hepatitis.

When Dog 6 presented with clinical signs consistent with acute hepatitis on 25 December 2021, doxycycline was discontinued. Supportive care was provided with a combination of colloid (6% hetastarch) and crystalloid (Lactated Ringer's Solution) IV fluid therapy, anti-nausea medication (ondansetron 0.1 mg/kg IV every 24 hours, metoclopramide 0.2 mg/kg subcutaneously every six hours), an appetite stimulant following the resolution of vomiting (capromorelin 3 mg/kg orally every 24 hours), and hepatic support medications including ursodiol 9 mg/kg orally every 12 hours, and s-adenosylmethionine (425 mg) and silybin-phosphatidylcholine complex (120 mg) orally every 24 hours. Hepatic values returned to normal limits by 19 January 2022 and these treatments were discontinued.

Discussion

The diagnostic testing in this case study showed one positive PCR result for *Leptospira* in a urine sample from Dog 1. However, other possible diagnoses that show similar clinical signs, such as *M. canis*, may not have been detected due to limited urine samples submitted for culture, the reported difficulty in detecting this organism with urine culture, and no urine samples being submitted for PCR testing. Many of the clinical signs seen in this population of dogs, such as perianal swelling, mucopurulent preputial discharge, stranguria, prostatomegaly, and painful testicles, were very atypical for leptospirosis and have not been previously reported and could better represent an infection caused by a different organism, such as *M. canis*. Even though consultation with multiple veterinary specialists was conducted at the time of the outbreak, some differential diagnoses, such as *M. canis*, were not originally considered. This highlights the importance of consulting multiple sources to help develop a robust list of differential diagnoses that will guide appropriate diagnostics and treatment. Therefore, a conclusion of a leptospirosis outbreak

cannot be confirmed, although there were a few factors that could support the development of a leptospirosis outbreak in this population.

First, this outbreak occurred at the end of summer, following a period of hot and humid weather. In the Kanto Region, the average temperature in July and August 2021 was 84 and 85 degrees Fahrenheit, respectively, and there was 11 and 10 days of precipitation, respectively, during these months.[31] The incidence of leptospirosis is significantly higher in warm countries due to longer survival of *Leptospira* in warm, humid conditions.[18] The soil testing performed in the area surrounding the kennels also indicated the presence of *Leptospira spp*., one of which was in a pathogenic *Leptospira* clade. Although it is not known if this *Leptospira spp.* caused infection in these dogs, it is possible since it was definitively located in multiple areas within the soil.

Second, when dogs are infected with *Leptospira*, they have an initial leptospiremia phase that lasts three to ten days, followed by a leptospiuria phase that ranges from seven to 14 days.[32] The first urine samples sent out for PCR testing were sent earlier than the seven to 14-day range needed to develop leptospiuria. Antibiotic therapy has been shown to possibly affect PCR testing.[32] Most of the affected dogs started antibiotic therapy soon after presentation of clinical signs and therefore this treatment may have affected PCR results, causing false negative results, during the period of expected leptospiuria.

Third, even though all dogs in this case series had been vaccinated for leptospirosis, some prefectures within the Kanto Region have been reported to have cases (less than 20% prevalence) of leptospirosis caused by the *L. autumnalis* serovar, which is not covered by the administered vaccine.[10,15] It is unknown if there is a correlation between clinical signs and serovar.[19] Many serovars cause significant renal insufficiency, but the affected dogs in this study had only mild indications of renal insufficiency (mildly elevated SDMA). However, the dogs did show signs lethargy, anorexia, abdominal pain, and polyuria and polydipsia which have been reported clinical signs noted in dogs infected with *Leptospira*, although these could have also been signs attributed to an undiagnosed *M. canis* infection. If the clinical signs were attributed to leptospirosis, is possible that these dogs presented with milder clinical signs due to acquiring some cross protection against clinical disease from the serovars contained in the administered vaccination, even though these serovars may have been different from the serovar causing the suspected acute infection.

Fourth, the administered vaccine has been shown to be effective against preventing leptospiremia and leptospiuria from the *L. canicola*, *L. icterohaemorrhagiae*, *L. pomona* and *L. grippotyphosa* serovars.[10, 33] It is unknown if this vaccine has a similar effect on other serovars. It is possible that if this population of dogs was infected with a different serovar, that the vaccine may have decreased or eliminated shedding of the *Leptospira* in the urine, resulting in multiple, negative PCR tests even in the face of an acute infection.

PCR testing was the test of choice in this population of dogs, but titers were not completed in this case series. Microscopic agglutination tests (MAT) are commonly used to detect antibodies against *Leptospira*. If antibody testing via ELISA is positive, but PCR testing is negative, as was the case with most dogs in this population, MAT testing helps provide a quantitative result. High titers (often ≥ 1:3200) in the face of clinical signs, is often consistent with leptospirosis, even if the patient has been vaccinated.[9] MAT testing can also be used to perform convalescent titers. A four-fold change in a MAT convalescent titer when compared with a baseline titer is consistent with an active infection.[9] An active infection in this population of dogs may have been confirmed if MAT titers were completed at the beginning of the outbreak, and then one to two weeks later.[9]

When evaluating the antibiotic treatment protocol in this population of dogs, after multiple *Brucella canis* tests were negative, it is reasonable to conclude that the enrofloxacin treatment could have been discontinued. This could have resulted in less gastrointestinal disturbances in these dogs and would have decreased the cost of treatment. The dose of doxycycline could have also been decreased sooner to 5 mg/kg, as this is the dose that is often referenced as an effective treatment dose.[9, 19]

The implemented isolation protocol was developed in response to the infectious disease outbreak, and not based on an existing local standard operating procedure (SOP). Therefore, implementing the initial isolation practices within the kennel may have been delayed due to the need to procure PPE and material to be used as barriers. If an existing SOP had already been developed, it would also have likely identified an alternate location for housing of the dogs in the event of an outbreak. In the case of this outbreak, the alternate location, along with temporary kennels, had to be located, inspected, and approved once multiple dogs started to become affected, which delayed movement of the healthy dogs out of the original kennel facility. An existing SOP would have also outlined cleaning and disinfection protocols to ensure effective practices were in place to prevent spread of organisms. During this outbreak, when cleaning the food and water bowls, they were only rinsed out and not cleaned with a detergent, first. If organic debris remained in the food and water bowls, the effectiveness of the bleach solution would have been decreased.

Conclusion

Even though only one dog tested positive for leptospirosis, there were many factors that may have decreased the sensitivity in detecting a definitive outbreak in this population,

although the author acknowledges that this infectious disease outbreak may have been caused by an undiagnosed organism. Ultimately, even if this was not an outbreak of leptospirosis, there are important takeaways from this case including a development of a robust list of differential diagnoses using specialist consultation and literature reviews, appropriate supportive care, and development of strict isolation protocols.

Throughout the initial presentation in this population of military working dogs, differential diagnoses were able to be narrowed down through thorough repeated physical exams, detailed medical record keeping, and diagnostic testing guided by clinical signs and symptoms. A robust world-wide network of veterinary clinical specialists allowed timely consultation to help guide diagnostic testing in real time. Peer-reviewed literature was easily accessible to further narrow down potential diagnoses and helped guide specific laboratory tests based on the timeline of clinical disease.

By providing supportive care and treatment to these dogs, all dogs fully recovered and returned to duty. Consistent monitoring of the dogs allowed adjustments to individual treatment plans and early detection of newly affected dogs. It is important to note that the isolation protocols implemented during this outbreak likely kept Dog 8 from becoming infected (although no testing was performed to rule out a subclinical infection) and no human caretakers became ill during the four-month outbreak. This case study highlights the importance of having written isolation protocols in place, as well as having readily accessible PPE and disinfectants. Prompt reaction and strict protocols, even in the face of an unknown diagnosis, can help limit the number of infected animals and allow mission to continue in the unaffected portion of a population, even in the face of a suspected infectious disease outbreak.

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Case Report: Ataxic Military Working Equine With Bilateral Choroid Plexus Cholesteatomas

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Abstract

A 25-year-old American quarter horse became severely cast (stuck) in the paddock exhibiting acute neurological signs. The patient was severely ataxic, with obtunded mentation, proprioceptive deficits, and bilateral deficits in cranial nerve (CN) II, CN III, the sensory branch of CN V, CN VI, CN VII, and CN XI. The patient was current on West Nile virus (WNV), rabies, tetanus, eastern equine encephalitis (EEE), and western equine encephalitis (WEE) vaccinations. Despite clinical interventions, the patient was euthanized due to the non-resolving neurological deficits. Significant gross pathological findings include bilateral firm, yellow to green masses, filling the lateral ventricles, and bilateral enlarged adrenal glands. Histopathological interpretation and gross diagnosis are consistent with bilateral cholesterol granulomas, and hydrocephalus. In addition, there was an adrenal pheochromocytoma and thyroid follicular adenoma confirmed with specific immunoreactivity to synaptophysin. This case represents the extreme clinical presentation of bilateral cholesterol granulomas, resulting in severe neurological signs. [1-5]

Keywords: *Cholesterol granuloma; Cholesteatoma; Cholesterol clefts; Choroid plexus hyalinization; Hydrocephalus; Multiple endocrine neoplasia; Pheochromocytoma; Equine.*

History & Clinical Findings

A 25-year-old, US Army Military Working Equine American quarter horse gelding became severely cast (stuck) in the paddock fence. The patient acutely exhibited progressive neurological signs, despite appearing normal a few hours prior during the morning feeding. Initial physical examination findings indicate a severe neurological disorder. While still weight bearing and ambulatory, the patient was severely ataxic, hypermetric with proprioceptive deficits in all limbs and obtunded mentation. Cranial nerve examination is consistent with bilateral sensory and motor deficiencies including fixed and dilated pupils, lack of menace, periodical horizontal nystagmus, with absent corneal and palpebral reflexes. The horse did not elicit a response to the superficial bilateral stimulus of the muzzle, nostrils, side of the face, ears, and neck. The neurological examination findings were suggestive of bilateral deficits in cranial nerves (CN) II, CN III, the sensory branch of CN V, CN VI, CN VII, and CN XI. The patient was still able to move tongue and chew food. Other reported clinical abnormalities included a grade III/VI systolic heart murmur with 2nd degree AV block, pale mucous membranes, and a prolonged capillary refill time. The only reported clinicopathologic finding was a mild stress leukogram. The horse was recently vaccinated against West Nile virus (WNV) and current on rabies, tetanus, eastern equine encephalitis (EEE), western equine encephalitis (WEE). The horse was the only animal exhibiting neurological signs on the central Texas farm during the summer months. The patient showed limited response to the administration of intravenous fluids and corticosteroids, falling three more times. The patient was euthanized due to a guarded prognosis and non-resolving neurological deficits.

Gross Pathology Findings

The carcass went to the Texas Veterinary Medical Diagnostic Laboratory (TVMDL) for necropsy. External findings included fair to poor body condition, weighing 472.72 kgs (1040 lbs) with multiple linear excoriations throughout the head. The most significant gross lesions in the brain were bilateral

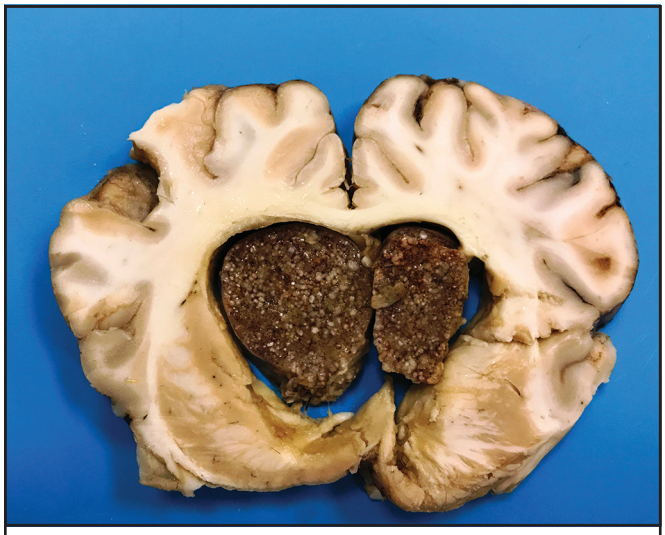

Figure 1. Brain, American quarter horse, equine (formalin fixed tissue).

Figure 2. Severe bilateral expansion of the lateral ventricles by the two dense cholesteatomas; Formalin fixed tissue

firm, yellow to green masses, filling and moderately dilating lateral ventricles (Figures 1 & 2). Also reported were bilateral enlarged adrenal glands with 2.5 cm mottled red to dark-red nodules (Figure 3). No additional gross lesions were reported. Representative formalin fixed samples were forwarded to the Joint Pathology Center (JPC) for histopathology evaluation.

Histopathological Findings

Histopathological interpretation and gross diagnosis are consistent with bilateral cholesterol granulomas that completely occlude the lateral ventricles, along with a concurrent mild hydrocephalus contributing to mild cerebral cortical compression.

Extensively filling both lateral ventricles, completely replacing the choroid plexus and compressing the overlying gray and white matter are multiple densely cellular cholesterol granulomas (Figure 1). These granulomas are composed of large sheaves of negative staining acicular clefts (cholesterol clefts) which contain small amounts of amphophilic crystalline debris, surrounded by numerous multinucleate giant cells (Langhans, foreign body, and Touton type), macrophages with phagocytized green to yellow pigment (hemosiderosis) admixed with abundant polymerized and granular fibrin, lymphocytes, plasma cells and neutrophils (Figures 4A-4B). Surrounding these areas are plump fibroblasts forming thin bands of mature collagen, which often encircle blood vessels throughout the mass. The adjacent and overlying neuropil is multifocally vacuolated (spongiosis) with a moderate amount of gliosis and frequent cuffing of subependymal vessels by 1-2 layers of neutrophils, lymphocytes, plasma cells and hemosiderin laden macrophages. Microscopically there are only mild changes within the white and gray matter, the degree of cerebrospinal fluid outflow obstruction can explain the reported neurological abnormalities.

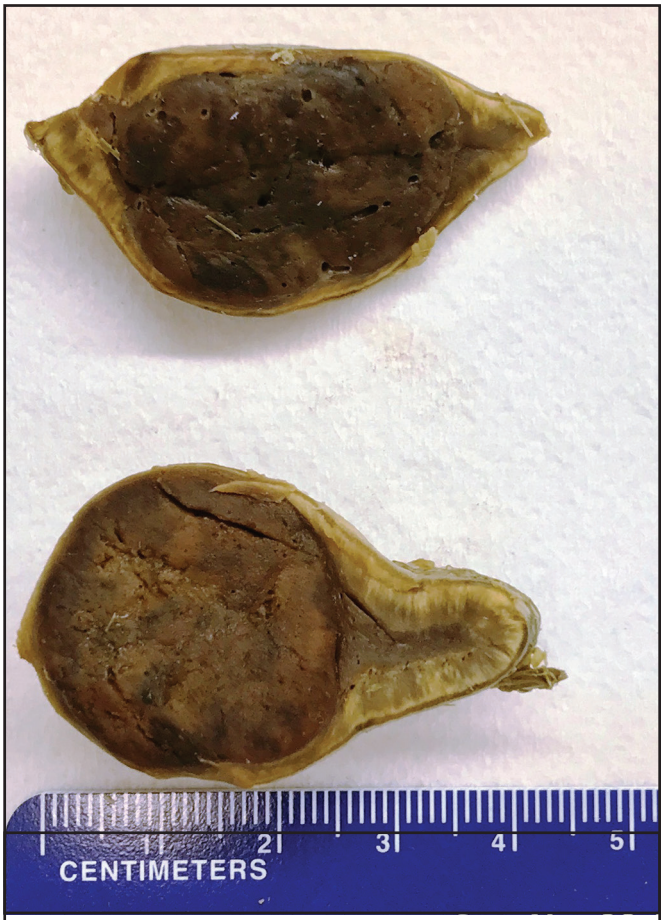

Figure 3. Adrenal gland, focally and extensively expanding and replacing the medulla, compressing the adjacent cortex, and extending to cut borders is an unencapsulated, well demarcated, multilobulated neoplasm, grossly consistent with a pheochromocytoma; formalin fixed tissue.

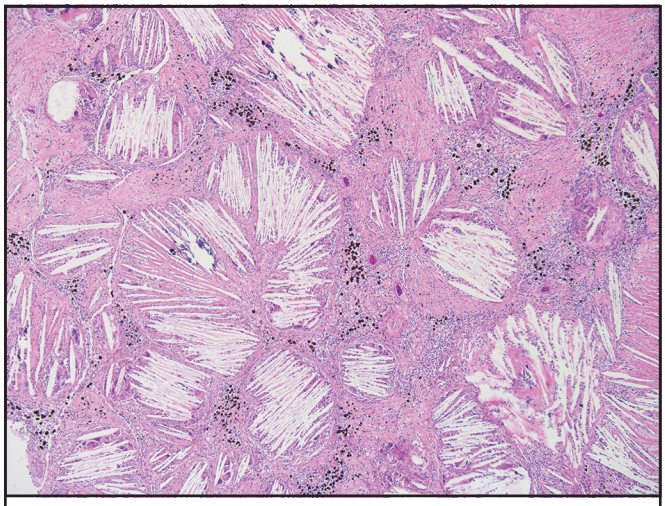

Figure 4A. Closely adhered granulomas are composed of large sheaves of negative staining acicular clefts (cholesterol clefts) which contain small amounts of amphophilic crystalline debris; H&E, 1.25x

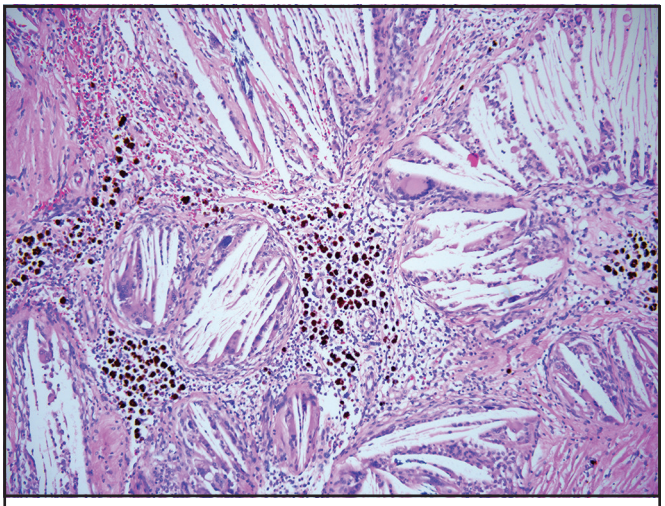

Figure 4B. Within granulomas are numerous multinucleate giant cells (Langhans, foreign body, and Touton type), macrophages with phagocytized green to yellow pigment (hemosiderosis) admixed with abundant polymerized and granular fibrin, lymphocytes, plasm cells and neutrophils; H&E, 20x

In addition, there is an adrenal pheochromocytoma (Figure 3) in the medulla of both adrenal glands and a thyroid follicular adenoma in the thyroid gland. Both neoplastic populations exhibit strong specific immunoreactivity to synaptophysin. The neoplastic cells within the medulla of both adrenal glands have positive immunoreactivity for synaptophysin, which is consistent with a pheochromocytoma. The neoplastic nodule in the thyroid gland is identified as a follicular adenoma, expressing immunoreactivity to Thyroid transcription factor 1 (TTF-1) and immunonegative to thyroglobulin and calcitonin.

Morphological Diagnosis & Case Summary

Morphological Diagnosis:

1. Brain: Cholesterol granulomas (cholesteatoma), lateral ventricles, with choroid plexus hyalinization and loss; moderate, bilateral, internal (obstructive), hydrocephalus; and mild, multifocal, spongiosis, gliosis, and hemosiderosis.
2. Adrenal gland, right and left: Pheochromocytoma.
3. Thyroid gland: Adenoma, follicular, nodular.

Case summary: Bilateral cholesteatomas with hydrocephalus and concurrent multiple endocrine neoplasia (MEN).

Discussion

This case demonstrates a severe clinical presentation of a common lesion in horses. Cholesterol granulomas (cholesteatomas) are expansile nodules believed to arise from the choroid plexus. They are composed of numerous foci of cholesterol crystals surrounded by reactive pronounced xanthogranulomatous inflammation with unique Touton type epithelioid macrophages. Choroid plexus cholesteatomas are incidental findings at necropsy or computerized tomography and present in approximately 20% of older horses, often associated with the third ventricles.[1-5] Severe bilateral expansion of the lateral ventricles by these dense cholesteatomas often obstruct cerebrospinal fluid outflow, resulting in pressure atrophy of the cerebral cortex from internal hydrocephalus.[1,4] Currently, the exact pathogenesis of these granulomas is unclear; many believe chronic congestion and trauma to the choroid plexus are contributing factors.[1-5] The presence of choroid plexus cholesteatomas in horses 15 years or older could be closer to 40%, but the size and clinical severity does not appear to be correlated with advanced age.[3] Extreme cases present with acute to sporadic neurological abnormalities, more often associated with the lateral ventricles, like in this case. The acute severe neurological signs often render an array of clinical differential diagnoses including traumatic injury, neoplastic and, most concerning, numerous infectious agents.[1-2,6] Regional endemic infectious diseases including but not limited to equine encephalitis viruses (Venezuelan, Eastern, and Western and West Nile viruses), rabies virus, Equine Protozoal Myelitis and Equine Herpesvirus 1 must be considered to limit spread and possible zoonosis.[1-2,6] Cholesteatomas also occur in dogs and cats; however, most canine and feline cholesteatomas occur in the middle ear secondary to chronic inflammation while intracranial cholesteatomas are considered rare.[7-8]

Pheochromocytomas are the most commonly reported adrenal neoplasm in domestic animals, rarely reported in equine.[9] Clinical signs of functional pheochromocytoma include tachycardia, intraperitoneal hemorrhage, generalized

sweating, excitation and non-specific colic. When reported in equine, pheochromocytomas are most often nonfunctional, unilateral, and concurrent with thyroid tumors and pituitary neoplasms, suggestive of the MEN syndrome.[9] This case is suggestive of MEN, but definitive diagnosis would require microscopic examination of the pituitary gland.

Acknowledgments

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Task Force-Military Working Equid: Improving Health and Welfare of the Army's Military Working Equids

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Abstract

In February 2022, the unexpected deaths of two military working equids assigned to the Caisson Platoon of The Old Guard at Joint Base Myer-Henderson Hall, Virginia, resulted in negative media attention and increased Congressional oversight. The Director of the Army Staff (DAS) established Task Force-Military Working Equid (TF-MWE) to evaluate the health and herd management of over 240 Army-owned equids across 12 installations. TF-MWE identified multiple issues negatively impacting equid health and welfare and recommended initiatives for improvement, all of which were approved by the DAS. Implementation of these initiatives is ongoing with the status monitored by Congress and senior Army leadership. TF-MWE is an excellent example of the versatility and responsiveness of Army veterinary teams whose activities will promote lasting, positive impacts on the future of Department of Defense-owned equids.

Key Words: MWE, military working equid, Veterinary Corps, DoD-owned equid

Introduction

In February 2022, two caisson military working horses belonging to 3d U.S. Infantry Regiment (The Old Guard) died unexpectedly within four days of each other. The Old Guard (TOG) Regimental Commander requested a detailed inspection of all TOG military working equid (MWE) facilities from a senior veterinarian of the supporting regional public health command, Public Health Command-Atlantic (PHC-A). The purpose of this inspection was to identify any deficiencies that may have contributed to the causes of death. A team of three PHC-A veterinarians performed the inspection and identified numerous, long-standing issues associated with herd management, facilities, and diet/nutrition. The veterinarians' findings were summarized in a detailed report, which resulted in a negative media article published by CNN.[1] Congress, aware of the deaths, subsequent inspection, and negative media attention, directed Department of the Army (DA) leadership to address MWE health and welfare issues identified in the inspection report. As a result, the Director of the Army Staff (DAS) established in April 2022 the Task Force-Military Working Equid (TF-MWE), under the direction of The Surgeon General of the U.S. Army (TSG) and led by the U.S. Army Veterinary Corps Chief (VCC). The mission of TF-MWE is to identify and categorize risks of all major issues affecting the health and welfare of MWEs and other equid herds residing on installations across the Army.

Department of Defense-owned equids include horses, mules, and donkeys serving as MWEs, as equid mascots, or in morale, welfare, and recreation (MWR) roles, and have a variety of missions within the military. MWEs provide funeral services to honor fallen service members, participate in community outreach events, execute mounted color guard requirements, take part in calvary competitions and demonstrations, provide mounts for soldier horsemanship training, conduct goat herd defense, and act as mascots on orders to represent their units or teams. MWR-owned equids support Army families and cadets as mounts for trail rides, riding lessons, and cadet intercollegiate competitions.

There are numerous challenges to ensuring the health and welfare of DoD-owned equid herds. Most importantly, there is little guidance in federal regulations, DoD policies, or Army regulations regarding the treatment and care of equids. Guidelines are often adapted from military working dog doctrine and do not directly address specific equid husbandry and welfare needs. In general, any published DoD guidance or policy relating to equids in the military simply outline

processes and procedures that govern MWEs as U.S. Government property. Not only do these documents fail to follow current industry management standards for equids, but they also do not take into account current public perceptions regarding the appropriate care and attention that working equids should be afforded.

Although veterinary care of DoD-owned equids has been an integral and ongoing part of the U.S. Army Veterinary Service's (AVS's) mission since the U.S. Army Veterinary Corps was established in 1916,[2] the AVS does not own, operate, or manage these herds. Those responsibilities belong to infantry or other Army units where equine health and welfare expertise may be limited or nonexistent. The lack of subject matter equine experts within equid-owning units negatively affects herd management, resourcing efforts, and overall welfare of the equids. Additionally, with the changing demographics in veterinary medicine and self-selected options for veterinary school curricula, not all Army veterinarians are competent equine practitioners.

As a result of these factors and the recent MWE deaths, TF-MWE was charged with identifying and categorizing risks of all major issues affecting the health and welfare of MWE herds residing on installations across the Army. The VCC and TF-MWE lead is a previous private practice equine veterinarian with over 20 years of clinical experience. Component (COMPO) 1 (active duty) and COMPO 3 (reserve) subject matter experts consisting of Army veterinarians and animal care specialists with specific equine veterinary and husbandry expertise were identified from U.S. Army Forces Command (FORSCOM), U.S. Army Medical Command (MEDCOM), the U.S. Military Academy West Point, and the U.S. Army Reserves to serve on the task force under the direction of the VCC. Within 60 days of inception, the TF used collective knowledge to rapidly develop tools, communication channels, and supporting logistics to enable execution of staff assistance visit (SAV) assessments by mobile teams to define the scope of equid health and welfare problems across 12 Army installations identified as housing DoD-owned equids. The ability of the Veterinary Corps to decisively execute directed tasks in a short amount of time in the absence of any published relevant policy, doctrine, or methodology to guide efforts and identify critical gaps demonstrated the Corps' relevancy in the modern military operational environment.

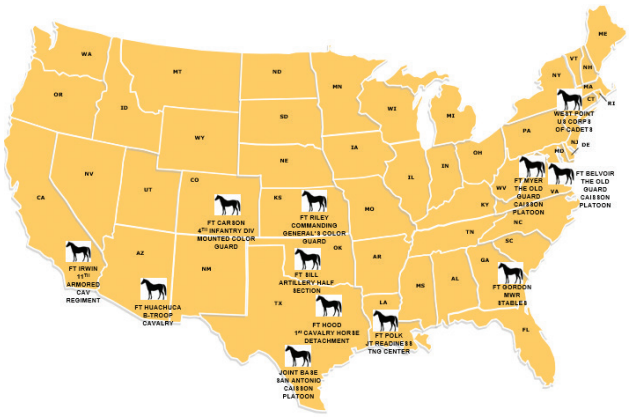

Figure 1. Installations and Units with Army-Owned Equids

Methods

With the lack of equine-specific regulations, policy, and guidance, an early TF initiative was to create interim equid health and welfare standards based on best practices within the equine industry and equine veterinary practice until official Army policy and guidance could be published. A tabulating spreadsheet checklist tool with gradable standards was designed by a military data scientist and members with equine expertise on the TF to assess areas of communication, feed and nutrition, pasture and turnout, facilities, herd management, and veterinary support. This tool allowed for objective scoring of each equid-owning unit during TF SAV assessments.

Concurrently, the TF initiated contact with leadership of each DoD equid-owning unit and non-appropriated fund-(NAF-)funded stable to notify them of the required SAV at their installation. Email and phone communication was utilized to coordinate the SAV with the DoD equid-owning unit commander or NAF-funded stable manager. This often proved challenging, and the intent communicated to higher-echelon leadership levels was not always shared with boots-on-the-ground staff. Ongoing communication to address misconceptions was important to ensure units and organizations fully understood their responsibilities and roles during each SAV. After initial email or phone contact, video teleconferences were conducted to provide the DoD equid-owning unit or organization a detailed description of the purpose and intent of the SAV and develop an agenda for the visit. Balancing schedules of TF members with ongoing unit/organization mission was critical to ensure adequate preparation time and personnel availability for the SAV and minimize any mission impact for the unit. The checklist tool was shared with each unit or organization two to four weeks prior to the scheduled SAV to afford the unit or organization adequate preparation time.

From June to August 2022, mobile teams of two to four TF-MWE members, inclusive of the VCC, conducted a comprehensive SAV at each of 12 installations identified as housing DoD-owned equids (Figure 1). Prior to the visit, a holistic review of the unit's policies, standard operating procedures, memorandums, previous facility inspection results, and MWE medical records was conducted by TF members to inform expectations and facilitate understanding of herd dynamics at each site.

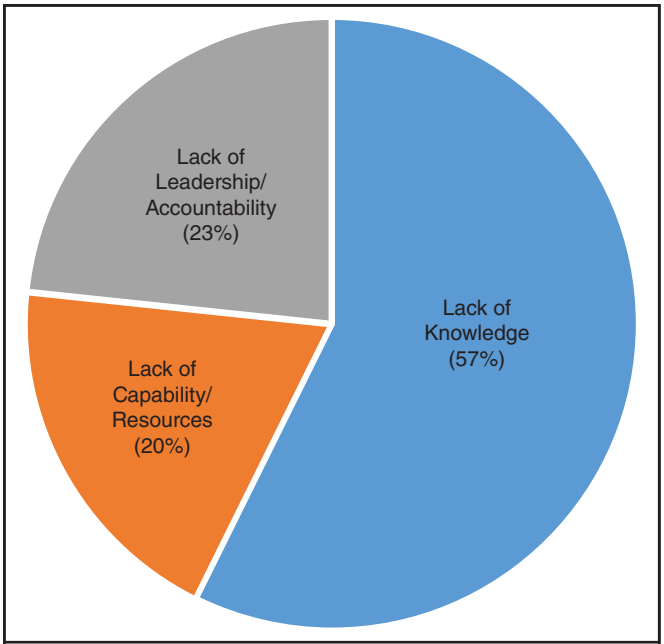

Figure 2. Root Cause Analysis for Findings of "Partially Met" or "Not Met"

Each SAV was conducted over the span of two days to assess major factors affecting health, herd management, and welfare of MWEs along six lines of effort (LOEs): communication, feed and nutrition, pasture turnout, facilities, herd management, and veterinary support. Inspections included a terrain walk of the facilities, clinical examination of at least 20% of the herd, and interviews with unit leadership, the installation-assigned military veterinary team, and herd management personnel.

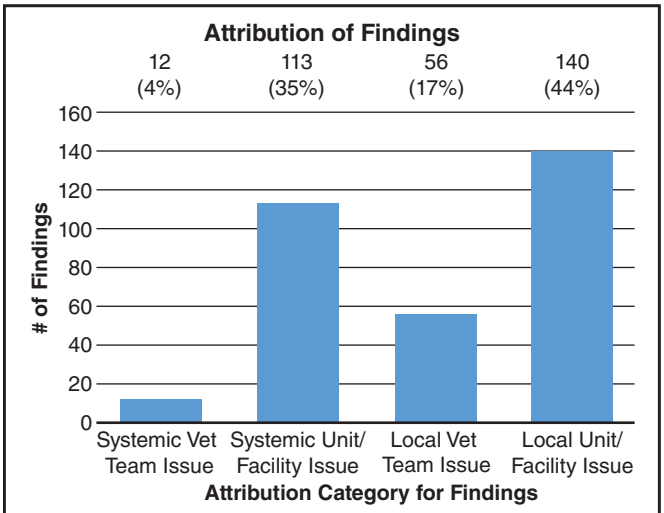

Figure 3. Findings categorized by attribution to local, systemic, unit/facility, or veterinary team issues.

During each SAV, 104 inspectable items categorized under the six LOEs were assessed using the checklist tool. Each LOE included requirements, standards, references, methodology, and specific interview questions. Each requirement was assessed as *met*, *partially met*, or *not met*. These ratings were automatically tabulated by the assessment tool to generate a percentage-based aggregate score and an overall green/amber/red rating for the LOE. The calculation for each LOE was generated:

$$\frac{(\text{No. Partially Met} \times 0.5) + \text{No. Met}}{\text{No. Not Met} + \text{No. Partially Met} + \text{No. Met}}$$

The aggregate percentage for each LOE was categorized as green if the score was equal to or greater than 80%, yellow if the percentage was between 60–79%, and red if the score was less than 60%.

Each item categorized under the six LOEs was assigned a root cause if the finding was partially met or not met. Root causes were categorized as *lack of knowledge*, *lack of capabilities/resources*, or *lack of leadership/accountability*. Each root cause was further categorized by a sub-category of *never knew*, *forgot*, *implied task*, *scarce resources*, *don't know how*, *impossibility*, *no reward*, *no penalty*, *disagree*, or *lack of veterinary input*. Finally, the finding was determined to be either a local or systemic issue and attributed to either the supporting military veterinary team or owning-unit/facility.

Installation and equid-owning unit leadership teams received an individual outbrief at each site before the departure of the SAV team. Focused areas of sustainment and improvement were outlined to facilitate interim and near-term solutions as well as inform required long-term efforts. A TF-MWE back brief to the DAS in November 2022 was executed by the VCC to inform senior Army leadership of the scope and health of the MWE herds on all 12 Army installations. The back brief detailed risks associated with enterprise-wide areas for improvement as well as best practices for sustainment across the Army.

Results and Findings

The SAV team documented a total of 403 findings of either *partially met* or *not met* within the six LOEs across the installations. *Lack of knowledge* was the root cause for 231 findings (57%), *lack of leadership/accountability* was the root cause for 94 findings (23%), and *lack of capability/resources* was the root cause for 78 findings (20%) (Figure 2). Each finding was also determined to be a local or systemic issue and attributed to either the supporting military veterinary team or owning-unit/facility as seen in Figure 3. The aggregate scores for each LOE across the 12 assessed installations are in Figure 4.

Both positive and negative trends were observed across the installations and were grouped into best practices and enterprise-wide issues.

Best Practices within the Army Enterprise

Installations with the highest aggregate scores employed a "team of teams" approach involving leadership from the equid-owning unit, the garrison command, installation teams, the installation-assigned veterinary team, and members involved with equine management. These collaborations had clear and visible positive impacts when compared to installations that did not use similar collaborations.

Technology-assisted management practices (eg, QR [quick response] code data keepers) were used at one site for communication, training, nutrition, and duties, which increased fulfillment of equid regimen and improved overall health and welfare of resident equids. In addition, the use of a 24/7 Charge of Quarters (CQ) watch at more than one site allowed for rapid detection of illness/injury and provided the opportunity for timely intervention, which decreased the risk of serious consequences from critical and acute equid health problems, such as the occurrence of colic, and from health and welfare safety issues, such as water system ruptures, barn fires, intruders, and lack of feed in mangers.

With respect to resourcing, contracts with specific performance clauses and remedies for noncompliance optimized appropriate resources for MWEs. Installations with lower aggregate scores in the herd management and feed and nutrition LOEs often had issues with contracts for hay, feed, supplements, farrier services, and herd management.

Lastly, one unit's ability to leverage community support to supplement MWR programs decreased the installation's fiscal responsibility and workload in the effort to ensure health and welfare of the installation DoD-owned equid herd.

Army Enterprise-wide Issues

Due to a lack of DoD and Army policy and doctrine for management of equid herds, authorities and responsibilities were largely unclear. Different sites had varying levels of commitment and support from necessary stakeholders. A major overarching issue observed at numerous installations was poor hierarchical communication between the equid-owning unit, the garrison command, the installation-assigned veterinary team, and members involved with equid management. This issue compounded existing deficiencies and amplified health and welfare concerns. In several instances, equid-owning units and members involved with equine management were inattentive to veterinary equine health and welfare subject matter expertise. Dangerous or inappropriate fencing and facility design/improvements occurred due to lack of soliciting equine subject matter expertise. Several installations had unresolved facility inspection findings or deficiencies that were not properly elevated to appropriate leadership levels.

The deterioration of hooves and prevalence of lameness due to unskilled farrier care was of great concern. Many sites relied on untrained or poorly trained individuals to perform farrier care. Although a few sites had properly contracted civilian farrier care or well-trained unit personnel conducting internal farrier work, most sites struggled with ensuring appropriate hoof care.

LOE	Number of Installations with Each Aggregate Score		
	Aggregate Score ≥ 80%	Aggregate Score of 60%-79%	Aggregate Score < 60%
COMMUNICATION	1	6	5
FEED & NUTRITION	3	2	7
PASTURE & TURNOUT	6	5	1
FACILITIES	6	3	3
HERD MANAGEMENT	4	4	4
VETERINARY SUPPORT	4	5	3

Figure 4. Aggregate Scores by LOE Across 12 Assessed Installations

Numerous units lacked adequate MWE procurement and disposition policies at the equid-owning unit level. In some cases, this resulted in procurement of equids who were not suitable for the mission for various reasons including health or temperament issues, age, or lack of training. In the past, lack of appropriate disposition policy and procedures has resulted in substandard placement for retired MWEs.

Supporting echelons also had inadequate policies to assist with resourcing in many instances. A general lack of feed and nutrition knowledge at the equid-owning unit level, inflexible feed procurement methods, and poor contract specifications all contributed to these issues. Further, a lack of long-term capital improvement and maintenance plans for equid facilities and requirements was evident across the Army enterprise.

Unpredictable equid-owning unit force management structure and in some cases, uncodified mission mandates, contributed to a lack of manning support to ensure each unit had the appropriate soldier or NAF formation to execute appropriate routine equid care. Observed across multiple installations was a trend of equid-owning units' preference for volunteer soldiers with no equine or riding experience. Many units also had inadequate safety protocols at facilities that housed equids, to include a lack of fire suppression systems and functioning CQs.

By regulation, installation-assigned military veterinary teams provide veterinary care support for DoD-owned equids. However, TF-MWE documented that AVS lacks a talent management strategy that produces an adequate number of Veterinary Corps Officers (VCOs) and Animal Care Specialists (MOS 68T) with specialized education and training in equine veterinary care or which reliably assigns personnel with this skillset to installations with DoD-owned equids. Insufficient equine-specific veterinary equipment and supplies were noted at numerous sites. This resulted in occasional suboptimal clinical case outcomes and erosion of confidence in care provided by AVS personnel as reported by multiple equid-owning units.

Discussion

The TF-MWE served as a flexible construct which was able to adapt to changing requirements and needs of senior Army leaders. As each SAV was conducted, verbal after action reports were used to adjust mobile team execution to improve efficiency and increase effectiveness at subsequent site visits. The checklist was refined to correct any functional issues and additional best practices were communicated between team members. Throughout the continuous process of traveling, assessing facilities, performing physical exams, and communicating with members of each DoD equid-owning unit or organization, TF-MWE became a cohesive unit capable of moving quickly to rapidly identify trends relating to the health and welfare of DoD-owned equids across the Army.

Root cause analysis of the trends and findings revealed that many units were not adequately prepared, resourced, or manned to appropriately care for DoD-owned equid herds. For well over half of the requirements listed in the checklist, individuals either did not have the requisite knowledge to assess requirements or they were unaware that such requirements even existed. Findings under the lack of leadership/accountability root cause resulted from the failure of leadership to ensure compliance with required duties and tasks as well as leadership's unwillingness to follow the recommendations of equine veterinary and subject matter experts. Several broad categories contributed to failings in findings identified with a root cause of a lack of capability/resources: lack of or inappropriately prioritized funding for infrastructure; funding processes that caused difficulties procuring necessary equid feed and supplements; direct hiring of local talent leading to personnel with a lack of required experience and expertise; poorly written position descriptions (PDs) for civilian team members that did not encompass requirements for equine-specific skills; inadequate, denied, or lack of requested funding streams; insufficient NAF funds generation to adequately address health care needs of aging herds; and lack of adequate support by the parent Public Health Activity resulting in equine equipment or operation short falls.

Overall, significant risks exist including decreased mission readiness, shortened equid serviceable life, increased cost and labor, and decreased equid mission availability; and these risks will continue to exist if identified issues are not addressed with short-term, interim, and long-term solutions. Many issues are adversely impacting equid health, safety, and welfare, contributing to increased occurrence of acute illness, chronic conditions, lameness, trauma, and death.

Without appropriate health, management, and welfare measures to correct deficiencies, equids will remain or become underweight and inadequately muscled. At some sites, facility issues contribute to dangerous and unsanitary living conditions. Poor communication at all echelons significantly affected risk assessments being understood and elevated along the chains of responsibility (equid-owning unit and garrison command). This issue resulted in inappropriate assumption of risk at lower echelons that led to increased and unknown risk at all leaders' levels to include the highest Army echelons.

Four critical areas were outlined by TF-MWE with specific recommendations to improve the health and welfare of DoD-owned equids across the Army. These areas are policy/doctrine, resourcing, veterinary-specific talent management, and nonveterinary talent management.

Policy/Doctrine Recommendations

As a result of the significant findings on Army installations, the TF recommended the Secretary of Defense direct similar TF-MWE SAV reviews of U.S. Air Force and U.S. Marine Corps DoD-owned equid herds. Since AVS is directed to provide complete veterinary medical care for all DoD-owned animals across all components of the DoD,[3] expanding the scope of TF-MWE's mission to conduct a SAV at each DoD installation with a DoD-owned equid herd would be appropriate.

Very limited equine-specific DoD policy and regulation exists. Findings from TF-MWE SAVs clearly outline the requirement for comprehensive DA policy and regulation. Recommendations include a need for an overarching DA MWE management program, outlining responsibilities and functions for all entities involved with equid ownership, care, and management; describing appropriate injury and disease prevention/control; development of facility design and maintenance guidelines; and identifying proper fiscal management and general administrative procedures.

Numerous installation and equid-owning unit leaders requested routine, recurring inspections to ensure best practices were being implemented for their DoD-owned equid herds. The TF-MWE recommended development of a DA-directed, MEDCOM-executed Organizational Inspection Program (OIP) to ensure ongoing deficiencies are addressed and best practices continue to be implemented despite routine leadership and service member transitions. This program would assess compliance with required standards, identify gaps and current best practices, and provide opportunities for consistent teaching/training events. The TF-MWE also recommended incorporation of MWR-owned stables into the

installation OIP as well as inspections of any installation nonfederal entity herds such as pony clubs or therapeutic riding organizations, following provisions outlined in Army Regulation 210-22, "Support for Non-Federal Entities Authorized to Operate on Department of the Army Installations."

Resourcing Recommendations

The TF-MWE recommended Program Objective Memorandum programming across U.S. Army Installation Management Command (IMCOM), MEDCOM, and FORSCOM for long-term resourcing to address installations with historic, aging, and inadequate infrastructure/resources needed to support MWE herds. Further, the TF recommended that senior and garrison commanders include MWR stables and their programs in annual work plans for developing sustainable readiness models to address herd health and welfare.

Similar to a lack of published equine-specific policy and regulation, there is limited program management, business solutions, and oversight for specific resourcing in support of DoD-owned equid herd management and welfare. TF-MWE recommended resourcing for IMCOM and U.S. Army Mission and Installation Contracting Command to safeguard implementation of best business and industry solutions with appropriate oversight. Incorporation of common industry practices and standards in DoD contract requirements for herd management is an additional measure to ensure appropriate standards for herd resourcing. Professional and trade organizations such as the American Association of Equine Practitioners, academic institutions, and state agricultural extension offices, and certified farrier training programs are ideal sources for these types of industry practices and standards.

Veterinary-specific Talent Management Recommendations

Throughout SAV engagements at each installation in coordination with onsite AVS teams, TF-MWE identified a significant need for veterinary-specific talent management regarding VCO and 68T assignments supporting DoD-owned equid herds. Recommendations included increasing the pool of Army veterinary equine expertise, stationing of equine-experienced VCOs and 68Ts at installations with DoD-owned equids, and development of a framework for functional equine specialty support to onsite AVS teams supporting DoD-owned equid herds.

To increase the pool of Army veterinary equine expertise, TF-MWE outlined the need for increased Long Term Health Education and Training residency and internship opportunities for VCOs. Targeted recruiting efforts to identify and recruit equine-experienced veterinarians for direct commission and veterinary technicians or assistants for enlistment into the Army would be an additional method to increase organic Army equine expertise. Further, establishing a veterinary equine-related skill identifier for VCOs and 68Ts would encourage AVS personnel to seek out equine-specific training and continuing education opportunities and would facilitate matching of personnel with the requisite skillsets to installations with DoD-owned equid herds.

Non-veterinary Talent Management Recommendations

Many equid-owning units did not have appropriate Tables of Distribution and Allowances (TDA) structure necessary to adequately support their missions. A large majority of units relied on volunteer soldiers to fill critical MWE rider roles who were recruited from larger Army organizations. The TF recommended updating of TDAs to allow assignment of soldiers to these units. A trend of equid-owning unit preference for volunteer soldiers with no equine or riding experience was documented by SAV evaluators. Changing this culture is critical. Soldiers with equine and/or riding experience are more likely to be ready resources for assistance with maintaining appropriate health and welfare of equid herds. To identify soldiers across the Army with this skillset, establishment of a (nonveterinary) equine-related additional skill identifier was recommended.

Standard, enterprise-wide PDs that reflect accurate requirements for education, equine expertise, and experience for highly technical General Schedule or NAF civilian positions that support DoD-owned equid herds is needed. These positions include herd managers, horse trainers, and farriers. Difficulty hiring the right candidate for these positions necessitates expansion of the candidate pool through national recruitment and establishing a framework for hiring overlaps to maintain institutional knowledge and continuity of equid care.

Strategic Impact

In December 2022, the James M. Inhofe National Defense Authorization Act (NDAA) for Fiscal Year 2023 (FY23) was published.[4] Section 391 directs the Secretary of the Army to implement the equine veterinarian recommendations contained in the memo, dated February 25, 2022, titled "Animal Facility Sanitation Inspection Findings for the Fort Myer Caisson Barns/Paddocks and the Fort Belvoir Caisson Pasture Facility." In addition, the document directs the Secretary of the Army to submit a master plan for the housing and care of all horses within the care of the 3rd U.S. Infantry.

In the bill report accompanying the FY23 NDAA, the Senate Armed Services Committee (SASC) noted that three-years-worth of monthly unsatisfactory condition reports of animal waste disposal, insufficient pasture or training areas, and moldy food for TOG horses occurred from February 2019 to February 2022. They also noted that the grave and unsanitary conditions required decisive action as soon as possible. As a result, the SASC required the Secretary of the Army to provide a briefing to the committee on all sites where the Army

currently houses and cares for military working horses. Congress requested the briefing include the size of the herd, size of the facility, whether monthly condition reports have been conducted at each site, and whether any unsatisfactory condition reports occurred over the past two years. TF-MWE's final report to the DAS significantly informed the Secretary of the Army's briefing to Congress and served as a foundation document for future DoD-owned equid health and welfare efforts.

As of July 2023, Congressional interest in the health and welfare of DoD-owned equids across the Army continues. The DAS-approved TF-MWE recommendations were tasked out to the appropriate offices of primary responsibility. The Office of the Surgeon General established a MWE Sprint Team to analyze actions required to implement veterinary-specific recommendations. The DAS chairs monthly update briefs to monitor progress both at individual installations and at the enterprise level. TF-MWE anticipates requests to perform assessments on Air Force and Marine Corps installations with DoD-owned equid herds, as well as conduct a second round of SAVs on units with Army-owned equids, projected for Summer/Fall 2023.

TF-MWE's inception and activities will have a lasting, positive impact on the future of DoD-owned equids. The TF serves as an example of how versatile veterinary teams can be and how capable they are to lead through a crisis. Previously unresolved, long-standing equid issues on Army installations are being addressed by senior leaders and solutions are receiving prioritized focus and funding. Congress continues to be engaged with the DA to ensure MWEs receive the care and attention deserved by any soldier. Using actionable metrics and Army OIP best practices, TF-MWE has identified a need and set the standard for routine re-evaluation of equid herds that should be implemented across the military enterprise to ensure the continued health and welfare of all DoD-owned equids.

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Lessons Learned for DOD Food Protection, Planning, and Support During the COVID-19 Global Pandemic

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Abstract

The COVID-19 pandemic created many challenges for the Department of Defense when attempting to support the necessary feeding systems for troop movements associated with COVID-19 emergency responses and maintain a safe food supply for other DOD beneficiaries. Throughout the pandemic, routine operating processes and systems in the food protection program proved impractical and sometimes insufficient to meet mission requirements. In many cases, food protection policy and procedural requirements were unknown to primary recipients of this support.

The Food Protection working group of the Veterinary Services COVID-19 Operational Planning Team solicited lessons learned toward the end of the primary pandemic response to document and improve the DOD's food protection emergency response program. This article summarizes these lessons learned, including analysis and recommended actions to sustain or improve food protection support in response to emergency pandemic situations in the future.

Key words: food protection, COVID-19 pandemic, Veterinary Services

The COVID-19 pandemic resulted in a plethora of challenges for the Department of Defense. In anticipation of a worsening situation, the Defense Health Agency (DHA) Veterinary Services (VS) established a COVID-19 Operational Planning Team (OPT) for veterinary service support in January 2020 to institute a framework of appropriate subject matter experts and reach-back capabilities. The OPT consisted of three sub-working groups: animal health; food protection (food safety and food defense), and veterinary-related diagnostics and research. The parent OPT included subject matter experts from across the DOD, including DHA, United States (US) Army Medical Command (MEDCOM), and the Veterinary Services and Public Health Sanitation Directorate (VSPHS), Army Public Health Command (APHC). The parent OPT represented the single point of contact with interagency partners to ensure DOD's veterinary-related efforts were coordinated and synchronized with those of the other Federal agencies. The OPT created a milSuite repository for all VS COVID-related products and guidance produced by the OPT as an easily accessed, singular repository. This site also included weblinks to pandemic-related guidance and publications produced by other Federal agencies and national groups (eg, American Veterinary Medical Association, Centers for Disease Control and Prevention) that were helpful resources for the field.

The Food Protection working group included broad stakeholder representation from all Services and relevant Components, including the Defense Health Agency, Defense Commissary Agency, Army Air Force Exchange Service, Defense Logistics Agency, DOD Food Analysis and Diagnostic Laboratory, Army Public Health Center, Navy Marine Corps Public Health Center, US Air Force School of Aerospace Medicine, US Army Combat Capabilities Development Command Soldier Center, Naval Supply Systems Command, and the US Army Medical Command. Early in the pandemic, it was unknown whether food was a transmission vehicle for the SARS-CoV-2 virus. This ambiguity led to an abundance of caution and planning to ensure DOD beneficiaries had access to a safe food supply. Other challenges related to food protection included difficulties in supporting feeding plans for rapid CONUS deployments

of military personnel, inability to conduct in-person audits at many commercial food processing establishments supplying the DOD, and knowledge and coordination gaps regarding food protection within certain stakeholder communities.

Institutionalizing the OPT early in the crisis before the worst of the pandemic hit the United States was critical to a successful VS effort in addressing pandemic-related issues. As much as reasonably possible, the OPT facilitated a proactive approach to food protection issues and organized an optimally postured, multi-Component, multi-Service network of subject matter experts who frequently met and recommended solutions to food protection challenges that were synchronized across the DOD. This article captures the major food protection lessons learned associated with the pandemic and recommendations for ensuring a safe food supply. Lessons learned are grouped into two sections: Operational Planning, Deployments, and Digital Training Support; and Auditing Establishments, Monitoring Programs, and Lab Sampling.

Operational Planning, Deployments, and Digital Training Support Pre-deployment Site Survey (PDSS) and Advanced Operational Node (ADVON) Team

Lack of Veterinary Service (VS) personnel consultation or inclusion in PDSS and ADVON teams hindered force health protection (FHP) measures and deployment readiness support, particularly in the area of food protection. In accordance with Department of Defense Instruction (DODI) 6490.03 "Deployment Health," the Secretaries of the Military Departments are required to provide deployment health support, which includes food protection support and the use of DOD-approved sources for food and water during deployments by Combatant Commanders.[1]

Across the Services, operational planners' ongoing insufficient understanding of approved source requirements aggravated an already stressed system during the COVID-19 crisis response, exacerbating DOD food procurement issues. An incomplete understanding of requirements led to an absence of VS personnel in PDSS and ADVON teams or consultation with VS personnel about how to meet deployment food protection requirements. Failure of notification about pending PDSS and ADVON team deployments to support troop deployments precluded the inclusion of VS personnel and timely identification of approved food and bottled water sources to support deploying troops. As the sole provider of VS within the DOD[2] and the principal manager of the Worldwide Directory of Sanitarily Approved Sources for Armed Forces Procurement[3] (Worldwide Directory), Army Veterinary Service (AVS) personnel have the responsibility to assist Service operational planners in the assessment and early identification and establishment of approved commercial food and water resources for deploying troops. Army veterinary service support was critical to sustaining feeding plans and food procurement for Urban Augmentation Medical Task Forces (UAMTF) and other deployed teams. However, the lack of inclusion in planning and PDSS and ADVON teams delayed establishing safe food sources. Geographic Combatant Commands and ASCCs should include VS personnel in all PDSS or ADVON planning sessions, ideally as part of the PDSS/ADVON deployment team. DHA Veterinary Services should coordinate with the Navy Bureau of Medicine (BUMED) and Air Force Medical Readiness Agency to discuss this issue and request assistance in setting a requirement for the inclusion of VS personnel in deployment health planning sessions.

The Army has a Veterinary Corps Officer (VCO) at each Army Service Component Command (ASCC) to assist with planning. However, a gap exists within the Navy and Air Force due to the absence of a VCO to support staff surgeon cells. In past decades, Army Veterinary Services had established authorizations in multiple Geographic Combatant Commands (GCC), which helped close this gap. However, over time, GCC commanders reallocated these authorizations and accepted risk in strategic level planning in several areas of veterinary expertise, including food protection, military working animal support, veterinary support to global health engagement, veterinary public health, and other force health protection areas. The only remaining GCC VCO authorization is at the United States Africa Command.

A proactive VCO with food protection knowledge and operational and generating force experience is required within each Geographic Combatant Command to work across Services to inform both Military Health System (MHS) and non-MHS leadership on the deployment health requirements associated with food protection. Army Service Component Commanders should carefully review the knowledge, skills, and behaviors (KSB) of applicants when determining which VCO is best suited to enable mission success at the ASCC level. Army Veterinary Services Veterinary Preventive Medicine (AOC 64B) Consultant to the Army Surgeon General and Chief, Veterinary Corps Branch, Human Resources Command should continue encouraging VCOs with the appropriate knowledge, skills, and behaviors to seek ASCC and GCC staff positions. Staff officers with relevant KSBs will facilitate the necessary flow of communication both up and down the ASCC/Combatant Command chain required to ensure food protection requirements are accurately captured. The addition of Food Safety Officer (MOS 640A) authorizations within all GCCs or ASCCs should also be explored.

Analysis of Alternate COAs, Policy, or Models of Food Procurement and Protection to Support Rapid Deployments under Emergency Conditions

The VS COVID-19 OPT recognized early in the pandemic that a more agile and responsive commercial food protection audit process was needed to support rapid, CONUS-based

COVID-19 deployments adequately. The current AVS commercial food protection audit process that exists to verify food safety, sanitation, and food defense for DOD beneficiaries during routine, non-emergency operations requires an in-depth and lengthy process that is incompatible with crisis action response food protection deployment health requirements. This audit process delayed the procurement of safe food during the initial emergency response.

In March 2020, the VS COVID-19 OPT Food Protection working group established a modified process for supporting organizations (eg, Army Medical Detachments [Veterinary Service Support] and Army Public Health Commands). This process specifically addressed initial commercial food protection audits for establishments not already listed as sanitarily approved sources. Updated procedures included streamlining the pre-audit questionnaire for commercial food processing plants and caterers and adjusting requirements for food sample collection and laboratory analysis.

The tasking process from audit request to completion was abbreviated, with direct support provided by the VSPHS Directorate, APHC, to both the requesting and tasked units, tremendously shortening the tasking process. This process resulted in a five-day turnaround from initiation to the approval of establishments, which can take up to eight weeks during non-emergency operations. The VSPHS Directorate provided a COVID-19 tip sheet to guide auditors on remaining healthy while conducting audits in a COVID environment. AVS personnel performed fifty audits across CONUS to support feeding plans for DOD personnel deploying as part of the COVID-19 pandemic response.

Both veterinary and non-veterinary MHS personnel expressed interest in leveraging the Food and Water Risk Assessment (FWRA) process to support food protection requirements for these deployments. Current Department of Defense Veterinary Service Activity policy and DOD doctrine (Military Standard 3041, "Requirements for Food and Water Risk Assessments") specify that FWRAs are solely for use outside the United States or its territories and only when conducting a commercial food protection audit is not feasible.

Streamlined audit processes precluded the need to extend the use of FWRAs to CONUS, which enabled VS to maintain the highest standard of food protection (commercial food protection audits) and provide optimal food protection support to feeding plans for deploying personnel.

The streamlined commercial food protection audit process was comprehensive, effective, and sufficiently agile to meet the deployment health requirements of the Commander, U.S. Northern Command (NORTHCOM). The details of this modified process should be identified as a best practice and codified within either a Technical Bulletin-Medical or multi-Service regulation for use during crisis response operations and Defense Support of Civil Authorities (DSCA) events.

Coordination between Veterinary Service Personnel and Sustainment Elements

Execution of commercial food protection audits was delayed due to the lack of integration of veterinary personnel within sustainment elements and the lack of coordination with veterinary personnel external to those elements. Early and ongoing close coordination between the supporting ASCC staff veterinarian and supporting sustainment element contracting personnel is critical.

Service component command planners should be prepared to execute the commercial food protection audit as a part of the PDSS process. Audits should be performed on at least three potential vendors identified by the contracting officer (KO) so that the vendors are added to the Worldwide Directory in advance of awarding contracts. Importantly, VS personnel cannot actively seek sources on their own; they must remain disinterested parties when conducting audits that the KO requests. This process requires coordination between the KO, ASCC VCO, and the VSPHS food protection staff.

VS personnel should be integrated with the supporting sustainment element arriving prior to the UAMTF or another tactical element. This integration will ensure that commercial food protection audit requirements are identified, VCOs are tasked, and timely audits are performed to support the feeding plan for deploying personnel.

Service Members using Per Diem-Funded Feeding Plans

Veterinary Service personnel do not have the legal or regulatory authority to inspect vendors that Service members patronize while on per diem, even if requested to do so by the Service Component Commander. Lack of DOD inspection oversight at establishments patronized by deployed DOD personnel on per diem-based feeding plans (paying Service members a daily stipend to purchase their food) was of particular concern early in the pandemic when it was unknown if the COVID-19 virus could be transmitted through food. DOD veterinary and preventive medicine personnel had no direct recourse to evaluate the risk associated with the potential transmission of the SARS-CoV-2 virus through food or food packaging.

During the DSCA response to the COVID-19 pandemic, Service members ate at a contracted commercial food catering establishment (ie, hotel), which had been audited, or they were on per diem. Current DOD policy only requires commercial food protection audits for DOD-contracted establishments subject to applicable requirements for specific products and caterers in the Worldwide Directory.

Eating establishments frequented by DOD personnel while on per diem are governed by city, county, and state food safety and defense regulations. The DOD relies upon inspections

performed by the appropriate state regulatory entity for food protection compliance and mitigation of foodborne risks. To the authors' knowledge, coordination with state public health personnel for DOD access to inspection reports was not attempted.

Feeding plans based on a DOD-contracted food supply or operational rations should be the primary source of subsistence for deployed personnel. In instances of per-diem-based feeding plans, coordination should occur between the state, county, or city inspection authority and DOD veterinary and preventive medicine personnel to access inspection reports.

Food Protection Support to Deployed USNS Hospital Ships

Food protection inspections did not occur on all prime vendor subsistence deliveries to the USNS Comfort while deployed in support of the COVID-19 pandemic. Despite the strain the crisis placed on operations, food source protections are essential.

Supporting AVS elements did not fully understand the difference between the logistical management of Navy ships ('USS' hull) and Military Sealift Command (MSC) ships, which includes USNS hulled Hospital Ships. The MSC provides logistical support to USS and USNS ships under separate programs. Differences in these programs led to confusion between AVS food protection personnel and personnel from the MSC program that supplies USNS Hospital Ships on how food protection support should be provided to deployed USNS Hospital Ships.

Army Veterinary Service has mechanisms to provide robust food protection support to deployed USS hulled Navy ships, including the Veterinary Food Inspector (MOS 68R) Ship rider program. Because USNS Hospital Ships fall under a different MSC program than USS ships, the assumption that AVS could provide seamless support through similar mechanisms to deployed USNS Hospital Ships led to confusion. Neither personnel at the MSC program that supplies USNS Hospital Ships nor supporting AVS personnel could effectively plan for support. Army Veterinary Service food protection personnel were unaware of subsistence deliveries to the USNS Comfort. In more than one instance, Veterinary Food Inspectors were not allowed onto docks to inspect delivered subsistence. The sole prime vendor inspection that occurred while the USNS Comfort was docked in New York City returned potential unwholesomeness issues in a large amount of delivered subsistence, resulting in the rejection of the product. The quality issue demonstrates the need for food protection support for these ships.

Current food protection policy and doctrinal publications do not contain guidance on the provision of support to USNS Hospital Ships. These documents describe support to the US Navy on a Service basis; no differentiation in support is made based on vessel type. No details for support to USNS Hospital Ships are included.

USNS Hospital Ships may request a Veterinary Food Inspector for deployments under the Ship rider program, as stated in the current MOU between VS and MSC. To facilitate this critical support, AVS Public Health Command personnel should establish an ongoing relationship with the centralized points of contact for galleys aboard the USNS Hospital Ships. Early establishment and maintenance of relationships with contacts for USS and USNS Hospital ships are crucial for effective support. A request for food inspection support must come from the MSC and not from AVS. Therefore, it is critical that personnel at the MSC program that supplies USNS Hospital Ships are aware of the value and importance of providing this support. Supporting units at Naval Stations Norfolk, VA, and San Diego, CA, must maintain an updated roster of the points of contact at the MSC who oversee the management of galleys on the USNS Hospital Ships.

The US Army VCO assigned to the Naval Supply Systems Command (NAVSUP) headquarters should be leveraged to provide liaison assistance between the applicable Army Public Health Command veterinary personnel and the MSC. This liaison should be supplemental to communication lines and relationships previously established in local Public Health Command or Activity Veterinary Service Installation Support Plans. Through established relationships, personnel at the MSC program supplying USNS Hospital Ships and AVS should identify veterinary food inspection support as both a planning factor and a mission requirement. Current food inspection policy and doctrine must identify the support available to USNS Hospital Ships. The only mention of support available to USNS Hospital Ships is in the current MOA between VS and MSC. Doctrine must explain the availability of assigning Ship riders to USNS Hospital Ships when deployed overseas, the possibility of food inspection support while deployed in support of DSCA missions and docked in CONUS but away from home port, and the availability of inspection support while at homeport if required. This recommendation will be codified in the new edition of AR 40-657/NAVSUP 4355.4H/ MCO P10110.31H, *Veterinary/Medical Food Safety, Quality Assurance, and Laboratory Service*, which is currently awaiting publication.

Virtual Audit Training

DOD travel restrictions combined with commercial food processing establishments barring entry to personnel other than employees made for a challenging audit training and certification environment. Novel training strategies were implemented to continue the mission.

Virtual dairy audit training was conducted via Microsoft Teams and used as refresher training for veterinary personnel due to constraints presented by the global pandemic. This method was moderately effective and could be used as temporary contingency refresher training. Ultimately, dairy audit training must be conducted in person due to the complexity of

dairy technology. The combination of initial in-person training and recurrent virtual refresher training could be extended to other commodities, such as slaughterhouses. Virtual refresher training has the added benefit of expanding to an audience regardless of geographic location. However, multiple information technology barriers require resolution prior to the institutionalization of an enduring virtual training platform.

The use of innovative technologies as a method to accomplish required training and certification should remain a secondary option. These methods should be reserved to augment in-person training and certification and are most appropriate during times of emergency, such as the COVID-19 pandemic. Virtual methods are not appropriate as the sole method of audit training or certification.

Auditing Establishments, Monitoring Programs, and Lab Sampling Contracting Officer Knowledge of Approved Sources Requirements

Some contracting officers were unfamiliar with the requirements identified in both DOD Instruction (DODI) 6490.03, "Deployment Health," and AR 40-657/NAVSUP 4355.4H/MCO P10110.31H, *Veterinary/Medical Food Safety, Quality Assurance, and Laboratory Service*, 21 January 2005, for use of approved sources for subsistence purchased with either appropriated or non-appropriated funds, which resulted in delays in contracts, commercial food protection audits, or both. Furthermore, recognizing the urgency of the situation, proactive contracting officers occasionally scheduled the initial food protection audit for the DOD veterinary auditor. This action ultimately resulted in audit delays due to proper procedures not being understood or followed in tasking and scheduling food protection audits (ie, pre-audit questionnaires) and led to confusion for the auditor and the establishment being audited.

Both contracting and veterinary personnel, particularly those at Geographic Combatant Commands and Service Component Commands, bear responsibility for ensuring that all relevant stakeholders understand food protection requirements to support feeding plans for deployments and have familiarity with relevant aspects of the commercial food protection audit process to support those feeding plans. A common understanding of food protection audit policies will maximize FHP and minimize food protection risk to deployed personnel. For the CONUS COVID-19 pandemic response, the Veterinary Service OPT published an information paper (IP) to assist senior and ASCC staff veterinary personnel in informing appropriate supporting contracting officers of these requirements.

Command or staff veterinary personnel must be proactive in engaging contracting personnel during non-emergency periods to ensure they are aware of approved sources requirements, contractual obligations, and relevant aspects of the auditing process for planning purposes. An additional measure that should be examined is whether adequate procedures currently exist to inform a common understanding across the applicable DOD contracting framework and within NORTHCOM and subordinate Service commands to establish safe food sources for DOD personnel. The Joint Culinary Center of Excellence is responsible for training contracting officers and should explore the development of a centralized training course, such as a Joint Knowledge Online offering. The development of training should be a collaborative effort with the Army Medical Center of Excellence.

Performing Audits Prior to Contract Award or Start of Production

Audits of commercial food establishments identified to support feeding plans for the CONUS deployment of DOD personnel were delayed due to a misunderstanding by DOD personnel on the requirement for the establishment to be in production at the time of the audit. For example, VS personnel were unable to conduct an audit in Baton Rouge, Louisiana, during the initial attempt because the vendor was waiting for the DOD contract to be awarded prior to rehiring their employees. Cooking operations were suspended at the establishment, and food samples for laboratory analysis were unavailable during the audit attempt. Per Army Regulation 40–657/NAVSUP 4355.4H/MCO P10110.31H, *Veterinary/Medical Food Safety, Quality Assurance, and Laboratory Service, 21 January 2005* audits are authorized to be conducted prior to contract award only if the commercial food processing plant or caterer is in production. The Veterinary Service COVID-19 OPT and the APHC VSPHS discussed these requirements with the ARNORTH staff veterinarian to ensure DOD contracting personnel were aware of these requirements. They requested that he engage DOD contracting personnel.

Contracting personnel should give identified food establishments as much notice as possible about the requirement to be in production during an audit to maximize the time both food establishment personnel and Veterinary Service auditors have to prepare for the audit. Though expedited audit preparation procedures were established to support feeding plans for rapid CONUS deployments, this process normally takes weeks, and any additional lead time will assist in preparations during crisis action response situations.

Veterinary personnel conducting audits on establishments already identified by the KO during the PDSS or by veterinary personnel included on the ADVON team will facilitate the availability of approved establishments to support feeding plans in a timely manner instead of relying on audit requests once the PDSS team returns. Audits performed after the contract award will delay the use of the food establishment until the commercial food processing plant or caterer has passed the audit, which impedes the use of these establishments to support feeding plans for rapid deployments. Combatant Command or ASCC staff veterinarians must engage with

DOD contracting personnel as early as possible when feeding plan requirements are being determined to discuss food protection contractual requirements.

Performing Audits Prior to Service Member Consumption of Food

Lags in audit execution, particularly in support of the earliest CONUS deployments, sometimes resulted in audits being performed after deployed service members were already eating at an establishment, increasing FHP risk to these service members. Rapid deployments of UAMTFs and other response forces resulted in a short or no-notice notification to veterinary personnel to support identified feeding plans also contributed to delays. Other root causes of audit delays are described elsewhere in this article.

Service members eating at establishments that had not yet been audited increased food safety and defense risk to deployed forces. Commanders may not realize the risk they are assuming in these cases. The importance of appropriate food protection contractual requirements and auditing establishments supporting feeding plans for deployed personnel became apparent during the January-March 2021 deployment of National Guard personnel to the US Capitol. Media sources reported multiple instances of widespread probable foodborne outbreaks in this cohort of deployed personnel. Department of Defense veterinary support was not solicited to advise, conduct food protection requirements, or assist in identifying already approved sources for this US Capitol deployment.

In order to appropriately identify and mitigate food protection risks to CONUS-deployed personnel, establishments supporting feeding plans must always be audited by Army veterinary personnel prior to use. An additional measure to assist in closing this gap is to set the requirement within emergency preparedness plans and crisis action planning for Veterinary Corps Officers to advise on feeding plans and contracts for feeding plans.

Conditional Approval of Food Establishments Pending Receipt of Laboratory Sample Results

Routine audit procedures during normal operations specify that food establishments cannot be approved until receipt of passing laboratory sample results. Following this requirement, as outlined in MIL-HDBK-3006C, *Guidelines for Auditing Food Establishments, 1 June 2008,* would have significantly delayed the approval of eating establishments for Service members deployed to the COVID-19 response.

The expedited commercial food protection audit measures established to support rapid CONUS-based COVID-19 deployments included a measure to conditionally approve commercial food establishments with acceptable audit results pending the receipt of laboratory food sample results. The receipt of laboratory sample results can take longer than a week, even with the prioritization of samples by the DOD Food Analysis and Diagnostic Laboratory. Conditional approval enabled food establishments with acceptable audit scores to begin supporting DOD personnel. The DOD accepted risk while waiting for laboratory results but prevented delays in executing desired feeding plans. In the event that a caterer's laboratory results were outside of acceptable limits, its use as a source of food for the DOD was immediately discontinued. This practice resulted in one establishment being removed as an approved source due to a positive laboratory sample for *Bacillus cereus*. Another audit was performed at this establishment, and three sets of serial laboratory testing, all of which were negative for pathogens. The catering establishment was then relisted in the Worldwide Directory as an approved source.

Conditional approval of establishments pending receipt of laboratory sample results should be continued as a best practice during crisis action responses. This practice should be limited to commercial catering establishments required for feeding personnel on short notice.

Comprehensive Active Surveillance Program (CASPr) for Food Laboratory Samples

The destination monitoring program, a legacy subsistence laboratory sampling program, was refocused during the COVID-19 pandemic to incorporate a deliberate sampling selection methodology based on aggregate risk values of various inputs. Renamed the Comprehensive Active Surveillance Program (CASPr), this enhanced laboratory sampling strategy contributed to strengthening the overall DOD pandemic food protection response through more than a 150% increase in unacceptable product detection during the pandemic. CASPr employs a scientific approach for targeting food commodities of most concern that broadens food sample selection from origin to consumption. The CASPr provided an innovative decision tool to determine which types of food commodities to target, derived from multiple data platforms within the DoD, FDA, and CDC. Implementation of CASPr methodology resulted in both national and DOD recalls and prompted numerous directed audits of commercial facilities and interagency engagements with the FDA and USDA.

The flexibility and relevancy associated with CASPr as a surveillance tool that can pivot to emerging areas of concern during crisis action responses and DSCA events should be incorporated as a critical part of ensuring the safest food supply during uncertain times. Customer complaints and other issues identified at DOD food establishments are additional areas where CASPr should be focused during crisis action responses or DSCA events. This recommendation will be codified in the new edition of AR 40-657/NAVSUP 4355.4H/

MCO P10110.31H, *Veterinary/Medical Food Safety, Quality Assurance, and Laboratory Service*, which is currently awaiting publication.

Flexibility of the Commercial Food Protection Audit System during Emergencies

Global challenges associated with the COVID-19 pandemic resulted in an inability to conduct in-person food protection audits at the required frequency for commercial food processing establishments already listed in the Worldwide Directory.

The Veterinary Services COVID-19 OPT quickly recognized that in-person commercial food protection audits were not executable at the required frequencies during the pandemic. The VSPHS Directorate at APHC initially extended suspense dates for routine audits by 90 days. During this time, the Food Protection working group began drafting mitigation measures for food protection risk in the event the pandemic impacted the conduct of in-person audits for longer than expected. When APHC extended audit dates for another 180 days due to pandemic-related constraints on performing in-person audits, the Systems Review Audit (SRA) process that VSPHS Directorate developed and the OPT approved was activated. The SRA process afforded opportunities to stratify food protection risk by commodity, establishment history, and specific country factors, and, when risk was deemed low enough, authorized an SRA in lieu of an in-person audit.

The SRA relied on a thorough review of food production processes at an establishment as an alternative to an in-person audit on a temporary basis. Establishment personnel emailed digital documentation to an auditor who reviewed these documents for acceptable food protection practices, helping to mitigate the risk incurred by missed audits. This process also aligned with the FDA's COVID-related initiative of performing virtual audits of commercial food processing establishments. Extensions in due dates for routine audits prevented establishments from being suspended from the Worldwide Directory and auditors from repeating an initial audit when pandemic conditions permitted access to in-person establishment visits. Audit extensions combined with the SRA process mitigated shortages while maintaining a safe food supply for DOD beneficiaries worldwide.

During emergencies or disasters, the Commercial Audit Program Manager at VSPHS should maximize flexibility within the audit system while appropriately minimizing food protection risk. Best practices implemented during the COVID-19 pandemic, such as the SRA process, should be outlined and included in relevant doctrinal and policy publications for future use when appropriate.

Collaboration with Preventive Medicine on Food Safety and Food Service Sanitation Requirements

The Veterinary Service COVID-19 OPT was informed early in the pandemic that auditors and inspectors noted that some food establishments were using inappropriate concentrations of sanitizers and disinfectants due to confusion about concentrations authorized for food contact surfaces versus concentrations required to "disinfect" for the coronavirus. During the first months of the pandemic, the possibility that food could be a transmission vehicle for the SARS-CoV-2 virus led to increased concern among food establishment personnel about taking appropriate measures to sanitize and disinfect to prevent possible viral transmission.

Preventive medicine staff at the APHC VSPHS Directorate published guidance for food establishment personnel reinforcing standards for proper cleaning, sanitizing, and disinfection procedures during the pandemic. The Veterinary Service COVID-19 OPT, APHC, and the military service branches widely distributed this guidance to food establishment personnel, inspectors, and auditors. The installation Medical Authority ensured this guidance was followed at food establishments on DOD installations.

Synergizing efforts with preventive medicine personnel across Services during the early chaotic stages of the pandemic reinforced existing food safety and food service sanitation guidance and regulations with food establishment personnel, particularly on DOD installations.

This early collaboration during relevant crisis action responses or DSCA events should continue to ensure that all aspects of food safety, food service sanitation, and food defense are addressed. The collaborative efforts will assist in ensuring the safest possible food supply for Service members and beneficiaries during emergency situations.

Conclusion

The DOD response to the COVID-19 pandemic revealed strengths and weaknesses in food protection support for crisis action planning and DSCA response. Early OPT establishment and its universal organizational representation facilitated the proactive AVS response to pandemic issues, synchronized efforts across the DOD food protection enterprise, and was invaluable when addressing concerns and providing guidance to the field.

It is a best practice that should be sustained in future crisis operations. Established processes employed during routine operations proved cumbersome and required modification to meet the rapid timelines associated with a DSCA response. The lack of established, sustained coordination and communication between both AVS and other food protection stakeholders delayed audits required to ensure a safe food supply

for deployed personnel. Many of these documented lessons learned have associated recommendations that are difficult for AVS to influence easily. However, advocating for appropriate talent management at ASCCs and including VS personnel on crisis action teams and PDSS and ADVON teams will improve food protection support during future DSCA responses. These lessons learned are applicable to any event that significantly disrupts the military food procurement system and, if implemented, will ensure the safest food supply possible during a crisis.

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Army Veterinary Services and Food Safety in Large Scale Combat Operations

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Abstract

The U.S. Military is preparing to conduct large scale combat operations (LSCO) in a logistically contested environment after ending a 20-year phase of counterinsurgency operations (COIN) with relative logistical freedom. This provides new challenges for the combat services support branches. As part of preparing to support LSCO, Army Veterinary Services (AVS) must consider LSCO implications on both clinical care of working animals and force health protection (FHP). This article focuses on predicting future FHP requirements using scenarios that AVS encountered during World War II (WWII) while also considering the training and organizational development of AVS, throughout its history, and how those considerations impact AVS preparation to meet the challenge of LSCO.

Introduction

As the entire Department of Defense (DOD) pivots from 60 years of counterinsurgency operations (COIN) to large scale combat operations (LSCO) in a multidomain operations environment with near-peer competitors, the Army Medical Department (AMEDD) is planning to support the warfighter in this arena.[1-2] Army Veterinary Services (AVS) plays a unique role in the AMEDD, with a joint requirement for both the protection and the sustainment warfighting functions as the sole DOD veterinary services provider. The question now is: how does the AVS medical function best support the AMEDD and joint force in LSCO/multidomain operations? AVS and AMEDD leaders will answer that question. They will consider both health services support (HSS) of military working animals for the sustainment warfighting function and FHP for the protection warfighting function. This article focuses on the latter. To predict these requirements, it is necessary to start with a history of AVS FHP support, focusing on WWII LSCO, U.S. food safety and other FHP responsibilities, and their metamorphosis over time. The article will then apply this historical lens to the problem statement: how does AVS best support FHP in LSCO/multidomain operations with current threat models?

The Spanish-American War and "Embalmed Beef" Scandal

The Spanish-American war and the "embalmed beef scandal" that emerged from it both took place before AVS existed, but they played a significant role in its establishment. The scandal began when newspapers in the U.S. published accounts of soldiers dying from poor sanitation and poisoned food.[3] In fact, 5,438 soldiers perished from disease, while only 968 died from battle or accident-related wounds.[4] Service Members complained their canned meat rations tasted terrible, produced a chemical odor, and blamed this food for their illnesses. These service member reports were published in the newspapers, creating public outrage.[4] When President McKinley appointed the Dodge Commission to investigate these media reports, General Nelson Miles saw this as a political opportunity. He coined the term "embalmed beef" to describe the meat provided to service members, indicating that the meat was preserved for troops with formaldehyde and subsequently poisoned the soldiers.[3] The Dodge Commission published its findings in 1899. While it did not find any evidence of chemically adulterated meat, it uncovered unsanitary practices during processing and temperature abuse during transit that may have led to soldiers with foodborne illnesses.[4] The Surgeon General of the Army stated that the disease in the soldiers was caused by Yellow Fever, not poisoned food.[3] Regardless of the Dodge Commission report or the Surgeon General's statement, the public believed that soldiers were fed poisoned meat by producers trying to profit from the war. Media outrage and the government investigations resulted in improvements to meat processing and inspection for both the Army and the civilian population.[4]

Changes began for the Army Veterinary Services within two years. In 1901, a veterinarian was transferred from the United States Department of Agriculture (USDA) and appointed as meat inspector for the U.S. Army, initiating the Army's Veterinary Food Inspection Service.[5] The purpose of this

veterinarian appointment was to conduct receipt inspection of meat products sold to the Army, which complemented the sanitary inspections already conducted by USDA. By 1906, the number of veterinarians in the Army Food Inspection Service had increased to six, and post commanders were directed to "use veterinarians to conduct ante-mortem and postmortem inspections of beef procured locally."[5] Both the military and civilian population were impacted when President Theodore Roosevelt signed two laws supporting safe food. He signed both the Federal Meat Inspection Act (FMIA) and the Pure Food and Drug Act in 1906. The FMIA required USDA to inspect meat processing plants that conducted business across state lines. The Pure Food and Drug Act resulted in creation of the Food and Drug Administration. In 1912, congressional legislation created the Quartermaster Corps (QMC) and the six civilian veterinarians in the Army were transferred to the QMC. Thus, over a short period of time, meat inspection became a significant regulatory issue in the federal government for both civilian and military personnel, with inspection responsibility spread across military and government agencies.

Creation of the Veterinary Corps and World War I

In 1916, Congress authorized creation of a corps made up of veterinary officers. In 1917, the American Veterinary Medical Association (AVMA) recommended to the Surgeon General that enlisted members become part of an AVS. This AVS was subsequently used in preparation for, and in expeditionary support to, World War I (WWI). The AVS swelled to over 2000 people during the war, including Regular Army (RA), Army Reserve (AR), and National Guard (NG) officer and enlisted personnel, most of whom supported the Army's working equine mission.[6] However, the Veterinary Corps also provided 78 officers and 109 enlisted members to inspect meat in 102 establishments across 31 cities during this time period.[7] This veterinary team inspected 1.26 billion pounds of meat at origin and condemned 11 million pounds of that total.[5] This prevented it from entering the military food supply as it had during the Spanish-American War, and likely prevented foodborne illness in deployed service members.

Interwar Years and Non-Animal Source Foods

The peace of the interwar years provided time for the Veterinary Corps to establish its doctrine. They also brought a new opportunity for AVS – food safety support to a civilian population. As part of the New Deal, President Franklin D. Roosevelt established the Civilian Conservation Corps (CCC) in 1933. Originally, the USDA was charged with inspecting food going to the CCC camps. However, the USDA was not able to meet the demand, and AVS was placed in charge of inspecting animal source foods.[8] As a result of AVS successfully executing this request, it was asked to expand inspection responsibilities to other foods, such as fresh fruits and vegetables, initiating the AVS mission of inspecting both animal and non-animal source foods.[5] This time period allowed the AVS to develop its skillset in preparation for significant expansion in WWII.

World War II

In 1939, there were 126 veterinary corps officers in the Army. During World War II (WWII), the AVS grew significantly to provide food inspection support to the military, reaching a peak of over 2000 officers and 6,000-8,000 enlisted personnel by 1945.[9] While the AVS focused on animal health in WWI, in WWII 90-95% of the veterinary mission focused on food.[5] AVS conducted point of origin inspection of animal source food at facilities in the United States for products heading to the operational areas. As an example of AVS impact, by June 1945 it had disapproved 1,100 meat and dairy facilities from providing items to the military due to unsanitary conditions.[9] Army Veterinary Services also conducted receipt and surveillance inspections of food in the combat theaters. This was a particularly daunting task in the Pacific, as service members were scattered on multiple islands, and there was difficulty deploying veterinary personnel to all of the locations.[9] Moreover, food was often offloaded in haphazard manners, stored in hot/humid conditions.

Importantly, AVS was directly engaged in supporting local food procurement when contested sea lines of communication resulted in a shortage of subsistence or when contracts were created with local producers for direct supply. For example, on Bataan, AVS supported the foraging of carabao, mules, horses, cattle, and hogs by establishing field abattoirs to support food production. Cold storage was frequently destroyed by Japanese bombing, and service members relied on fresh meat, making these field abattoirs crucial.[9] In India, veterinarians conducted critically needed ante- and post-mortem inspections at abattoirs for meat procured through contracts with the Royal Indian Army Service Corps. Entire herds of animals were rejected due to poor condition and diseases such as anthrax or rinderpest.[9] Eggs were another problem and 90% were rejected during candling that identified mold, rot, blood rings or other issues.[9] In China, U.S. forces relied on veterinary inspection for local subsistence items which were considered even poorer quality than those described for India.[9] In the Middle East and Africa theaters, AVS supported British units who controlled the area. The most common animal source foods procured for consumption here were fish, eggs, and poultry, with the poultry processing being continuously supervised by veterinarians.[9] Veterinarians also supported testing of dairy herds for tuberculosis so fresh milk supplies could be established.[9] In the European theater, AVS focused food inspection on receipt and surveillance inspection of products shipped from the continental

United States to the deployed forces. This was particularly important since transport and storage conditions negatively impacted food safety.[9]

Army Veterinary Services contributed to civil affairs and military governance (CA/MG) during and after WWII. "During the war, in the Allied-liberated countries and recaptured areas and in the occupation of surrendered countries, these personnel succeeded in the application of civilian public health and veterinary measures which protected the health of American fighting forces and its animals against the threats of indigenous animal and foodborne diseases, and concurrently aided in the early restoration and beginning rehabilitation of the respective countries' veterinary public health and agricultural livestock industries."[9] There was no significant veterinary support to CA/MG in Africa. As the allies moved from Africa into Italy, AVS was instrumental in supervising the restoration of livestock disease control programs to their pre-war levels. This included zoonotic disease programs for brucellosis, tuberculosis, swine erysipelas, anthrax, and glanders.[9] AVS advised the Italian government on controlling diseases that, during the war, spread throughout livestock. These diseases included hog cholera, newcastle disease in poultry, and Foot and Mouth Disease (FMD) in ruminants. Veterinary support was also used to re-establish veterinary control of livestock disease in Holland, Luxembourg, and Belgium. This included supervision of local national veterinarians in examining and destroying livestock spreading FMD along borders.[9] It should be noted that it was important for future food production to ensure that as many breeding stock were saved as possible and veterinarians were critical to this process of preserving breeding stock while simultaneously removing disease vectors from the system. Germany had a robust veterinary system. However, as a result of denazification, many veterinarians were removed from their positions. As national veterinary services were re-established in Germany, AVS acted as liaisons between occupied nation veterinary services and the Allied Forces CA/MG.[9]

Veterinarians supported CA/MG in the Pacific Theater as well. Many of the island chains did not have large livestock herds and did not require significant disease management. The first big impact of AVS on CA/MG in the Pacific happened on Okinawa. As that island was captured, AVS supervised the care and treatment of captured animals and inspected food and food animals used for feeding civilians interned on Okinawa. They also supervised captured Japanese veterinarians who oversaw management of animals at internment camps. Finally, as in Europe, AVS supported disease management programs for zoonotic diseases such as equine encephalitis, erysipelas, and bovine brucellosis.[9] In the Southwest Pacific Area, AVS had little role in CA/MG. In Japan, the government was not abolished as in Germany. So, although AVS provided some recommendations regarding animal disease management and sanitary control of meat and dairy industry, the Japanese government remained in charge of their own veterinary system.[9]

The Korean veterinary system was run by Japanese veterinarians after the Japanese annexation of Korea in 1910. When the Japanese in Korea were sent back to Japan after the war, AVS ran the Korean veterinary system including disease and slaughter management. Army Veterinary Services established veterinary training programs in Korea and slowly transitioned veterinary services to these students as they completed training. Once transitioned, AVS assumed a supervisory role in the Korea veterinary system.[9]

Post World War II

Many responsibilities of the AVS, such as food safety inspections within the U.S., transitioned to other U.S. government agencies after WWII. Where AVS had been responsible for grading all carcasses, poultry, and eggs sold to the military, these responsibilities were transferred to the USDA Agricultural Marketing Service (AMS).[5] The United States Public Health Service (USPHS), and later the FDA, took responsibility for monitoring dairy pasteurization compliance, The USDA was now responsible for fresh fruit and vegetable inspection, and the Department of Commerce took responsibility for waterfoods such as fresh fish.[5] Duties relating to inspections in the U.S., previously conducted by AVS, were transferred to other U.S. agencies, removing responsibility from AVS. The removal of responsibility was coupled with the removal of AVS personnel's opportunity for gaining expertise and readiness to assess local food sources and conduct inspections in future expeditionary operations as they had during WWII. At this time, AVS was still in meat processing plants that provided product to the military and in overseas dairy plants.

During the Vietnam War, AVS heavily supported food safety through receipt and surveillance inspections in Vietnam. This was a massive effort with approximately 30 million pounds of food rejected during procurement inspection and approximately 600 million pounds rejected during surveillance.[5] Fresh milk and ice cream were a significant morale boost for service members deployed to Vietnam. However, limited refrigerated shipping capacity restricted transport of these products from the United States. Several private firms were contracted to establish dairy and ice cream plants in Vietnam to solve this logistics problem. AVS supported sanitation training for the Vietnamese personnel working in these plants to ensure the morale-enhancing products being provided to service members wouldn't create disease and nonbattle injuries (DNBI).[5] In addition, ice posed a significant risk because it was made from local water containing Hepatitis A. AVS supported inspection of a company that treated local water to make safe ice, and helped establish a method to identify

ice manufactured in this plant. The ice was dyed with blue food coloring to positively identify the safe ice and prevent future Hepatitis A transmission.[5]

"Boston Massacre"

The next critical point in AVS FHP history occurred shortly after the Vietnam War. In late 1974, an event that would lead to the "Boston Massacre" dramatically changed AVS inspection of meat production facilities. Boneless beef was rejected by the AVS from a long-time U.S military supplier in Florida. The meatpacker was upset and wrote to his congressman who requested an investigation of the AVS inspection process for meat in the DOD procurement system. The government inspection discovered that most frozen fabricated beef products were not conforming to government requirements, triggering a DoD investigation that uncovered multiple deficiencies in both the AVS inspectors and a beef facility in Boston. The co-called "Boston Massacre" ensued: the officer-in-charge and other inspectors were relieved and replaced. This led to another investigation by the Defense Investigative Service that expanded beyond Boston: "A federal grand jury brought a 51 count indictment against the owners of several firms for bribery, conspiracy to upgrade meat, falsely labeling cuts of meats, and substitution of meats."[5] This ultimately caused a loss of trust in the AVS inspection process, and the U.S. Congress transferred origin inspection responsibility from AVS to the USDA, thus removing AVS from meat-processing facilities in the U.S.[5] Over time, AVS was also removed from overseas facilities with the exception of scheduled sanitary audits. As a result, AVS lost its platform to train AVS personnel to perform the type of inspection and military governance oversight services they had performed during WWII CA/MG.

Executive Agency and Creation of the Veterinary Service's Food Safety Warrant Officer

The fiscal year 1980 Department of Defense (DoD) Appropriation Bill disestablished the Air Force Veterinary Services. The Army was then appointed Executive Agent for DoD veterinary functions effective October 1980. Food inspection remained one of the DoD veterinary functions but there was no requirement for the food inspection to be completed by a veterinarian. It was at this point that the Surgeon General directed formation of the Food Safety Warrant Officer (FSO) within AVS to ensure expertise in this critical mission.[5] In addition to military experience and training as an FSO, these officers obtain additional food safety expertise through civilian universities and training with industry. The lesson learned from the preceding historical synopsis is that an Army asset, AVS, is now the sole provider of veterinary services to the joint force, including food safety; therefore, coordination is required to plan for and provide AVS FHP support to all the services in future LSCO.

Global War on Terror (GWOT)

The AVS continued to provide receipt inspection, surveillance inspections, and civil affairs support to animal health programs in all the expeditionary missions from Vietnam through the present day. It did not revert to providing origin inspection of meat products procured for Service Members; AVS relied on USDA for this support. AVS continues to maintain an origin inspection mission at U.S. operational rations assembly plants. AVS inspectors could be placed in overseas processing plants subsequent to contract negotiations with facilities providing subsistence to the U.S. military but is not judged necessary by senior overseas veterinarians at the time of this writing due to current safety assessments.

AVS did create a Food and Water Risk Assessment program to support commander's risk assessments when procuring food from local eateries, during limited duration overseas engagements, with the understanding the locally approved sources may not be available or practical for short engagements and cognizant that local eating is a risk to health of the force that commanders must understand. Throughout this period, the military did not suffer from significant foodborne infection and the AVS FHP support system functioned well to support COIN operations. Additionally, AVS created training programs such as the Veterinary Support to Stability Operations Course and Skill Identifiers for Global Health Engagement to support combatant commander CA/MG type of missions although these mission sets have not approached the requirements placed on WWII AVS personnel.

Current AVS Requirements for LSCO/ Multidomain Operations

The Army is now tasked to prepare for LSCO in multiple domains (land, sea, air, cyber and space) against near-peer competitors. The discussion above reviewed what AVS FHP looked like when supporting LSCO in WWII to illustrate what was required: inspect food products from point of origin (including ante- and post-mortem inspection of livestock); support field abattoirs and manage local herds processed in those facilities; manage disease spread among livestock during the chaos of conflict; act as and reestablish the national veterinary system in military governance; and liaise between military governance and local government or allied agencies on veterinary concerns. There is no reason to think AVS would not need to perform these same functions in a future LSCO.

Moreover, there are some things WWII AVS did not confront that current and future AVS personnel will need to address. For example, global population has grown from approximately 2 billion to approximately 8 billion. Large scale urbanization was part of this population boom. In WWII, conflict-area civilian populations were frequently forced to support food needs by harvesting locally raised animals and plant-based

foods. Today's urban areas do not have the same animal infrastructure to support this food resilience and the knowledge base of the general population to process their own food items dramatically decreased since the 1940s. This will be a stability concern in LSCO and AVS should be prepared to rapidly address food safety during stability operations as part of consolidating gains.

Current large scale food production uses automation within facilities and for the entire value chain from farm to fork. Where the veterinarians on Bataan had to create field abattoirs for fresh meat when cold storage facilities were destroyed by Japanese bombs and resupply lines of communication were cut through area denial, current AVS may face a combat environment with an entire food processing network destroyed by attacks in the cyber domain. For example, in 2021 the world's largest meat company (by sales) paid cybercriminals an $11 million ransom after the criminals used the cyber domain to knock out their plants.[10] This attack put 20% of the U.S. meat supply at risk. If this happened as part of multidomain operations in the U.S. or overseas, it could require massive support from AVS as processors adapt to functioning without automation or refrigeration. Poultry and swine operations have network-controlled climate, ventilation, and food/water systems. All these functions could be impacted in the cyber domain, causing massive disruption to agriculture and food production. At the time of this writing, the Russian Federation is destroying Ukrainian power and water infrastructure. Food has been used as a weapon of war throughout history. There is no reason to believe that future LSCO multidomain operations would not include infrastructure attacks that could include food production.

During WWII, AVS supported agriculture and food security by managing livestock disease outbreaks such as rinderpest. Although postwar rinderpest outbreaks once caused famine after spreading through herds, it is currently the only animal disease that has been eradicated outside of laboratory samples.[11] However, just as its human corollary, smallpox, poses a concerning biologic warfare threat, rinderpest and other devastating livestock diseases are a biologic warfare potentiality that could shatter food security. Learning from history, AVS must be prepared to manage outbreaks of herd health diseases resulting from biologic attack to minimize their impact on food security.

Conclusion

As we prepare to support LSCO in future conflicts, AVS can leverage the lessons learned from history to predict future requirements. It must be able to oversee animal source food processing from tactical (individual animal slaughter) to strategic (oversight of a national processing system) levels. It must also be prepared to manage a national-or theater-level animal disease prevention program, and potentially disease eradication programs, through large scale culling, quarantine and/or vaccination operations. In addition, AVS must be ready to act as the liaison to military commanders regarding the impact of food safety system breakdowns (from farm to fork) on civilian populations during consolidation of gains and recommend solutions to enhance stability.

As emphasized in this discussion, AVS used to have personnel placed in point of origin processing plants completing inspections from ante-mortem through processed products. The Army Veterinary Corps was created in 1916 to accomplish that exact goal and grew to meet the military's ever-expanding need for that service. However, those responsibilities were moved from AVS to other agencies. AVS may consider returning to some of its roots to train for the mission it performed in the past and must be ready to perform again. There are programs, including area of concentration (AOC) producing long term health education and training (LTHET) programs for 64Bs (Veterinary Preventive Medicine Officers) and 640As (Food Safety Warrant Officers), that prepare AVS personnel to support herd health and national veterinary system responsibilities. However, most of these personnel do not have an opportunity to exercise these skills in their daily jobs. In order to prepare for "worst day" scenarios of LSCO and multidomain operations, AVS will need to train on those skills and plan to train new recruits to perform these tasks in the case of a rapid expansion of personnel as in WWII (from 126 to 2000 veterinarians). This is a big challenge but one that must necessarily be met.

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Veterinary Service Support to Operations Allies Welcome and Allies Refuge

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Abstract

Army Veterinary Services (AVS) personnel from across the Army Public Health Enterprise provided support to Afghan refugees through Operations Allies Refuge (OAR) and Allies Welcome (OAW). Multiple Army Veterinary Service units provided food inspection support, commercial audit support, and installation support to the sites that housed the refugees. Refugee support in the continental United States adapted to the evolving mission. Several lessons learned have been identified, and numerous proposed changes to the Tactics, Techniques, and Procedures have been addressed. Civilian outreach and engagement, synergy development across the Joint Logistics Enterprise, and changes to the existing procurement process for culturally sensitive foods have all been incorporated into policy. The support provided for this mission was unique and provided a learning opportunity for its successful completion.

Introduction

AVS personnel across the Army Public Health Enterprise supported Afghan refugees through OAR and OAW. AVS personnel from Public Health Activities Belvoir, Bragg, Hood, and Knox, along with the 72nd Medical Detachment (Veterinary Service Support), played a vital role in providing food safety, food defense, and other public health functions throughout the operations.

Background

The US government negotiated with the Afghan government to withdraw all US troops from the country by July 31, 2021. Following the withdrawal, the US intended to repatriate US citizens and at-risk Afghan citizens. Due to the sudden withdrawal, a need arose to provide logistical, medical, and transitional support for incoming Afghan citizens.

Support operations began on July 17, 2021. The Department of State (DOS) was appointed the lead federal agent. The DOS requested that the Department of Defense (DOD) provide emergency housing, sustainment, and support to Afghan Special Immigrant Visa (SIV) applicants and their families. The US Army North Fifth Army, serving as the US Northern Command, Joint Force Land Component Command, provided the necessary support as requested by the DOS. The DOD provided the requested support or temporarily provided support as the Fifth Army completed the medical, security, and administrative processing of SIV applicants and their families prior to their movement and transition.

Mission

OAR initially began with Task Force Eagle at Fort Gregg-Adams (formerly Fort Lee), with the processing of Afghan SIV applicants. Later, it encompassed operations for Afghan Special Immigrants and Afghans at Risk at seven additional DOD installations and one off-installation conference center:

- US Marine Corps Base Quantico, VA—TF Quantico,
- Fort Barfoot, VA (formerly Fort Pickett)—TF Pickett,
- Joint Base Maguire-Dix-Lakehurst, NJ—TF Liberty,
- Fort McCoy, WI—TF McCoy,
- Camp Atterbury, IN—TF Atterbury,
- Fort Bliss, TX—TF Bliss,
- Holloman Air Force Base NM—TF Holloman,
- National Conference Center in Leesburg, VA.

When OAR transitioned to OAW on August 29, 2021, the Department of Homeland Security became the lead federal agency. Over 75,000 Afghans from all three categories were received, supported, processed, and resettled at the nine support sites. OAW officials declared the mission complete on September 30, 2022, after the final support staff departed the National Conference Center.

To ensure the food met all regulatory requirements, AVS personnel provided food protection oversight of contracted services and resources while coordinating with onsite representatives from other departments and agencies. On average, 165 000 meals were prepared daily throughout the nine support sites. AVS personnel performed receipt inspections on all incoming food deliveries, inspected all donated food items for food safety and defense conditions, performed surveillance

inspections of all food storage facilities, provided subject matter expertise to logistic managers to prevent over-ordering, provided sanitation oversight of all food facilities, and provided many other vital support services on each of the support sites. In addition to the site-specific support, AVS performed commercial food protection audits of 10 civilian facilities that delivered catered meals to the installations.

Lessons Learned

Due to the rapid development of the situation and lack of organic assets, numerous sites were without preventive medicine support. As such, AVS personnel performed many preventive medicine functions throughout the support sites. These preventive medicine functions ranged from sanitation evaluations of dining facilities to onsite water potability testing. A small preventive medicine team was recommended that work jointly with AVS to ensure a comprehensive approach to public health with all food safety areas covered.

AVS personnel have deployed to many different locations outside the continental United States in this type of food protection role. However, the population the AVS personnel support are military members and their families. The Afghan refugees required a different approach than the normal policies and procedures. Due to the wide age range (infant to elderly), cultural differences, and families displaced on short notice, optimal food service support for OAW required an expansion and modification of standard practices to better serve the supported population of Afghan refugees and SIV applicants, limit food waste, and improve morale. Since most Afghans evacuated to the United States had little familiarity with US food service operations and culinary practices, a US Armed Forces standard 14-day master menu or expanded commercial menu was not readily accepted. This led to long lines at the dining facilities, wasted food, food hoarding, and some people not eating at all. AVS personnel were integral in making several adaptations to the mission.

Outreach and Feedback

AVS personnel participated in installation food council meetings to provide groups with food safety and defense subject matter expertise. The food councils were formed to address differences in cultures and food preparation. During the food council meetings, refugees shared their cultural needs, and AVS personnel expressed their requirement to provide them with safe, wholesome food.

Adjusting Tactics, Techniques, and Procedures (TTPs)

Standardized and simplified menus across all guest locations ensured a consistent, safe food supply acceptable to involved groups. After identifying several operational problem areas and shortages, AVS personnel adjusted their techniques to ensure the proper inspection of subsistence items delivered to the installations. Receipt inspection procedures in heightened security environments, increased surveillance inspections, and sanitation evaluation of facilities were some of the TTPs that AVS personnel adapted to meet the unique mission requirements. AVS met the mission requirements by adapting the TTPs to the unique environment faced, which resulted in all subsistence contractual requirements being met.

Improving Infant and Toddler Subsistence

Adults who required powdered milk supplements for their children's dietary needs posed an additional concern since infant and toddler subsistence is not a normal part of the DOD field feeding subsistence supply chain. Approved source vendors were contacted to supply the required supplements. Additional vendors were contacted for expansion of sources and audited by Veterinary Corp officers. In addition to the added sources, AVS received infant and toddler food donations from non-government organizations. AVS personnel prioritized daily inspection of this subsistence to ensure that it could be used and ensured all donated infant and toddler subsistence met food safety requirements.

Synergy Across the Joint Logistics Enterprise

AVS personnel were integral in the synchronization of the Joint Logistics Enterprise. On many installations, AVS personnel were the primary liaison between the Food Program Management Office, Defense Logistics Agency, and US Army North supply logistics, G4. AVS also provided input to several program areas such as fresh fruits and vegetables, fresh dairy, and fresh bakery products by identifying several over-ordering situations and remedying them with the procurement agencies. Those actions saved several hundreds of thousands of dollars of subsistence from deteriorating and becoming unfit for human consumption.

Changes to Procurement Methods to Provide Culturally Specific Food

AVS personnel worked with procurement and logistic specialists to supply regulated food that met the cultural dietary requirements of the Afghan refugees. AVS also coordinated with Afghan refugees to ensure recipes were adjusted to accommodate the palate of the guests and improve the food defense posture within the facility.

Conclusion

AVS personnel provided food safety and food defense support to OAR and OAW. The support of US Army Forces Command and other organizations provided sufficient AVS personnel to cover the missions.

There were lessons learned and best practices developed throughout the fourteen months of support. AVS personnel were fully integrated into the day-to-day operations on each of the support sites. AVS personnel served with distinction and were recognized for their accomplishments by senior US Army Medicine Command leadership.

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Review of Comprehensive Active Surveillance Program and the Legacy Subsistence Surveillance Activities in the United States Army Veterinary Service

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Abstract

The US Army Veterinary Service has performed subsistence laboratory surveillance for decades. In FY 21, the Army Public Health Center, Food Protection Division initiated the first phase of comprehensive active surveillance and replaced the legacy subsistence surveillance Destination Monitoring Program (DMP). The Comprehensive Active Surveillance Program (CASPr) is a risked-based approach intended to anticipate the food risks and threats within the Department of Defense (DoD) supply chain. CASPr broadens the scope of legacy monitoring activities by identifying commodities most likely to contribute to an unacceptable laboratory analysis from off-installation manufacturing to on-installation processing. The new surveillance program has increased the detection of unacceptable food by over 150% compared to the previous four years of legacy DMP surveillance.

Keywords: Comprehensive Active Surveillance Program, CASPr; Destination Monitoring Program, DMP; subsistence; sampling

Introduction

The US Army Veterinary Service historically performed at-destination laboratory surveillance activities in support of the overall subsistence monitoring program. In addition to regular inspections performed on military installations, the Destination Monitoring Program (DMP) facilitates the identification of unwholesome and unacceptable subsistence that may otherwise appear acceptable to the inspector. Taste, smell, or appearance may or may not indicate spoilage, and according to the Centers for Disease Control and Prevention (CDC), food containing pathogens will most likely appear normal. The subsistence monitoring program enables the Veterinary Service mission to project and sustain a healthy and medically protected force through the identification and subsequent removal of subsistence that is unfit for human consumption or otherwise unfit for its intended purpose.

Destination Monitoring

The Destination Monitoring Program (DMP) is the legacy subsistence monitoring program accomplished primarily through surveillance of closed packaged subsistence located in storage and within sales floors on military installations. The decision on the types of products selected for testing lacked a scientific and statistical approach. Within this sampling concept, there is no sample selection methodology, regional variation or consideration, or identification of emerging public health risks. The DMP applies to subsistence activities at Army, Navy, and Marine Corps installations.

Comprehensive Active Surveillance

The Comprehensive Active Surveillance Program (CASPr) employs a strategic monitoring concept based on a calculated risk. The sample selection methodology is based on the aggregate value of several inputs that are aligned categorically and determine the prioritization of sampling by commodity. Additional inputs are applied to this calculation to integrate regional variations and considerations and carefully review external agency data to reveal current and emerging threats. CASPr is accomplished primarily through the deliberate surveillance of all types of subsistence, from all sources, in all forms (eg, raw, packaged, and prepared), and is applied to the following locations:

- Product testing of foods at the manufacturing plant (off installation).
- Product testing of packaged foods received on installation.

- Environmental testing of food contact surfaces on installations.
- Product testing of foods processed on installations (ie, serving lines and direct-to-consumer).

Background

The number one goal is to prevent the purchase or consumption of unwholesome and low-quality subsistence. Actions taken after discovering an unacceptable laboratory result are similar between DMP and CASPr. In the CASPr methodology, unacceptable laboratory results become inputs to future risk calculations. Protecting the financial interest and conserving the fighting strength are paramount to both strategies. Each surveillance program applies within a globally dispersed area of responsibility where geographically aligned DoD laboratories perform analysis. The force health protection and quality assurance objectives are supported through analysis based on the following three requirements:

- Pathogenic or toxigenic hazards are reasonably likely to occur in the product.
- Federally established limits and statutes are in place (eg, US Food and Drug Administration, US Department of Agriculture, and Environmental Protection Agency).
- Quality specifications are outlined in the contract.

Laboratory results that establish products as unwholesome or otherwise fail to meet quality specifications are immediately reported and flagged for action according to the severity and risk to public health (Figure 1). Pathogenic or toxigenic results may lead to a DoD or nationwide food recall. Nonpathogenic (quality) results may lead to a DoD and national food recall; however, these results are typically addressed within the regional public health command where discovered. Possible outcomes after unacceptable laboratory results include[3]:

- Recalls.
- Medical hold actions.
- Additional sampling.
- Suspension of authorized deliveries.
- Special visits to manufacturers and producers (both on and off the military installation).
- Referral to external regulatory agencies.

In the case of flagged laboratory results after environmental monitoring, the communication is generally the same. Environmental monitoring results provide insight into sanitary conditions at a given facility and are addressed with local Veterinary Service personnel through root cause analysis and appropriate corrective actions outlined in a positive results action plan.

Despite the similarities in the DMP and CASPr, significant differences fundamentally change the strategies. In FY20, a multidisciplinary working group consisting of Veterinary Corps officers and laboratory specialists assigned to various organizations (eg, public health commands, public health activities, and DoD laboratories) reviewed the current DMP strategy and explored areas of improvement. The group identified three main efforts to establish a deliberate worldwide subsistence surveillance strategy. These areas for improvement included:

- Validation of sampling criteria.
- Regional variations and considerations.
- Identification of emerging public health risk.

In an attempt to meet the main efforts explored by the working group, a CASPr selection methodology was developed. In FY21, the CASPr sample selection methodology was employed as part of a phased introduction of the program. During the initial phase, CASPr achieved a 150% increase in unacceptable laboratory results over the previous 4-year average

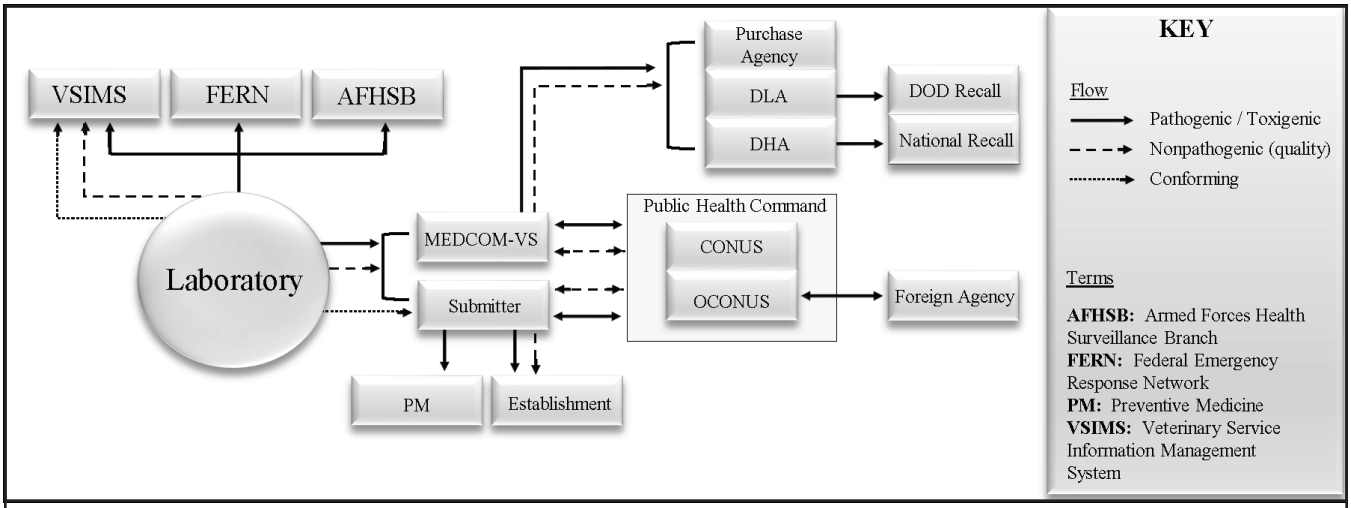
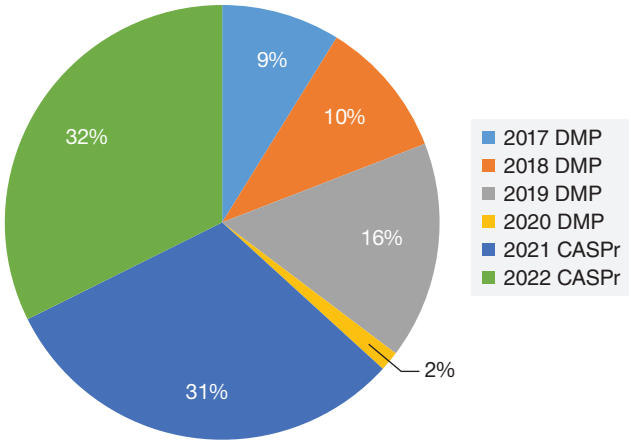


Figure 1. Laboratory Reporting Wire Diagram

Table 1. Distribution of Flagged Reports by Program



of DMP. In FY22, CASPr achieved the same 150% increase compared to the 4-year DMP sample and is now responsible for 63% of all flagged reports within the 6-year period (Figure 2). There are two remaining phases within the CASPr glide path before the program reaches full operational capability. In FY 23, surveillance sampling will occur at manufacturing facilities in conjunction with routine food protection audits. In FY24, surveillance of prepared products on installation (eg, salad bars and deli sandwiches) and a more equitable environmental monitoring program (ie, food processing locations other than the Defense Commissary Agency) will be employed. Applying the deliberate surveillance strategy beyond packaged foods on the military installation and beyond is expected to increase the capability to identify and remove unacceptable subsistence from the DoD supply chain.

Comprehensive Active Surveillance

CASPr has led to the identification of both pathogenic and nonpathogenic microorganisms. While most findings are nonpathogenic (quality), discoveries of pathogens have resulted in a nationwide recall and the removal of 10 000 pounds of potentially affected products. It is important to mention that CASPr does not remove the basic tenets of the DMP; it builds upon the foundation of the earlier program. The new surveillance strategy is a living program influenced by characteristics of the inputs that shape the vision of current risks and threats. The following points provide a better understanding of this strategy in juxtaposition with DMP. A summary of the sampling methodology (Figure 3) is provided for reference and additional clarity. These points are explained in the subsequent sections.

Validation of Sampling Criteria

The legacy DMP did not incorporate deliberate or strategic sample selection criteria. The DMP program manager relied solely on intuition and an individual assessment of the perceived risks. Sample selection was not consistent and failed to draw from substantiating information. The working group reviewed this approach and determined that sample selection must be based on validated sampling criteria. The criteria used to validate the CASPr sample selection methodology are based on three main data inputs:

- National CDC surveillance data (2011-2017).[15]
- DoD laboratory results (2011-2021).
- DoD recall history (2011-2021).

Each source of information is independently researched and categorized using the Interagency Food Safety Analytics Collaboration (IFSAC) Food Categorization Scheme Level 2 (produce, seafood, dairy, etc.). Priorities of risk are established for each source of information to determine the likelihood that subsistence may contribute to foodborne illness. Sampling criteria are determined by aggregating and averaging the three inputs to determine categorically which food category is most likely to contribute to illness. The top three commodities across these inputs are selected as the baseline and are further prioritized during subsequent layers of risk analysis.

Regional Variation and Other Considerations

The legacy DMP lacked a formalized approach to surveillance based on unique characteristics and circumstances relating to various geographic regions. The food safety and quality concerns unique to the various geographical areas play a valuable role in projecting the likelihood of an unacceptable result. CASPr categorizes three regional areas of responsibilities (continental United States [CONUS], European Command [EUCOM], and Indo-Pacific Command [INDO-PACOM]) aligned with their supporting area laboratories performing the analysis. Using regional variations highlights areas of emphasis and provides additional clarity regarding risk by category (vegetables, crustaceans, fluid milk, etc.). For example, the EUCOM area of responsibility may not be appropriate for surveillance of a SAMPLE-A (eg, vegetables) when there is no history supporting an associated risk. SAMPLE-A may be more appropriate in CONUS or INDO-PACOM, where the risk is more prevalent. In this example, SAMPLE-B (eg, fruits) is more relevant in EUCOM based on unique regional variations.

Identification of Emerging Health Risks

The legacy DMP approach to sample selection had no formalized process for introducing sample selection criteria based on the emerging public health risk. It is important to mention that within DMP, current outbreaks strongly influenced sample selection. Selecting samples is a quarterly endeavor, and chasing today's news may not achieve actionable results due to several months between sample selection, tasking, and sample submission. There is an apparent gap between the sample criteria and the current threats. The emerging health risk considers recent recall history and current investigations of foods contributing to foodborne illness. The CASPr selection methodology (see Figure 3) anticipates threats

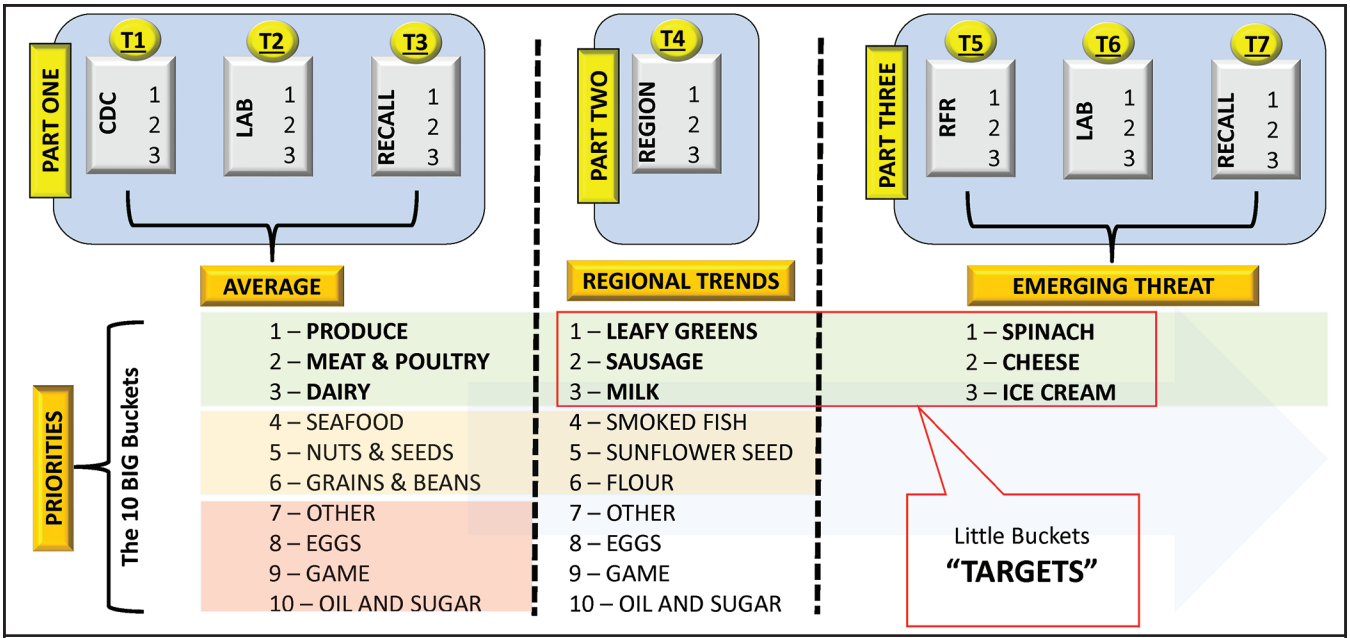


Figure 2. Sample Methodology

categorically, applying emerging health risk drives further IFSAC Food Categorization (eg, canned or containerized, vine-grown, and seeded vegetables). When significant health risks are identified in current recalls or interagency reports (eg, FDA investigations), a determination is made regarding the current threat against the sampling criteria for prioritization. If the current threat matches what has been established in the validated sample criteria, this product is prioritized for surveillance.

Sample Methodolgy

Comprehensive active surveillance aims to find "little rocks in big buckets." Sometimes, little buckets are easier to sift through than big buckets. The earlier sections explained how a sample target moves from produce, to vegetables, to canned or containerized, vine-grown, and seeded vegetables. The sample methodology (see Figure 3) demonstrates this process. Each part of the sampling methodology is further explained below.

Part One

The 10 big buckets represent the IFSAC Food Categorization Level 2 with slight modifications to better align with the Federal Supply Class codes utilized by the DoD. These categories have been prioritized based on the aggregate risk across the aforementioned data inputs. The score is calculated by listing the priority by source and then adding commodities categorically to find the average priority across all sources. The average is taken and reprioritized to find the sample priority. The sample priority in step one includes produce, meat and poultry, and dairy.

Part Two

The 10 big buckets become three little buckets. Calculations derived from regional variations are compared against sample priorities, and sample selection begins to take shape. Within the three little buckets, you see that produce starts to look like *leafy green*, meat & poultry reveals *sausage*, and dairy is *milk*.

Part Three

The little buckets begin to uncover tiny rocks. Sample selection has progressed from IFSAC Categorization Level 2 "Produce" in *Part One* and "Leafy Greens" in *Part Two* to a more specified sample type. In *Part Three,* the sample selection begins to look like specific targets for analysis (eg, spinach). The idea is to get to the highest IFSAC Food Categorization Level possible.

Part Four

Everything performed in *Parts One, Two, and Three* feed into this part. In *Part Four*, the CASPr manager can make their sample target selections based on the consolidated view from the earlier parts.

Conclusion

The main difference between CASPr and the legacy program is the deliberate sample selection methodology employed at the strategic level. Tactical and organizational levels of laboratory surveillance activities may not immediately identify the differences between these programs. CASPr is shaped by the current threat; it is not static and will continue evolving to match the perceived risks' surveillance needs.

Acknowledgements

I would like to thank Mr. Michael Killian, DoD food protection officer, HQ Defense Health Agency Veterinary Services Division and CW5 Christopher Heryford, deputy chief, MEDCOM-DCoS Force Health Protection Food Protection Division for their many years of mentorship and imparting their valuable guidance, insight, and perspectives on surveillance laboratory programs.

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COVID-19 Pandemic Commercial Food Audit Risk Assessment Decision Tool

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CW3 Zachary S. Nyland
CW5 Christopher L. Heryford

Abstract

Each year, US Army Veterinary Corps officers perform on-site food protection audits of commercial establishments to verify sanitary practices meet Federal and Department of Defense food protection standards. Between 2020 and 2022, national and international COVID-19 mitigation measures restricted US Veterinary Corps officers' ability to perform on-site food protection audits in various locations globally. In the absence of protocols to address this unpredicted circumstance, the US Army Medical Command Deputy Chief of Staff, Force Health Protection–Veterinary Services Directorate, Food Protection Division developed a commercial Food Audit Risk Assessment Decision Tool. This tool is used to assess the risks of commercial food facilities and determine the acceptability of performing virtual audits as temporary replacements for on-site audits. The decision tool is easy to use and instantly identifies risk based on food characteristics, past facility performance, and country of origin. From December 2020 to February 2022, 245 of the 701 commercial establishments affected by COVID-19 were evaluated with the decision tool. The tool provided a risk-based approach to evaluating the need for on-site food establishment audits. Continued research and adjustments should be made to prepare the Food Audit Risk Assessment Decision Tool for future public health emergencies.

Key words: risk assessment, Army Veterinary Services, COVID-19, virtual audit, food protection

Introduction

The US Army Veterinary Services (AVS) develops military sanitary standards for commercial food and bottled water establishments that supply the Department of Defense (DOD) and publishes a list of these suppliers authorized for procurement in the Worldwide Directory of Sanitarily Approved Food Establishments for Armed Forces Procurement (the directory).[1] Yearly, AVS performs approximately 3,200 on-site audits at commercial food establishments globally to ensure procurement of safe and wholesome food products (eg, dairy, seafood, red meats, poultry, eggs, baked goods, fresh fruits and vegetables, bottled water, and ice).[2]

On January 18th, 2020, the Centers for Disease Control and Prevention reported the first laboratory-confirmed 2019 COVID-19 case in the United States.[3] As the number of people infected accelerated, the US government implemented mitigating measures such as social distancing and mask wearing to reduce the spread of the virus. In addition, the food industry and other foreign government entities also implemented mitigating measures. These COVID-19 mitigation measures prevented AVS personnel from conducting on-site audits at commercial food establishments.

To ensure continuity of logistics and support DOD procurement while reducing DOD beneficiary foodborne illness risk, the Director, US Army Medical Command Deputy Chief of Staff, Force Health Protection–Veterinary Services Directorate (DCOS-FHP[VS]) authorized auditors to conduct virtual audits in place of physical on-site audits, when appropriate, as a temporary contingency. DCOS-FHP(VS) Food Protection Division created the Food Audit Risk Assessment Decision Tool to determine when virtual audits were appropriate. This decision tool facilitated a systematic review of each commercial establishment's specific food characteristics, performance history, and country of origin, calculating a final risk assessment score. Veterinary Corps officers conducted virtual audits for a subset of establishments with an overall risk assessment score of moderate or low. Establishments with an overall risk assessment score of high or extremely high could not be audited virtually and required an exception to the COVID-19 mitigation measures for an on-site audit or were suspended from the directory.

Commercial Food Protection Audits

An audit is required for an establishment's listing in the directory. Audits involve an in-depth review of the establishment's food protection plan and physical verification of food

handling and manufacturing practices in accordance with regulatory and DOD requirements. Findings assessed during the audit are assigned to one of the following groups. An *observation* refers to a condition, practice, step, or procedure that is not in accordance with food safety and defense requirements and does not meet the criteria of a critical or major finding.[4(p.3)] A *major* finding refers to a condition, practice, step, or procedure that in itself does not present a food defense or imminent health hazard yet has the potential to affect food safety or the product's intended use due to loss or lack of verifiable control.[4(p.3)] A *critical* finding refers to an imminent health hazard caused by a condition that presents a biological, chemical, or physical food safety or food defense hazard that, if not prevented, eliminated, or reduced, may cause food to be unsafe for consumption or otherwise adulterated.[4(p.2)] An establishment receiving an acceptable audit rating is listed in the directory and becomes an authorized source for DOD procurement.

Food protection audits are broken down into five geographical regions of responsibility and include Public Health Command-Pacific (PHC-P), Public Health Command-Atlantic (PHC-A), Public Health Command-Central (PHC-C), Public Health Command-Europe (PHC-E), and Central Command (CENTCOM).

- PHC-P covers the US West Coast along with the Indo-Pacific region.
- PHC-A covers everything east of the Mississippi in the United States.
- PHC-C covers the central and Midwest portions of the United States and Central and South America.
- PHC-E covers the European countries and the African continent.
- CENTCOM covers the Middle East region.

AVS performed an average of 3254 audits yearly between 2016 and 2019; however, due to the impacts of the COVID-19 pandemic, the number of on-site audits performed was greatly reduced to an average of 1896 yearly audits between 2020 and 2022. While a reduction in the number of audits was observed uniformly across all public health commands (Figure 1), the impact varied based on the geographical area of operations and the various restrictions and mitigations. The safety measures implemented by government entities, DOD, or commercial food establishments decreased the number of on-site audits performed.

The operational environment was dynamic. On-site audits were preferred but were not possible in all settings. When an on-site audit was not possible, the establishment was cued for a risk assessment to determine aggregate risk and aid in the decision to remove or suspend the facility from the directory, authorize a virtual audit, or pursue an exception to the COVID-19 mitigation measures.

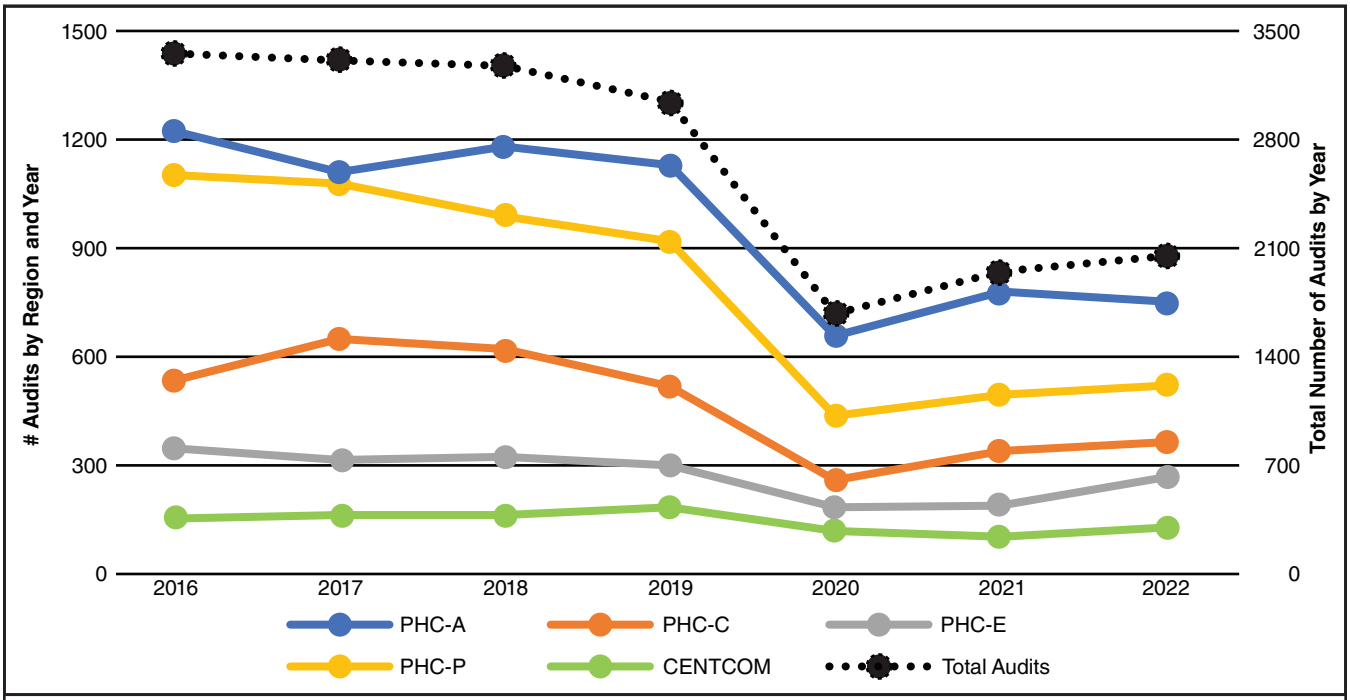

Figure 1. Distribution of Audits Over Time.

PRODUCT FACTOR				
Indicators	Low [Score = 1]	Moderate [Score = 2]	High [Score = 3]	Extremely High [Score = 4]
Water Activity (aw)	(< 0.80 aw)	(0.80 - 0.89 aw)	(0.90 - 0.95 aw)	(> 0.95 aw)
Power of Hydrogen (pH)	(< 4.5 pH)	(4.5 - 5.5 pH)	(5.6 - 6.5 pH)	(> 6.5 pH)
Shelf Life	≥ 181 Days	13 - 180 Days	30 - 8 Days	≤ 7 Days
Intended use	Thermal Processed	Ready to Cook	Ready to Eat	Prepared Meals

PRODUCT CALCULATOR				
Indicators	Weight	Indicator Scores [Enter 1-4]	Weighted Score	
aw	25%	4.0	1.0	
pH	25%	4.0	1.0	
Shelf Life	20%	4.0	1.0	
Intended Use	30%	4.0	1.0	
TOTAL			3.1	Overall Product Risk

Figure 2. Example of product factor risk assessment calculation.

Food Audit Risk Assessment Decision Tool

The Food Audit Risk Assessment Decision Tool identifies the risk to consumers and encompasses a systematic review of each establishment's specific food characteristics, performance history, and country of origin. Each factor includes indicators that contribute to the aggregate risk. The percentage factors were established by a team of subject matter experts assigned to the DCOS-FHP(VS) Food Protection Division. The risk assessment process includes four main steps to determine aggregate risk.

Step One - Product Factor (Food Characteristics)

The food product factor includes four indicator values: water activity (aw), power of hydrogen (pH), shelf life, and intended use. The aw and pH each account for 25% of the total product factor. The pH and aw intrinsic characteristics provide insight for potential pathogenic microorganisms or their associated toxins to thrive in each product. The aw depends on the specific product type. The aw ranges from low (<0.80 aw) to extremely high (>0.95aw). The pH ranges from low (<4.5 pH) to extremely high (>6.5 pH). The shelf-life score is weighted as 20% of the total product factor (based on protection characteristics such as packaging technology and preservation techniques) and demonstrates a product's susceptibility to spoilage or growth of microorganisms. A longer shelf life is designated as a lower risk (≥180 days), and a shorter shelf life as a higher risk (≤7 days). The intended product use accounts for 30% and demonstrates its ability to control microorganisms. The intended use indicator is broken down into four areas: thermal processed (low), ready to cook (moderate), ready to eat (high), and prepared (extremely high). All four indicators (pH, aw, shelf life, and intended use) are then calculated into an overall product score.

For example, a product risk assessment is performed for a facility located in a country that produces bottled water. The bottled water has aw of 1.0 (score of 4, extremely high). The bottled water has a pH level of 7.0 (score of 4, extremely high). The product has a shelf life of 2 years (score of 1, low). The intended use is ready to eat (score of 3, high). The combined product risk indicators result in a weighted score of 3.1 for the product factor (Figure 2).

Step Two - Facility Factor (Production Facility)

The production facility (commercial food establishment) factor uses three indicators: previous audit findings, the food safety plan, and the length of directory listing. The combination of previous audit findings, whether the facility has a food safety plan, and the length of directory listing demonstrates the quality history of the facility and food safety system resilience over time. Findings from the last four historical audits account for 60% of the facility factor. The type and frequency of previous findings provide insight into how a facility controls its food safety system. Audit findings from the last four audits can range from low (observations) to extremely high (critical findings).

The food safety plan is reviewed and contributes to 20% of the weight for the facility factor. The food safety plan indicator provides insight into the facility's current strategy and capacity to meet regulatory and DOD requirements. The food safety plan can range from low (validated food safety plan exists) to extremely high (no structured food safety plan exists). The length of continuous directory listing contributes to 20% of the facility factor and is used because the quality history of the facility indicates the condition of the food safety system over a length of time. The establishment's time listed in the directory can range from low (< 1 year) to extremely high (> 4 years).

FACILITY FACTOR				
Indicators	Low [Score = 1]	Moderate [Score = 2]	High [Score = 3]	Extremely High [Score = 4]
Water Activity (aw)	Observations	Major ≤ 1	Majors ≥ 2	Critical ≤ 1
Food Safety Plan	Validated Food Safety Plan Exists	All Components are Present	Critical Components are Missing	No Structured Food Safety Plan Exists
Length of Directory Listing (continuous)	> 4 Years	3 - 4 Years	1 - 2 Years	< 1 Year

PRODUCT CALCULATOR				
Indicators	Weight	Indicator Scores [Enter 1-4]	Weighted Score	
Previous Findings	60%	1.0	0.6	
Food Safety Plan	20%	2.0	0.4	
Time Listed	20%	2.0	0.4	
TOTAL			1.4	Overall Facility Risk

Figure 3. Example of facility factor risk assessment calculation.

For example, using the same facility in step one, the facility was discovered to have no major or critical findings during the last four audits, generating a low score of 1. After reviewing historical audit reports, all components were present for a food safety plan, creating a moderate score of 2. The facility has been listed for three continuous years in the directory, providing a moderate score of 2. The combined facility risk indicators result in a weighted score of 1.4 for the facility factor (Figure 3).

Step Three - Country Factor (Country of Origin)

The country factor uses three indicators: World Health Organization (WHO) Food Safety capacity, WHO laboratory capacity, and US State Department travel advisories. The country risk determination requires research from outside sources such as WHO[5] and US Department of State (DOS)[6] websites.

The WHO food safety data demonstrate a nation's capacity to detect and respond to food safety events that may constitute a public health emergency of national or international concern. The WHO website presents the percentage of a country's food safety capabilities.[5] This WHO food safety data can range from 100% capacity (low risk) to less than or equal to 50% capacity or no data (extremely high risk) and accounts for 60% of the country factor. The WHO laboratory data demonstrates the capacity of a nation to deliver laboratory testing services and surveillance. WHO presents the percentage of a country's laboratory support capabilities.[5] This WHO laboratory data can range from 100% capacity (low risk) to less than or equal to 50% capacity or no data (extremely high risk) and accounts for 20% of the country factor. Food defense is a necessary component of the country factor. The DOS list of travel and security risks associated with various nations indicates the susceptibility of subsistence to nefarious actors. The DOS website presents travel advisories associated with individual countries.[6] The DOS indicator can range from "exercise normal precautions" (low risk) to "do not travel" (extremely high risk) and accounts for 20% of the country factor.

For example, the facility mentioned in steps one and two is reviewed for the country. Regarding the WHO food safety indicator, the country's food safety capacity is 80%, which receives a moderate risk score of 2. The country's food laboratory capacity is determined to be 93%, receiving a low risk score of 1.

COUNTRY FACTOR				
Indicators	Low [Score = 1]	Moderate [Score = 2]	High [Score = 3]	Extremely High [Score = 4]
WHO Questionnaire - Food Safety	100% - 90%	89% - 75%	75% - 51%	≤ 50% - NO DATA
WHO Questionnaire - Laboratory	100% - 90%	89% - 75%	75% - 51%	≤ 50% - NO DATA
State Department	Exercise Normal Precautions	Exercise Increased Caution	Reconsider Travel	Do Not Travel

COUNTRY CALCULATOR				
Indicators	Weight	Indicator Scores [Enter 1-4]	Weighted Score	
Food Safety	50%	2.0	1.0	
Laboratory	20%	1.0	0.2	
State Department	30%	3.0	0.9	
TOTAL			2.1	Overall Product Risk

Figure 4. Example of country factor risk assessment calculation.

FINAL RISK ASSESSMENT SCORE

Factors	Weight	Factor Scores (1-4)	Weighted Score	
Product	60%	3.1	1.9	
Facility	20%	1.4	0.3	
Country	20%	2.1	0.4	
TOTAL			2.6	Total Risk Assessment Score

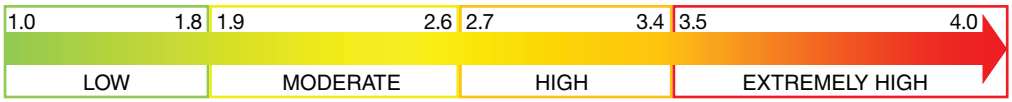

Figure 5. Example of final risk assessment calculation.

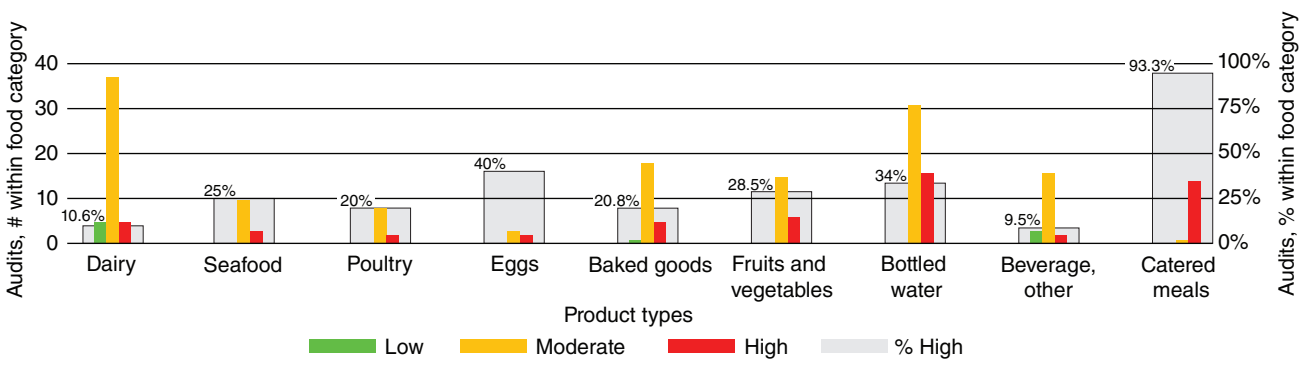

Figure 6. Distribution of Assessed Risk by Product Type

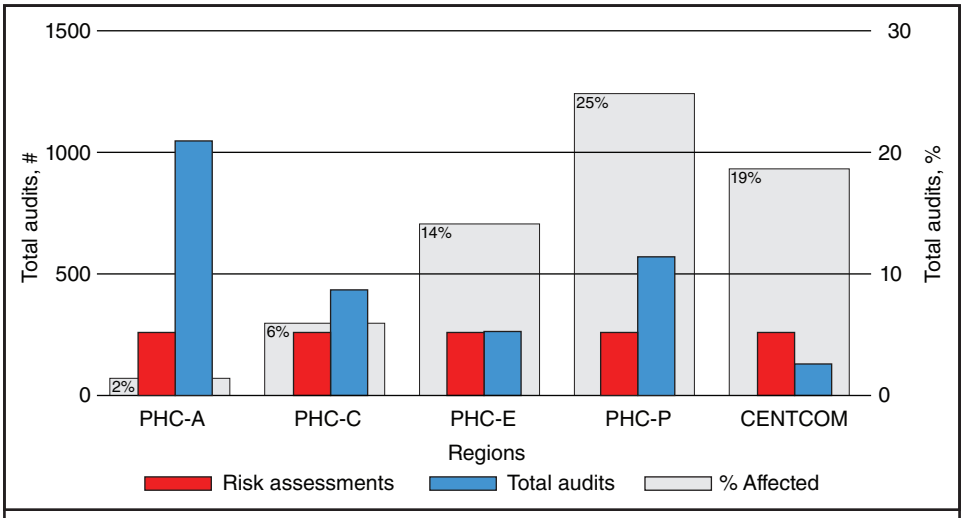

Figure 7. Regional Distribution of COVID-19 Mitigation Impacts

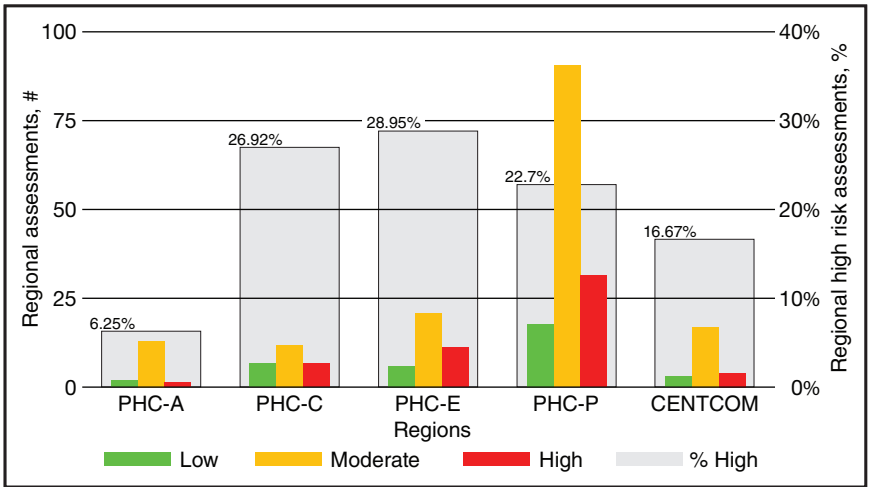

Figure 8. Regional Distribution of Facility Risk

The DOS website recommends "reconsider travel," producing a high risk score of 3. The combined country risk indicators result in a weighted score of 2.1 for the country factor (Figure 4).

Step Four – Overall Risk

Once scores are complete for all three factors (product, facility, and country), they are combined and weighted for an overall score. The product factor score is weighted at 60% of the overall score. The facility factor is weighted at 20% of the overall score. The country factor score is weighted at 20% of the overall score. Overall scores can range from 1.0 to 1.8 (low risk), 1.9 to 2.6 (moderate risk), 2-7 to 3.4 (high risk), and 3.5 to 4.0 (extremely high risk). The bottled water establishment used in steps one through three received an overall score of 2.6, a moderate risk (Figure 5).

Results

AVS performed 2561 audits of commercial establishments between December 2020 and February 2022, of which 701 (27%) were affected by COVID-19 mitigation measures. Of these 701 commercial establishments, 245 (35%) were evaluated using the decision tool, representing 10% (245/2561) of total AVS audits performed within this time. Of the 245 commercial establishments evaluated, 22% (55/245) had an overall risk assessment score of high, and 78% (190/245) had an overall risk assessment score of low or moderate. Of the 245 commercial establishments evaluated, a virtual audit was performed at 54 facilities, 61 were removed from the directory, and an on-site audit was performed at 130 facilities.

Figure 6 identifies the number of audits in low, moderate, and high risk categories by product types and shows the percentages of high risk assessments for each product type. The categories red meat, ice, storage facilities, and prepared meals had no high risk audits and were not included in the figure. There was a total of 245 audits and 55 (22%) of these were assessed as high risk. Catered meals were the most likely to contribute to a high risk assessment (93%, 14/15), accounting for 26% (14/55) of all high risk assessments identified. Only 34% (16/47) of bottled water facilities were assessed as high risk but they represented the greatest single commodity type evaluated as high risk (30%, 16/55). Food storage and distribution facilities were identified as the audit type most likely to be assessed as low risk (89%, 24/27).

The percent of assigned audits affected by COVID-19 mitigations resulting in the performance of a risk assessment varied among the five geographic regions: PHC-A 2% (16/1051), PHC-C 6% (26/437), PHC-E 14% (38/270), CENTCOM 19% (24/128) and PHC-P 25% (141/574) (Figure 7). There were 101 audits not assigned to specified regions; these were included in the total audit denominator but excluded from the regional data. While PHC-P accounted for the highest percent of risk assessments performed (58%, 141/245), PHC-E carried the highest percentage of high risk assessments (29%, 11/38) (Figure 8).

Conclusion

The Food Audit Risk Assessment Decision Tool based on food characteristics, performance history, and country of origin is an easy method for rapidly assigning risk to commercial food facilities. The data necessary to facilitate the enumeration of risk was readily available within the constructs of the decision tool criteria. Limitations of the tool include the disproportionate high risk scores assigned to catered meals and low risk scores of food distribution and storage facilities.

The decision tool provided a risk-based approach to evaluate the need for on-site food establishment audits. Continued research and adjustments should be made to prepare the Food Audit Risk Assessment Decision Tool for future public health emergencies.

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Developing a Global Health Engagement Capability within the Army Veterinary Corps: Past, Present, and Future

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Abstract

In July 2017, the Department of Defense formalized its Global Health Engagement (GHE) policy and program with the publication of DOD Instruction (DODI) 2000.30, Global Health Engagement (GHE) Activities. As the sole service providing veterinary service support, a critical need existed for the Army Veterinary Corps (VC) to develop veterinary support of GHE capability to deliver Veterinary Corps Officers (VCO) prepared to support GHE missions across all Services. This article examines the underlying strategy for the deliberate development of a GHE support capability within the VC, beginning with a RAND Corporation study in 2008 to the culmination in 2022 of finalizing a VCO authorization at the last remaining Army Service Component Command aligned under a Geographic Combatant Command without one. Recommendations are offered for future capability development, particularly at the strategic echelon.

Keywords: global health engagement, Veterinary Corps

Introduction

DODI 2000.30 establishes DOD policy to "seek to develop and improve the human and animal health capabilities and capacities of DOD and Partner Nation (PN) personnel" to enhance readiness, improve interoperability, promote stability and security, and "establish or maintain a level of health and a state of preparedness conducive to healthy human and animal populations, in turn bolstering the civilian population's confidence in PN governance."[1] By the time DODI 2000.30 was published in 2017, the Army Veterinary Corps (VC) had been developing capability in veterinary support of GHE for nearly a decade.

In 2008, the Army G-3/5/7 Strategy, Plans, and Policy office sponsored the RAND Corporation's Arroyo Center to assess doctrine, organization, training, materiel, personnel, facilities, and policy (DOTmLPF-P) domains and determine the optimal utilization of Army veterinarians within a subset of GHE, stability operations. The sponsor recognized the potential value of Army veterinarians to stability operations and resourced the study. RAND study authors validated the importance of Army veterinarians to stability operations, characterizing it as a unique capability for competition and conflict, including highly specialized skill sets to strengthen economic agricultural value chains, improve food security through improved animal health, and facilitate access to semi-permissive environments.[2]

The study documented areas for maximizing DOD capability for the utilization of military veterinarians within stability operations. The VC acted immediately to address RAND-identified capability gaps in the leadership and training domains. RAND's recommendations in these and other DOTmLPF-P domains were used as a roadmap for early capability development within the VC. Major milestones for VC GHE capability development over the next 14 years are reflected in Figure 1.

Leadership 1

RAND study authors reported a lack of leader knowledge at all levels with respect to appropriate employment of veterinarians for GHE opportunities within their area of operations.[2] To fix this knowledge gap, VC subject matter experts focused on ensuring a common understanding across VC leadership regarding the importance of veterinary support to stability operations and GHE. In 2009 upon the update of DODI 3000.05[3], Stability Operations, the VC convened a forum of senior leaders and subject matter experts to discuss the requirement for the VC to support stability operations.

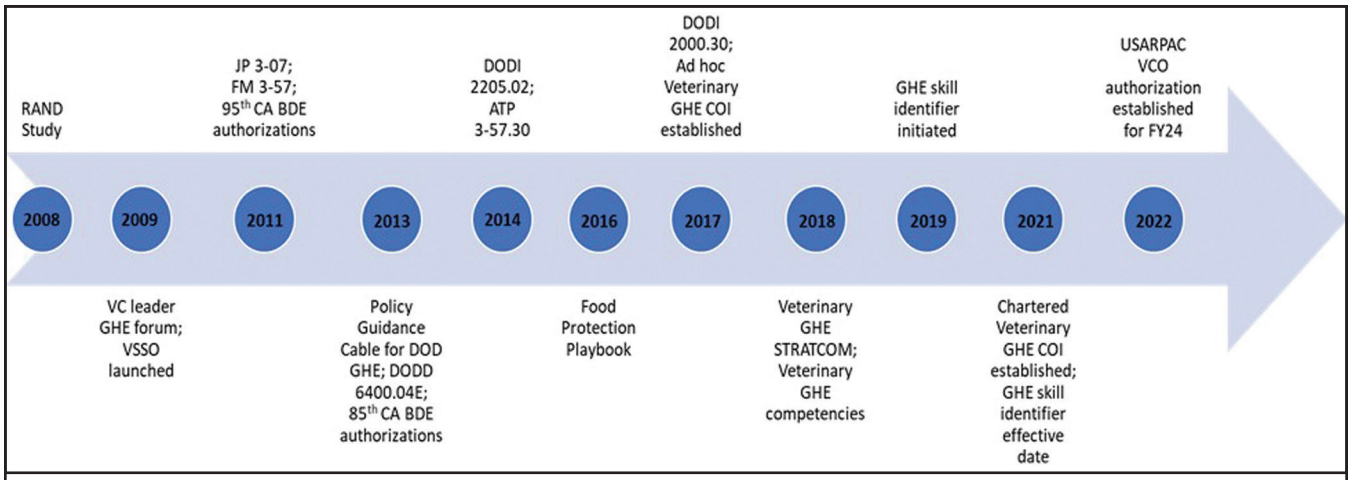

Figure 1. Major Milestones in VC GHE Capability Development.

This symposium contributed to a consensus among senior VC leaders of how the VC could and should contribute to stability operations. Using the 2008 RAND DOTmLPF-P[2] assessment as a foundation, the group examined this emerging support requirement and outlined a plan to develop a supporting veterinary capability. The VC addressed the education of non-veterinary leaders through subsequent efforts in later years.

Training

The RAND assessment identified a lack of institutional training support inherent to the VC to deliver effective VCO support, planning, and execution of GHE.[2] The major effort to address this gap was the development of a formalized course for VCOs. Veterinary Support to Stability Operations (VSSO) was launched in 2009 in collaboration with the University of Georgia School of Veterinary Medicine. This 80-hour, two-part workshop series began as a Corps Specific Branch Proponency Office, Postgraduate Professional Short Course Program funded course and transitioned to a functional course conducted by the Division of Veterinary Science at the Medical Center of Excellence in 2021. The only course of its kind available in the DOD, VSSO provides early, mid, and senior Components (COMPO) 1 (active duty) and COMPO 3 (reserve) VCOs with the critical skills, competencies, and knowledge required to provide tactical, operational, and strategic support through all phases of stability operations/GHE.

The course continues today and directly supports the Surgeon General's 2022-2023 Army Medicine Campaign Plan objective, "Strengthen Alliances and Partnerships," through the supporting objective of optimizing security cooperation. The course has a core curriculum but retains the flexibility to incorporate current operational needs, Geographic Combatant Command (GCC) demand signals, and lessons learned from the field. The Cadre is a mix of civilian and military subject matter experts from across academia, the Army, Air Force, Public Health Service (PHS), and various Federal agencies. Course participants include VC personnel, veterinarians from PHS, and relevant Federal agencies. The diversity of cadre and participants directly supports DOD interoperability in joint and combined environments. Through the end of the calendar year 2022, 710 personnel across the three Army Components (Active Duty 65%, Reserve 34%, and National Guard 1%) have been trained on essential general and veterinary-specific principles and skills to support GHE.

Policy and Doctrine

Veterinary Corps staff officers routinely monitor policy and doctrinal publications related to stability operations and GHE to ensure the inclusion of veterinary equity. This process translated into a robust emphasis on the importance of food production and agricultural systems as critical infrastructure for stability operations focus, which is also emphasized during the VSSO curriculum. Doctrinal publications in which staff officers ensured appropriate veterinary equity and representation for stability operations support include:

- Joint Publication 3-07, Joint Stabilization Activities, (2022)[4]
- Field Manual 3-57, Civil Affairs Operations (2011/2021)[5];
- Army Techniques Publication (ATP) 3-57.50, Civil Affairs Civil Information Management (2013)[6];
- Army Techniques Publication (ATP) 3-57.20, Multi-Service Techniques for Civil Affairs Support to Foreign Humanitarian Assistance (2013)[7];
- Army Techniques Publication, (ATP) 3-57.30 Civil Affairs Support to Nation Assistance (2014)[8]; and
- Army Doctrinal Reference Publication 1-03, The Army Universal Task List (2015)[9].

Veterinary staff officers also successfully influenced the inclusion of veterinary equity within certain DOD policy documents, such as the policy guidance cable for DOD GHE (2013)[1], and DODI 2205.02, Humanitarian and Civic Assistance (HCA) Activities (2014).[10] The requirement for veterinary support to stability operations and global health engagement was distinctly spelled out in DODD 6400.04E, "Veterinary Public and Animal Health Services[11]," clearly establishing a policy requirement for ongoing veterinary capability development in these areas:

> *"Provide veterinary coordination, manning, and support to plan and conduct agricultural, veterinary public health, and animal health activities across a range of military operations, to include support of DOD Stability Operations and Medical Stability Operations in accordance with DODI 3000.05...[and] Global Health strategic goals..."*[11]

Appropriate veterinary equity in policy and doctrine, in conjunction with integrated VC staff representation at multiple echelons, laid the necessary groundwork for DODD 6400.04E[11] as well as animals and agriculture to be included in the inaugural version of DODI 2000.30, Global Health Engagement Activities.[1] Veterinary Corps GHE subject matter experts were included in the working group that drafted this DODI, ensuring the strategic importance of veterinary activities in GHE was recognized. For the first time, the development of animal health capabilities was emphasized equally, with activities focused on human health as equally important for security cooperation efforts. The acknowledgment of veterinary equity throughout the GHE DODI continued to provide the policy requirement and momentum necessary for advancing the development of veterinary support of the GHE strategic capability.

With policy and doctrinal requirements firmly established, an ongoing training course delivering VCOs with the necessary skills to be successful in stability operations/GHE, and the enthusiastic backing of senior VC leadership, attention turned to developing capability in other DOTmLPF-P domains and educating non-veterinary leaders about the veterinary support of GHE capability.

Materiel

In 2016, the Division of Veterinary Science at the Army Medical Center of Excellence (MEDCoE) developed the first ever GHE playbook. The playbook concept improves the consistency and quality of GHE activities executed in multi-year engagements while building toward capacity in a specific capability.[12] This playbook focused on food protection capability, and its inaugural use was during an engagement in the spring of 2017 with the Chilean Army Veterinary Service. This military-to-military subject matter expert exchange used standardized engagement packages from the playbook to strengthen the Chilean military's capacity for expeditionary food protection to mitigate foodborne risk in preparation for a United Nations Peacekeeping mission in Africa. A second, smaller playbook for Military Working Dog Healthcare was developed in 2018.[12] The food protection playbook[12] was used as a template for early playbook development efforts at the DOD level, with veterinary subject matter experts solicited for inclusion in DOD-level working groups and guidance on playbook use and composition. The two veterinary playbooks are available on the Veterinary Global Health Engagement/Army Veterinary Services community page in milSuite. The milSuite site also contains information on the newly created skill identifier discussed in this article and storyboards and after-action reviews by country for veterinary support of GHE engagements that VCOs can reference to help shape future engagements.

Leadership 2

One of the biggest gaps identified by VC GHE subject matter experts was the lack of understanding across Army and sister Service leadership of how veterinary support to the GHE activity or strategy could contribute to security cooperation goals. Non-veterinary senior leaders often equated veterinary expertise with companion animal (dog and cat) medicine and Veterinary Civic Action Programs (VETCAP). To better inform leaders at all levels and counter this narrative, a small ad hoc VC GHE community of interest (COI) was established in 2018, comprised of subject matter experts. This group determined that a deliberate strategic communication plan was required consisting of the following:

- Functional areas for GHE, lines of effort, and goals toward achieving Theater Campaign Plan objectives;
- Delivery of consistent, VC-approved messaging across Services and Components;
- Incorporation of content demonstrating a clear linkage between veterinary support of GHE activities and security cooperation; and
- Explanation of veterinary core competency areas and how each relates to security.

The COI crafted an exportable one-hour presentation, including a script to ensure consistent messaging independent of the VCO delivering the lecture. The presentation included a series of three short videos from an Army Veterinary Civil Military Support Element engagement with a Mauritanian civil affairs team during which they trained government veterinary extension workers in taking care of livestock. Not only was this a training event for the newly formed Mauritanian civil affairs team, but the engagement also assisted with gaining access to a semi-permissive environment while improving livestock health and livelihoods on the Mauritanian-Mali border and denying recruitment of locals by violent

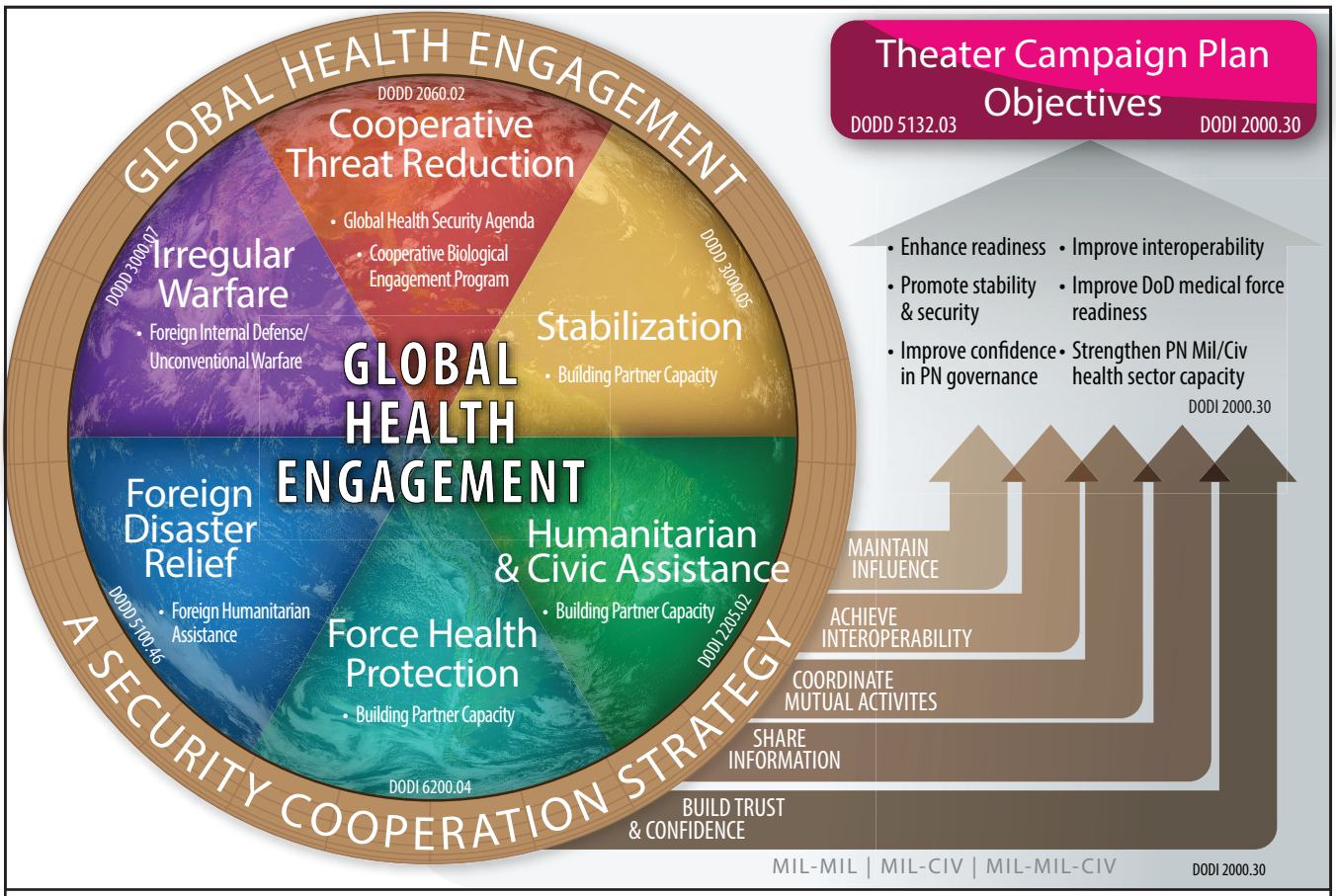

Figure 2. Global Health Engagement as a Security Cooperation Strategy.

extremist organizations. Feedback at nearly every delivery of this presentation included audience members' comments that the videos were eye-opening, engaging, and informative and that audience members were unaware of the extensive role veterinary support of GHE could play in security cooperation.

The presentation also included a graphic generated by the COI with assistance from the Army Public Health Center Visual Information Division that conveys the framework for GHE as a security cooperation tool as outlined in DODI 2000.30 (Figure 2).[1] The COI also defined four veterinary supports of GHE core competencies: agriculture and livestock livelihood systems; food protection; veterinary public health; and military working animal healthcare. An explanation in the presentation describes the relationship of each competency to achieving human security and larger security cooperation goals. This presentation gained tremendous traction, and military services and components began requesting delivery in various courses, conferences, and other meetings of senior strategic leaders. The presentation also created opportunities for introductions and dialogue that led to the incorporation of veterinary support of GHE content into numerous courses, such as the Fundamentals of GHE, Global Health Strategies for Security, and multiple other Uniformed Services University Health Sciences (USUHS) courses.

A week-long veterinary support of the GHE module is now included as part of the Global Health 3 – "Global Health Engagement" course in the USUHS Global Health and Global Health Engagement Certificate Program. This deliberate, consensus-based strategic communication messaging campaign is currently one of the most effective capability-developing strategies employed by the VC for raising the profile of veterinary support of GHE across the DOD.

Personnel

After the development and roll-out of the strategic communication plan, the COI determined that a mechanism for more appropriate talent management was required and settled on the development of a skill identifier for veterinarians with specific training and experience to support GHE. The justification for the skill identifier rested on the fact that the Army is the sole Service with veterinarians recruited for that purpose. Army VCOs are employed on Joint GHE missions with US

Airforce (USAF) and US Navy (USN) service members who hold service equivalent GHE skill identifiers. Army VCOs require the same level of education, training, and competency as their sister service colleagues to be effective during these Joint missions.

Using the USAF International Health Specialist program as a guide, the COI developed requirements for a two-tiered skill identifier (8D and 8E). The skill identifiers target different timeframes within the career lifecycle and different authorizations with the increasing complexity of GHE-related responsibilities and roles (Figure 3). The 8D skill identifier is awarded upon completion of both phases of the VSSO course and the Military Veterinary Medical course. The 8E skill identifier has additional requirements, including participation in at least one "boots on the ground" veterinary support of GHE activity; an accumulation of 12 weeks of GHE-related staff or operational experience; and completion of 12 credits of the USUHS distance learning courses for the aforementioned GHE certificate program.

The veterinary support of the GHE skill identifier initiative took two years from inception to approval. The two levels of skill identifier were approved by Headquarters, Department of the Army G-1 in 2020 with an effective date of 1 October 2021. During FY22, 21 VCOs attained the 8D identifier, while 5 attained the 8E skill identifier. To improve talent management, more than 80 VC authorizations were approved for coding with one of the two skill identifiers. VCOs applying through the Assignment Interactive Marketplace (AIM-2) marketplace for positions coded with the skill identifier should hold the respective 8D or 8E identifier, which should be discriminators during the interviewing process.

Organization

The VC is developing a subset of well-equipped officers through training programs and skill identifiers to effectively communicate the benefits of employing veterinary support of GHE activities and strategies to commanders.

The effectiveness of this cohort is dependent upon VCO authorizations in organizations that plan and execute GHE strategies. A VCO with the appropriate knowledge, skills, and behaviors can effectively influence peers and leaders and employ veterinary support of GHE strategies when appropriate to assist in achieving Army Service Component Command (ASCC) security cooperation goals. Authorizations for VCOs have existed at all ASCCs aligned to GCCs for decades, with the sole exception of the United States Army Pacific (USARPAC). The VC only has one authorization at a GCC–US Africa Command, which is a major organizational gap.

Beginning in 2006 and extending through 2011, the VC gained five authorizations within the Special Operations Forces civil affairs community at the 95th Civil Affairs Brigade (Airborne) and associated battalions. US Army Forces Command (FORSCOM) also established 6 VCO authorizations within the conventional 85th Civil Affairs Brigade between 2011 and 2013. These civil affairs groups aligned VCOs within COMPO 1 greatly contributed to expanding the awareness and utilization of veterinary support of GHE to achieve strategic goals.

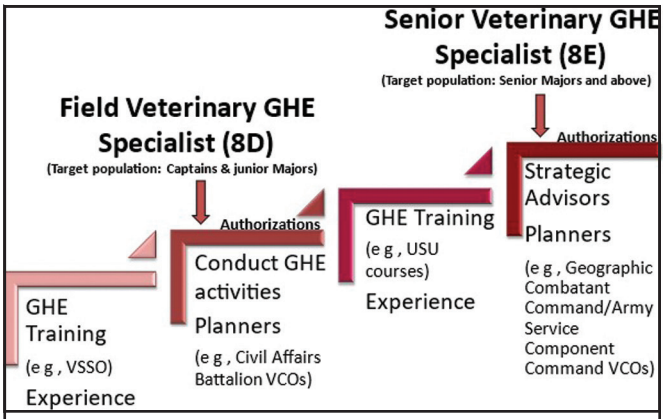

Figure 3. Veterinary GHE Skill Identifiers as Related to GHE Roles / Authorizations

The "Pivot to the Pacific" led to external support and momentum for establishing an authorization at the only ASCC aligned to a GCC without one – the USARPAC Surgeon's Cell. A VCO was sporadically assigned to USARPAC through various non-permanent processes (MEDCOM Substituted Position). USARPAC has been without a staff VCO physically present at Fort Shafter, HI, since 2018. An MTOE Aligned Personnel (MAP) authorization existed at USARPAC beginning in 2019. However, that authorization's physical location was in San Antonio, TX, and the operational tempo combined with the time difference made this an untenable solution for effective USARPAC support. The contribution of VCO subject matter expertise has become increasingly valued, emphasizing US Indo-Pacific Command operations, including multi-lateral exercises and strengthening partner-nation relationships through subject matter expert exchanges and other engagements. A permanent VCO authorization was established at the end of 2022 (effective date FY24) with the full support of USARPAC leadership, FORSCOM, and the Deputy Surgeon General.

Leadership 3

The ad hoc VC GHE COI was chartered and institutionalized as the Veterinary Corps GHE Community of Interest at the Defense Health Agency (DHA) Veterinary Services in 2021. The ad hoc members agreed that the COI needed to continue to exist and steer the strategic future of GHE within the VC to ensure that DOD veterinary personnel remain ready and relevant to meet GHE-related challenges associated with the future operational environment. The COI was also asked

by the Army Human Resources Command Veterinary Corps Branch to be the adjudicating entity for 8E skill identifier applicants. A need existed for broad organizational representation in the COI; the charter designates representatives from COMPOs 1 and 3, Geographic Combatant Commands/Army Service Component Commands, Special Operations Forces, applicable consultants to the Surgeon General, the Medical Center of Excellence, and DHA. The intent for this formal COI is to act as both a steering committee and advocate at the strategic level for continued capability development and alignment of veterinary support of GHE initiatives with those of the larger DOD and to exist as an accessible repository of subject matter experts who can be easily consulted by veterinary and non-veterinary planners when veterinary support of GHE issues arise.

Conclusion

Though much has been accomplished to develop GHE capability across the VC since the RAND assessment in 2008, much remains to be done, particularly at the strategic level. Extensive veterinary-specific GHE doctrine needs to be published. Veterinary subject matter experts drafted veterinary support of the GHE chapter awaiting publication in the next evolution of the "Veterinary Health Services" multiservice regulation (currently published as Army Regulation 40-905).[13] Turbulence created by the transition of public health to DHA has delayed staffing and publication of this regulation. FM 4-02.18, Veterinary Services Tactics, Techniques, and Procedures[14] was last published in 2004 and is due to be updated and republished soon. It will contain a comprehensive section detailing the veterinary support of GHE.

Authorizations for VCOs at the GCCs should be pursued to actualize the full contribution of veterinary support of GHE at the strategic level. Despite the implementation of the GHE skill identifiers for VCOs, talent management of the right officer for the right authorization must continue to improve, as should tasking for VCO support to GHE missions. These are difficult improvements to effect, hindered by a "no growth" environment, the constraints inherent within the AIM-2 system, and the processes governing taskers (timelines, routing). In addition, the VC GHE COI needs to fully achieve its potential and effectiveness as a steering committee and advisory body.

The Veterinary Corps developed its current GHE support capability through deliberate effort over the last fifteen years. The GHE development was usually done as an additional duty, diligently pursued due to individual interest to see this capability developed. It is only with a cohort of volunteers dedicated to such a cause that these efforts were able to build upon each other, enabling the Veterinary Corps to lead the way for GHE capability development for the Army Medicine at the Corps level.

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Veterinary Support to Global Health Engagement (vGHE) in the Indo-Pacific Command Area of Operation

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Abstract

The Indo-Pacific region is complex, diverse, and geographically vast, with multiple national security threats and transnational challenges. US Army Veterinary Services (AVS) represents an invaluable tactical and operational resource for the Department of Defense (DOD), yet it is easy to overlook the vital strategic-level influence AVS can have across the globe through its support to Global Health Engagement (GHE). In the US Indo-Pacific Command (USINDOPACOM), veterinary support to GHE (vGHE) is an agile tool that can support theater security cooperation objectives and build resilience in the region to meet national security goals.

Keywords: global health engagement; army veterinary services; USINDOPACOM

Background

The United States' approach to foreign policy can be summarized into the "3 D's" of diplomacy, development, and defense,[2] which are balanced to meet national security goals. In the Indo-Pacific region, there is a constant interplay between the 3 D's, where hyper-competition, "the persistent struggle for transient advantage across highly contested domains and competitive spaces,"[3] defines interactions among powerful nations operating in the theater. Two of these nations, China and Russia, have proven their willingness to bypass diplomacy and rules-based order through skillful all-of-government, military, paramilitary, and commercial maneuver.[1] While the US strives to provide an alternate way to do business in the Indo-Pacific, these and other key players influence USINDOPACOM's interactions and theater security goals. The foil to the hypercompetitive approach of authoritarian regimes operating in the region is one in which the United States excels: cultivating true partnership. Admiral Aquilino, Commander of USINDOPACOM (IP), stated to Congress, "A key United States asymmetric advantage that our security challengers do not possess is our network of strong alliances and partnerships. Because these relationships are based on shared values and people-to-people ties, they provide significant advantages such as long-term mutual trust, understanding, respect, interoperability, and a common commitment to a free and open Indo-Pacific."[4]

USINDOPACOM's mission is rife with challenges and opportunities. It is one of six geographic combatant commands and encompasses the entire Indo-Pacific region, stretching across about 52% of the Earth's surface. It is home to more than 50% of the world's population in 36 nations – two of which are the most populous in the world; 3,000 different languages; some of the largest economies and some of the smallest; several of the world's largest militaries; and five nations allied with the United States through mutual defense treaties.[5] As a result, USINDOPACOM has "a number of dynamic and complex regional challenges with worldwide implications, including nuclear powers, disputed territories, ballistic missiles, and highly adaptive adversaries."[6] With peer and near-peer powers dominated by authoritarian regimes, as well as violent extremist organizations (VEO), climate-based environmental hazards, disasters and more, the region has many challenges to face. In the words of Admiral Aquilino, "the Indo-Pacific is the most consequential theater and home to four of the five identified national security threats."[4,7]

The spectrum of development in the region is vast, meaning that the opportunities for security cooperation are varied and innumerable. While some partners face fundamental development challenges like safe food and water sources or basic healthcare infrastructure, others surpass the United States in development, providing higher quality of life and life expectancy. A commonality of these nations is that they all provide security cooperation opportunities, including well-planned and executed US-led vGHE events. US government strategy in USINDOPACOM is heavily focused on enabling allies and partners, which often falls into the realm of security cooperation (Figure 1).

In addition to conventional military and VEO threats to security in the region, there are significant environmental threats. Specifically regarding the climate-based environmental hazards, Admiral Aquilino noted their significance to Congress, saying that "conditions associated with climate change, such as frequency and intensity of regional storms, continue and could add risk to internal stability and governance of small island states and developing countries in South and Southeast Asia."[4] In other words, climate change is not limited to only small island nations or countries with extensive coastlines. Many partner nations (PN) will be challenged to ensure their disaster management systems and processes are truly all-hazard, as increasing numbers and severity of disastrous natural hazards are predicted. Moreover, changes in vector ecology will predicate changes in vectorborne disease transmission, making new areas vulnerable to diseases they have not faced in the past.

Global Health Engagements

GHE is a critical, multifaceted tool that supports US national security policy and defense security cooperation strategy. Its combined approach to foreign policy includes aspects of all three "D's" and is most efficient when nested with the efforts of other government agencies and non-governmental organizations. As shown in Figure 2, GHE activities can contribute to security cooperation in a wide variety of ways—they "build trust and confidence, share information, coordinate mutual activities, maintain influence, and achieve interoperability in health-related activities that support US national security policy and military strategy."[8] Moreover, when GHE activities are executed well, they can simultaneously increase civilian confidence in a PN, increase capacity and capability of PN civilian or military health systems, and reduce a PN's susceptibility to destabilizing influences.[9] GHE is undergoing a paradigm shift to better align US national security objectives and current global health best practices. The goal of GHE is to no longer administer direct care to patients in a PN but instead focus on PN needs and desires, based on assessments performed by trained military professionals,[10] that align with DOD objectives. Although direct care engagements may still provide positive results and contribute to operational theater objectives, GHE activities are transitioning to those that establish, reconstitute, maintain, or improve the capabilities or capacities of the PN's military or civilian health sector or those of the DOD.

GHE can be implemented in developing countries with minimal healthcare infrastructure and trained professionals and in developed countries with more robust healthcare capabilities. Further, GHE is not a unilateral direction of information from the United States to PNs but an exchange of information back and forth in a subject matter expert exchange (SMEE). Applicable to any topic, these knowledge-sharing exchanges between professionals with different experiences improve interoperability and individual understanding.

Figure 1. The U.S. government strategy in USINDOPACOM.

Although the DOD excels in many aspects of healthcare, much can be learned in SMEEs with USINDOPACOM PNs, especially in tropical medicine and healthcare-related disaster management, and simultaneously demonstrates that the DOD respects the expertise of its partners. SMEEs contribute to building and achieving a "network of strong alliances and partnerships," just as Admiral Aquilino desires. Overall, GHEs encompass a wide variety of competencies and subjects, including the diverse specialties represented in AVS, resulting in an endless potential of possible activities to serve as a tool in achieving USINDOPACOM security cooperation objectives.

Veterinary Support to Global Health Engagements

vGHE is a recognized subspecialty of GHE and can be an invaluable resource in security cooperation. AVS leaders have identified four core competency areas and their security

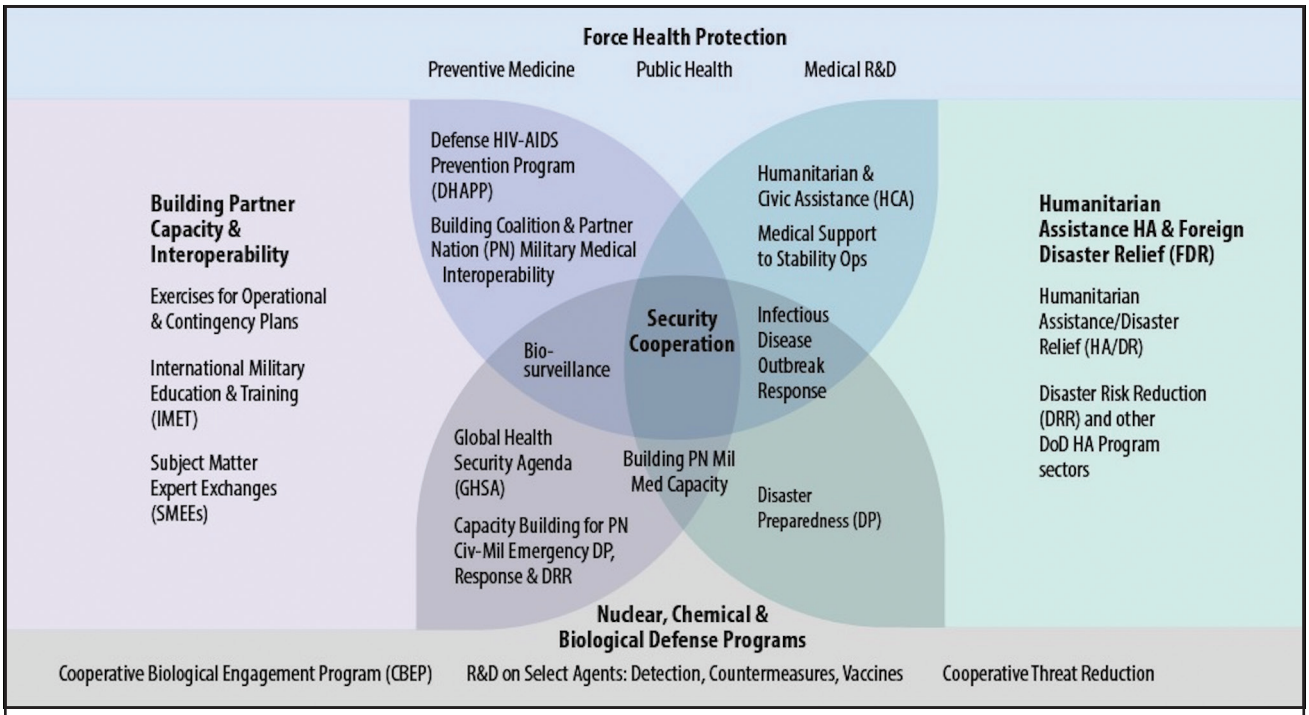

Figure 2. Global Health Engagement and Security Cooperation

impacts in relation to GHE activities, answering the question, "How can veterinary engagement activities contribute to security and theater campaign plan objectives?"[11]

1. Agricultural and livestock livelihood systems

This area is invaluable to many developing nations, increasing the quality of livestock management and care and directly impacting food security and economic prosperity. Climate change and natural disasters also affect the resiliency of a nation's food system. Work in livelihood systems contributes to improved economic and human health security.

2. Food protection systems

Food protection encompasses food safety (preventing unintentional contamination of the food supply) and food defense (preventing intentional contamination of the food supply). AVS personnel have expertise in the full spectrum of food protection--from basic food handler safety to advanced industrial commercial food production. By helping prevent devastating foodborne illnesses, food protection improves human health security.

3. Veterinary public health

Veterinary public health (VPH) encompasses many potential areas of opportunity for GHE activities. One of the largest is zoonotic disease prevention, mitigation, and control, including activities in pandemic preparedness. Key topics like biosecurity, health system reform, human resources, and bio-surveillance are contained in this area. VPH contributes to improved human health security in various ways, especially by helping to prevent the occurrence and severity of zoonotic disease outbreaks. Demonstrating the versatility of VPH, members of AVS have been instrumental in the execution of the Indo-Pacific Military Health Exchange (IPMHE):

IPMHE is a strategic-level security cooperation GHE in the form of a professional conference conducted around the region since 1995. While serving as Public Health Command-Pacific Veterinary Services Director, (then) MAJ Tselane Ware participated as a member of the US scientific and planning committees for IPMHE 2021-22, a multinational scientific event co-hosted by USINDOPACOM and the Indian Armed Forces Medical Services. The 2022 team included US medical and public health personnel from USINDOPACOM J07, United States Army Pacific (USARPAC), Pacific Fleet, Tripler Army Medical Center, and the Uniformed Services University of Health Sciences, representing the broad spectrum of Joint and Multinational healthcare in USINDOPACOM (Figure 3). IPMHE is a forum for professionals to share their accomplishments with international colleagues and build partnerships in line with USINDOPACOM's security cooperation goals. This event served as a high-level SMEE with key military

Figure 3. The Indo-Pacific Military Health Exchange 2021-22 planning committee.

leaders, like the Surgeon General equivalents of PNs, the USINDOPACOM surgeon, and the senior medical officer. AVS representation at such a strategically significant event for multiple years demonstrates the value of AVS participation for US and PN personnel.

4. Military (or police, border patrol, etc.) working dog health care

This area includes the entire spectrum of healthcare for the working canine, from handler first aid training through the provision of specialized and definitive veterinary care. Working animal health care contributes to improved human health and physical security by ensuring animals working in the security sector receive the best veterinary medical care possible to perform their critical functions. A great example of this type of engagement in USINDOPACOM is a series of MWD (Military Working Dog) SMEEs in support of Hanuman Guardian in Thailand:

> Hanuman Guardian (HG) is an annual bilateral military exercise hosted by the Royal Thai Army (RTA) and USARPAC. LTC Jocelin Blake, Public Health Command-Pacific Regional Clinical Consultant, joined the USARPAC MWD Program Manager and a Handler Dog Team from the 8th Military Police Brigade for a MWD SMEE with the RTA MWD Program. The event occurred at the MWD Academy in Pak Chong, Thailand (Figure 4). It focused on the RTA's MWD breeding program, prevention of ectoparasites, MWD and handler training program, animal health specialist and veterinary training, and an overview of MWD prophylactic surgery protocols. LTC Blake demonstrated applied trauma management incorporating canine tactical combat casualty care doctrine and prolonged field care operations. A few months later, the 520th Military Police Detachment hosted an RTA General Officer, MWD handlers, and four MWDs at Schofield Barracks, Hawaii. The RTA handlers and MWDs participated in situational training exercise lanes while LTC Blake supervised the RTA handlers' training with a canine medical simulator. This GHE supported one of the USARPAC Commander's strategic goals--advancing the US Army relationship with our Thai partners—through shared training to promote interoperability and increased readiness of handlers and their MWDs. As a security cooperation exercise, this event included security and medical competencies and demonstrated how vGHE could nest seamlessly with non-medical engagements with great success. Because this is an engagement within the greater HG exercise, it directly supports the engagement plan developed and vetted by USINDOPACOM security cooperation officers for Thailand.[12]

These competencies cover activities conducted by members of AVS but are in no way restrictive. AVS personnel, by virtue of training and experience, are uniquely equipped to contribute to a wide variety of exercises, key leader engagements, symposia, forums, and so on. With training in animal medicine, public health, food protection, emergency management, business management, and more, AVS members possess many capabilities that can be incorporated into multiple GHE activities. The breadth of expertise, coupled with the depth of specialty knowledge across AVS, means it is an incomparable resource in the Joint Force for GHE. AVS spans Health Service Support and Force Health Protection, making AVS personnel vital to any vGHE planning and execution. vGHE can fit seamlessly into scheduled bilateral or multinational exercises such as US Navy's Pacific Partnership, US Air Force's Pacific Angel, or US Army's Pacific Pathways; within humanitarian or disaster response engagements; peacekeeping operations training; separately planned SMEEs; or as stand-alone events hosted by key organizations. Even during a global pandemic, veterinary military-to-military (MIL-MIL) engagements and SMEEs continued to be part of multinational exercises, conferences, and virtual knowledge exchanges.

Figure 4. The Hanuman Guardian subject matter expert exchange leaders.

One of the most impactful exercises in USINDOPACOM is the US Navy Pacific Fleet's Pacific Partnership (PP), which provides the opportunity to showcase the full spectrum of vGHE events. Originating from the response to the devastating 2004 Indonesia Tsunami, PP is the largest annual Humanitarian Assistance and Disaster Relief mission conducted. The PP's stated goal is to improve interoperability with the region's military forces, governments, and humanitarian organizations during disaster relief operations. Two excerpts from AVS members demonstrate the limitless potential associated with the exercise:

> As a participant in PP19, CPT Patrick McFadden, of Public Health Activity-Fort Lewis, was tasked with planning and executing vGHE in the Philippines, Malaysia, Timor Leste, Vietnam, and Thailand. PP19 exhibited the diversity that vGHE can play within the GHE community. Only one PN, the Philippines, requested a Veterinary Civic Action Program. CPT McFadden trained Armed Forced Philippines and civilian veterinarians in aseptic technique to reduce post-operative infections and improved surgical techniques to reduce mortality over the course of three Community Health Engagements. In every nation visited, there was an intense demand for food safety, food chain stability, and food security discussion. In the Philippines, Timor Leste, and Vietnam, CPT McFadden conducted SMEE's with local department of public health officials with an eye toward reducing transmission of debilitating fecal-oral pathogens (Figure 5). Zoonotic and transboundary diseases, particularly rabies, avian influenza, and African Swine Fever, were topics of concern in the Philippines, Malaysia, Timor Leste, and Vietnam. Vietnam requested a robust continuing relationship with AVS partners to provide continuing education regarding agricultural best management practices and zoonotic disease mitigations to local veterinarians.[13]
>
> Nearly 2000 military and medical personnel from the United States, the Philippines, Australia, Chile, South Korea, and the United Kingdom participated in PP22, promoting cooperation between military and civilian organizations to prepare for disaster response effectively. The 438th Medical Detachment (Veterinary Service Support) (MDVSS) supported PP22 with two Veterinary Corps Officers (VCOs), four Animal Care Specialists and two Veterinary Food Inspection Specialists. CPT Kathleen Moore was an integral part of this team, and they executed vGHEs in Vietnam, Palau, the Philippines, and the Solomon Islands. These engagements included multiple SMEEs, side-by-side care for animals, MWD handler training with the Philippine Armed Forces, and a One Health Symposium in Palau. SMEE topics included rabies control, zoonotic & biosecurity diseases, food safety/defense, laboratory sample collection and handling techniques, veterinary medical emergency protocols, livestock husbandry & common diseases, and postmortem examinations (Figure 6). A highlight was the first ever One Health Symposium planned and led by the 438th MDVSS team. The team worked closely with various components of the remainder of the PP22 Medical team to include Navy preventive medicine, laboratory, infectious disease, and pharmacy teams. These engagements strengthened the relationships between PNs and the United States and provided tools and knowledge to bolster agricultural and animal production aspects of their economies. [14]

As geographic combatant commanders are responsible for guiding GHE events that will support their theater campaign plan, the USINDOPACOM Commander plays a central role in GHE direction in the area of responsibility. Fortunately, USINDOPACOM has recognized GHE as "a key enabler for

Figure 5. Pacific Partnership 19 zoonotic and transboundary disease discussion.

Figure 6. Pacific Partnership 22 instruction on laboratory procedures.

Figure 7. Public Health Activity-Japan providing basic care and treatment instructions to working dog handlers.

full-spectrum theater security cooperation" for years.[15,16] This challenging theater requires that the United States increase its regional engagement in a variety of ways, and GHE, specifically vGHE, can contribute to this aim. vGHE can improve defense through force health protection and ensuring the health of a working animal security force while also furthering diplomacy by helping encourage the spread of food safety practices and agricultural efficiency. Further, many nations share sustainable, resilient agriculture and aquaculture in the USINDOPACOM area of responsibility, which can be addressed in well-planned vGHE events. While stand-alone vGHE events can contribute to security cooperation goals already established by USARPAC and USINDOPACOM, sustained events, which consistently involve assessment and reevaluation, often reap the most rewards over time. An enduring MIL-MIL and MIL-MIL plus civilian (MIL-MIL-CIV) MWD vGHE conducted in Japan demonstrates such an event:

During his assignment with Public Health Activity-Japan (PHA-J) at Yakota Airbase, Japan, MAJ James Gaffney took advantage of the US Air Force kennel's working relationship with different agencies to train alongside Japanese partners. Dog handlers from the Tokyo Metropolitan Police Department, Tokyo Airports (Japan Customs), Japanese National Police, Air Self Defense Force, and Ground Self Defense Force received training on basic care and treatment for their working dogs from PHA-J AVS personnel (Figure 7). Veterinary care to these working dogs was normally provided by civilian Japanese veterinarians on a reimbursable basis, so handlers were eager to learn some basic skills such as bandaging, and heat injury care. COL Matthew Levine's (former PHA-J Commander) aim was to export this plan to other US bases in Japan and set some objective goals for incrementally deepening the training relationship among the entities. The ultimate output of these engagements was more culturally competent AVS personnel that understood and shaped their operational environment in a positive way while bolstering the partnership between US and Japanese organizations.[17]

Conclusion

At the core of security cooperation in USINDOPACOM is the idea that true partnerships are mutually beneficial and based on respect and genuine interest in the success of each partner. USINDOPACOM can and should use vGHE to show our partners that their success is our success. Using vGHE to influence improved food, economic health, and health and human securities in one of our PNs will benefit them and enhance their view of us. Security cooperation activities like GHE have a variety of significant benefits, including access for more conventional military activities. However, the greater strategic importance of security cooperation is that of partnership. A stronger group of partners is much more advantageous than the United States trying to stand on its own. Whether for essential food protection, advanced prolonged casualty care for working animals, basic public health measures, or cutting-edge bio-surveillance and biosecurity programs, vGHE is invaluable to security cooperation across the theater.

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The Comparative Pathology of Intranasal, Intratracheal, or Small Particle Aerosol Exposure of SARS-CoV-2 (COVID-19) Virus in Five Animal Models

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Abstract

A novel coronavirus, SARS-CoV-2, first identified in Wuhan, China, in late 2019, caused a global pandemic resulting in significant morbidity and mortality in humans worldwide. Disease presentations in humans range from asymptomatic virus carriers to fatal systemic disease. A historic effort is underway to develop therapeutics and vaccines to slow or stop virus spread and treat those infected with coronavirus disease (COVID-19). Animal models play vital roles in understanding the pathogenesis of SARS-CoV-2 and evaluating therapeutics and vaccines. We compare the pathologic findings, including macroscopic, microscopic, and molecular findings, in three nonhuman primate species (cynomolgus macaques, rhesus macaques, and African green monkeys), ferrets, guinea pigs, hamsters, and mice following experimental exposure to SARS-CoV-2 by the intranasal, intratracheal or small particle aerosol routes to the disease as it occurs in humans who died during the current pandemic.

Keywords: animal models; COVID 19; SARS-CoV-2; pandemic; coronavirus

Introduction

Since the early months of 2020, when the global medical and scientific community began to grasp the magnitude of the emerging pandemic, an effort to understand the disease was based mainly on previous coronavirus outbreaks. These included severe acute respiratory syndrome (SARS) associated with SARS-CoV, which occurred in 2002-2003, and the more recent Middle East respiratory syndrome coronavirus (MERS), which occurred from 2012 to 2015. While SARS and MERS are caused by coronaviruses that share similarities with SARS-CoV-2, many differences have also emerged, necessitating the search for new virus-specific animal models, while using past models to inform development.[1-2]

SARS-CoV-2 is a member of the Coronaviridae family, Orthocoronavirinae subfamily, *Betacoronavirus* genus, *Sarbecovirus* subgenus, similar to the virus that caused SARS.[3] The virus that causes MERS is in the *Merbecovirus* subgenus, and the four other coronaviruses that infect humans and typically cause mild disease are either in the *Alphacoronavirus* genus (*Divinacovirus* and *Setracovirus* subgenera) or *Betacoronavirus* genus (*Embecovirus* subgenus).[4-5] In addition to infecting humans, the various genera of coronaviruses contain many pathogens of domestic and wild animals and include organ system-specific pathogens that affect a single system, such as the gastrointestinal or respiratory tract, to systemic diseases in which the virus can infect and cause pathology in multiple organ systems. Aside from the more pathogenic viruses that cause SARS and MERS, the four other coronaviruses that

infect humans most commonly result in mild disease isolated to the respiratory tract (ie, what is generally described as the common cold).[4] All coronaviruses that infect humans are thought to have animal origins, such as rodents or bats (currently unknown for SARS-CoV-2). This includes the more pathogenic viruses that cause SARS, MERS, and COVID-19, as well as the four that cause milder respiratory disease.[4, 6] The evolution of the more pathogenic coronaviruses that infect humans (ie, the viruses that cause SARS-CoV, MERS-CoV, and SARS-CoV-2) is thought to involve an intermediate host through which the virus evolves to infect humans.[1]

As with other respiratory infections, transmission of SARS-CoV-2 can occur via direct contact through saliva or respiratory secretions and via contaminated surfaces (ie, fomites). Aside from during medical procedures, aerosol transmission frequency and degree have also been the subject of much debate and ongoing investigation.[7] While the precise relationship between the initial virus dose and disease severity is unclear, there have been reports that a higher viral load is associated with decreased survivability.[8] Additionally, virus dose has been suggested to play a role in the severity of other viral diseases, such as influenza, and may also be the case with SARS-CoV-2.[9] It has also been suggested that more severe disease may result in increased viral transmission.[10] Animal models can play an important role in investigating viral pathogenesis and medical countermeasures and answering questions regarding virus transmission dynamics.[11]

Numerous animal models are being used to investigate disease pathogenesis and to facilitate the study of vaccines and therapeutics. There is wide variation in study design, not only in animal species, numbers, day of harvest, and tissues examined, but also in virus dose, route of administration, and virus identification methods with tissues. Animal models currently being developed and described in the literature include cynomolgus macaques (CM), rhesus macaques (RM), common marmoset, African green monkey (AGM), BALB/c mice using mouse-adapted SARS-CoV-2, various models of hACE2 transgenic mice, golden Syrian hamsters, Guinea pigs, and ferrets.[2,12] This paper aims to summarize a subset of different animal models currently under development by highlighting organ system-specific pathology in each model and comparing it to what is being described in human disease.

This approach may facilitate determining which model is most suitable for studying specific aspects of SARS-CoV-2 as it occurs in humans. Pathology associated with SARS-CoV-2 infection, either due to direct infection or damage, or virus-induced vascular changes, has been described in the following organ systems in humans: lung, lymph nodes, spleen, kidney, heart, liver, and brain.[13-25] Although the description of pathology in these systems has been less straightforward, clinical symptoms associated with the gastrointestinal and musculoskeletal systems have also been described, with the detection of virus in tissue samples from multiple locations in the gastrointestinal tract as well as detection of virus in clinical specimens including airway samples, feces, and blood.[23, 26-27]

Methods

Virus Strain

The same viral isolate, SARS-CoV-2 isolate 2019-nCoV/USA-WA1/2020, was used for all experiments described herein. A seed stock of this isolate was obtained from the Centers for Disease Control and Prevention and was grown on ATCC Vero 76 cells. It was fully sequenced and evaluated for sterility, tested for mycoplasma and endotoxin levels, and tested in several real-time reverse transcriptase polymerase chain reaction (RT-PCR) assays, including two specific for SARS-CoV-2 virus. There were no contaminants detected, and the identity was confirmed by RT-PCR.

Nonhuman Primate Studies

In the first study, adult SARS-CoV-2 serologically naïve AGM (n=3), RM (n=4), and CM (n=4) were exposed to SARS-CoV-2 by small particle aerosol route as described.[28] Animals had been implanted with telemetry devices to monitor activity level and body temperature. They were evaluated for signs of illness and development of fever and were euthanized 17 or 18 days after viral exposure. Necropsies were performed, and a full complement of tissues was collected. Histopathology, in situ hybridization (lung, spleen, right kidney, and tracheobronchial lymph node), and immunofluorescence antibody test (lung) were performed.

In another study, the disease and lesions were compared in the RM and CM following exposure to SARS-CoV-2 by either small particle aerosol or intratracheal/intranasal (IT/IN) administration of the virus. Briefly, four adult RMs and four adult CMs were anesthetized and exposed to a target dose of 5 × 104 – 5 × 105 pfu/mL of SARS-CoV-2 using the small particle aerosolization method described above. For comparison, four adult RMs and four adult CMs received a dose of 2.65 × 107 SARS-CoV-2 virus by IT/IN administration. Animals were implanted with telemetry devices to monitor activity levels and body temperature. Animals were monitored daily for clinical illness and were euthanized and necropsied between 9 to 10 days after viral exposure. A full complement of tissues was collected at necropsy. Histopathology, in situ hybridization (lung, spleen, kidney, tracheobronchial lymph node, and nasal turbinates), and immunofluorescence antibody test (lung) were performed.

Ferret Studies

Twelve adult male ferrets were exposed to a target dose of 1 × 104 to 1 × 105 pfu of SARS-CoV-2 virus by the intranasal route, and another group of twelve adult males were exposed to a target dose of 10 000 to 100 000 pfu by small particle aerosolization using a whole-body aerosol chamber. Animals were implanted

with a subcutaneous chip for identification and temperature monitoring. Following viral exposure, the ferrets were monitored for signs of disease, and temperatures and body weights were recorded daily. Animals were euthanized if they met specified criteria for euthanasia or on designated scheduled euthanasia study days. Three animals exposed by the intranasal route and three exposed by the aerosol route were euthanized on study days 4, 7, 10, or 14 after viral exposure. Following euthanasia, necropsies were performed, and a complete complement of tissues was collected. Histopathology was limited to the upper and lower respiratory tract plus kidney, and immunohistochemistry (IHC) was performed on sections of nasal turbinates, lung, tracheobronchial lymph node, and kidney.

In another study using ferrets, six adult female ferrets were exposed to SARS-CoV-2 by the intranasal route, monitored for signs of disease and fever, and euthanized 14 to 16 days after viral exposure. Necropsies were performed, and a complete set of tissues was collected for histopathology and IHC.

Guinea Pig Studies

Twelve adult male Hartley guinea pigs were exposed to SARS-CoV-2 by the intranasal route and another twelve were exposed to SARS-CoV-2 by small particle aerosolization in a whole-body aerosol chamber. After viral exposure, the guinea pigs were monitored for clinical signs of disease. Three animals from each group were euthanized on study days 4, 7, 10, and 14. Necropsies were performed on all animals, and a complete set of tissues was collected. Histopathology was limited to the upper and lower respiratory tract plus kidney, and IHC was performed on sections of nasal turbinates, lung, tracheobronchial lymph node, and kidney.

Hamster Studies

Groups of twelve animals consisting of six males and six females were anesthetized using isoflurane and exposed to SARS-CoV-2 by intranasal instillation of 1 × 105 pfu of virus in a volume of 100 µL. Hamsters were euthanized and necropsied 3 or 7 days after viral exposure.

Mouse Studies

Groups of eight mice of the following strains: C57BL/6, BALB/c, C3H/HeJ, A/J, RAG2, and MyD88KO were exposed to 1 × 104 pfu of SARS-CoV-2 virus by the intranasal route and monitored for signs of disease (ruffled fur, respiratory distress, hunched posture, and individual weight loss). Animals that met specified criteria were euthanized. Otherwise, subsets were euthanized on days 3 or 28 post viral exposure. Necropsies were performed, and lung, nasal turbinates, and brain were collected and submitted for histopathology.

Histopathology

Table 1 summarizes the tissues collected and the day of collection after viral exposure. After 14 days of fixation in 10% buffered neutral formalin, tissues were removed from the level

Table 1. Summary of Tissues Collected and Day of Collection After Viral Exposure

Species	Route	Target Dose	Tissues Collected	Days of Death (PI)
NHP-CM	Aerosol	1 x 10^5 – 1 x 10^7 pfu	Full necropsy including axillary, inguinal and tracheobronchial lymph nodes (LN) and nasal turbinates	18, 19
NHP-RM	Aerosol	1 x 10^5 – 1 x 10^7 pfu	Full necropsy including axillary, inguinal and tracheobronchial LN and nasal turbinates	18
NHP-AGM	Aerosol	1 x 10^5 – 1 x 10^7 pfu	Full necropsy including axillary, inguinal and tracheobronchial LN and nasal turbinates	19
NHP-RM	IT/IN	1 x 10^6 pfu	Full necropsy including axillary, inguinal and tracheobronchial LN and nasal turbinates	5, 6
NHP-CM	IT/IN	1 x $10^{6\ pfu}$	Full necropsy including axillary, inguinal and tracheobronchial LN and nasal turbinates	5, 6
Ferret	IN	1 x 10^4-1 x 10^5 pfu	Nasal turbinates, brain, trachea, tracheobronchial LN, olfactory bulb, lung, kidney, large intestine, mesenteric LN	4, 7, 10, 14
Ferret	Aerosol	1 x 10^4-1 x 10^5 pfu	Nasal turbinates, brain, trachea, tracheobronchial LN, olfactory bulb, lung, kidney, large intestine, mesenteric LN	4, 7, 10, 14
Guinea pig	IN	1 x 10^4-1 x 10^5 pfu	Nasal turbinates, brain, trachea, tracheobronchial LN, olfactory bulb, lung, kidney, large intestine, mesenteric LN	4, 7, 10, 14
Guinea pig	Aerosol	1 x 10^4-1 x 10^5 pfu	Nasal turbinates, brain, trachea, tracheobronchial LN, olfactory bulb, lung, kidney, large intestine, mesenteric LN	4, 7, 10, 14
Hamster	IN	1 x 10^5 pfu	Nasal turbinates, olfactory bulb, brain, eye, ear, trachea, lung, liver, spleen, heart, kidney, intestine	3, 5, 7
Mice	IN	1 x 10^4 pfu	Nasal cavity, brain, olfactory bulb, lung	3, 30

Key: PI = post infection, NHP = non-human primate, CM= cynomolgus macaque, RM = rhesus macaque, AGM = African green monkey, IT = intratracheal, IN = intranasal, pfu = plaque forming units

3 biosafety laboratory and transferred to the histology laboratory, where they were routinely trimmed and stained with hematoxylin and eosin. Replicate sections of certain tissues were cut and placed on positively charged slides for use in in situ hybridization and/or IHC and immunofluorescence procedures.

Immunohistochemistry

IHC was performed using a commercially available kit. Briefly, after deparaffinization, peroxidase blocking, and antigen retrieval, sections were covered with a mouse monoclonal antibody to the SARS-CoV nucleocapsid protein at a concentration of 1:8000. They were incubated at room temperature for 45 minutes. Next, the slides were rinsed, and the peroxidase-labeled polymer (secondary antibody) was applied to the slides for thirty minutes at room temperature. Following incubation with the polymer, the slides were rinsed, and a 3, 3' diaminobenzidine solution was applied for 8 minutes. The substrate-chromagen solution was then rinsed off the slides and the slides were counterstained with hematoxylin and rinsed again. Finally, the sections were dehydrated, cleared with Xyless, and a cover slip was applied.

In Situ Hybridization

To detect SARS-CoV-2 genomic RNA in formalin-fixed paraffin-embedded tissues, in situ hybridization (ISH) was performed using a commercially available kit. Forty ZZ ISH probes targeting SARS-CoV-2 genomic RNA fragment 21571-25392 were custom-designed and synthesized. Tissue sections were deparaffinized with xylene, underwent a series of ethanol washes and peroxidase blocking, and were then heated in kit-provided antigen retrieval buffer and digested by kit-provided proteinase. Sections were exposed to ISH target probe pairs and incubated at 40 °C in a hybridization oven for 2 hours. After rinsing, the ISH signal was amplified using a kit-provided pre-amplifier and amplifier conjugated to alkaline phosphatase and incubated with a Fast Red substrate solution for 10 minutes at room temperature. After the sections were stained with hematoxylin and air-dried, a cover slip was applied.

Immunofluorescence Procedure

Select sections were stained by an immunofluorescence assay to several antibodies. After deparaffinization and treatment with 0.1% Sudan Black B to reduce autofluorescence, tissues were heated in citrate buffer, pH 6.0, for 15 minutes to reverse formaldehyde cross-links. After rinsing with phosphate-buffered saline (PBS), pH 7.4, sections were blocked overnight with PBST (PBS+ 0.1% Tween-100) containing 5% normal goat serum at 4 °C. Sections were then incubated with the following primary antibodies for 2 hours at room temperature: rabbit polyclonal antibody against Ki67 at a dilution of 1:400; rabbit polyclonal anti-CD3 antibody at a dilution of 1:200; mouse anti-human CD68 antibody at a dilution of 1:200; and mouse monoclonal antibody against CD45 at a dilution of 1:200. After rinsing in PBST, sections were incubated with secondary goat IgG Alexa Fluor 488-conjugated anti-rabbit and with goat IgG Alexa Fluor 561-conjugated anti-mouse antibody for 1 hour at room temperature. Sections were cover-slipped using an anti-fade mounting medium with DAPI. Images were captured on an LSM 880 Confocal Microscope and processed using open-source ImageJ software.

Results

Nonhuman Primates

For the nonhuman primate study that utilized small particle aerosol exposure only, only CMs developed fever during the in-life phase, but all species developed increased respiratory sounds between days 5 and 9 and lung opacity on radiographs.[28] Despite these clinical findings, no animal met the criteria for euthanasia. However, using a clinical scoring system to assess disease severity, CMs had higher scores overall.[28]

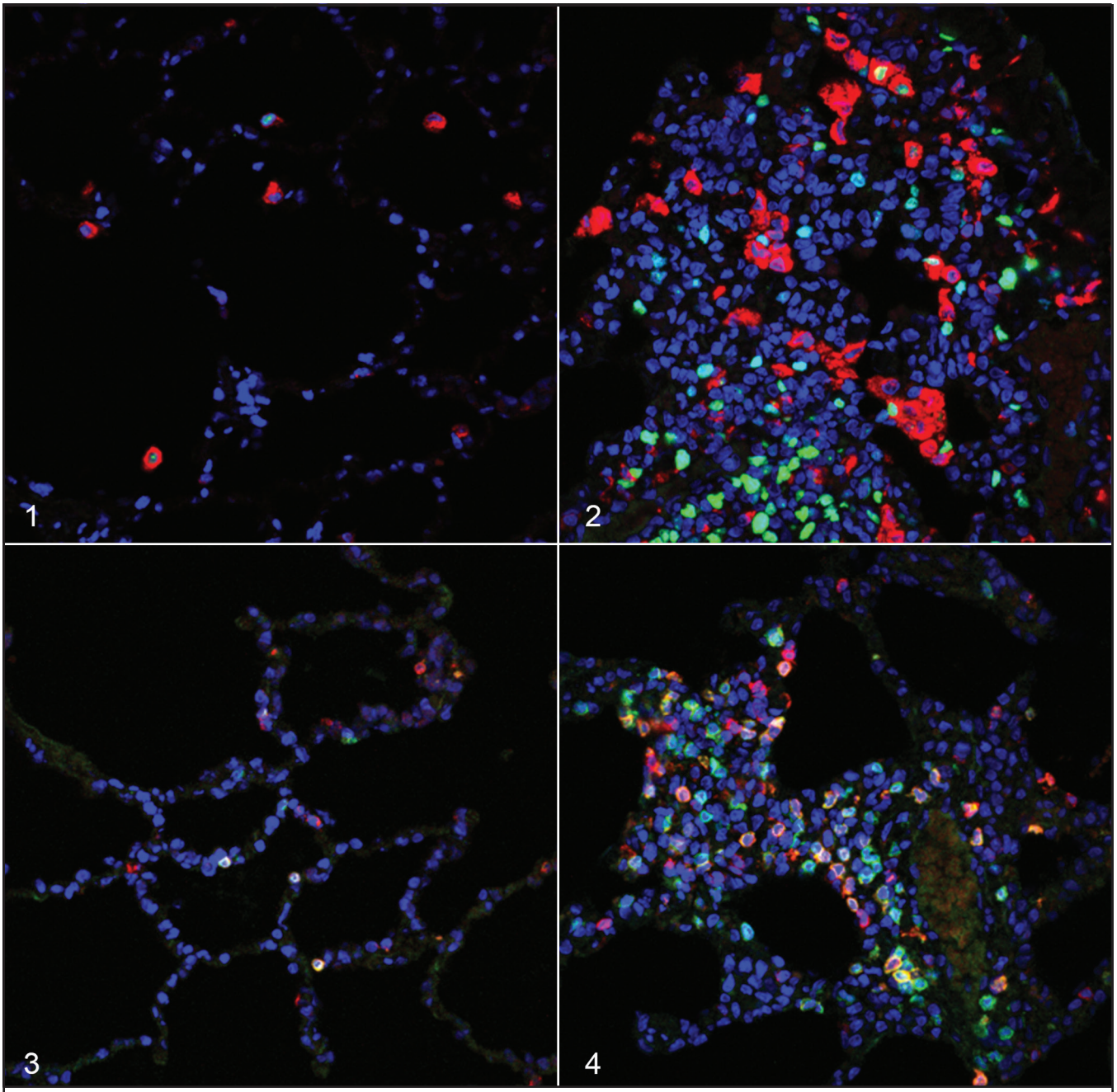
Gross necropsy lesions were not common and only included red mottling of one or more lung lobes that were present in only AGMs and CMs. Except for a single CM, by histopathology, all animals in the study had some degree of inflammation in the lung with variable alveolar fibrosis and type II pneumocyte hyperplasia. Multinucleate cells in the lung were only present in two AGMs, and one AGM and a single CM had similar multinucleate cells in the axillary and inguinal lymph nodes, respectively. All animals except a single RM had some degree of lymphoid hyperplasia of the tracheobronchial lymph node. No SARS-CoV-2 viral RNA was detected in any animal by in situ hybridization.[28]

The inflammation in the lung across all three species that were solely exposed to SARS-CoV-2 by small particle aerosol was mostly composed of lymphocytes, plasma cells, and macrophages in low numbers that expanded the perivascular spaces and interstitium (Figures 1-4). There was variation in the severity and number of inflammatory cells between lung lobes and areas within a given lobe. Two of the four (50%) RMs had inflammation in one lung lobe only. A single AGM had neutrophilic inflammation in addition to lymphocytes, plasma cells, and macrophages expanding the interstitium and peribronchiolar area. This animal also had degeneration and necrosis of the bronchiolar epithelium, a finding not observed in any of the other animals in this study.

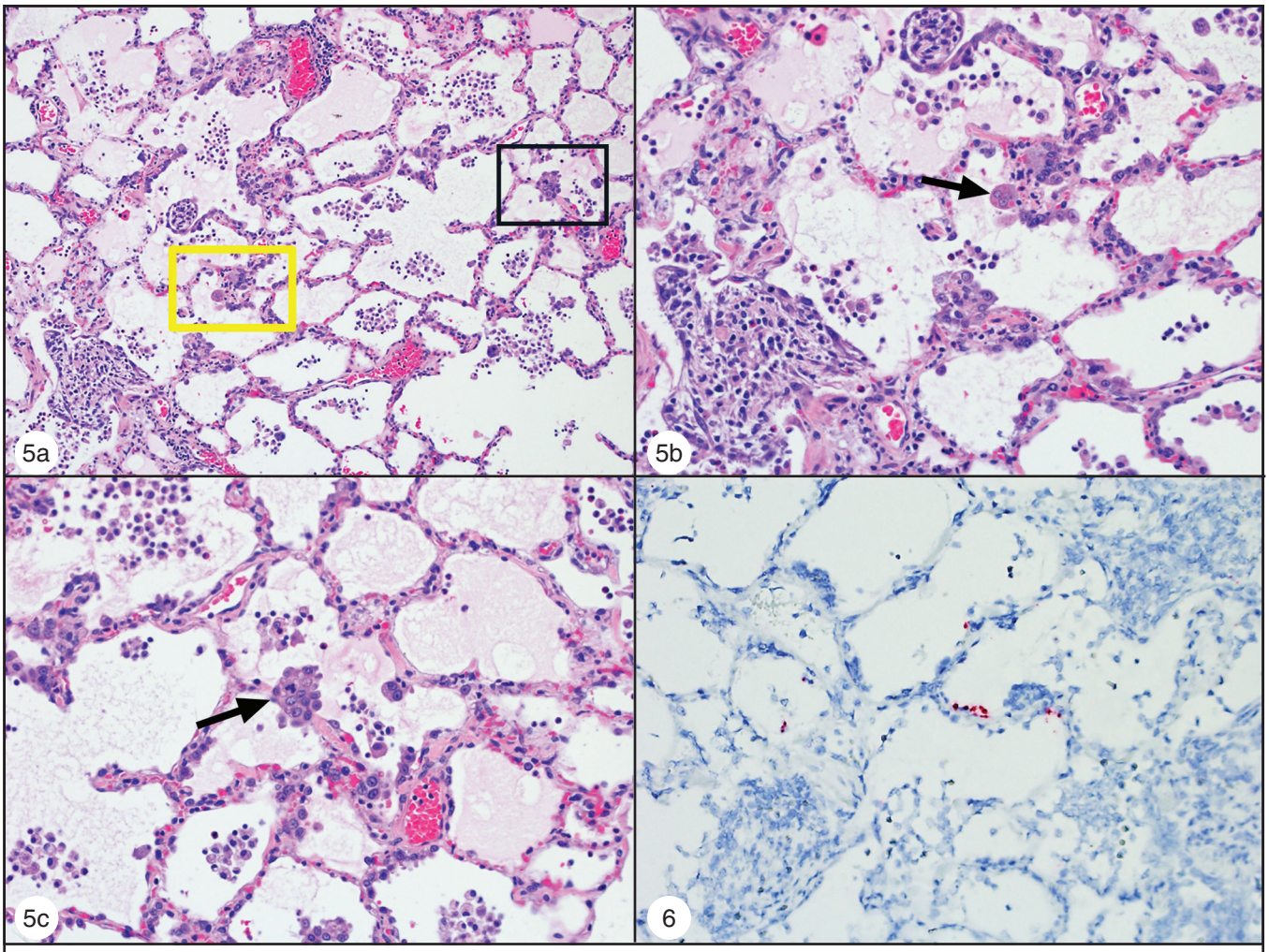
Inflammation within the nasal turbinates and nasal septum was less common than pulmonary inflammation and occurred in 1/3 (33%) AGMs, 1/4 (25%) RMs, and 2/4 (50%) CMs. Among these four animals, the most common location was the right ethmoturbinate. The character of the inflammation was variable and included lymphoplasmacytic, neutrophilic, neutrophilic and histiocytic, and lymphoplasmacytic and eosinophilic, and the severity was also quite variable, ranging from minimal to moderate. When present, the inflammatory

cells expanded the subepithelial mucosa and, less frequently, the nasal cavity lumen.

While clinical signs were largely absent in all groups in the study comparing IT and IN exposure to small particle aerosolization in the RM and CM, there was radiographic evidence of respiratory disease in all animals beginning on day 2 post exposure, peaking at days 4 to 6 post exposure, and followed by stabilization or improvement on days 6 to 8 post exposure. The group that developed the most pronounced radiographic changes was the CMs challenged via small aerosol route.



Figures 1-4. Immunofluorescence antibody staining, cynomolgus macaque, SARS-CoV-2. **Figure 1.** Uninfected lung, cynomolgus macaque. Normal alveolar septa with a few CD68-immunolabeled macrophages (red signal) and sparse immunolabeling with Ki67 (green signal). Immunofluorescence assay. **Figure 2.** SARS-CoV-2 infected lung, cynomolgus macaque. There are increased CD68-immunolabeled macrophages and increased Ki67 immunolabeling. Immunofluorescence assay. **Figure 3.** Uninfected lung, cynomolgus macaque. There are low numbers of CD45-immunolabeled lymphocytes (red signal) and CD3-immunolabeled lymphocytes (green signal) within the alveolar septa. Immunofluorescence assay. **Figure 4.** SARS-CoV-2 infected lung, cynomolgus macaque. There are increased numbers of both CD45 and CD3 immunolabeled lymphocytes that expand the alveolar septa. Immunofluorescence assay.



Figures 5-6. SARS-CoV-2 infection, small particle aerosol exposure, cynomolgus macaque. **Figure 5a.** Lung, left caudal lobe, cynomolgus macaque. The alveolar septa and spaces are expanded by lymphocytes, macrophages and neutrophils with multifocal type II pneumocyte hyperplasia, some of which are multinucleate cells (black box) with occasional mitotic figures (yellow box). Hematoxylin and eosin. **Figure 5b.** Higher magnification of yellow box in figure 5a. Multinucleate type II pneumocyte lining the alveolar septa. Hematoxylin and eosin. **Figure 5c.** Higher magnification of black box in figure 5a. There are occasional mitotic figures. Hematoxylin and eosin. **Figure 6.** Lung, left caudal lobe, cynomolgus macaque. There is positive signal for SARS-CoV-2 (red signal) in the alveolar septa and spaces. In-situ hybridization.

Gross lung necropsy lesions were uncommon and only included pulmonary adhesions between the left cranial and caudal lung lobes and the thoracic cavity in one CM. All animals in the study had some degree of pulmonary inflammation with variable septal fibrous change, type II pneumocyte hyperplasia, fibrin deposition, and the presence of multinucleate cells. The severity of pulmonary lesions was greater in CMs than RMs and was greater in the CMs challenged via small aerosol route than those challenged IT/IN. All animals except one CM and one RM had some degree of lymphoid hyperplasia of the tracheobronchial lymph node. All animals had some inflammation in the sections of nasal turbinates examined.

SARS-CoV-2 viral RNA was detected in the lung of all CMs challenged via small aerosol route (Figure 6), in the lung of 3/4 CMs challenged IT/IN route, and in 1/4 RMs challenged via the small aerosol route and IT/IN route. SARS-CoV-2 viral RNA was not detected in any other tissues examined.

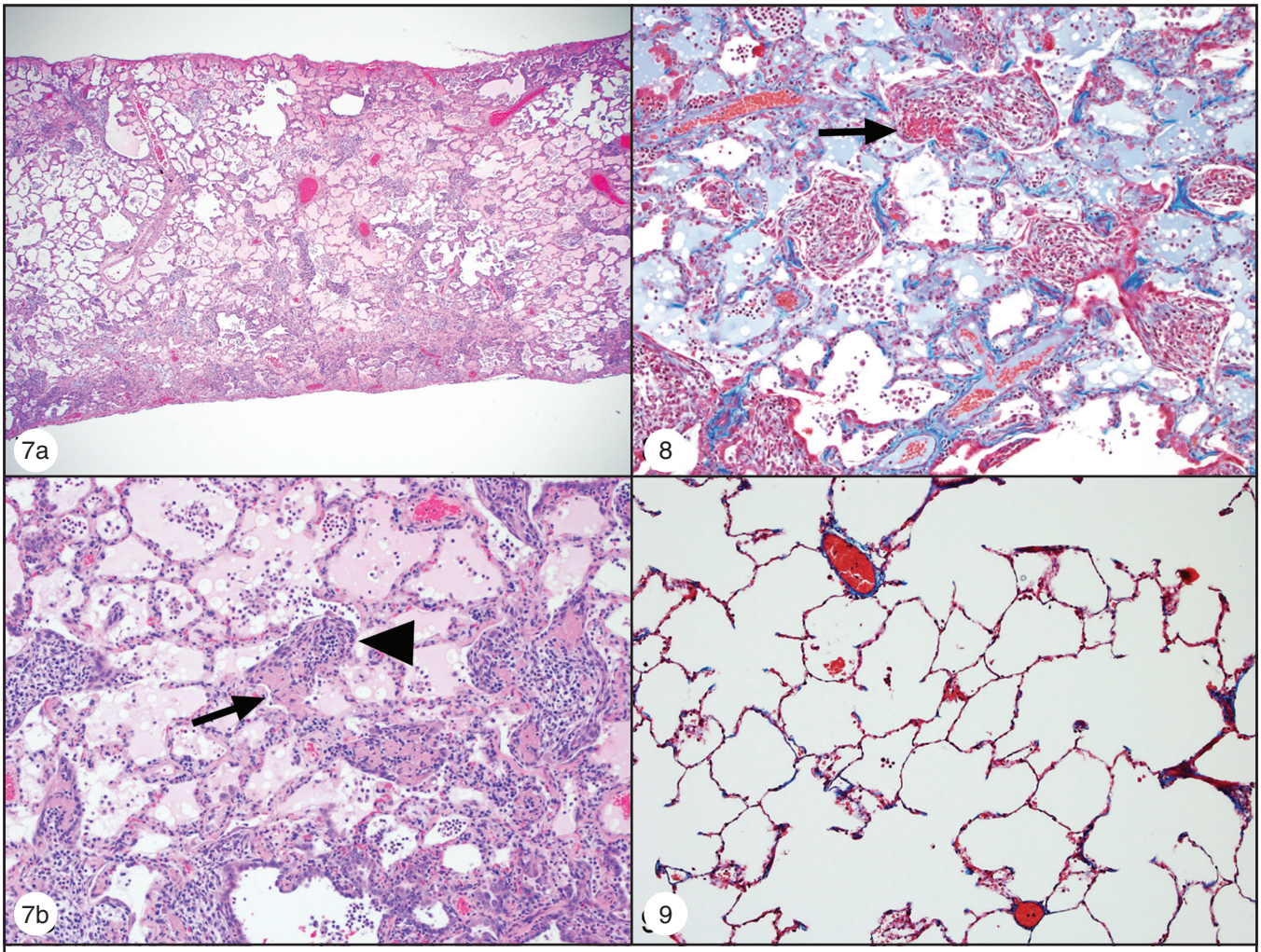
The lung inflammation across the two species, regardless of the challenge route, was composed predominantly of macrophages and lymphocytes with fewer neutrophils. The inflammation surrounded bronchioles and vessels, expanded the alveolar septa, and extended into the alveolar lumina. In addition to the inflammation, variable degrees of type II pneumocyte hyperplasia were present and were occasionally exuberant with the presence of mitotic figures (Figure 5). Multinucleate cells are present lining the alveolar septa and free within the lumen. SARS-CoV-2 viral RNA was not detected in these cells. Fibrin deposition within the alveolar septa and alveolar lumen occurred predominately with CMs and was confirmed using Masson's trichrome (Figure 8).

The inflammation in the nasal turbinates expanded the subepithelial connective tissue and was composed predominately of neutrophils, lymphocytes, and plasma cells admixed with edema. One CM had a focal area of mucosal ulceration. The multifocal inflammation involved one or more of the sections examined with no common location identified.

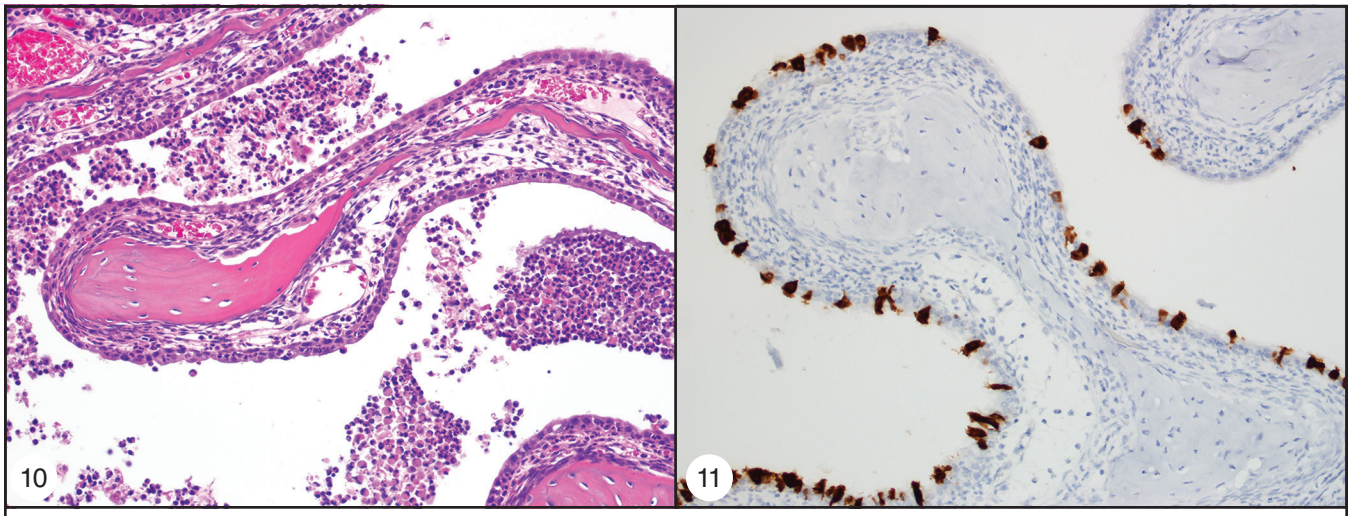
Ferrets

The most common microscopic findings in ferrets for both intranasal and aerosol-exposed animals consisted of inflammation in the nasal turbinates (>95%), which was composed of neutrophils and mononuclear cells (Figure 10). Twenty-five percent of the animals had necrosis of the mucosa, described as single-cell death and loss. No full-thickness necrosis or ulceration was noted in any of the animals. Vacuolation of the mucosal epithelial cells and congestion were other findings noted in the nasal turbinates. In the lower respiratory tract, minimal to mild lung inflammation was the most common finding, associated with blood vessels and less frequently seen in the alveolar space or bronchioles. Inflammation consisted of neutrophils and macrophages with few lymphocytes and plasma cells. Rarely, in a few animals, multinucleated cells were present. Necrosis was not a feature observed in these animals. Other microscopic changes included vacuolated bronchiolar epithelial cells. The remaining tissues examined, including kidney, trachea, tracheobronchial lymph node, mesenteric lymph node, large intestine, and olfactory bulb, had no significant findings.

IHC was performed and had a positive signal in the nasal turbinate epithelium in half of the animals tested, and most were early in the disease process (days 4 and 7). A positive signal was in individual epithelial cells and did



Figures 7-9. SARS-CoV-2 infection, IT/IN route, cynomolgus macaque. **Figure 7a.** Lung, left caudal lobe. There is increased cellularity expanding alveolar septa and alveolar spaces. Alveolar spaces contain fibrin and edema. Hematoxylin and eosin. **Figure 7b.** Higher magnification of 7a. There are multifocal aggregates of inflammatory cells and fibrin (black arrow) surrounded by fibrous connective tissue (large black triangle). Hematoxylin and eosin. **Figure 8.** Lung, left caudal lobe. There is fibrin within the alveolar space (black arrow) with deposition of collagen within the alveolar septa (blue). Masson Trichrome. **Figure 9.** Uninfected lung, cynomolgus macaque for reference. Masson Trichrome.



Figures 10-11. SARS-CoV-2 infection, ferret, day 4 post infection. **Figure 10.** Nasal turbinates. Exudate and necrotic debris within nasal passages; individual cell necrosis of mucosal epithelial cells with inflammation, and submucosal edema and inflammatory cells. Hematoxylin and eosin. **Figure 11.** Nasal turbinates. Individual mucosal epithelial cells are immunolabeled for SARS-CoV-2 virus. Immunohistochemistry.

not exceed 25% of the cells in the section (Figure 11). The remaining IHC slides in ferrets, including lung, trachea, olfactory bulb, tracheobronchial lymph node, and kidney, were all negative.

Unlike the ferrets that were euthanized earlier in the in-life phase (described above), within the group of six ferrets that were euthanized between 14 to 16 days following viral exposure, the most common finding was inflammation within the lungs. Five of six (83%) had some degree of pulmonary inflammation in one or more lung sections. The inflammation was composed of lymphocytes, plasma cells, macrophages, and sometimes neutrophils that most commonly expanded the perivascular spaces and less frequently involved the interstitium and peribronchiolar spaces.

Lesions within the nasal turbinates affected only two of six (33%) animals in this group, and like the ferrets euthanized at earlier time points, some neutrophils expanded the lumen and the submucosa. There was only minimal epithelial degeneration and loss.

IHC was performed on replicate sections of lung, trachea, larynx, esophagus, aorta, thyroid gland, and posterior nasal turbinates, and there was no immunoreactivity in any examined sections.

Guinea Pigs

The most common microscopic findings in the guinea pig for both intranasal and aerosol exposure groups consisted of vacuolation of the nasal turbinate epithelium (100% of animals), with most having inflammatory infiltrates within the submucosa (96%). Necrosis was not observed in these animals.

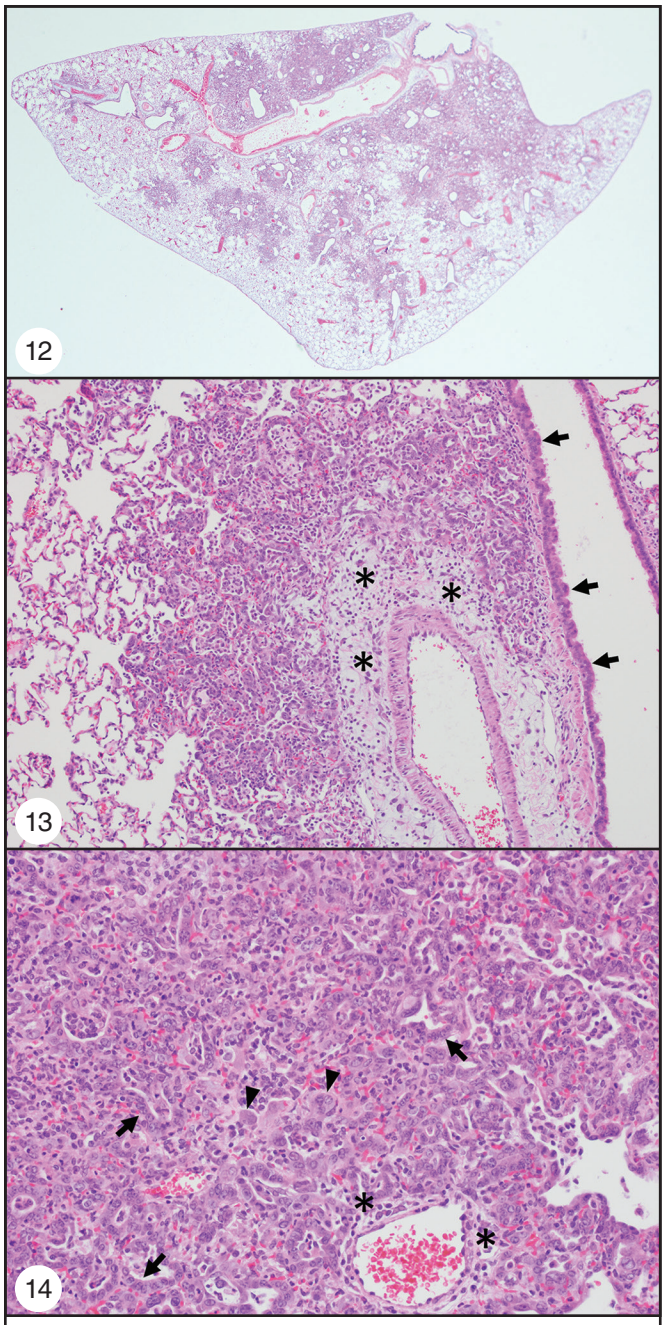
Lung inflammation was the most common finding in guinea pigs' lower respiratory tract, affecting nearly 80% of animals. The inflammation was located within the alveolar lumen, alveolar septa, or blood vessels. Inflammation consisted of macrophages and heterophils with fewer lymphocytes and plasma cells. Rare multinucleated cells were present in a few animals. Necrosis was not observed in the lungs.

Other less common findings included granulomatous foreign body reaction to aspirated food material (35%), congestion, and inflammatory infiltrate in a few animals. Other tissues examined including kidney, trachea, tracheobronchial lymph node, mesenteric lymph node, large intestine, and olfactory bulb, had no significant findings. There was no IHC signal observed in any of the tested tissues in guinea pigs.

Hamsters

At 3 days post infection (dpi), the predominant histopathologic lesion of hamsters intranasally challenged with 1×10^5 pfu of SARS-CoV-2 were multifocal to coalescing, heterophilic and histiocytic foci of bronchointerstitial pneumonia with extension into alveolar lumina. Areas of inflammation also included variable amounts of hemorrhage, edema, fibrin, and cellular debris. Bronchiolar lumina were multifocally filled with degenerate inflammatory cells and necrotic cellular debris. Multifocally, bronchiolar epithelial cells were vacuolated and shrunken. Perivascular connective tissue was expanded by edema with inflammatory cell aggregates with transmigration of vessel walls.

At 7 dpi, the predominant histopathologic lesion of hamsters challenged via the same route and dose mentioned above included a spectrum of changes with multifocal consolidation, multifocal to coalescing aggregates of heterophilic and histiocytic inflammation, and type II pneumocyte hyperplasia (Figures 12-14). Less frequently interspersed in areas of inflammation were multinucleate cells, hemorrhage, edema, and cellular debris. Perivascular connective tissue was



Figures 12-14. SARS-CoV-2 infection, hamster, day 7 post infection.
Figure 12. Lung, hamster. There are multifocal areas of hypercellularity within the section. Hematoxylin and eosin.
Figure 13. Higher magnification of image 12. There is expansion of the alveolar septa and spaces with heterophilic and histiocytic inflammation. There is marked perivascular inflammation and edema (asterisks). Bronchiolar epithelial cells are mild hyperplastic (arrows). Hematoxylin and eosin.
Figure 14. Higher magnification of image 13. There is marked expansion of the alveolar septa and spaces with heterophilic and histiocytic inflammation, cellular debris and few multinucleate cells (arrowheads). Septa are variably lined by type II pneumocytes (arrows). There is mild perivascular inflammation and edema (asterisks). Hematoxylin and eosin.

multifocally expanded by edema and previously mentioned inflammatory cells. Bronchiolar epithelial cells were hyperplastic, with 4-5 layers of epithelial cells admixed with rare mitotic figures. The pleura at 7 dpi was variably thickened and lined by hypertrophic mesothelial cells, and less frequently, there were dense, narrow bands of fibrous connective tissue replacing the pleura.

Nasal cavity lesions of hamsters at 7 dpi included multifocal olfactory epithelial necrosis with erosion and ulceration of the mucosa. Less frequently, mitotic figures were scattered throughout the olfactory epithelium. Heterophils, macrophages, and/or lymphocytes infiltrated the olfactory submucosa and frequently surrounded the submucosal glands (Steno glands). The nasal cavity lumina were partially occluded by varying degrees of viable and degenerate inflammatory cells admixed with cellular debris and sloughed olfactory epithelium. The olfactory submucosa was frequently elevated and expanded by edema.

Positive in situ hybridization (ISH) labeling was commonly noted within areas of inflammation and less frequently in bronchiole epithelium within the lung at both 3 and 7 dpi. Within the nasal cavity, positive ISH labeling was most common in inflammatory cells and cellular debris within the lumen followed by olfactory epithelium and inflammatory cells scattered throughout the submucosa.

Mice

The pathology findings in the lung of the mice strains listed above were few, with most findings being minimal in degree and potentially unrelated to viral infection. Bronchiolar associated lymphoid tissue (BALT) hyperplasia was present in three of five C3H/HeJ mice, two day-3 mice, one day-28 mouse, and one day-3 A/J mice. This relatively nonspecific response to antigenic stimulation may be related to viral infection, but it was only minimal to mild in these mice. A single Day-28 MyD88KO mouse had a focal area of pyogranulomatous alveolar inflammation. Given the type of inflammation, it is less likely to be virus-related and may be secondary to another cause, such as aspirated foreign material from the gastrointestinal tract. Three animals, one Day-28 RAG2 and two Day-28 MyD88KO mice, had a perivascular infiltrate composed of mononuclear cells. Like the BALT hyperplasia, this may be due to antigenic stimulation associated with viral infection; however, it was a very uncommon finding and of a minimal degree in all cases. A single Day-3 BALB/c mouse had a multifocal infiltrate composed of predominantly mononuclear cells and fewer neutrophils in interstitial areas adjacent to vessels and bronchioles. This infiltrate may be related to the viral infection but was minimal in severity, or it may be secondary to another cause of antigenic stimulation, given that it was only found in a single animal. Another animal, a Day-3 RAG2, had a focal area of neutrophilic infiltration into the alveolar lumen, but again, the severity is minimal and may not be precisely related to viral

infection. In summary, there were no significant pathological lesions identified in the lung suggestive of moderate or severe viral infection. Virus was not identified by ISH in the lung of any animals, which also suggests the above-listed findings may not be due to viral infection. Ultrastructural examination of the lungs from the A-J, BALB-c, C3H-HeJ, C57BL/6, RAG2, and MYD88KO did not demonstrate any ultrastructural changes or viral particles.

Like the pattern in the lung, changes in the nasal turbinates were few, and the majority were minimal and potentially unrelated to viral infection. There were few animals with minimal degeneration of olfactory epithelium, including two Day-3 C3H/HeJ and two Day-3 RAG2 mice. However, virus was not identified in any of these areas by ISH, and in fact, virus was not identified by ISH in the nasal turbinates of any animals. No significant pathological lesions were identified in the brain of any of the mouse models, and virus was not identified by ISH in the brain of any animals. In summary, these findings indicate these mouse strains are not permissive to viral infection with SARS-CoV-2.

Discussion

The essential need to identify and develop animal models to study infectious diseases is paramount. This need was intensely tested during the SAR-CoV-2 pandemic. Animal model development includes natural history studies, pathogenesis, and follow-through with preventive to therapeutic testing. Pathologic lesions are key to determining the best animal models through this process. One method to validate the process and models is the pathologic comparison with human cases completed here. The pathologic lesions in each species set the scope of this review and comparison.

In humans, early data showed the median incubation period was estimated at five days, and 97.5% of patients developed symptoms within 11.5 days of infection with SARS-CoV-2.[29-30] Manifestations of COVID-19 range from asymptomatic carriers to fulminant disease. The most common symptoms are fever, dry cough, and shortness of breath. Other relatively common symptoms include fatigue, myalgia, nausea, vomiting, diarrhea, headache, and weakness. Anosmia or ageusia may be the sole presenting symptom.[31] The molecular diagnosis is typically made using real-time RT-PCR via a nasopharyngeal swab. On admission, lymphocytopenia, thrombocytopenia, leukopenia, and elevated levels of C-reactive protein are commonly seen. Less common laboratory abnormalities include elevated AST, ALT, and D-dimer. The most common features of chest CT were ground-glass opacity and patchy bilateral shadowing.[29,32] Risk factors associated with mortality with COVID-19 patients include older age, male sex, the high fraction of inspired oxygen and high positive end-expiratory pressure on ICU admission, history of cardiovascular disease, chronic obstructive pulmonary diseases, hypercholesterolemia, type 2 diabetes, and hypertension.[33-35]

None of the species reviewed here succumbed to SARS-CoV-2 infection by the three routes of exposure (intranasal, intratracheal, or small particle aerosolization). However, several animals did show clinical signs of disease that were predominantly transient and commonly associated with viral respiratory diseases (respiratory rate, fever, fatigue, etc.) and, rarely, ill thrift. In the nonhuman primate species we studied, some animals exhibited clinical pathology findings similar to those reported in humans (thrombocytopenia, elevated liver enzymes, and lymphopenia).[28] While there may be some similarities with COVID-19 in humans (eg, no clinical disease to mild disease manifestations), none of the species evaluated here exhibited the severe clinical disease and fatal outcomes that occur in humans.

Macroscopic findings of major organ systems in COVID-19 patients that were mainly obtained from autopsy studies are limited.[36] In the lung, common findings include increased lung weight, diffusely congested and edematous parenchyma, hemorrhagic changes, and pulmonary emboli. Macroscopic findings identified in other organ systems, including the cardiovascular, central nervous, hepatobiliary, gastrointestinal, and renal systems, are limited and nonspecific.

The most common pathologic lesion identified at necropsy were red mottled lungs in the NHPs in the AGMs and CMs only. There were no other significant gross lesions in the NHPs. No significant gross lesions were recorded for the mice, hamsters, ferrets, and guinea pigs. While the red mottling we observed in the AGMs and CMs may correspond to the congestion described in the autopsy cases described above, the remaining lung findings were not observed in any species we evaluated. Gross lesions outside the respiratory tract were limited in human autopsy cases, and this was true of the five species we evaluated.

Microscopically, like macroscopic findings that are mainly identified in the lung, changes in the pulmonary system are the most significant, but they are not specific in humans.[36-39] In the lung, major microscopic findings in acute and organizing phases include diffuse alveolar damage (DAD), acute fibrinous and organizing pneumonia, desquamation of pneumocytes, proteinaceous exudate, vascular congestion, patchy acute alveolar hemorrhage, pleural edema, dilation of lymphatics, and fibrin thrombi in the alveolar wall. In addition, interstitial fibrosis is a significant finding in the fibrotic phase. Reported microscopic findings in other organ systems are limited and nonspecific. At the Joint Pathology Center, we received 18 partial autopsy cases, and the primary microscopic findings were consistent with findings published in the literature.

Histologically, the lesions in all the species we studied were identified along the respiratory tract, including both the upper and lower tracts and regional lymph nodes. Lung lesions were minimal to mild, with predominant inflammation

composed of low numbers of lymphocytes, plasma cells, and macrophages, with inconsistent low numbers of neutrophils in NHPs. In guinea pigs, mice, and ferrets, the inflammation was more of a mixture of inflammatory cell types with similar locations in the lung. The inflammation was most common in the respiratory interstitium and perivascular in alveolar areas, sometimes extending up and around bronchioles. Hamsters had a more distinct pattern of bronchiolar epithelial hyperplasia. Multinucleated giant cells described in human cases were identified inconsistently in each species.

Lesions in the upper respiratory tract were identified in the nasal cavities (turbinates) in each species. Nasal turbinate lesions included previously described inflammatory components with epithelial degeneration and vacuolation with swelling in hamsters that caused partial occlusion of the nasal passages. Ferrets had the least significant lesions of the nasal passages compared to others. RMs were the least affected of the three NHPs. How these findings compare to humans infected with SARS-CoV-2 virus is not known, as a literature search produced no information on lesions in the nasal passages in humans.

A good animal model mimics the anatomy and physiology, immune system response, host-pathogen response, and pathologic findings of a disease or condition in humans. In our studies, CMs that were exposed to SARS-CoV-2 by IT/IN exposure appeared to most closely follow the microscopic findings of alveolar damage and inflammation in our experiments compared to the reported findings in humans. Nonhuman primates are good laboratory animal models for various infectious respiratory diseases, including tuberculosis, influenza, respiratory syncytial virus, and SARS/MERS, among others, based on their similar anatomic structure, immune system, and host-pathogen responses.[40] Smaller, less expensive species that are easier to handle, such as hamsters and other rodents, may still be viable models to study aspects of the SARS-CoV-2 virus. Although they share some similarities with lung lesions found in NHPs, rodents' respiratory anatomy and immune systems differ from humans far more than NHPs.

None of the species in our studies exhibited the moderate to severe clinical disease observed in some humans. This may be due to several reasons, including the lack of underlying comorbidities in the five species examined versus the presence of previously discussed conditions and diseases in humans and the influence of these comorbidities on disease severity. Differences in anatomy, physiology, host-pathogen response, and immune systems between study species and humans is another possible reason for the lack of moderate to severe clinical disease. None of our experiments utilized immunosuppressed or transgenic animals. Studies using these types of animals have shown great promise in furthering our understanding of the pathophysiology of SARS-CoV-2.

Conclusions

These experiments conducted on five species have added to our understanding of the disease and associated lesions after exposure to SARS-CoV-2 virus. While some of the findings are similar to those seen in humans, especially in CMs, there is a need for additional investigation and refinement in potential animal models to more thoroughly investigate SARS-CoV-2.

Acknowledgments

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Animal Welfare

Research was conducted under animal use protocols approved by the USAMRIID Institutional Animal Care and Use Committee (IACUC) in compliance with the Animal Welfare Act, PHS Policy, and other federal statutes and regulations relating to animals and experiments involving animals. The facility where this research was conducted is accredited by the Association for Assessment and Accreditation of Laboratory Animal Care International (AAALACI) and adheres to principles stated in the Guide for the Care and Use of Laboratory Animals, National Research Council, 2011.

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Canine Audiology: Noise Surveys and Distortion Product Otoacoustic Testing in Kenneled Canines

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Abstract

Military Working Dogs (MWD) are placed in high levels of noise inside and outside their work activities. These hazardous noise levels have the potential to have adverse effects on the dog's auditory system. This study aimed to measure the typical kennel noise levels over a 24-hour period and conduct audiological testing on the MWDs. Most audiological testing is normed on humans but there is a need for canine norms. This study used four different distortion product otoacoustic emissions (DPOAE) protocols on 36 MWDs. The protocols varied in L_1/L_2 intensity levels at L_1=65dB, L_2=65dB ($DP_{65/65}$), L_1=65dB, L_2=55dB ($DP_{65/55}$), L_1=55dB, L_2=55dB ($DP_{55/55}$), and L_1=55dB, L_2=45dB ($DP_{55/45}$). Descriptive statistics and one-way ANOVAs were used for analysis. Kennel noise exceeded the DoD hearing conservation program action level of 85 decibels A-weighting for humans. DPOAE testing showed that the largest amplitude responses came from the $DP_{65/55}$ protocols. This is seen similarly in human DPOAE testing. $DP_{65/55}$ reports a twofold advantage of producing higher DPOAE amplitudes with an improved sensitivity to cochlear mechanics. Optimal testing parameters allows veterinarians and audiologists to understanding the status of an MWD's auditory system and support in providing feedback regarding hearing abilities or hearing loss.

Keywords: Military working dogs, kennel noise, DPOAE, noise exposure

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Introduction

Military working dogs (MWD) are placed in high levels of noise, both inside and outside their work activities[1]. Noise exposure can be in the form of small arms, aircraft, or kennels, to name a few. These activities are known to have an adverse effect on the dog's auditory system[3-6], just as they do on a human. Normal hearing is important for MWDs as it enables them to extract auditory cues from the environment and take verbal commands from their handlers in order to execute trained tasks. The status of a canine's auditory system can be assessed through audiological tests, which are normed on humans, but assess the same anatomy in a canine[7]. Determining optimal audiological protocols can help standardize audiological assessments for use in a canine. Information about kennel noise levels can support the use of prevention efforts (e.g., use of hearing protection devices, noise mitigation) or increased monitoring of hearing levels (e.g., repeated audiological assessments).

Kennel noise is the type of noise exposure most frequently investigated in studies involving dogs[4,5,8]. Kennels are designed for ease of cleaning and sanitation with little consideration for noise mitigation. Commonly used construction materials, such as concrete block and metal roofing, tend to exacerbate noise levels[4]. Several studies have measured peak kennel noise above 100 dBA[4,5,8,9], equivalent in noise levels to a chain saw, impact wrench, or bulldozer[10]. Factors that contribute to higher noise levels in kennels include the number of dogs housed in a single location[8], indoor vs. outdoor kennel locations, barking, and the presence of people or other stimuli[5,8]. Most exposure levels recorded from kennel noise would necessitate enrollment of humans into a hearing conservation program[11,12]. However, no regulatory guidance or permissible exposure level currently exists for canines.

Noise-induced hearing loss (NIHL) in dogs has been frequently documented in the literature.[3,4,6,13,14] Scheifele, Martin, Clark, Kemper, and Wells determined that kennel noise exposure over 3 months contributed to decreased auditory sensitivity via brainstem auditory evoked responses (BAER). Venn [5] found that kenneled dogs had reduced auditory function in as little as 4 weeks via distortion product otoacoustic emissions (DPOAE). Other noise exposures

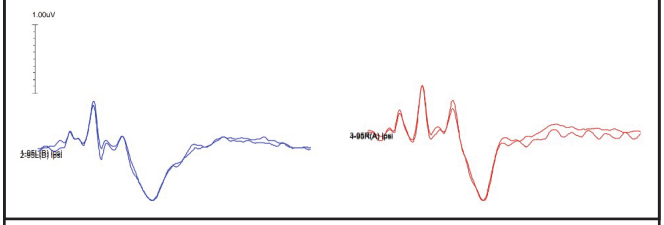

Figure 1. Representative tracing of a BAER waveform from an anesthetized dog.

List of Acronyms

MWD: Military Working Dog
SPL: Sound Pressure Level
DPOAE: Distortion Product Otoacoustic Emissions
DP: Distortion Product
dB-A: decibel A-weighted
BAER: Brainstem Auditory Evoked Response
NIHL: Noise Induced Hearing Loss
OAE: Otoacoustic Emissions
OHC: Outer Hair Cells
LAeq: Equivalent Continuous Sound Level
LAMax: Level A-weighted maximum decibel peak
dB pe SPL: decibel peak equivalent Sound Pressure Level
nHL: normalized Hearing Level
dB SPL: decibel Sound Pressure Level
OSHA: Occupational Safety and Health Administration
DoD: Department of Defense
SNR: signal to noise ratio

such as firearms[14], helicopters[3], magnetic resonance imaging (MRI)[15], and explosions[6] have resulted in immediate changes in BAER or DPOAE responses. There are limitations in some of the previously mentioned studies such as small sample sizes with low statistical power, no inferential statistics, or lack of peer review.

Several audiological assessments can be performed on dogs. The current gold standard is the BAER [7,16]. The BAER is a noninvasive test that records neuronal responses from cranial nerve VIII (vestibular-cochlear) and the ascending auditory brainstem nuclei[2]. Using an electroencephalogram (EEG), the summation of electrical potentials resulting from the auditory stimuli is recorded and measured[2,17]. A single channel electrode montage records an active electrode on the dog's test ear compared to a referenced electrode located on the dog's forehead or dorsal neck. The ground electrode is placed on the nontest ear. Auditory stimuli are presented through an insert earphone.

BAER tracings are characterized by 5 to 7 waves and typically labeled with roman numerals. See figure 1 for an example of a BAER tracing. These wave amplitudes and latencies provide insight into the ascending auditory pathways and can be used to estimate hearing threshold and other auditory pathology [2,7,17-19]. In animal and human models of NIHL, the higher frequencies are affected first [20-22], resulting in sloping configurations. The typical broadband click stimulus used in BAER testing makes it challenging to isolate frequency specific information and difficult to determine hearing loss configurations. BAER testing with tone burst stimuli is an option to determine hearing loss configuration, but it is time intensive and often requires sedation of the dog. Therefore, the use of additional audiological assessments is helpful to gather more details about the auditory status of a dog.

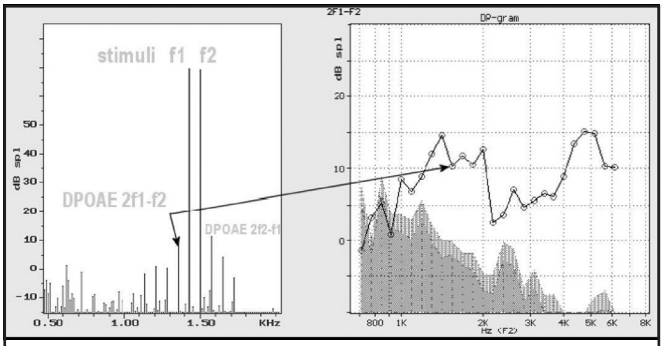

Figure 2. Left side represents stimuli input with f1, f2, and DPOAE 2f1-f2 output. Right side is DP-gram output. Amplitude (dB SPL) of DPOAE on the y-axis and frequency (Hz, KHz) on the X-axis. The DPOAE responses are displayed on the graph. The dark area represents noise floor. Reprinted with permission.[23]

DPOAE is another non-invasive audiological test that is routinely used in humans to assess cochlear function via the outer hair cells (OHC). In screening tests, the absence or presence of DPOAE gives information about the integrity of the cochlea, specifically the OHC, in addition to frequency specific information [23]. The OHC are arranged in the cochlea tonotopically, meaning high frequencies are situated at the basal end or entrance of the cochlea, and low frequencies are located at the apical end[24]. DPOAE testing is conducted by emitting two tones, often denoted as frequency$_1$/frequency$_2$ (f_1/f_2), into the ear canal which then travel through the middle ear system to the cochlea. Through the nonlinear properties of the cochlea a third tone, the DPOAE most commonly measured as 2f1-f2, is generated. The DPOAE provides frequency specific information as it assesses the OHCs along the cochlea. The 2f1-f2 response is thought to be arithmetically related to the f_1/f_2 inputs [24]. The DPOAE response is detected with a sensitive microphone placed in the ear canal. This measurement is completed for a series of frequency pairs (f_1/f_2). The measured 2f1-f2 DP response is often displayed as a DP-gram. See figure 3 for a DP-gram. Detailed analysis of these responses includes absolute amplitude or signal to noise ratio.

The clinical utility of DPOAEs in humans is well-established, and various levels of success have been seen in canines[5,25-29]. DPOAEs have been successfully used to screen puppies for congenital hearing loss[30], identify age related hearing loss[29], monitor ototoxicity[27], and demonstrate NIHL[5]. However, there is no standardized stimulus or recording parameters for DPOAEs in canines currently agreed upon in the audiological or veterinary communities. The variation in stimulus and recording parameters used to elicit DPOAE highlights the need to determine optimal DPOAE stimulus parameters across all its applications[31]. One variation in DPOAE stimulus parameters is the input level used for the f_1/f_2 primaries. These can be equal, level 1 (L_1) =level 2 (L_2) or varied, with the most common being L_1-L_2=10. Current literature states that the higher the L_1/L_2 the larger the DPOAE response from the mammalian cochlea [31,32]. Determining optimal DPOAE stimulus parameters in canines will help support future research on the canine's auditory system.

There are two aims to this study. The first is to measure the amount of noise an MWD is exposed to during a 24-hour kenneling. The second is to examine the DPOAE response from four different DPOAE testing protocols in kenneled canines.

Participants

Dogs were procured outside the continental United States as a group purchased for the purposes of being potential MWD. Exact history prior to their arrival at 341st Training Squadron Kennels (TRS) on Joint Base San Antonio (JBSA)- Lackland is unknown. All dogs were estimated to be older than 1 year of age, but younger than 3 years of age. All dogs arrived at the facility on October 20, 2020. Dogs were quarantined for 13 days in a quarantine kennel located on (JBSA)-Lackland Chapman Training Annex and then moved to kennels located on JBSA-Lackland, in San Antonio, Texas.

Research was conducted in compliance with the Animal Welfare Act, the Animal Welfare Regulations, and the principles of the Guide for the Care and Use of Laboratory Animals, National Research Council. The LTC Daniel E. Holland Memorial Military Working Dog Hospital's Institutional Animal Care and Use Committee approved all research conducted in this study on 21 September 2020. The facility where this research was conducted is fully accredited by Association for Assessment and Accreditation of Laboratory Animal Care International (AAALAC International).

Methods

Noise Measurements. Kennel noise assessments were completed previously at the 341st TRS kennels located on JBSA-Lackland in May 2019[9]. Repeat noise measurements were taken as part of this study following the same protocol, but the duration of measurement was extended from 12 hours to 24 hours. A Bruel & Kjaer 2270 sound level meter was used to conduct the noise surveys in dB A using equivalent continuous sound level (LAeq), or the average sound energy over time. Measurements were taken on slow, A-weighted, for a continuous 24-hour period. Meters were placed above the dogs' runs in the center of the kennel. The meter was placed in the morning and retrieved the following day after a 24-hour period. In addition to long term averages (LAeq), peak noise levels were also recorded (LAMax). Noise data were downloaded, and the sound level meter was reset and placed in another kennel.

Screening BAER. To determine if the dogs met inclusion criteria for the study, all dogs were administered a click BAER presented at 95 dB peak SPL (pe SPL) as a screening prior to DPOAE testing. BAER were performed using the Intelligent Hearing Systems (IHS, Miami, FL). BAER recording parameters used were a 100-µsec broadband rarefaction click stimulus at a rate of 33.1 clicks per sec with filter settings at 100 to 1500 Hz. The stimulus was delivered separately to the dog's left and right ears via an insert EAR3. Inclusion into the study required identifiable waves I, III, and V of the BAER for any ear. The 95 dB pe SPL BAER screening was completed to ensure auditory sensitivity in CNVIII and the ascending auditory nuclei of the brainstem prior to DPOAE testing. Once an intact CNVIII was established, DPOAEs were administered.

DPOAE Testing. DPOAE protocols consisted of 13 frequency pairs (f1<f2) with f1 ranging from 905Hz to 7243Hz. The f1/f2 frequency ratio was fixed for all runs at 1.2. The four protocols had varying L_1 and L_2 intensity levels, namely L_1=65dB, L_2=65dB ($DP_{65/65}$), L_1=65dB, L_2=55dB ($DP_{65/55}$), L_1=55dB, L_2=55dB ($DP_{55/55}$), and L_1=55dB, L_2=45dB ($DP_{55/45}$). These protocols were scripted in the IHS equipment and order of testing for all dogs was $DP_{65/65}$, $DP_{55/45}$, $DP_{55/55}$, $DP_{65/55}$. One run was completed for all protocols on each test ear.

Auditory testing took place in the LTC Daniel E. Holland Memorial MWD Hospital operating rooms between December 7- 18, 2020. All auditory testing was performed while dogs were under general anesthesia for previously scheduled routine surgery with supervision from the surgical veterinarian. All auditory testing was completed by the first author.

Participants

Thirty-six (36) dogs were eligible for participation in the study. Breeds were 55% (n=20) German Shepherd, 45% (n=15) Belgian Malinois, and one Dutch Shepherd. Seventy-five percent (75%) were male and 25% (n=9) were females. A total of 71 ears were tested, bilateral testing completed for 35 dogs and unilateral testing for one dog due to equipment issues. All 71 ears passed a BAER screening at 95 dB pe SLP with waves I, III, and V identified. This suggests overall hearing sensitivity was adequate for DPOAE testing.

Analysis

Descriptive statistics and one-way analysis of variance (ANOVA) were used for analysis. Any significant findings were subject to post-hoc pairwise comparisons. All analyses

Figure 3. a) Outdoor view of kennel with wind shields raised. b) View inside kennel.

were performed using R studio version 1.3.1093. Absolute DPOAEs amplitudes (dB SLP) were used as the response variable for all ANOVAs. Categorical independent variables were DPOAE protocols and frequency. To be included for analysis, DPOAEs had to be above the noise floor, as a DPOAE amplitude below the noise floor cannot be accurately measured[24]. In an effort to control for excessive noise, the mean noise floor was calculated for each frequency. Any data point with a noise floor that exceeded 1SD above the mean noise floor was excluded from analysis.

Results

Noise Measurements

Sound level measurements were completed at 6 kennels. Kennels were identical in terms of size and material composition. Dimensions were 150ft by 34ft. Primary construction materials were concrete, chain link fence, and metal pieces located on both the individual cages and the roof. The kennels were classified as outdoor and were semi-open as their outer walls consisted of chain linked fencing that lined the perimeter of the kennel length. Plastic wind shields were attached to the outer wall and are raised or lowered depending on the weather. For this assessment the plastic wind shields were raised. Total kennel capacity was 50 dogs, 25 individual kennel runs on each side. No kennel was filled to capacity. See figure 3 for kennel pictures. The number of dogs can impact the noise levels[8] and therefore were counted at the time the sound level meter was placed. However, the number of dogs present in the kennel can fluctuate due to different training cycles, dogs in hospital or recovery kennels, or daily operations involved in the movement of dogs.

Table 1. Kennel demographics and noise survey results.

Kennel Name	Dogs in kennel	LAeq (dB A) 24 hours	LAMax (dB A) 24 hours
O	36	96.5	133.8
J	32	97.4	135.3
G	21	98.0	132.1
K	31	99.1	138.5
M	32	101.5	136.5
L	34	102.2	137.1

Note. LAeq = Equivalent Continuous Sound Level; dB A = decibel A weighting; LAMax= Level A-weighted maximum decibel peak

The kennel LAeq ranged from 96.5 to 102.2 dB A. The LA-Max peaks measured from 132.1 to 138.5 dB A. Refer to table 1 for kennel demographics and noise survey summaries. Previous 12-hour noise measurements were taken in May 2019 on kennels A, O, and N with measured LAeq of 114.0, 106.2, and 104.6 LAeq respectively. The most recent measurements taken in December 2020 were slightly lower overall, but all kennels exceeded a long-term average of 96 dB A. More than half (n=21, 58%) of the dogs that received audiological assessments in this study were maintained in kennel M (LAeq = 101.5 dB A).

Distortion Product Otoacoustic Emissions

All 71 ears were tested with the 4 DPOAE protocols. Any DPOAE amplitude below the noise floor was eliminated from the data set. The two lowest frequencies accounted for much of the data lost. This is not unexpected as lower frequencies are impacted by the noise floor more so than higher frequencies[24]. The higher frequencies, 2001Hz and above, retained at a minimum 85% of the data and as high as 96%.

Overall, the absolute DPOAE amplitudes were largest in the $DP_{65/65}$ and $DP_{65/55}$ protocols at 14.4- and 14.3-dB SPL. The smallest amplitude was in protocol $DP_{55/55}$ at 9 dB SPL. See figure 4 for side-by-side comparisons of mean DPAOE amplitudes for each protocol. The absolute DPOAE amplitudes were not normally distributed over the four protocols as assessed by Shapiro-Wilk's test ($p < 0.05$), and therefore a Kruskal-Wallis One Way ANOVA on Ranks was performed. This was significant at a level of <0.001 and post hoc dunn test pairwise comparison tests were performed. While there was no difference between protocols $DP_{65/65}$ and $DP_{65/55}$, all other protocols amplitudes differed statically ($p<0.001$) The largest difference existed between protocol $DP_{55/55}$ and protocols

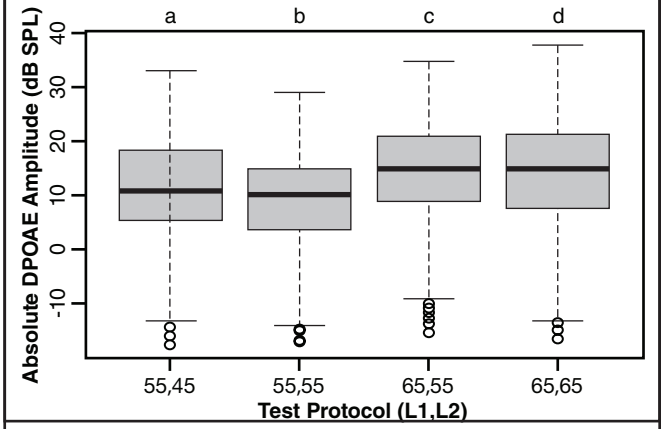

Figure 4. Mean DPOAE amplitudes of the four test protocols. For all protocols with the same letter, the difference between the means is not statistically significant. If two variables have different letters, they are significantly different ($p<0.05$)

$DP_{65/65}$/$DP_{65/55}$. The DPOAE amplitudes in protocol $DP_{65/65}$ and $DP_{65/55}$ were always larger when compared to the values in protocol $DP_{55/55}$ or $DP_{55/45}$.

ANOVAs were performed within each individual frequency with 11 of 13 frequencies showing significant differences while two frequencies, 705Hz (p=0.148) and 1002Hz (p=0.172), did not reach a level of significance. Below 2000Hz protocols $DP_{65/65}$ and $DP_{65/55}$ remained similar; however, once above 3365Hz the $DP_{65/55}$ produced the largest amplitudes (p<0.001). All protocols above 3365Hz differed statistically, with $DP_{65/55}$ producing the most robust responses and $DP_{55/55}$ producing the smallest responses. See figure 5 for a graphic representation of the DPOAE amplitudes by frequency organized into protocols. Generally, when comparing higher frequencies (>2800Hz) to lower frequencies (<1000Hz) a difference in amplitudes exists, with higher frequencies producing higher amplitudes specifically for the unequal protocols $DP_{65/55}$ (p=0.001) and $DP_{55/45}$ (p=0.001). This is visually shown in figure 5, as $DP_{65/55}$ and $DP_{55/45}$ represented have the same rising configuration across the frequency spectrum (figure 5b). $DP_{65/65}$ and $DP_{55/55}$ remain relatively flat across the frequency spectrum (Figure 5a).

Discussion

Noise Exposure. One aim of this study was to characterize and compare noise exposure levels for kenneled canines. Kennel noise is intermittent; therefore, the continuous permissible exposure level was below federal guidelines, but noise levels in the kennels exceeded the action levels for the Occupational Safety and Health Administration (OSHA) and Department of Defense (DoD) Instruction 6055.12, Hearing Conservation Program of 85 dB A[11,12]. The kennel with the lowest sound output was recorded at a LAeq of 96.5 dB A with peak levels at 133.8 dB A. The peak or LAMax of 133.8 dBA would limit the time in the noise to less than one second for humans as auditory damage can occur at these levels [33]. As seen in Table 1, of the other 5 kennels measured, 4 of them had LAMax levels above 133.8 dB A. Although an LAeq of 96.5 dBA is not continuous exposure as it averages the exposure over the 24-hour period it does provide insight into the enormous amount of sound being produced.

These noise levels are consistent with previous literature regarding kennel noise. Scheifele et al[4] found kennel noise levels at 100 to 108 LAeq. Venn[5] found that outdoor kennels

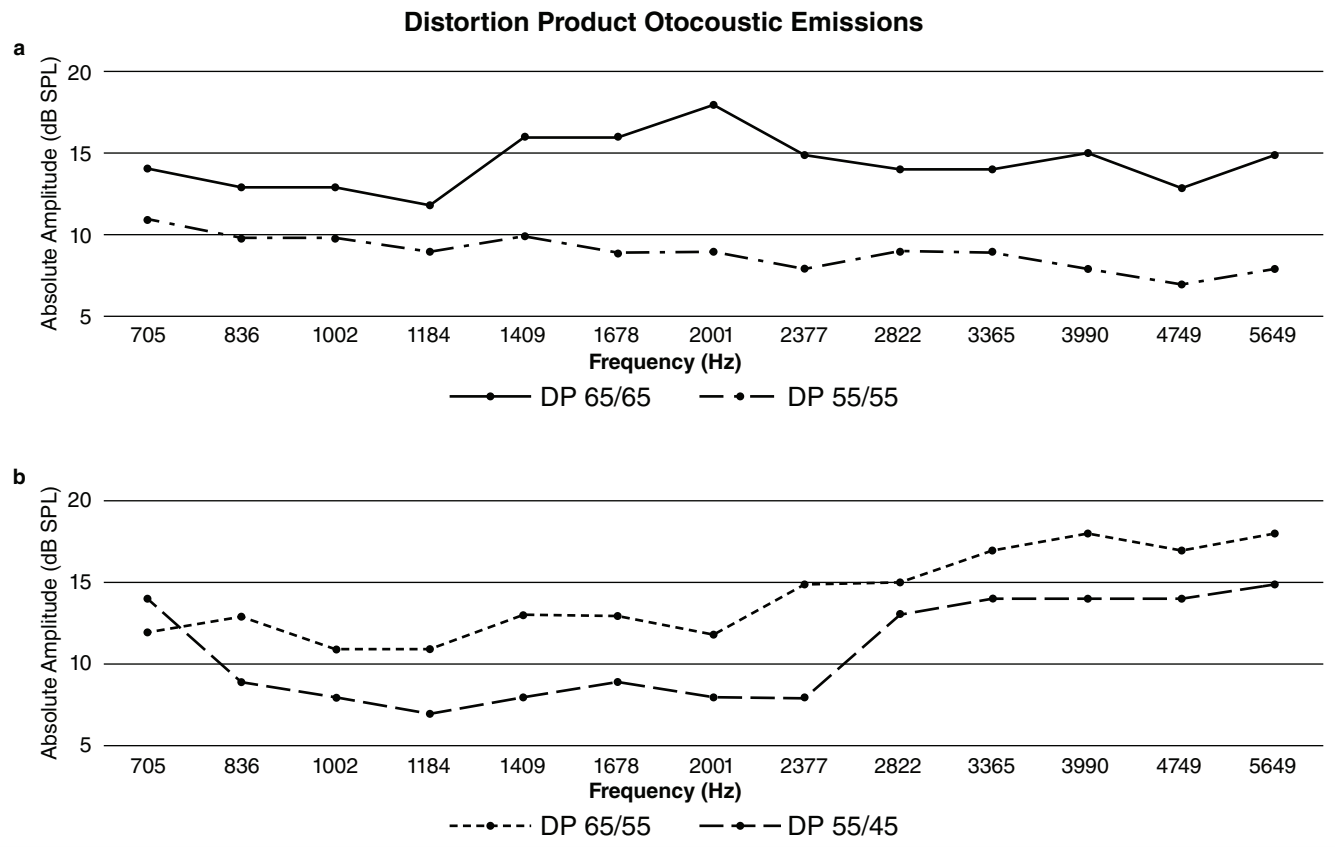

Figure 5. Mean DPOAE amplitudes for each protocol plotted by frequency. The average noise floors for all frequencies were below the DPOAE average response and therefore not depicted on this graph. Top of figure 5 is the equal level protocols $DP_{65/65}$ and $DP_{55/55}$. Bottom of figure 5 shows unequal protocols $DP_{65/55}$ and $DP_{65/55}$.

were often quieter than indoor kennels. Indoor kennels ranged from 91 to 101 dB LAeq and outdoor kennels from 73 to 91 dB LAeq; maximum levels recorded were 109- and 93-dB dBA, respectively. Coppola et al [8] found that larger areas with more animals exceeded 100 dBA more often when compared to smaller areas. Although the duration of this noise assessment was limited to a single day it was similar to the assessments conducted in 2019 by Scheifele[9]. There is research to suggest that prolonged exposure to noise can have a deleterious effect on the canine's auditory system [4,5,15]. Lauer, El-Sharkawy [34] were able to demonstrate mathematically how excessive noise levels have the potential to impact hearing sensitivity in research and companion animals, including dogs. Scheifele, Martin [4] demonstrated that kennel noise reduced BAER responses in dogs in as little as 4 weeks. Venn [5] showed that kennel noise also had an adverse effect on cochlear function through DPOAEs testing. These studies suggest that excessive kennel noise can have an adverse effect on the canine auditory system.

Kennels are designed to be durable and easily cleaned with little to no noise mitigation considerations[8]. There is a need to develop noise mitigation efforts for our dog kennels to reduce these exposure levels. This includes architectural and structural redesign, use of sound dampening materials, or even decreasing the overall number of dogs housed in kennels to reduce noise levels. This could benefit both the dogs and the humans who frequently interact in the kennels.

A second aim of this study was to examine different stimulus parameters used to elicit DPOAEs in dogs. The protocol stimulus levels L_1/L_2 had an impact on the size of the DPOAE amplitudes. The greater the stimulus intensity level the larger the return OAE responses. Overall, the largest absolute DPOAE amplitude responses came from the $DP_{65/65}$ or $DP_{65/55}$ protocols, with $DP_{65/55}$ ultimately producing the highest responses in the higher frequencies. This is consistent with the way human DPOAE responses react [24,35]. Energy is lost as the L_1/L_2 stimuli are propagated through the middle ear system to the OHC of the cochlea. Then the DPOAE response (2f1-f2) from the OHCs is reverse propagated back through the entire system to the probe in the ear canal measuring the output. The larger the original input the more energy that can return and therefore be measured. In a healthy human auditory system, a 65 dB SPL input will consistently produce a larger output than a 55 dB SLP input[24]. These results were seen in this study. In every instance the $DP_{65/65}$ produced a larger OAE response than the $DP_{55/55}$. Similarly, the protocol $DP_{65/55}$ produced a larger OAE response than the $DP_{55/45}$ protocol.

For this study as the frequencies increased the overall amplitude of the DPOAE increased, but only for inputs where L_1-L_2=10. When the protocol levels were equal, L_1=L_2, as in $DP_{65/65}$ and $DP_{55/55}$ the DPOAE amplitudes were flat across the frequency spectrum (p = 0.1724 and 0.9481). Refer to Figure 5. When the input levels were unequal, L_1-L_2=10, as in protocols $DP_{65/55}$ and $DP_{55/45,}$ the DPOAE amplitudes increased in response to increasing frequency ($p < 0.001$), refer to Figure 5. This increased DPOAE amplitude has been documented in both human and animal studies[36]. Due to the combination of the psychoacoustic properties of the f_1/f_2 tones and acoustic nonlinearities of the cochlea, a L_2 that is 5 to 10 dB lower than L_1 produces the largest geometric mean at the $2f_1$-f_2 location on the cochlea and therefore the DPOAE response[24]. The DPOAE stimulus parameter with L_1 - L_2 =10 resulted in larger DPOAE responses, specifically in the higher frequencies when compared to the L_1=L_2 DPOAE parameters. This could prove more important in a dog as they have greater high frequency sensitivity when compared to a human[37,38]. $DP_{65/55}$ is the screening stimulus level inputs for human DPOAE testing for its reported twofold advantage of producing higher DPOAE amplitude levels with an improved sensitivity of cochlear mechanics.

Previous DPOAE testing in dogs demonstrate similar findings. Robert K Rogers [39] examined the presence or absence of DPOAEs in dogs. Responses were more prevalent for stimulus levels 75/75 dB SPL when compared to 55/55 dB SPL. However, clinicians no longer recommend testing at levels greater than 70 dB SPL because of the increased risk for causing artifact and not eliciting the DPOAE response [24]. Sockalingam, Filippich [40] measured signal-to-noise ratio (SNR) in canine DPOAEs and similarly found that increased stimulus levels produced larger DPOAE SNR with the largest DPOAE present in frequencies greater than 5000 Hz. Direct comparison to these studies is challenging as stimulus parameters differed such as stimulus input intensity levels, DPOAE analysis (absolute amplitude vs. SNR), or only partial data was published.

Limitations. Most of the data were not normally distributed which resulted in nonparametric analysis. Parametric analysis for the few frequencies that were normally distributed were not significant, 705Hz (p = 0.148) and 1002Hz (p = 0.172). This may suggest that lower frequencies are not as sensitive to DPOAE testing or more data are required to obtain a normal distribution. There were not enough dogs in differing noise levels to determine if noise level itself had an effect on DPOAE amplitude responses. The next step in this line of research is to obtain this data set on dogs with differing levels of noise exposure. Cross-sectional and longitudinal studies charting DPOAEs are needed to gain clarity on MWD exposure to hazardous noise and its effect on the auditory system. Future research should continue to develop normative data sets on MWD and optimal protocols for testing the canine's auditory system.

Conclusion

Enrollment of the MWD into a hearing conservation program should be considered. Their exposures exceed federal and DoDI action levels although not long-term permissible

exposure levels when considering their kennel noise exposure alone. However, there are likely more noise exposures as MWD are trained alongside small arms fire, explosives, and ride in military transportation that can exceed hazardous noise levels, all without the benefit of hearing protection devices[1,3,6]. Hearing conservation programs include noise measurement and abatement, personal hearing protectors, audiological testing, and education. With these program elements in mind, there should be consideration of noise mitigation in kennels. Efforts should be made to gather baseline audiological assessments with BAERs and DPOAEs to better track potential decreases in hearing levels. $DP_{65/55}$ looks promising as an initial DPOAE protocol. A collaborative approach to understanding the impact of noise on an MWD and its performance is necessary. Audiologists' support with hearing assessments and their understanding of NIHL, veterinarians' knowledge of canine health, and the handlers' familiarity of their dog are all needed to determine what degree NIHL may affect an MWD.

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Exposure to *Ehrlichia canis*, *Anaplasma* spp., and Other Vector-Borne Pathogens in Military, Police, Shelter, and Pet Dogs in Different Regions of Colombia

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Abstract

Background: As vector-borne diseases (VBD) continue to rise, US military working dogs (MWD) and handlers are at increased risks of exposure particularly during recurring missions to Colombia. Little is known regarding the burden of VBD in Colombian working dogs. In Colombia, military and police dogs provide support in a variety of capacities including jungle, anti-narcotic, anti-explosive, and national defense missions. The objectives of the study reported here were (1) to estimate and compare the frequency of dogs with selected vector-borne pathogens among military, police, shelter, and pet dogs in different regions of Colombia and (2) to examine the association between seropositivity to selected pathogens and occupation in study dogs.
Methods: 1,392 dogs were sampled in six different geographic locations in Colombia during 2011 to 2018 to evaluate for common VBD pathogens. Blood samples from each dog were tested for positive antibody titers to *Ehrlichia* spp., *Anaplasma* spp., *Borrelia burgdorferi*, *Leishmania* spp., and antigen titers to *Dirofilaria immitis.*
Results: The frequency of dogs with positive antibody titers to *Ehrlichia* spp. was higher in shelter dogs (83%; CI = 80%, 86%), compared to military dogs (50%; CI = 44%, 57%), police dogs (42%; CI = 38%, 46%), or pet dogs (35%; CI = 27%, 44%). In 2011, among police dogs, the odds of seropositivity to *Ehrlichia* spp. were 37 times higher in Cartagena (adjusted OR = 37.84; CI = 14.49, 98.85) compared to Medell**ín**, after controlling for age. Among police dogs only, the odds of seropositivity to *Anaplasma* spp. were 13 times higher in Cartagena (adjusted OR = 13.25; CI = 6.84, 25.66), compared to Medellín, after controlling for age. The frequency of dogs in all four occupations exposed to *B. burgdorferi*, *D. immitis*, or *Leishmania* spp was low.
Conclusion: Exposure to *Ehrlichia* spp. and *Anaplasma* spp. in military dogs and police dogs was similar to pet dogs and lower than shelter dogs. Among police dogs, exposure to *Ehrlichia* spp. and *Anaplasma* spp. was higher in Cartagena (coastal, sea level) than Medellín (mountain, high altitude) after controlling for age. Study results can support revising standard operating procedures for disease risk management in MWDs and police dogs in Colombia. Attending veterinarians can consider a risk-based disease control and prevention approach, where geographic location (coastal, sea level) is a risk factor for *Ehrlichia* spp. and *Anaplasma* spp. infection in working dogs.

Keywords: Ehrlichia canis, Anaplasma spp., vector-borne pathogens, tick-borne pathogens, military working dogs, police dogs, Colombia

Introduction

Over the last decade, vector- and tick-borne pathogens (eg, *Ehrlichia canis*, *Anaplasma* spp., *Dirofilaria immitis*, *Borrelia burgdorferi*, and *Leishmania* spp.) have undergone expansive emergence globally,[1] and increasingly cause zoonotic and infectious diseases in both humans and animals.[2] Many tick-transmitted infections are blood-borne pathogens that cause diseases resulting in significant interruption in work in people and production losses in animals.[3] Most of the information regarding the burden of VBD, specifically tick-borne diseases (TBD) in dogs, has been generated from studies performed in higher-income countries. One of the largest studies was conducted in the United States from 2004 to 2021. In the study, analysis of blood from 14496 dogs demonstrated that the prevalence of *B. burgdorferi*, *Ehrlichia* spp., *Anaplasma* spp., and *D. immitis* was 5.2%, 4.3%, 1.9%, and 0.8%, respectively.[4] But, the few comprehensive studies of VBD and TBD in dogs in low-income or middle-income countries, especially in Colombia, prevent the development of rational intervention and mitigation strategies for the control of TBD in animal and human populations.[5,6] A prior point prevalence surveillance study examining ehrlichial pathogens in Colombian working dogs, shelter dogs, and pet populations revealed a high prevalence of dogs with positive antibody titers to *Ehrlichia canis* (74%) and *Anaplasma platys* (53%).[7]

Understanding the VBD burden in military and police working dogs is critical because of their additional value in the overall protection and reduction of morbidity and disease burden in humans, in which little is known about VBD prevalence. In the US military, approximately 2500 active duty MWDs are trained and certified in detecting explosives and narcotics and in sentry and patrol. MWDs deploy to combat zones, on select exercises, on special missions abroad, and to secure continental US bases. The nature of this work results in exposure to environmental pathogens that cause significant morbidity and, in some cases, mortality. MWDs are athletic breeds, most commonly German Shepherds and Belgian Malinois, whose work requires repeated jumping, climbing, running, and bite work, among others. Because of the nature of this work, one cause of non-battle injury in US MWDs is musculoskeletal disorders (eg, osteoarthritis, lumbosacral stenosis). The US military mitigates musculoskeletal risks through advancements in exercise physiology, routine low-impact training, routine physical exams, and improved handler awareness of associated signs. Likewise, there are infectious diseases that may adversely affect a working dog's optimal performance or that can reduce its working lifespan. Infection with VBDs, specifically ehrlichiosis, anaplasmosis, Lyme, and leishmania, are of most concern during overseas missions. The US military mitigates the threat of infectious diseases through continual medical evaluations of dogs, provision of prophylactic medications, and diagnostic and environmental surveillance. The relentless emphasis on these measures resulted from critical lessons learned during Vietnam, in which *Ehrlichia canis*, the causative agent for canine ehrlichiosis, led to 250 working dog deaths and threatened the overall US working dog program.[8] As a result, the prevalence of VBDs in US working dogs is low, as indicated by a study published in 2021 of 476 US MWDs tested in 40 different states. The prevalence of *Ehrlichia* spp., *Anaplasma* spp., *Leishmania* spp., and *B. burgdorferi* was 1.3%, 1.5%, 2%, and 0.84%, respectively.[9]

Police and MWD are essential assets and force multipliers utilized globally, especially in Colombia, where enhanced security is a strategic US interest. US service members and MWDs routinely deploy to Colombia as part of the overall objective to end Colombia's armed conflict by training and supporting Colombia's military and paramilitary forces. US service members and US MWDs are in Colombia specifically to train and assist Colombian partner forces in the fight against narcoterrorism. The US Department of State also provides trained working dogs to Colombia to increase the working dog numbers and add high-value assets to the inventory. The estimated value of a fully trained working dog can be over $150,000, so there is a real need to protect the investment and ensure optimal program functionality. US MWDs receive routine veterinary and preventive medical care including semiannual physical exams, advanced diagnostics, pre- and post-deployment pathogen testing, and vector prevention measures.

Figure 1. Map of Colombia

Conversely, in Colombian working dogs, health screenings are limited and performed as part of a diagnostic workup, primarily in the clinically affected dog. Basic knowledge of the disease burden in Colombian working dogs and the resultant occupational risks to working dog handlers in Colombia is limited. In Colombia, police working dogs are assigned to work with the Colombian National Police (CNP) in various capacities, including jungle, anti-narcotic, anti-explosive, and other urban police patrol operations. Colombian MWDs are assigned within the Ministry of Defense and work with Army, Navy, and Coast Guard units on various exercises and missions. Although the CNP and Ministry of Defense utilize similar working dog breeds, the exposures to VBD likely depend upon the assigned location and unit of assignment. Both military and police working dogs are kenneled individually and receive focused care and training from their assigned handler.

The primary objective of the study reported here was to estimate and compare the frequency of dogs with positive antibody titers to *Ehrlichia* spp., *Anaplasma* spp., *Borrelia burgdorferi*, and *Leishmania* spp., and antigen titers to *Dirofilaria immitis* among military, police, shelter, and pet dogs in different regions of Colombia and secondarily to examine the association between seropositivity to selected pathogens and occupation in study dogs.

Methods

This study was approved by the Colombian Ministerio de Defensa, Nacional Policía Nacional, Direccion de Antinarcoticos (Memorandum No. 039344), the University of Florida's Institute of Animal Care and Use Committee (protocol # 201207460) and Institutional Review Board (protocol # 414-2012) as well as the US Naval Medical Research Center (Memorandum Ser-00F0/0227). It was conducted in six geographic locations (Figure 1) in Colombia during 2011 to 2018, representing regions with varying environmental conditions: (a) Cartagena—Bolívar department with a population of about 1 million, 1 m above sea level, average temperature 81 °F, tropical wet and dry, coastal; (b) Barranquilla—Atlántico department with a population of 2 million, 3 m above sea level, average temperature 82 °F, tropical monsoon, river; (c) Bucaramanga—Santander department with a population of 1 million, 959 m above sea level, average temperature 68°F, tropical monsoon, mountain plateau; (d) Cali—Valle del Cauca department with a population of 2.3 million, 1,014 m above sea level, average temperature 69 °F, tropical savanna, coastal, mountain plains; (e) Medellín—Antioquia department with a population of 3 million, 1,499 m above sea level, average temperature 62 °F, subtropical highland, mountain valley; (f) Bogotá—Cundinamarca department with a population of 7 million, 2,640 m above sea level, average temperature 58 °F, savanna, high plateau; and (g) San Andrés, a coral island in the Caribbean off the northwest coast with a population of 75 000 and average temperature 84 °F.

In this period prevalence study, a convenience sample of 1,392 dogs was included from 2011 to 2018: (a) Cartagena (20 military dogs, 94 police dogs); (b) Barranquilla (69 military dogs, 326 shelter dogs, 46 pet dogs); (c) Bucaramanga (45 military dogs, 48 police dogs, 211 shelter dogs, 69 pet dogs); (d) Cali (46 police dogs); (e) Medellín (210 police dogs); (f) Bogotá (75 military dogs, 128 police dogs); and San Andrés island (5 police dogs). Dogs at each site were randomly selected for testing by handlers and shelter personnel from the kennel or shelter to yield a representative sample of that population.

Table 1. Frequency (%) of dogs with positive antibody titers to E. canis/ewingii by occupation, year and location

		Occupation			
Year	Location	Shelter	Military	Police	Pets
2011	Barranquilla Medellín Cartagena	184/223 (82.5)	8/20 (40.0)	43/175 (24.6)[b] 72/80 (90.0)[a]	
2012	Barranquilla	91/103 (88.3)	57/69 (82.6)		21/46 (45.7)
2013	Cartagena/S.A.			9/19 (47.4)	
2014	Cali			51/113 (45.1)	
2016	Bogotá		39/75 (52.0)		
2017	Bogotá Bucaramanga	90/100 (90.0)		22/52 (42.3)	10/47 (21.3)
2018	Bogotá Bucaramanga	81/111 (73.0)	1/45 (2.2)	19/44 (43.2)[a] 8/48 (16.7)[b]	9/22 (40.9)
All years		446/537[1] 83.1 (79.7, 86.0)[2]	105/209 50.2 (43.5, 57.0)	224/531 42.2 (38.1, 46.4)	40/115 34.8 (26.7, 43.9)

[1]Data are reported as number of seropositive dogs/total dogs tested
[2]Data are reported as seroprevalence (%) of positive dogs (95% confidence intervals). https://epitools.ausvet.com.au/ciproportion
[a,b] Within columns, groups with different superscripts are significantly different ($p < 0.05$).

Table 2. Results of multivariable logistic regression analyses of investigated exposure factors associated with E. canis/ewingi seropositivity in study dogs sampled and tested in 2011, 2012, 2017, and 2018.[1]

Variable	Category	Crude OR	95% CI	p	Adjusted OR	95% CI	p
Year 2011							
Occupation	Shelter	1.00	Reference	NA	-	-	-
	Military	0.14	0.05, 0.36	< 0.01	0.13	0.05, 0.35	< 0.01
	Police	0.17	0.11, 0.26	< 0.01	0.18	0.12, 0.28	-<0.01
City	Medellín	1.00	Reference	NA			
	Cartagena	12.28	6.75, 22.34	< 0.01			
	Barranquilla	14.48	8.90, 23.58	< 0.01			
Age (yrs)	1	1.00	Reference	NA	-	-	-
	2-5	7.81	3.52, 17.30	< 0.01	7.16	3.07, 16.71	<0.01
Year 2012[2]							
Occupation	Shelter	1.00	Reference	NA	-	-	-
	Military	0.62	0.26, 1.48	0.28	0.55	0.22, 1.35	0.19
	Pets	0.11	0.04, 0.25	< 0.01	0.08	0.03, 0.28	< 0.01
Age (yrs)	1	1.00	Reference	NA	-	-	-
	2-5	1.10	0.41, 2.93	0.84	2.57	0.88, 7.50	0.08
Year 2017							
Occupation	Shelter	1.00	Reference	NA	-	-	-
	Police	0.08	0.03, 0.19	< 0.01	0.08	0.03, 0.19	< 0.01
	Pets	0.03	0.01, 0.07	< 0.01	0.03	0.01, 0.08	< 0.01
City	Bogotá	1.00	Reference	NA	-	-	-
	Bucaramanga	1.51	0.62, 3.71	0.36			
Age (yrs)	1	1.00	Reference	NA	-	-	-
	2-5	3.16	1.26, 7.95	0.01	2.41	0.73, 7.93	0.14
Year 2018							
Occupation	Shelter	1.00	Reference	NA	-	-	-
	Military	0.01	0.00, 0.06	< 0.01	0.007	0.001, 0.05	< 0.01
	Police	0.15	0.08, 0.28	< 0.01	0.13	0.07, 0.25	< 0.01
	Pets	0.25	0.09, 0.66	< 0.01	0.24	0.09, 0.64	< 0.01
City	Bogotá	1.00	Reference	NA	-	-	-
	Bucaramanga	1.78	0.51, 6.15	0.36			
Age (yrs)	1	1.00	Reference	NA	-	-	-
	2-5	1.58	0.46, 5.39	0.46	4.48	0.09, 0.64	0.02

[1]The variable for City was not examined in the multivariable analysis because it was correlated with occupation.
[2]In year 2012, all dogs were from the city of Barranquilla.

Blood was collected via cephalic venipuncture directly into 2 mL vacutainer tubes with no anticoagulant for harvesting serum and into 2 mL vacutainer tubes containing ethylenediaminetetraacetic acid (EDTA). Whole blood samples collected in EDTA were stored at −20 °C, while blood collected without additives was immediately centrifuged; serum was harvested and stored at −20 °C. The samples were then transported under cold conditions and stored at −20 °C in designated laboratories at the University of Florida, College of Veterinary Medicine, for further analysis. The samples were shipped following guidelines set in Permit no. 2012-05-164 from the Public Health Service at the US Centers for Disease Control and Prevention in Atlanta, GA. Canine whole blood samples were analysed onsite for the simultaneous detection of antibodies against multiple vector-borne pathogens: *E. canis*, *E. ewingii*, *A. phagocytophilum*, *A. platys*, *B. burgdorferi*, and antigen to *D. immitis* using commercially available ELISA tests (NSN 6550-016504412) following the manufacturer's directions. Canine whole blood samples were also tested onsite for *Leishmania* spp. by commercial ELISA Leishmania test kits (NSN 6640-NCM093803). The following data were collected from each study dog: name or identification number, age, sex, spayed or neutered, location, occupation (military, police, shelter, or pet), and the sampling date.

For statistical analyses, age was calculated and reported as mean ± SD. Proportions of dogs with positive antibody titers to *E. canis*, *Anaplasma* spp., *B. burgdorferi*, *Leishmania* spp., or positive to *D. immitis* antigen were calculated by dividing the number of positive dogs by the total number of dogs tested. Ninety-five percent confidence intervals (95% CI) were calculated for each proportion estimate using the software Epitools epidemiological calculators.[10] The proportion of positive dogs for each pathogen was compared between occupation groups (military, police, shelter, pet dogs) in selected years and cities by using a chi-square test. A logistic

regression analysis examined the relationship between exposure factors (occupation, age, city) and dogs positive to *E. canis* or *Anaplasma* spp. in selected years. Logistic regression models were not constructed for seropositivity to *B. burgdorferi*, *Leishmania* spp., or *D. immitis* because the frequency of seropositive dogs was low in selected years. Values of $p < 0.05$ were considered significant.

Results

Overall, this study consisted of 1392 dogs: 658 (47%) female and 734 (53%) male. The mean ± SD age of the study dogs was 3.8 ± 1.3. The frequency of dogs with positive antibody titers to *E. canis* or *E. ewingii* was higher in shelter dogs (83%; CI = 80%, 86%) compared to military dogs (50%; CI = 44%, 57%), police dogs (42%; CI = 38%, 46%), or pet dogs (35%; CI = 27%, 44%) (Table 1). In 2011, in police dogs, the frequency of seropositive dogs was higher in Cartagena (90%) compared to Medellín (25%) ($p < 0.05$). Similarly, in 2018, in police dogs, the frequency of seropositive dogs was higher in Bogotá (43%) compared to Bucaramanga (17%) ($p < 0.05$). Using univariable logistic regression, in 2011, 2012, 2017, or 2018, the variables for occupation, age, and department (geographic location) had values of $p < 0.20$ and were further examined. The variable occupation was associated with department; thus, department was excluded. In 2011, in the multivariable analysis, the odds of seropositivity were 7.8 (adjusted OR = 0.13; CI = 0.05, 0.34) and 5.5 times lower (adjusted OR = 0.18; CI = 0.11, 0.28) in military dogs and police dogs, respectively, compared to shelter dogs, after controlling for age (Table 2). The Hosmer–Lemeshow goodness of fit test (0.55; df = 2; $p = 0.75$) indicated no evidence of a poor fit for the data. In the final model, the odds of seropositivity changed from 0.14 and 0.17 (crude ORs) to 0.13 and 0.18 (adjusted ORs) (6%-7% change) in military dogs and police dogs, respectively, after controlling for age. This indicates that the association between occupation and seropositivity to *E. canis* and *E. ewingii* was not confounded by age. In subsequent years, the odds of seropositivity were lower in military or police dogs, compared to shelter dogs, after controlling for age. In 2011, among police dogs only, the odds of seropositivity were 37 times higher (adjusted OR = 37.84; CI = 14.49, 98.85) in Cartagena compared to Medellín, after controlling for age. Shelter dogs had the highest frequency of seropositive dogs for *A. phagocytophilum/platys* 33% (CI = 29%, 37%), compared to military dogs 22% (CI = 17%, 28%), police dogs 18% (CI = 15%, 21%), and pet dogs 14% (CI = 9%, 22%) (Table 3). In 2011, in police dogs, the frequency of seropositive dogs was higher in Cartagena (63%) compared to Medellín (11%) ($p < 0.05$). In 2011, 2012, 2017, and 2018, using univariable logistic regression, the variables for occupation, age, and department had values of $p < 0.20$ and were further examined. The variable occupation was associated with department; thus, department was excluded.

Table 3. Frequency (%) of dogs with positive antibody titers to A. phagocytophilum/platys by occupation, year and location

Year	Shelter	Military	Police	Pets
2011	90/223 (40.4)	0/20 (0)	71/255 (27.8)	
Barranquilla	90/223 (40.4)	0/20 (0)	20/175 (11.4)[b]	
Medellín				
Cartagena			51/80 (63.8)[a]	
2012	40/103 (38.8)	40/69 (58.0)		15/46 (32.6)
Barranquilla	40/103 (38.8)	40/69 (58.0)		15/46 (32.6)
2013			2/19 (10.5)	
Cartagena / S.A.			2/19 (10.5)	
2014			11/113 (9.7)	
Cali			11/113 (9.7)	
2016		7/75 (9.3)		
Bogotá		7/75 (9.3)		
2017	27/100 (27.0)		7/52 (13.5)	1/47 (2.1)
Bogotá	27/100 (27.0)		7/52 (13.5)	1/47 (2.1)
Bucaramanga				
2018	23/111 (20.7)	0/45 (0)	5/92 (5.4)	1/22 (4.5)
Bogotá	23/111 (20.7)	0/45 (0)	3/44 (6.8)[a]	1/22 (4.5)
Bucaramanga			2/48 (4.2)[a]	
All years	180/537[1]	47/209	96/531	17/115
	33.5 (29.7, 37.6)[2]	22.5 (17.4, 28.6)	18.1 (15.0, 21.6)	14.8 (9.4, 22.4)

[1]Data are reported as number of seropositive dogs/total dogs tested
[2]Data are reported as seroprevalence (%) of positive dogs (95% confidence intervals). https://epitools.ausvet.com.au/ciproportion
a,b Within columns, groups with different superscripts are significantly different ($p < 0.05$).

Table 4. Frequency (%) of dogs with positive antibody titers to B. burgdorferi by occupation, year and location

Year	Shelter	Military	Police	Pets
2011	0/223 (0)	0/20 (0)	0/255 (0)	
Barranquilla	0/223 (0)	0/20 (0)	0/175 (0)[a]	
Medellín				
Cartagena			0/80 (0)[a]	
2012	0/103 (0)	0/69 (0)		0/46 (0)
Barranquilla	0/103 (0)	0/69 (0)		0/46 (0)
2013			0/19 (0)	
Cartagena / S.A.			0/19 (0)	
2014			0/113 (0)	
Cali			0/113 (0)	
2016		1/75 (1.3)		
Bogotá		1/75 (1.3)		
2017	0/100 (0)		1/52 (1.9)	0/47 (0)
Bogotá			1/52 (1.9)	
Bucaramanga	0/100 (0)			0/47 (0)
2018	1/111 (1.0)	0/45 (0)	1/92 (1.1)	0/22 (0)
Bogotá			0/44 (0)[a]	
Bucaramanga	1/111 (1.0)	0/45 (0)	1/48 (2.1)[a]	0/22 (0)
All years	1/537[1]	1/209	2/531	0/115
	0.2 (0, 1.1)[2]	0.5 (0, 2.7)	0.4 (0.1, 1.4)	0 (0, 3.2)

[1]Data are reported as number of seropositive dogs/total dogs tested
[2]Data are reported as seroprevalence (%) of positive dogs (95% confidence intervals). https://epitools.ausvet.com.au/ciproportion
[a,b] Within columns, groups with different superscripts are significantly different ($p < 0.05$).

Table 5. Frequency (%) of dogs with positive antibody titers to D. immitis by occupation, year and location

Year	Shelter	Military	Police	Pets
2011	0/223 (0)	2/20 (10.0)	1/255 (0.4)	
Barranquilla	0/223 (0)	2/20 (10.0)		
Medellín			0/175 (0)[a]	
Cartagena			1/80 (1.3)[a]	
2012	0/103 (0)	0/69 (0)		0/46 (0)
Barranquilla	0/103 (0)	0/69 (0)		0/46 (0)
2013			0/19 (0)	
Cartagena / S.A.			0/19 (0)	
2014			0/113 (0)	
Cali			0/113 (0)	
2016		3/75 (4)		
Bogotá		3/75 (4)		
2017	0/100 (0)		2/52 (3.8)	0/47 (0)
Bogotá			2/52 (3.8)	
Bucaramanga	0/100 (0)			0/47 (0)
2018	0/111 (0)	0/45 (0)	0/92 (0)	0/22 (0)
Bogotá			0/44 (0)[a]	
Bucaramanga	0/111 (0)	0/45 (0)	0/48 (0)[a]	0/22 (0)
All years	0/537[1]	5/209	3/531	0/115
	0 (0, 0.7)[2]	2.4 (1.0, 5.5)	0.6 (0.2, 1.7)	0 (0, 3.2)

[1]Data are reported as number of seropositive dogs/total dogs tested
[2]Data are reported as seroprevalence (%) of positive dogs (95% confidence intervals). https://epitools.ausvet.com.au/ciproportion
[a,b] Within columns, groups with different superscripts are significantly different ($p < 0.05$).

In the multivariable analysis, the odds of seropositivity were 1.6 times lower (adjusted OR = 0.60; CI = 0.40, 0.88) in police dogs compared to shelter dogs after controlling for age. The Hosmer–Lemeshow goodness of fit test (3.65; df = 2; p = 0.16) indicated no evidence of a poor fit for the data. The association between occupation and seropositivity to *A. phagocytophilum*/*platys* was not confounded by age. In 2018, the odds of seropositivity were five times lower in police dogs, compared to shelter dogs, after controlling for age (adjusted OR = 0.20; CI = 0.07, 0.57). In 2011, among police dogs only, the odds of seropositivity were 13 times higher (adjusted OR = 13.25; CI = 6.84, 25.66) in Cartagena, compared to Medellín, after controlling for age. The frequency of dogs with positive antibody titers to *B. burgdorferi* was very low and not different between shelter dogs (0.2%; CI = 0%, 1.1%), military dogs (0.5%; CI = 0%, 2.7%), police dogs (0.4%; CI = 0.1%, 1.4%), or pet dogs (0%; CI = 0%, 3.2%) (Table 4). Similarly, the frequency of dogs with positive antibody titers to *D. immitis* was very low and not different between shelter dogs (0%; 95% CI = 0%, 0.7%), military dogs (2.4%; CI = 1.0%, 5.5%), police dogs (0.6%; CI = 0.2%, 1.7%), or pet dogs (0%; CI = 0%, 3.2%) (Table 5). Likewise, the frequency of dogs with positive antibody titers to *Leishmania* spp. was low and not different between shelter dogs (4.8%; CI = 3.1%, 7.4%), military dogs (2.1%; CI = 0.7%, 6.1%), police dogs (4.2%; CI = 1.8%, 9.5%), or pet dogs (1.5%; CI = 0.3%, 7.8%) (Table 6). Lastly, the seroprevalence of VBD pathogens in CNP working dog handlers was evaluated by the CNP medical staff as an initial look into occupational exposures and risk due to high working dog seroprevalence. Eight CNP working dog handlers were randomly sampled by the CNP medical staff in 2011 and 2018 at the same time the 119 CNP working dogs were being sampled. Testing performed included Lyme disease ELISA; scrub typhus indirect immunofluorescence assay (IFA); spotted fever group, rickettsia (IFA); *Ehrlichia* spp. (IFA); *Anaplasma* spp. (IFA); and both cutaneous leishmaniasis and visceral leishmaniasis. All eight (100%) of the CNP working dog handlers sampled tested positive for *Leishmania* spp., specifically cutaneous leishmaniasis, demonstrating the need for further investigation.

Discussion

This study provides new information on the burden of exposure to *Ehrlichia* spp., *Anaplasma* spp., *B. burgdorferi*, *D. immitis*, and *Leishmania* spp in military dogs and police dogs in Colombia. The inclusion of shelter dogs and pet dogs served as a reference for dog occupations at high risk or low risk of exposure to selected VBD pathogens.

In this study, exposure to *Ehrlichia* spp. and *Anaplasma* spp. in military dogs and police dogs was similar compared to pet dogs and lower compared to shelter dogs. These findings are likely due to increased environmental exposures to vectors in crowded living conditions and a lack of veterinary care. Most shelter dogs were previously stray dogs on the streets or in the countryside, just trying to survive with intermittent direct exposure to people. Although, to the authors' knowledge, there are no other comparable published studies from Colombia, other studies from varying locations are similar to our study's findings and conclusions, specifically related to the increased prevalence of VBD in shelter and stray canine populations defined by crowded living conditions.[11,12]

Among police dogs, exposure to *Ehrlichia* spp. and *Anaplasma* spp. was higher in Cartagena (coastal, sea level) compared to Medell**ín** (mountain, high altitude) after controlling for age. Tropical humid climates provide an adequate environment for vectors including the brown dog tick, *Rhipicephalus sanguineous*, and *Ixodes* spp. (primary vectors for *E. canis* and *A. platys*) and *Ixodes* spp. (primary vectors for *A. phagocytophilum*). These findings are likely due to the impacts of environmental conditions and vector exposures. Cartagena is at sea level with a hot, humid, year-round tropical climate that provides optimal conditions for vectors such as ticks, mosquitoes, and other biting insects. Medellín, in contrast, is at a much higher elevation in a mountainous region with much colder temperatures, thus resulting in less favorable conditions for vector proliferation.

Table 6. Frequency (%) of dogs with positive antibody titers to Leishmania spp. by occupation, year and location

Year	Shelter	Military	Police	Pets
2011	10/223 (4.5)	0/20 (0)	0/27 (0)	
Barranquilla	10/223 (4.5)	0/20 (0)		
Cartagena			0/27 (0)	
2012	0/103 (0)	0/69 (0)		0/46 (0)
Barranquilla	0/103 (0)	0/69 (0)		0/46 (0)
2013				
2014				
2016		1/75 (1.3)		
Bogotá		1/75 (1.3)		
2017	7/63 (11.1)			0/47 (0)
Bucaramanga	7/63 (11.1)			0/47 (0)
2018	2/111 (1.8)	2/45 (4.4)	5/92 (5.4)	1/22 (4.5)
Bogotá			4/44 (9.1)[a]	
Bucaramanga	2/111 (1.8)	2/45 (4.4)	1/48 (2.1)[a]	1/22 (4.5)
All years	19/397[1] 4.8 (3.1, 7.4)[2]	3/140 2.1 (0.7, 6.1)	5/119 4.2 (1.8, 9.5)	1/69 1.5 (0.3, 7.8)

[1]Data are reported as number of seropositive dogs/total dogs tested
[2]Data are reported as seroprevalence (%) of positive dogs (95% confidence intervals). https://epitools.ausvet.com.au/ciproportion
[a,b] Within columns, groups with different superscripts are significantly different (p < 0.05

Although there are no published research reports in the literature to compare our findings specifically related to the effects of environmental conditions, some studies in Colombia identify outbreaks in areas conducive to vector activity in human and canine populations. One report from 2010 described an outbreak of the tick-borne disease Rocky Mountain spotted fever near the Caribbean Sea on the northern coast of Colombia,[13] an area similar to some of our study's locations with favorable conditions for vector proliferation. A 2015 published study conducted in the Ecuadorian Galapagos found a positive interaction effect between locations of canines (rural compared to urban environmental conditions) and spay/neuter status on seropositivity to canine distemper virus.[14]

Study dogs had low exposure to *B. burgdorferi*, *D. immitis*, and *Leishmania* spp. These findings are likely due to a low prevalence of these pathogens in the vector and canine populations from the regions of Colombia surveyed, especially the locations impacted most by higher altitude and lower temperature environmental conditions. To the authors' knowledge, there are no other published studies that have measured the frequency of working dogs exposed to these selected pathogens in Colombia; however, other studies from Ecuador,[15] a bordering country with similar geography, and Mexico,[16] another Latin America country, support our study's findings and conclusion.

This study had limitations. The study sample was not fully randomized. Therefore, it is difficult to extrapolate the observed frequency of dogs exposed to selected pathogens as a proxy for prevalence in entire subpopulations of military dogs, police dogs, shelter dogs, and pet dogs in Colombia. The study results reported here apply to a large data set of 1,392 dogs but dogs in all four occupations were not sampled and tested in every city and every year as planned due to travel restrictions and security limitations. Thus, the epidemiologic analysis was limited to selected years and occupations where appropriate data were available.

Conclusion

Exposure to *Ehrlichia* spp. and *Anaplasma* spp. in military dogs and police dogs was similar to pet dogs and lower compared to shelter dogs. Among police dogs, exposure to *Ehrlichia* spp. and *Anaplasma* spp. was higher in Cartagena (coastal, sea level) compared to Medellín (mountain, high altitude) after controlling for age. These study results can be used to revise standard operating procedures for disease risk management in military and police dogs in Colombia aimed to enhance current vector prevention countermeasures with improved tick prevention products, strategies, and awareness campaigns. Attending veterinarians can consider a risk-based disease control and prevention approach, where geographic location (coastal, sea level) is a risk factor for *Ehrlichia* spp. and *Anaplasma* spp. infection in service dogs. The high exposure to these pathogens in Colombia warrants comprehensive, multi-faceted precautionary measures for working dogs, working dog handlers, deployed US service members, and the public living and working in these areas. This study's results provide unique medical information to scientific literature and new science-based data for military medical planners and medics to implement actionable risk mitigation measures aimed to preserve and optimize the health of the working dog, arguably the most valuable force multiplier asset. Future studies can reference this period prevalence study design in efforts to obtain data in other countries where US MWDs and handlers deploy and have exposures to related vectors and host nation dog populations.

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Digital Pathology Update

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Abstract

The advent and maturation of whole slide imaging scanning technology brings another dimension to the practice of modern pathology. This new technology allows pathologists to view digitally scanned slides from any computer workstation, irrespective of distance, making consultation and education faster and easier. The purpose of this update is to educate personnel about this exciting new process and describe it's use in research, consultation, and diagnostics within the Army Veterinary Corps. Advantages and limitations are discussed, along with potential future applications.

Keywords: WSI, scanning, microscopy, pathology

Introduction

Invention of the Microscope

During the middle of the 13th century the concept of magnification first came into focus. Dutch spectacle makers created the first compound microscope in the last 1500s, but it was not until the middle of the 17th century that a microscope was used to look at living objects and English natural philosopher Robert Hooke coined the term "cell" in his microscopic picture book "Micrographia". Over the years, pioneers such as Antonie van Leeuwenhoek, Joseph Jackson Lister, and Ernest Abbe were able to look closer and see cells more clearly by improving the quality of the optics, eventually leading to the modern compound microscope.[1]

Slide Image Scanning

After relying on glass slides and microscopes for hundreds of years, advances in digital image capture technology made possible high-resolution static slide image scanning leading to the emergence of the field of telepathology. Initially pathologists remained bound to glass slides. A pathologist had to review each slide and choose an area to be imaged. A technician could then focus on the area of interest and produce a digital static image. The captured image could then be sent to other pathologists for consultation.[2] The ability to produce digital images from glass slides was useful, but technology was limited to scanning small areas of interest. Having the ability to view an entire slide can be invaluable, particularly in diagnostic work. This limitation was finally resolved in the year 2000, when whole slide imaging (WSI) scanners were made available for commercial use.[3]Additionally, digital slide scanning allows computer-based histopathological support using viewing software from anywhere the user has access to the secure image database.

Advent of Whole Slide Imaging Scanners

The first generation of WSI scanners took over 24 hours to scan a single slide.[2] This significant time investment limited day-to-day usefulness and widespread adoption of the technology. Advances in technology over the past 20 years dramatically improved processing time, and in 2022 scanning a single slide to 40x magnification is possible in just under one minute.[4] This increase in efficiency and quality prompted Army veterinary pathologists at the Joint Pathology Center (JPC), Walter Reed Army Institute of Research (WRAIR), Public Health Command Europe (PHCE) Laboratory Sciences, and the United States Army Medical Research Institutes of Infectious Diseases (USAMRIID) and Chemical Defense (USAMRICD) to buy into this technology. It is revolutionizing how researched is conducted, consultation with other pathologists, providing diagnostic consultations, and education of the next generation of veterinarians.

Research

Research initiatives at the main military veterinary research institutions (WRAIR, USAMRIID and USAMRICD) allow staff pathologists to capitalize on slide scanning in different ways. Each institution has unique foci of interest and applications of technology.

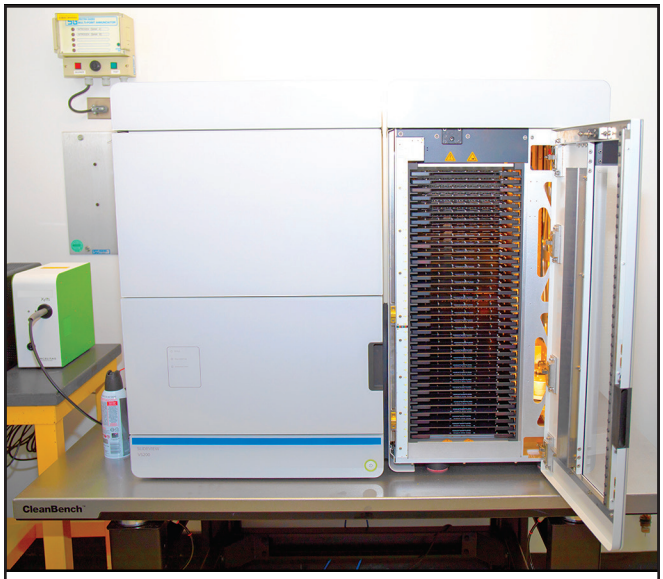

Figure 1. Digital slide scanner set-up. Courtesy of LTC Christopher Schellhase.

WRAIR

Army veterinary pathologists (AOC 64D) in the WRAIR Veterinary Services Program provide research support enabling scientific investigation in the creation, development, and delivery of advanced medical capabilities for the Warfighter. Research lines of effort include traumatic brain injury, post-traumatic stress disorder, barotrauma, treatment modalities in the event of prolonged access to care, and prevention and treatments for many infectious diseases of military and, by extension, public health concern. In 2021, the WRAIR Pathology Department acquired a digital slide scanner. Despite the COVID-19 work from home orders, pathologic analysis of the studies testing WRAIR's SpFN (Spike-Ferritin-Nanoparticle) coronavirus vaccine was still completed in the home office due to the digitally scanned histopathology images, enabling the advancement of lightning-speed product development.

USAMRIID

The USAMRIID Pathology Division's mission is focused on providing anatomic, ultrastructural, and molecular pathology services in support of an overarching mission to produce effective medical capabilities aimed at deterring and defending against biological threats. Current research efforts at USAMRIID include: vaccine development, animal model validation, advanced diagnostics, and novel pre- and post-treatment modalities for emerging pathogens. At present, the division utilizes a digital slide scanner acquired in 2021. Digital slide scanning at the institute has remained a pivotal component in biological select agent and toxin (BSAT) research. BSAT safety protocols restrict movement and review of glass histopathology slides off-site, therefore

Figure 2. Internal view of digital slide scanner showing racks of slides and capacity. Courtesy of LTC Christopher Schellhase.

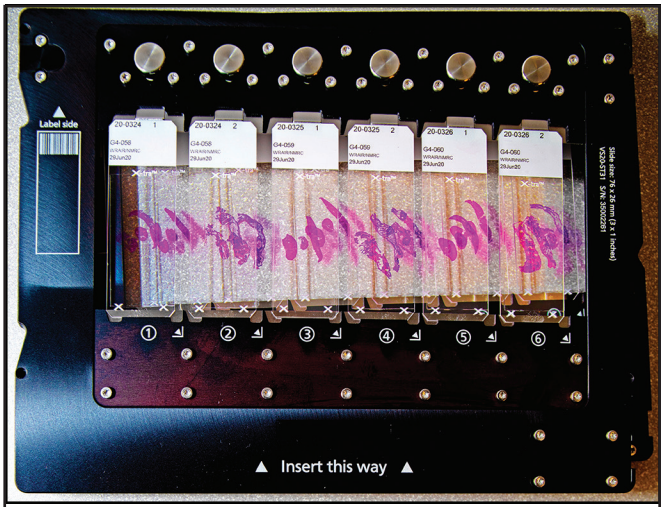

Figure 3. Filled rack of slides to scan on digital slide scanner. Courtesy of LTC Christopher Schellhase.

the capability to work with whole slide digital images is invaluable for remote work capabilities or inter-institutional collaboration.

USAMRICD

Veterinary pathologists in USAMRICD's Research Support Division provide expertise in comparative pathology to enable the discovery and development of medical solutions for chemical, biochemical, and other emerging non-kinetic acute battlefield injuries in support and protection of the Joint Warfighter. Research lines of effort focus on development of medical countermeasures to, and evaluation of decontamination efforts for exposure to traditional and non-traditional chemical agents, including interventions for standard battlefield trauma sustained in a chemically contaminated environment. The USAMRICD purchased their digital slide scanner in 2022, along with an image analysis and deep neural network software. Histopathological analysis of brain or inner ear damage caused by agent or non-kinetic weapons typically requires closely stepped serial sectioning of the organs. Digital scanned images of these sections have allowed pathologists to compare multiple sections from the same animal or sections from different animals in a research colony on one screen, or quickly screen multiple slides for the anatomic area of interest, while also conserving the ability to zoom images instantly. This has significantly decreased the amount of time required to complete the analysis of these tissues. Consultation on histology images with investigators or other pathologists, used to be hampered by the lack of a multi-head microscope at USAMRICD. Now, the pathology team can display the scanned slide image at any workstation or conference room, and quickly present and discuss the histopathological findings. Figures from articles or stereotaxic atlases can be displayed on an adjacent monitor, allowing for direct comparison to the digital histology image. In addition, manuscript-quality images can be captured directly from the scanned slide, with a larger variety of magnification and annotation tools than would be available from a traditional microscope.

Where appropriate, image analysis software has allowed analysis of pathological processes to shift from semi-quantitative (eg, mild, moderate, or marked severity) to quantitative values of the number of cells present or the percent of an area of tissue affected, increasing the ability of investigators to perform meaningful statistical analysis of the data. The deep-learning software is currently being taught to screen for specific histologic cellular alteration or immunohistochemical staining patterns that will alert the pathologist to sections requiring more thorough analysis or possible electron microscopic evaluation.

Consultation and Diagnostic Services

Consultation

Digital histology allows pathologists to consult with colleagues at other institutions without requiring expensive travel or shipment of hazardous or fragile materials. For example, PHCE receives veterinary tissue samples and cytology slides from veterinary treatment facilities and deployed military veterinarians located across Europe, Africa, and the Middle East. Only one diagnostic veterinary pathologist is stationed in Europe to handle the pathology submissions, so the capability to readily consult with colleagues back the United States is invaluable for difficult cases. Rather than expending the time and risk involved with shipping glass slides from Europe to the United States, PHCE can instead scan a slide in-house and send it digitally to the JPC. PHCE implemented their digital slide scanner in late summer 2022 and has already sent multiple cases for consultation. Sending digital slides instead of mailing glass slides has proven to be significantly simpler, faster, and cheaper. WSI allows the pathologist to provide the submitting clinician with a more thorough response in less time. Decreased time to arrive at a diagnosis means definitive treatment can begin sooner, which directly impacts the prognosis for a patient's recovery.

Figure 4. LTC Erica Barkei and MAJ Amanda Hauck reviewing a digital slide. Courtesy of LTC Erica Barkei.

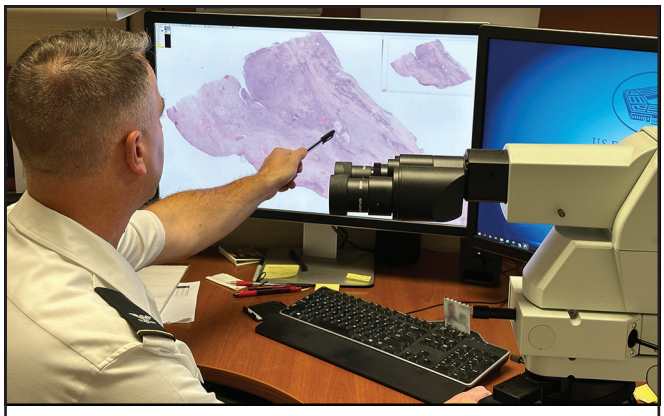

Figure 5. COL Jeremy Bearss reviewing a digital consultation case. Courtesy of LTC Sarah Cudd.

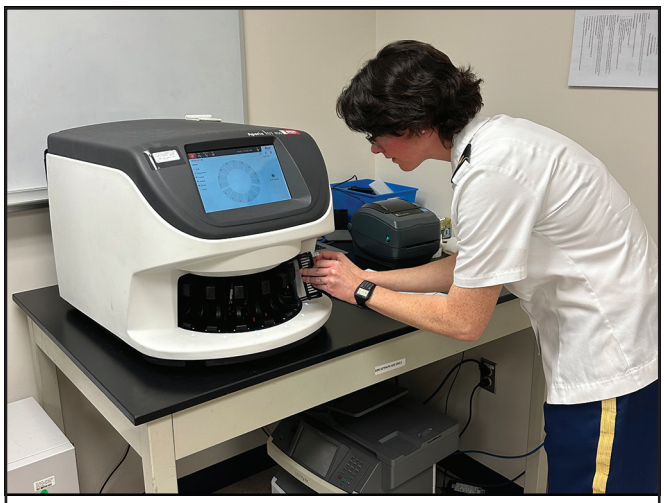

Figure 6. MAJ Sarah Cudd loading slides into digital slide scanner. Courtesy of LTC Sarah Cudd.

Diagnostic Services

Digital slide scanning allows computer-based histopathological analysis using viewing software from anywhere the user has access to the secure image database. For more strictly diagnostic services like the services available at JPC and PHCE, the additional step of scanning histology and cytology slides has improved turnaround times. PHCE obtained their scanner in late summer 2022 while the JPC obtained their in-house digital slide scanner in spring 2022. Now, staff pathologists and residents are able to view diagnostic slides from home if needed, which facilitates these rapid results. Also, whole slide image digital files produce clearer still images which can be embedded into consultation reports, furthering their educational purposes.

Advantages and Limitations

Storage

Permanent storage space is always a consideration with glass slides. The JPC tissue and slide repository contains 55 million glass slides, filling a 5,000 square foot building from top to bottom.[5] The conversion of glass slides to digital files saves a tremendous amount of physical space. Additionally, immunofluorescence and other immunohistochemical and histochemical stains have a finite diagnostic shelf life. Like fluorescence and indirect immunofluorescence assay, immunohistochemical slides begin to degrade soon after production; rapid digitization after slide creation preserves the information contained on the slide permanently. The same is true of conventionally prepared slides whose staining intensity fades over time. Digital files can replace the need to retain glass slides indefinitely, as digital files create a permanent, easily maintained archive. The entire slide, with multiple magnification levels retained, can be retrieved at a later date with no loss of image integrity, for use in further study or manuscript publishing.

For all the pathology locations currently utilizing digital slide scanners, the major limitations are procuring sufficient digital storage space and accessing the digital slide files. Digital slide file sizes range between 2 to 18 megabytes with supplementary files up to 35 megabytes, depending on how much of the glass slide is filled by the sample. Slide quantity can range from one slide for a single diagnostic case to hundreds or even thousands of slides for an individual research study; total institutional slide numbers can get astronomical quickly! Proper planning and communication with and between IT departments is invaluable. Dedicated servers are necessary and partitioning off sections for education, diagnostics, and research has been helpful in terms of organization, particularly at JPC where thousands of diagnostic case slides have been saved to date. The second limitation is accessing digital slide files. Most institutes have secure online slide databases, but JPC is still adding files to an internal share drive. Depending on security protocols it can take time to ensure all staff and consulting veterinarians have access.

Cost

Another limitation to consider is the cost to procure the digital slide scanners, associated software, and service contracts. Quotes to acquire the digital slide scanner at the JPC ranged from $150,000 to $275,000 depending on the machine manufacturer and model. Despite the initial cost, the overall ease of use, speed of slide scanning, ability to view slides from any workstation, and physical space saved for most of the pathology locations justify the investment. As with digital storage space, budgetary considerations must be accounted for early in the procurement process.

Education

In a group in-person setting or over virtual conferencing software, digital images projected on computer or large screen devices greatly facilitates consultation and education of scientists in numbers exceeding those typically permitted by a traditional multi-headed microscope. Even laypeople can follow along with a “TV” type presentation, and the rapid focus and zoom is far superior to using a conventional microscope

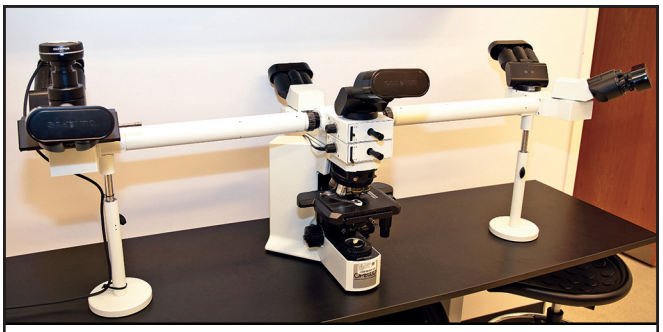

Figure 7. Example of a multi-headed microscope. Courtesy of LTC Sarah Cudd.

to demonstrate lesions. Most digital slide reading software also allows for digital annotations to be added, which assists in presentation of the case, as well as image adjustment capability for color and clarity.

At the JPC, during the COVID-19 pandemic, having all educational and diagnostic slides scanned allowed for safely teleworking while continuing a rigorous class schedule. This has since translated to virtual classes, rounds, and conferences which allow Veterinary Corps Officers (VCOs) who submit cases or are interested in pathology to tune in and listen to the discussion. The JPC online educational platform, Veterinary Systemic Pathology Online (https://www.askjpc.org/vspo/), has a full database of digital slides for viewing entities in all biological systems, normal animal slides, examples of background lesions, and artifacts. The JPC's Wednesday Slide Conference (WSC) receives materials from all around the world. With digital sharing there is no need to produce duplicate slides in the event of collaboration or consultation requests. Slide digitization also allows for submission of smaller lesions, lesions from exotic or endangered species, or lesions caused by pathogenic organisms with no concerns about shipping potentially infectious agents or tissues from endangered animals. These advantages directly increase the variety of cases available for all residents and international pathologists participating in WSC.

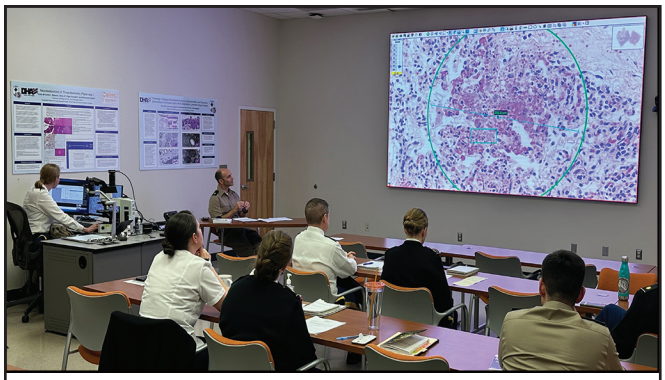

Figure 8: LTC Joseph Anderson moderating a fully digital WSC. Courtesy of LTC Sarah Cudd.

When pathologists present at conferences or give educational talks, having high quality images to show is invaluable to the learning experience. Digital slide scanning allows the production of high-resolution images of histologic lesions that are vastly superior to images acquired by other means. Digital slide scanners allow for near perfect color accuracy and incredible detail resolution, which is essential for a field such as pathology that is based on visual analysis of diagnostic specimens. This technology directly impacts the educational value and allows Army veterinary pathologists to maintain a reputation for excellence within the profession.

Conclusions

Future Applications

Leaders within the 64D community are pushing for all military institutes where veterinary pathologists work to eventually transition to WSI scanners, enabling not only information sharing, but workload sharing. This transition would be a boon as demonstrated by recent history during the rapid efforts to develop COVID-19 prophylaxis and treatments, ongoing Ebola outbreaks and increased research efforts, and in the event of personnel shortages.

Another future application is quantitative analysis using cell counting software. Again, USAMRICD has purchased it already, while other institutes are considering it. In essence, the user teaches the program what to look for and the system uses deep AI to self-educate. It can then scan a complete slide very rapidly and produce an objective (more so than a human) quantitative product making statistically generated results more accurate.[6]

Although they have a high initial price-tag, WSI scanners have already more than proven themselves in ease of use and by facilitating rapid turnaround of diagnostic and research results, image sharing and consultation, and in saved physical space. Over time, the technological limitations described will no longer be an issue as we develop more advanced methods to save large amounts of data. Army veterinary pathology has made a quantum leap forward with the acquisition of digital slide scanners, putting their pathology capabilities on par with many industry leaders and has positioned Army veterinary pathology and the military medical community for excellence far into the future.

Acknowledgements

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Animal-Assisted Interventions in the Military: Historical Perspective and Future Direction

LTC M. Todd French, VC, USA

Abstract

The United States Military was early to recognize the health benefits of animal-assisted intervention (AAI) in the health care setting and has supported and developed successful programs since World War I. Most of these programs simply provided the benefit of a friendly animal in the health care setting until the novel use of trained service animals as "co-therapists" was introduced at the Walter Reed National Military Medical Center in the early 2000s. Programs were further advanced in 2007 with the inclusion of service animal dogs embedded with occupational therapists in deployed combat environments. Despite the success of these programs, animal acquisition complications, conflicting terminology used to define animal participants, and unclear policy guidance has stifled the advancement of these AAIs in the Department of Defense. Fortunately, recent factors have created an avenue for program growth and expansion that make programs feasible and sustainable. The first is the continued growth of empirical data in the scientific literature on the benefits animals provide to physical, mental, spiritual, and emotional health. Next, there is a general increase in military community and key leader acceptance of the benefits of AAI coupled with recognition of the value of service animal effectiveness as a complementary therapeutic intervention (especially in the treatment of posttraumatic stress disorder). Lastly, there is a new focus on proper AAI terminology, comprehensive policy, and innovative approaches to acquiring trained psychiatric service dogs embedded with health care facilities (facility dogs) and military units (therapeutic support dogs).

Keywords: human-animal bond; military; animal-assisted interventions; policy; therapy dog; psychiatric service dog; facility dog; therapeutic support dog

The Human-Animal Bond, Animal-Assisted Interventions, and "Therapy Dogs"

The desire to incorporate animals into our everyday lives is evident throughout recorded history. Early humans saw the benefit of using pack and draft animals to accomplish working and transportation tasks, but this relationship likely expanded to include companionship with the domestication of dogs approximately 10-20K years ago. Strong bonds grew from this companionship as recent genetic evidence shows that these humans dispersed throughout the world in tandem with the dogs they domesticated.[1] As the bond deepened and broadened to include other companion species, societies integrated companion animals further into human culture. These animals became pets, then the pets became family members as humans shared their homes, and the science behind the bond began to take shape. Over time, the scientific community discovered that the human-animal bond existed because it provided value to humans and animals, as each party benefitted during human-animal interaction. As the research behind this mutually beneficial partnership evolved, so did efforts to define what makes the bond unique. The American Veterinary Medical Association (AVMA) describes it as a "dynamic relationship between humans and animals that is influenced by behaviors essential to the health and well-being of both."[2]

Animal-Assisted Interventions: Definitions and The Law

As the emphasis on the overall health and well-being effects of human-animal interaction expanded, so did the inclusion of companion animals in health-focused interventions. Health care providers like nurse Florence Nightingale, who pioneered the incorporation of birds, tortoises, and cats into her patient care, and therapists Sigmund Freud and Boris Levinson, who utilized their personal dogs to facilitate therapy sessions, were the first attributed with the concept of using human-animal interventions as part of health care.[3] Organizations like the Delta Society, now Pet Partners, and the American Red Cross developed modern applications of human-animal interactions.[4,5] The AVMA defined these animal and intervention programs through the creation of a Human-Animal Bond (HAB) Task Force, and more recently, an American Animal Hospital Association (AAHA) Working

Group of human-animal bond professionals.[4,6] The popularity of animal inclusions in the health field grew as the primarily anecdotal evidence of the benefits of the human-animal bond spread in the healthcare community. Healthcare providers in mental, physical, spiritual, and emotional health fields realized that the benefits of animal inclusion numbered beyond "a nonjudgmental presence," and roles of animal utilization in interventions began to be further delineated.[7,8.]

Animal-assisted intervention (AAI) encompasses all forms of animal inclusion in a structured and goal-oriented health promotion program. The umbrella term AAI includes the sub-terms Animal Assisted Activity (AAA) and Animal Assisted Therapy (AAT) (Figure 1).[9] Generally speaking, AAA programs utilize the simple presence of an animal to provide a health promotion benefit. These programs are typically characterized by a short "meet and greet" by well-behaved animals and their owners, directed by professionals at health care or assisted living facilities. These animal-assisted activities also include crisis response teams that provide comfort and support after a traumatic event, eg, after a natural disaster (Figure 2).[10] There is no international standard or requirement that these animals are trained beyond basic obedience to provide AAA. Still, some organizations offer or require advanced human-animal team training and certification to participate in an organization-sponsored intervention. These organizations exist as national and international entities, eg, Pet Partners, Therapy Dogs International, Alliance of Therapy Dogs, and programs that service a local area associated with health care facilities.

Animal assisted therapy (AAT) programs are more advanced, goal-directed, planned, and structured interventions where credentialed health, education, or human service providers, eg, social workers and psychologists, implement the interventions and measure patient progress in professional documentation or medical record.[10] The assistance of an animal to provide balance training during occupational therapy or complement the benefits of traditional psychology or social work treatment are a few examples of AAT. Most AAT programs require additional training for the human-animal team, given the specific nature of the intervention, even though there is no international standard or requirement that AAT animals are trained beyond basic obedience. The International Association of Human-Animal Interaction Organizations (IAHAIO) also released education and training minimum standard guidelines to ensure both human and animal health, safety, and well-being are maintained.[11]

The general public frequently uses inconsistent terminology not based on scientific or legal definitions to describe animals participating in programs despite attempts to standardize human-animal bond and intervention related definitions. The inconsistent use of terminology makes it difficult to develop and enforce AAI policy and causes potential confusion in the legal protections and access afforded to individuals with assistance or working dogs. To address this, the AAHA

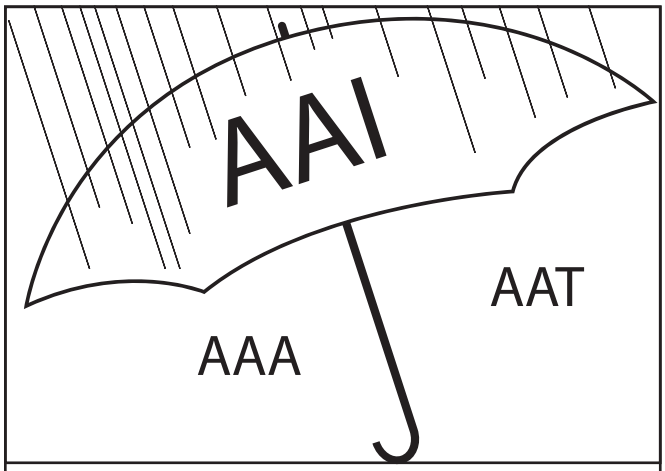

Figure 1. Animal-assisted intervention (AAI) is an umbrella term that includes animal assisted activity (AAA) and animal assisted therapy (AAT).

Figure 2. Keeper, a Crisis Response Dog, visits Schriever Air Force Base, Colorado. Photo by Kathryn Calvert, 50th Space Wing Public Affairs. 17 December 2019. DVIDS. Accessed 01 December at https://www.dvidshub.net/image/6047273/therapy-dogs-visit-schriever

working group published a guide to align the definitions for therapy, assistance, and working dogs.[6] "Therapy dog" has become common vernacular to describe a dog participating in any form of AAI. However, therapy dog is occasionally misused to describe any dog that provides comfort. The use of therapy dog is appropriate in most instances if it does not represent an assistance or working dog. A therapy dog differs from an assistance dog in that a therapy dog is a pet that participates in AAI, whereas an assistance dog's primary role is to provide aid to an individual with physical or mental impairments. There are two categories of assistance dogs: service and emotional support. A service dog is trained to be utilized by an individual to assist with activities of daily living and is the only category of animal legally protected under the Americans with Disabilities Act (ADA). An emotional support dog's (ESD's) primary role is to provide comfort, and their use is supported by a qualified health professional based upon a disability-related need. Emotional support dogs (ESDs) may have certain protections under the Fair Housing Act but, like therapy dogs, they are neither recognized nor legally protected under the ADA. A "working dog," further categorized as detection or protection animal, is used in military, public law enforcement, or disaster response/rescue settings. Service and working dogs are the only categories requiring formal training and certifications to perform their duties.

The Health Benefits of Animal-Assisted Interventions

Research-based evidence slowly began to replace anecdotal reports of the health benefits of the human-animal bond in the late 20th Century, anchored by Friedmann's landmark findings that pet ownership improved post cardio-traumatic event survival.[12,13] Since then, the science supporting the health-promoting effects of pet ownership on humans has become more robust in the peer-reviewed literature. In addition to improved cardio-traumatic event recovery, the human-animal bond decreases the risk of cardiac disease, lowers blood pressure, reduces anxiety and stress, decreases the incidence of allergies in children, and positively affects hormones related to well-being, including cortisol, oxytocin, b-endorphin, prolactin, phenylacetic acid, and dopamine.[14,15]

The scientific literature supporting the health-promoting effects of pet ownership provided a clear path to study the impact that AAI programs could have in the health care setting. Over the last few decades, researchers have sought to prove the hypotheses suggested by Nightingale, Freud, and Levinson's inclusion of animals in health care settings. Research on AAI shows that the positive human-animal bond effect is reproducible in health care settings. This literature indicates that implementation of AAI programs can result in reduced heart rate and blood pressure; increased immunoglobulin A (linked to enhanced immune function); reduced depression, anxiety and loneliness; and increased perceived quality of health services.[16] Multiple studies on infection control, bite/scratch, and allergy concerns of allowing AAI animals into health care facilities demonstrate that risks are easily mitigated through use of simple hygiene practices, recognizing signs of stress in the animal, and taking an approach that considers the interplay of human and animal health within the shared environmental space.[17,18] Ultimately, metaanalyses and systemic reviews on AAI in healthcare facilities show that the benefits far outweigh the risks, particularly when leaders and stakeholders develop then continuously refine best practice policies that prioritize animal welfare.[19-22]

There is also emerging research on the impact of AAI on the most important participant: the animal. Recent studies investigating the effect of AAI on animals, particularly dogs, indicate that animals benefit from the interaction as well. These studies show that dogs in AAI programs may have decreased stress and anxiety when participating in programs and general human-animal interactions as measured by decreased salivary cortisol and increased oxytocin.[23,24]

AAI Benefits Healthcare Providers

The demands of working in the mental, physical, spiritual, and emotional health care space are understandably associated with increased stress and anxiety. In fact, the 2022 US Bureau of Labor Statistics data shows that almost half of the "25 Most Stressful Jobs" are in health-care–related fields.[25] A recent large observational study investigating the impact of stress on 21,000 health care providers during the COVID-19 pandemic showed nearly half, 43% and 49%, experienced increased stress through burnout and work overload, respectively.[26] "Burnout," the state of emotional, mental, and often physical exhaustion brought on by prolonged and repeated stress, [27] is

Figure 3. Madigan Army Medical Center (MAMC) facility dog "Captain Earl" poses with the physical therapy staff. Photo provided by Valerie Cramer, America's VetDogs.

not a new concept. Still, it has recently gained popularity to exemplify the effects of ever-increasing demands in the workplace. In his study on burnout in health care providers, De Hert reveals that it impacts well-being and quality of care delivered, and 1 in 3 physicians experiences burnout at any given time.[28] Prolonged and repeated stress in health care providers may also be linked to higher infection rates among patients.[29] Disengagement by hospital leadership is one root cause frequently identified as playing a role in increased staff stress. When there is a noticeable lack of care or workplace strategies by leaders to decrease stress and mentally reward staff, perceived stress is much higher, and simply showing workers are valued can reduce perceived burnout by up to 40%.[26,30]

One potential approach to decreasing stress in health care workers may be implementing AAI. Animal assisted intervention (AAI) programs have the potential to provide a high health reward with low associated risk. The benefits of AAI on health care workers may provide a statistically significant stress reduction during as little as one 5-minute interaction (Figure 3).[31,32] There have also been increasing trends over the past decade, particularly since 2019, indicating a desire to include animals in business and organizational settings to counter social isolation and stress and improve work engagement, commitment, and quality of life.[33-35]

Animal-Assisted Interventions in The Military

Overview

The United States' military has a long history of highlighting the positive effects of the HAB dating back to the Revolutionary War. For example, George Washington ordered a ceasefire during the Battle of Germantown to feed, groom, and return a dog belonging to British General William Howe that had wandered onto the battlefield.[36] Today, military families consider their pets to be an integral part of the family and express long-term sadness when pets cannot be included during the frequent military moves inherent to the career.[37,38] Military children also frequently utilize companion animals as a successful adaptive coping strategy when a parent deploys.[39] Human animal bonds (HABs) can even be used as a strategy for the military community to achieve the sleep, nutrition, and activity goals outlined in the Army Surgeon General's public health initiative, the Performance Triad.[40] The US Army Veterinary Services considers the bond so important to military history that it included an entire chapter on military HAB in the 2019 Borden Institute book on *Military Veterinary Services*.[41]

Organized AAI in the military has a similarly lengthy past. Military-promoted programs can be traced to therapeutic interventions in psychiatric patients after World War I and American Red Cross AAA programs implemented after World War II that utilized dogs to comfort convalescing

Figure 4. MacGregor, a Red Cross Human-Animal Bond Dog, at the Camp Arifjan, Kuwait, Resiliency Center. Photo by SPC Angela Ohearn, U.S. Army Central. 01 July 2016. DVIDS. Accessed 02 December at https://www.dvidshub.net/image/2716747/deployed-life-not-ruff-with-help-therapy-dog

service members (SMs) in the Army-Air Force Convalescent Center in Pawling, New York.[5,42] The American Red Cross continued to implement organized meet and greet AAA into larger military treatment facilities (MTFs) (Figure 4), including the "gold standard" for robust programs located at Tripler Army Medical Center, Hawaii, which has been in place for over 30 years.[43] In addition to AAA programs, the military has been a leader in innovative AAT programs focusing on the physical and mental recovery of wounded SMs.[44] The most notable of these is the Mission-Based Trauma Recovery (MBTR) Program developed by the non-profit Warrior Canine Connection (WCC) organization at the Walter Reed National Military Medical Center (WRNMMC), in Bethesda, Maryland. The MBTR model helps SMs recover from

Figure 5. A Soldier does a physical exam on a WCC service dog in training through the Mission Based Trauma Recovery Program. 25 August 2015. DVIDS. Accessed 01 December at https://www.dvidshub.net/image/2162420/warriors-receive-therapy-through-service-dog-training-program

combat stress and reconnect with their families, communities, and life. The enrolled MBTR SM trains potential service dogs from puppy to adulthood, at which point a veteran in need of a service animal receives the service dog as a donation (Figure 5).[45] Further evidence supporting military AAT is in a 2012 study on the program's effect on 24 wounded SMs attending an Occupational Therapy Life Skills program. The study showed that the AAT treatment group displayed elevated mood and increased resilience compared to a control group without AAT.[46] Present-day military AAI comprises AAA/AAT programs across the Department of Defense (DoD) landscape and ranges from basic visitation programs to the inclusion of dogs embedded into medical and behavioral health treatment programs and AAI programs in the deployed environment.[4]

The Benefit of Facility Dogs and The WRNMMC Program

Facility dogs are a subset of animals embedded in a health care facility participating in AAI. These dogs require specialized training to perform AAI for multiple groups and reside in the facility during working hours. Handlers of facility dogs complete training to handle the dog, which lives in the handler's home during nonworking hours. Specialized training is essential in handler-dog teams. Animal assisted intervention (AAI) is performed over an extended period, so the handler must recognize signs of stress in the dog and alter the intervention when necessary. Because of the type of intervention, accredited service dog training organizations train facility dogs and their handlers as a team.[47,48] There is a scarcity of research[49] on facility dogs outside of qualitative assessments related to their use in support of children at pediatric hospitals and courtrooms, particularly when a child is called on to be a forensic witness. However, recently published studies on facility dog impact on veterans' mental and emotional health, child patients, and staff in health care facilities indicate that embedded dogs may improve stress, well-being, job morale, burnout, and perceived mental health.[50-52] Despite the lack of published research, it is reasonable to assume that facility dog programs confer similar health-related benefits to traditional AAI and that those benefits outweigh the infection control, bite/scratch, and allergy concerns associated with embedding the dog as long as animal welfare is prioritized.

The utilization of facility dogs in military health care facilities has been a novel concept since the early 2000s. Until 2019, the only recognized facility dog programs in the DoD existed at WRNMMC and the National Intrepid Center of Excellence (NICoE). The smaller NICoE program is atypical in that the primary focus is individualized, rehab-based MBTR and AAT.[53] The WRNMMC program became the first established facility dog program in the DoD in 2005. This program is typical in its utilization of facility dogs. It provides comprehensive AAA in the hospital and focused AAT for wounded SMs recovering from injuries such as limb amputation. The program at WRNMMC began with just one dog, Deuce, but now has seven, including former President George H.W. Bush's service dog, Sully, as the program advanced over the past 10 years.[54]

Military Animal Assisted Intervention Policy: 2007-2019

Despite the success and popularity of the WRNMMC program, the expansion of policy-anchored and, command supported, DoD facility dog programs did not truly begin until 2019. This was due, in part, to the rigidity associated with animal acquisitions that are considered donations to the Army and the lack of higher echelon policy guidance related to acquisition of the animals. In 2007, shortly after the WRNMMC program started, a collaborative effort between the Army Veterinary Command and the Office of the Surgeon General's (OTSG's) Behavioral Health Division resulted in the donation of two trained service dogs (Boe and Budge) to be embedded with the 85th Combat Operational Stress Control (COSC) unit occupational therapy team to pilot AAI in the deployed environment.[55] The success of this pilot program led to the donation of six additional dogs; eight total from 2007-2012. The dogs were designated as gifts to the Army and valued at >$25,000 each, not including the cost of continued care.[56] The value of these animals was subject to the policy guidelines of the *Army Gift Program*, Army Regulation 1-100. The program was ultimately discontinued in 2012 due to the logistical challenge required to acquire and decommission the animals as donated gifts.[57] Even though these dogs were not initially used as facility dogs[58], obtaining a facility dog potentially provided a roadblock preventing the development of new facility dog programs. Essentially, the WRNMMC program was the "exception to the rule." In the author's opinion, this was due to the partnerships with several nonprofit, veteran- focused, service dog training organizations, eg, Warrior Canine Connection and America's VetDogs, who provided dogs outside of the donation framework, coupled with the large, highly-visible, occupational therapy mission that guided local facility dog policy.

After the effective collaboration between the Army Veterinary Command and the OTSG on the COSC dog program, the organizations convened an AAT summit with other DoD stakeholders in 2009 to coalesce on standard definitions for AAI terms and propose military AAI policy going forward.[59] Until then, the only doctrinally relevant military AAI guidance came from Technical Bulletin TB MED 4: *DoD Human-Animal Bond Principles and Guidelines*, first published in 2003 and updated in 2015, which gave a historical perspective of military HAB and basic guidance for program implementation.[60] The summit, designating the U.S. Army Medical Command (MEDCOM) as the lead agency for policy development, helped produce the first modern-day Service specific

policy on AAI in military healthcare with the publishing of OTSG/MEDCOM Policy Memo 10-077: *Use of Canines and Other Service Animals in Army Medicine*. The Policy Memo directed hospital commanders to consider the benefits of allowing animals in the healthcare facility, provided a guide for general access procedures, and made designations between service animals, therapy animals, and companion pet animals.[61] This policy also gave specific guidance/permission for AAT that utilized service animals in training, ie, the WRNMMC programs. This AAI policy was updated in 2012 with the release of OTSG/MEDCOM Policy Memo 12-005: *Overarching Guidance on the Use of Animals in the Healthcare Setting: Service Animals, Animal Assisted Therapies, and Animal Assisted Activities*, OTSG/MEDCOM Policy Memo 14-051 in 2015 (minor updates to 12-005), and again in 2017 OTSG/MEDCOM Policy Memo 17-040: *Animal Access to Healthcare Facilities* with each update continuing to support and direct the use of AAI programs while also providing additional policy guidance on the acquisition of service animals by SMs, which began to be supported by the Army and the Department of Veterans Affairs (VA) in 2013.[62, 63]

Although the 2009 AAT summit accomplished its goal of developing AAI policy for military health care, it fell short in two ways: expanding AAI definitions to specifically include facility dogs and outlining a way ahead in facility dog acquisition. The resulting AAI policies did an excellent job developing a permission structure to support various AAI programs but ultimately relied on TB MED 4 to guide animal use. While the 2015 update to TB MED 4 did describe the property accountability, expected temperament, care, and disposition of animals once acquired, referred to as "category I, DoD-owned animals," it did not address the challenges of the acquisition process.[64] Unfortunately, the primary focus on these animals in TB MED 4 is horses and mascots. Technical Bulletin MED 4 refers to these as "resident animals," which is an outdated term that does not imply a training requirement.

The Emergence of Military Facility and Therapeutic Support Dog Programs in the DoD

Military Facility Dogs

Military health care facilities have been reluctant to institute facility dog programs. One explanation for this reluctancy is that policy did not specifically define facility dogs or address their acquisition outside of the Army donation program. However, things started to change in 2019 beginning with the implementation of the first recognized facility dog program outside of WRNMMC at the Uniformed Services University of Health Sciences (USUHS).[65] Since 2021, four additional programs have been established at various facilities across the DoD, with several more anticipated soon.[65,66] While multiple factors likely influenced facility program growth in the DoD, the following three are particularly important:

1. Continued growth of empirical data in the scientific literature supporting the benefit of animals in healthcare facilities, and a general increase in the military community and key leader acceptance of AAI.
2. Recognition of the value of service animal effectiveness as a complementary therapeutic intervention, especially in the treatment of posttraumatic stress disorder.
3. An innovative approach to the acquisition process.

The first of these factors was discussed at length above and HAB researchers and advocates can gain key leader support through continued research in the HAB field. The second factor, the acceptance of service animals, was crucial because it outlined a standard training requirement that could translate to military facility dog certification. Service animal policy originated at the VA in 2012 after the organization successfully piloted research confirming the benefit of service animal utilization as a complementary therapy for wounded SMs directed by the US Congress.[67] The Army soon followed in 2013 with the first in the DoD service animal policy, which aimed to establish requirements for training and acquisition.[68] The training standard required that dogs be acquired from service dog organizations accredited by either Assistance Dogs International (ADI) or the International Guide Dog Federation (IGDF) to mitigate the risks associated with an improperly trained dog.

Additionally important, was the recognition by the VA and DoD in 2015 of the benefit conferred by service animals to SMs with posttraumatic stress disorder (PTSD). Department of Defense (DoD) policy finally did not exclude PTSD service animals, sometimes referred to as Psychiatric Service Dogs or PSDs, which were prohibited in policy before 2015.[69] This was due in part to the evidence supporting the use of AAI to trauma victims that has been mounting over the past few years.[70,71] The evidence supporting the benefit of PSDs was so overwhelmingly positive that the US Congress directed the VA to open PSD training centers in 2021 through the Puppies Assisting Wounded Servicemembers (PAWS) Act.[72,73] In response, several veteran-focused service dog organizations began to seek ADI/IGDF accreditation while also increasing the volume of dogs trained as PSDs.[66, 74]

The nonprofits Warrior Canine Connection (WCC) and America's VetDogs (AVD), both ADI accredited to train PSDs, leaned forward in PSD practices. The WCC's primary contribution was continued support to their PSD-focused MBTR Model as it expanded through the PAWS Act.[75] America's VetDogs (AVD), the proponent and provider of the 2007 COSC dogs, continued to advocate for the benefit that PSDs provide to mental, physical, spiritual, and emotional health, and began working on expanding military facility dog programs outside of WRNMMC.[66] A key contribution from AVD was an innovative initiative to replace

Figure 6. Facility dog Lt. Cmdr. Shetland provides support and training to medical students at the military medical school, USUHS. Photo provided by Valerie Cramer, America's VetDogs.

dog donations with custody agreements.[76] This reframing of dog acquisition permits the utilization of a dog without the arduous logistical requirements associated with a donation to the DoD. Essentially, AVD's custody agreement provides custody to a handler but keeps liability with the donating organization. Further, AVD coordinates with the facility to assess the feasibility and sustainability of a program. This assessment is the most critical step in the process as facility dog programs are not a good fit for all facilities. The facility designates a handler(s) and cosigns a memorandum of understanding with AVD outlining the custodial and program conditions. The dog and handler are trained by the owning organization (AVD) and must revalidate training every year. The gaining command places the dog on appointment orders to "work" at the facility, but they live with their handler, who provides all essential care. Fail-safes built into the agreement ensure constant advocacy for the dogs, who are returned to AVD if found not to be a good fit for the program or upon retirement. Dogs participating in military facility dog programs are trained as PSDs to provide AAI by recognizing and responding to stress and anxiety in a group setting. Given the potential value this skillset could provide throughout the military and the success of the COSC dog program, AVD began to collaborate with military organizations outside of the clinical setting to initiate programs. Doing so showed that a PSD provided by a VA-accredited organization could be a training standard for facility dogs. This example led to the introduction of Labrador Retriever (Navy) Lieutenant Commander Shetland to USUHS as the first permanent facility dog at a medical school (Figure 6). In addition to his stress relieving duty, Lt. Cmdr. Shetland and his handler taught military medical students about the benefits of incorporating AAI in health delivery.[77] As of March 2023, including WRNMMC and USUHS, AVD helped integrate military facility dog programs in the Massachusetts National Guard; Camp Lejeune, North Carolina; Fort Liberty's Intrepid Spirit Center, North Carolina; VA facilities in California and Virginia; Air National Guard Readiness Center, Joint Base Andrews, Maryland; Brooke Army Medical Center, San Antonio, Texas; and, most recently, Madigan Army Medical Center, Joint Base Lewis-McChord, Washington, where Labrador Retriever Captain Earl provides AAI for the Madigan Peer Support Program.[66,78]

Attempts to Recreate The Combat Operational Support Control (COSC) "Therapy Dog" Program

Increased acceptance of AAI programs in the DoD led to attempts to recreate the COSC dog program, an AAI designed to support deployed military units. The 2009 Military AAT summit produced the initial COSC AAI policy that outlined all aspects of the program, to include detailed requirements for animal care and travel, and directed appropriate responsibilities to subordinate units. This policy provided a loose interpretation of training requirements when defining "COSC Therapy Dogs," meaning it did not indicate formal training was necessary.[79] The policy expired in 2013 and was not updated in the years following. With few notable exceptions, the lack of policy guidance led to several attempts to implement unauthorized programs in both COSC and nonCOSC units in the DoD Central Command (CENTCOM).[80] The primary issue was that most programs relied on the inclusion of poorly trained or untrained stray dogs. In addition to elevating the public health risk of zoonotic disease transmission, the Rabies virus is endemic in many countries in CENTCOM; the inclusion of these animals often violated CENTCOM General Order #1, which prohibits the acquisition of pets/mascots in the area of operation. However, confusion over the authorization of programs and the acceptability of animals also potentially arose over the poorly drafted theater-specific memoranda. One example of this was a 2012 Joint Task Force-Empire (Afghanistan) policy memorandum that indicated that an "AAT Dog" could either come from a service dog training organization (AVD mentioned) or "US Military veterinarians may approve dogs born in theater for use as AAT Dogs".[81] In the author's opinion, the implementors of these programs did not consult US Army Veterinary Services or MEDCOM leadership on the language in this memorandum. Still, this document is consistently used since 2012 as a reference policy for units

interested in implementing COSC Therapy Dog programs.[80] In 2018, an information paper to a CENTCOM medical commander outlined the increased risk this memorandum displayed. In the report, a COSC health care provider indicated that one of the COSC dogs (a stray rescued in theater) "has not adapted well to being a morale/therapy dog. She continues to jump and nibble inappropriately. Reasons for this include that she's not had any formal training…"[82]

Therapeutic Support Dogs: Rebranding and Expanding COSC AAI

The 2007 COSC Therapy Dog program was extremely popular within the 85th COSC and with the SMs that benefitted from the AAI the dogs provided. Several articles documenting these benefits were published, including one in which COSC Occupational Therapy handlers expressed the following,

> *"Ultimately, it was an experience of a lifetime for the occupational therapists who were the primary dog handlers, as well as for the Service Members and Civilians who had a therapy dog in their deployed environments. One of the most difficult coping aspects of deployment to a war zone is the fact that Service Members are away from family and loved ones during difficult and highly stressful times. The presence of a therapy dog in this situation offers our Service Members the ability to express and receive affection in an appropriate manner."*[83]

Unfortunately, the animal donation issues, a loose interpretation of training needs, and related policy gaps after 2012 prevented the program from being standardized appropriately. However, standardization and future implementation of these programs is possible as there is growing acceptance for instituting rigid training requirements, an understanding of animal acquisition through custodial agreements, and appropriate framework policy, especially Policy Memo 11-030, despite the overuse of the term "therapy dog." As described previously, the term "therapy dog" is used broadly to define dogs, trained or untrained, that participate in AAI and ranges from AAA "meet and greet" dogs to PSDs utilized in AAT. This is not an issue in military facility dog programs as "facility dog" has a distinction in the AAI field. To address this issue concerning "COSC Therapy Dogs," the author proposed an alternate descriptive term, "therapeutic support dog," to the Defense Health Agency-Veterinary Services, the proponent of animal related policy in the military.

> ***Therapeutic**: relating to the treatment of disease or disorders by remedial methods, having a beneficial effect on body and/or mind, and producing a useful or favorable result. (www.merriam-webster.com)*

The term "therapeutic support" is fitting as it denotes the AAI benefits the dog provides, is distinctive from the more ubiquitous "therapy," and allows for the expansion of the program beyond COSC units. As the utilization of service animal trained dogs for group AAI has grown, so has the recognition of the benefits they may provide to nonCOSC units in the deployed environment. This applies to military chaplains and their support staff, Unit Ministry Teams (UMT), that are tasked to provide religious, spiritual, and emotional support to deployed Soldiers.[84] These programs may also be associated with nondeploying religious support units whose primary mission is to provide services in the garrison environment.

The Future of Military Facility Dog, Therapeutic Support Dog, and AAI Programs and Policy

The current AAI policy development documents in the DoD are the OTSG policy on animals in healthcare facilities (Defense Heath Agency Procedural Instruction- DHAPI 6025.18: Animal Access to Facilities), US Army Veterinary Services regulatory guidance (Army Regulation: AR 40-905 *Veterinary Health Services*)[85], and TB MED 4: *DoD Human-Animal Bond Principles and Guidelines*. These documents are currently being revised and will include updated AAI policy and "facility dog" and "therapeutic support dog" definitions. The definitions will align the training requirements, ie, dogs and handlers must be specially trained by a VA-recognized service dog training organization for AAI but differ in scope. Facility dogs will be defined as attached to or embedded in a healthcare facility and having (primarily) civilian handlers. Civilian handlers will predominate as they are a more stable presence than military handlers who are expected to transition to new facilities frequently (Figure 7). One notable exception to association with a healthcare facility may be dogs embedded with Military Family Life Counselors who provide counseling support to SMs and their families outside of the hospital setting. Therapeutic Support Dogs, on the other hand, will be defined as attached to or embedded in an expeditionary military unit that provides ancillary clinical, spiritual, emotional, or psychological/psychiatric health services and having (primarily) military handlers. Military handlers are practitioners such as psychiatrists/psychologists, chaplains, licensed social workers, or professionals that work in the behavioral or occupational health fields. Given that the handler is in the military, there may be an occasion when the animal relocates with the handler to a new duty location. In addition to updated definitions, TB MED 4 is being rewritten to provide more specific AAI programs and policy guidance, emphasizing training requirements for each level of AAI and enhanced guidelines for animal advocacy and welfare.

Animal Advocacy and Welfare

It is imperative to remember that there is no AAI without animals; therefore, animal advocacy and welfare must always be a predominant factor in program planning, development,

Figure 7. Facility dog Tech. Sgt. Cleo provides support to a Senior Master Sergeant at the Air National Guard Readiness Center. Photo to provided by Valerie Cramer, America's VetDogs.

Figure 8. MAMC Facility dog Captain Earl, has an Instagram account (@earl.thewellnesspup) where fans can follow his daily activity. Photo provided by Valerie Cramer, America's VetDogs.

implementation, and evaluation. A recent paper on dog welfare considerations in AAT reminds us that prioritizing animal welfare is a "moral imperative" in AAI programs,

> *"If dogs are not properly matched to a job or handler, they may be subjected to unnecessary stress, anxiety, and miscommunication that can lead to disinterest in the work, overt problematic behavioral or health outcomes, or general unsuitability. In addition, it needs to be recognized that the dog could develop negative associations with the therapist, the client, the space, or develop chronic health problems"*[86]

Oversight and continuous evaluation of the appropriateness of military AAI are crucial and must be considered a joint responsibility between the handler, animal owning organization (if applicable), facility/military unit leadership, and US Army Veterinary Services. The current scientific literature on animal welfare in AAI shows that successful programs have knowledgeable handlers that utilize positive reinforcement and noncoercive training techniques, employ trained secondary handlers, create predictable AAI environments for the animals, involve facility leadership and staff to develop animal welfare centric policies, and involve veterinarians in environmental and welfare assessments.[21, 22, 42, 86-88]

Conclusions

This article provides examples of how the DoD successfully supports and implements AAI programs in locations around the world. Most of these programs simply provide the evidence-based health benefit of a well-behaved, basic obedience trained, animal as a nonjudgmental presence in a health care facility (AAA). These programs are effective when they are supported through local (facility-level) policy and persistent engagement between facility leaders/staff, informed handlers, and local Army veterinary services who all combine efforts to prioritize animal welfare. Programs that rely on specially trained animals to confer a more advanced or focused benefit, like facility and therapeutic support dogs, require higher level collaboration and policy guidance to succeed (ie, dog owning organization, installation leadership, DHA-Veterinary Services Division, and OTSG). The two most critical steps in this process are an organizational assessment of the program's feasibility and sustainability and coordination on dog acquisition and handler training from a VA-recognized service dog training organization (Figure 8). Future published military AAI program guidance and policy should stress animal welfare, collaborative efforts between all stakeholders, consistent program evaluation with data collection when practical, and continuous training at all levels of certification or accreditation.

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Resilience in US Army Veterinary Personnel: Imminent Threats and Proposed Solutions

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Abstract

The veterinary profession is experiencing a mental health crisis that critically threatens individual resilience; US Army veterinary personnel represent a high-risk population due to their unique circumstances and professional responsibilities. Individual resilience fundamentally contributes to the wellness of veterinary care providers. Current resilience models and mental health support frameworks within the military exist to identify factors that affect resilience for health care providers but fail to capture the complex challenge of resilience in US Army veterinarians. Existing solutions are insufficient to mitigate the crisis, presenting risk to both individual well-being and the veterinary service mission to provide unique military public health and specialty skill sets essential to readiness and combat effectiveness across the Department of Defense (DOD). Continuing US Army Medical Department efforts must consider the uniquity of professional stressors, focusing on individual resilience with organizational support and urgently preserving the military veterinary mission. Innovative solutions incorporating flexibility for the changing internal and external environments that military veterinary professionals navigate are necessary. Proposed solutions must address the full spectrum of threats US Army veterinarians encounter throughout their professional careers. This paper catalogs and explains imminent threats to resilience in the US Army veterinary population while offering practical solutions designed to ameliorate complex hazards and strengthen resilience in and across this critical service group.

Keywords: resilience, individual resilience, military resilience, organizational resilience, veterinary resilience, impostor syndrome, compassion fatigue, burnout, secondary traumatic stress, red shoes syndrome, loneliness

Introduction

The veterinary profession is facing a mental health crisis. Male veterinarians are 2.1 times more likely to die by suicide, and female veterinarians are 3.5 times more likely to die by suicide than the general population.[1] Death records for more than 11,600 veterinarians filed between 1979 and 2015 revealed that almost 400 veterinarians died by suicide. Risk factors cited by the authors include "long work hours, work overload, practice management responsibilities, client expectations and complaints, euthanasia procedures, and poor work-life balance." US Army veterinary personnel are exposed to these risk factors in addition to unique circumstances and professional responsibilities that we hypothesize result in a heightened risk for mental health concerns.

Within the military, veterinary medical providers are often compared to human health care providers for management purposes; however, their work environments and responsibilities vary considerably. The US Army Veterinary Service comprises over 800 uniformed officers and approximately 800 enlisted personnel (active duty and reserves). While human health care providers provide sustainment of the force through the provision of care for service members and their families, US Army veterinarians juggle an array of responsibilities that go far beyond conventional veterinary clinical care; providers are responsible for veterinary public health capabilities through veterinary medical and surgical care, food safety and defense, as well as biomedical research and development. The US Army Veterinary Service also provides military veterinary expertise in response to natural disasters and other emergencies.

Resilience is a key concept that fundamentally contributes to the well-being of veterinary care providers within the military. Current resilience models and mental health support frameworks identify factors that affect resilience for health care providers but fail to capture and explain the complex challenge of resilience in US Army veterinarians. Existing solutions are insufficient to mitigate the crisis. This paper investigates imminent threats to resilience in the veterinary care provider population and reviews predictive instruments, including self-assessments, behavioral cues, and professional opportunities for

value as potential preventive measures against adverse outcomes. Solutions are proposed to facilitate increased self-care measures in veterinary care providers, available resources are reviewed, and courses of action are recommended to empower individual resilience through innovative prevention, vital monitoring, and sustainable concepts.

The US Army Veterinarian Experience

US Army veterinarians employ unique military public health and specialty skill sets essential to the warfighter's readiness and combat effectiveness but face many challenges to their well-being. Most military veterinarians lack prior service experience, but lead formations comprised of dozens or more military and civilian personnel almost immediately upon reporting to their first duty stations. In addition to the shock of mentally pivoting to the new roles and responsibilities of personnel management, US Army veterinarians' workloads are expansive.

Public health, food protection, and leadership responsibilities demand time and attention, which detract from the clinical medicine that many veterinarians initially pursued as their passion. The shared mission set administrated by the US Army Veterinary Corps demands time management skills, business acumen, and human resources expertise. However, personnel may be unprepared for these responsibilities as these skills and concepts are often absent from graduate veterinary medical curriculums. In a short period, military veterinarians must engage in a tremendous amount of independent learning, adapting, and overcoming obstacles, with minimal social support.

Veterinary medicine is a four-year, postbaccalaureate professional course of study in the US, offered by 32 AAVMC-accredited institutions.[2] The average age for graduates is approximately 28 to 29 years.[2] Currently, 81.6 % of enrolled students are female.[2] Commissioned following doctorate-level degree achievement, most US Army veterinarians enter service at the rank of Captain and a pay grade designation of O-3. Outside of First Year Graduate Veterinary Education (FYGVE) internships, these company-grade officers typically serve their first 3 to 5 years geographically separated from their peers, friends, and families.

Leaving a highly competitive veterinary medical education environment with high peer-to-peer competition does not translate well to the immediate need for collaboration, camaraderie, and teamwork required for success from the beginning of a professional military career. In addition, the hierarchical structure of the military, exemplified by the chain of command supervision, is another unfamiliar element to new active duty US Army veterinarians. Though military veterinarians may be assigned with a civilian counterpart based on mission requirements, the responsibility of the US Army veterinarian to supervise civilian staff creates yet another hierarchical relationship that may be socially isolating for the service member. Moreover, this population of self-reliant, high achievers may struggle to admit fault or readily ask for assistance. Mentorship, coaching, and additional training early in the career of Army veterinarians are important to facilitate adaptation to their new environment. The paucity of related training merits further attention and is discussed later in this paper.

US Army veterinary personnel work on military installations in garrison, aboard ships, and deploy in support of combat operations, often as individuals assigned to non-veterinary teams. Veterinary personnel also embed with special operations forces, providing multi-faceted support to the warfighter. While military human health care providers benefit from having peers and command teams in the same physical hospital facility stateside or abroad, US Army veterinary facilities fall under the command and control of decentralized public health commands geographically dispersed across multiple states, countries, and areas of operation. Thus, professional isolation is commonplace for US Army veterinarians and offers a stark contrast to military human health care providers and civilian veterinary counterparts who work in centralized multi-doctor practices.

US Army veterinarians serve on sister service installations from the beginning of their professional military careers. While transitioning from graduate veterinary medical education to active-duty service is daunting, inculcating within a sister service culture may result in additional stress for the US Army veterinarian. Many veterinary personnel encounter cultural challenges complicated by different environments and expectations among the service branches. Such dissimilarities compromise US Army veterinarians' sense of belonging at the beginning of their careers. These dynamics add to the constant personnel fluctuation inherent to military workplaces due to new assignments and can result in inhibited, disrupted, or delayed team cohesion.[3]

Common to both the military veterinary profession and the civilian veterinary sector is the impact delivering veterinary medical care may have on care providers. Veterinary professionals often struggle when they cannot achieve their desire to provide quality veterinary care and counseling to patients due to limited resources, mission requirements (for the military), or a client's lack of resources or compliance. This phenomenon results in an emotional burden veterinary care professionals bear but are often unable to describe. The absence of a shared vocabulary regarding resilience and related phenomena described above inhibits collaboration with peers and undermines camaraderie. Unity of effort and shared understanding is integral to any solution. It is imperative to understand how individual experience and professional stress contribute to the current mental health crisis among US Army veterinarians.

Exploring the Crisis

Veterinarians are unique health care providers responsible for the well-being of clients and patients alike. Often, veterinarians enter the profession with a love for animals and a desire to care for them.[3] Due to the complexity and rigors of the work environment, US Army veterinarians experience occupationally related mental distress at higher rates than those experienced by the general population.[4] Moreover, multiple studies have found veterinary practitioners and students are at higher risk of mental health disorders than similar occupational groups (eg, physicians, dentists, and nurses).[4] Veterinary personnel further diverge from the general population with higher depression, anxiety, psychological distress, psychotropic medication use, problem (alcohol) drinking, and suicide risk.[4] However, veterinarians do not appear predisposed to greater levels of traumatic events in their childhoods compared to people in other professions.[5] This data suggests that work-related causality may contribute to the mental health crisis investigated by this paper.

The Millennium Cohort Study, the most extensive and longest-running ongoing study of US military personnel, indicated significant overall psychological distress among veterinarians compared to other medical professionals in the US Army. The prevalence of mental health concerns among veterinarians manifested as approximately twice those of physicians and dentists.[4]

In the final adjusted models, odds ratios depict mental health problems for veterinarians as roughly double those for physicians and dentists combined.[4] Sequential Veterinary Corps surveys found US Army veterinarians endorsed higher levels of psychological distress and recent mental health concerns than in similar studies involving US civilian counterparts.[6] Psychological distress was associated with euthanasia involvement, poor social support, and practice demands. Participants who reported current mental health concerns were significantly more likely to report a lack of social support, increased work and personal life stressors, and hazardous drinking.[6]

A recent US study identified standardized mortality ratios for suicide as significantly greater among veterinarians and veterinary technicians than in the general population.[7] Another US survey found a lower prevalence of suicide attempts among veterinarians than among the general population despite a similar prevalence of mental illness.[8] Witte et al[7] proposed the higher rate of suicide deaths paired with a lower prevalence of suicide attempts may indicate veterinarians are more likely to die on their first suicide attempt because of access to and knowledge about lethal means, specifically pentobarbital. Multiple studies suggest that veterinarians are more likely to attempt and complete suicide due to their attitude towards euthanasia and ease of access to drugs for animal euthanasia.[9] The most common mechanism of death among veterinarians is reported as poisoning, indicating increased access and willingness to employ lethal drugs.[9]

Among US veterinarians, recent female graduates appear to be at greater risk of suicide than the general population, with a significant number suffering from depression, anxiety, compassion fatigue, or burnout.[10] In a 2017 survey of all US Army veterinary personnel, approximately 28% of respondents reported considering or attempting suicide in the past.[6] At the time of the survey, several participants reported having thoughts of suicide, and some reported that they currently had a plan to complete suicide.[6] Despite high job satisfaction reported by the survey population, the top job stressors were administrative tasks, practice demands, career concerns, and disenchantment.[6] Participants also reported environmental workplace concerns, including family or personal plan changes due to work responsibilities, lack of time off for personal interests, and difficulty getting time and space to do physical training or exercise.[6] These stressors further socially isolate US Army veterinarians from established support networks by eroding purpose and belonging cues that personnel associated with their profession.

Author Thomas Joiner proposed an interpersonal-psychological theory of suicidal behavior that captures three variables most likely to contribute to an individual's death by suicide.[11] These begin with a sense of thwarted belongingness in which an individual perceives a lack of meaningful connections to others. Some may feel that previously solid relationships have become strained or lost and social isolation may be a contributing factor. Next is perceived burdensomeness, wherein an individual views themselves as a burden to the world and someone who fails to make meaningful contributions and is also a liability. Entering active-duty service and simultaneously taking on the mantles of leader and veterinarian can contribute to profound self-doubt as the US Army veterinarian begins on-the-job training. Joiner's theory posits that these two perceptions of belonging and burden may produce the desire for suicide.[12] Finally, acquired capability for suicide involves the degree to which an individual may enact a lethal suicide attempt. Joiner asserted that habituation to fear and pain is a prerequisite for serious suicidal behavior because of how fearsome and pain-inducing a suicide attempt can be.[12] In this sense, repeated exposure to painful and provocative events habituates individuals to stimuli that previously would have been highly aversive. Individuals become desensitized to both fear and physiological responses. Military veterinarians exposed to such patterns throughout their occupation build familiarity and maintain ready access to lethal means. Joiner's theory is especially salient when discussing US Army veterinarians' mental health crisis.

Recent suicidal ideation was significantly higher in military veterinary personnel who deployed, those currently involved with animal euthanasia, and those endorsing symptoms on the survey of US Army veterinary personnel for all the following: psychological distress, post-traumatic stress disorder (PTSD), depression, and anxiety.[4] Veterinary personnel

identified euthanasia as the leading cause of occupational stress in many studies; this should be no surprise considering the many stressors involved.[3] Most soldiers involved with animal euthanasia who were surveyed in 2017 (82%) endorsed the physical act of euthanizing an animal as disturbing.[4] Those reporting euthanizing healthy animals for population control purposes and hearing an animal vocalize during the euthanasia process endorsed higher psychological distress levels. Regarding euthanasia distress, few differences exist between those who deployed and those who did not. Responsibility for humane euthanasia is a heavy burden carried by veterinary care providers across work environments.

In addition to the concepts discussed above, multiple authors hypothesize that performing animal euthanasia could be related to increased risks for depression, suicidal ideation, and suicidal behavior.[4] In contrast, Tran et al[13] found that performing animal euthanasia is a protective factor against suicide among veterinarians with depression, with the performance of euthanasia greater than eleven times weekly attenuating the association between depression and odds of suicide. Euthanasia, like many other aspects of the job, may positively or negatively affect veterinarians' mental health. Some may view humane euthanasia as the ability to render a merciful ending to an animal's suffering and facilitate closure for the weary human family.[4] Studies estimate that veterinarians experience patient death approximately five times as frequently as their counterparts in human medicine.[14] Polarization of views on this topic merits targeted discussion with mental health care providers and leadership to determine how best to support US Army veterinarians for this responsibility. Recommendations made later in this paper will elaborate on the criticality of fostering awareness for this stressor.

Psychological distress among civilian and military veterinarians has several complex causes, as evidenced by the numerous study results on this topic. Young female veterinarians are at increased risk for adverse outcomes such as suicidal thoughts, mental health difficulties, and job dissatisfaction.[15] The main occupational challenges reported are related to managerial aspects of the job, long working hours, heavy workload and job demands, poor work-life balance, hostile interactions with clients, clients' expectations, and suspected patient (pet) abuse by owners.[9] Results of a 2014 survey show that pet owners cyberbully 1 in 5 veterinarians for various reasons, including failure to waive fees when requested.[16] Cyberbullying manifests most frequently as accusatory online reviews or social media trolling behavior. Clients often fail to comprehend the cost of care and may turn to emotional blackmail or cyberbullying to pressure veterinarians into compromise. This pervasive hostility may single out the veterinary practitioner with criticism that goes unchecked in today's expansive and influential cyber environment.

US Army veterinarians encounter similar occupational stressors as their civilian counterparts while also experiencing additional stressors unique to military service. A recent study of deployed veterinarians and veterinary staff highlighted more severe secondary traumatic stress symptoms (PTSD-like symptoms after witnessing patient trauma, also described as compassion fatigue) and anger reactions than non-veterinary healthcare personnel.[17] Additionally, isolation from family and friends is a known sacrifice accompanying military service. Overseas deployments, high operational tempo, and diverse leader responsibilities complicate an inherently stressful veterinary occupation. Loneliness is a common complaint among those courageous enough to speak their feelings. These challenges merit further exploration due to their influences on US Army veterinarian behavior and quality of life.

Imminent Threats to Resilience

The US Army veterinary community is experiencing a mental health crisis that critically threatens individual resilience through a series of unique threats. Military veterinary personnel are at high risk for erosion of resilience due to their unique circumstances and professional responsibilities. Meta-analysis has manifested a daunting arsenal of identifiable threats for the veterinary community, including impostor syndrome, compassion fatigue, burnout, secondary traumatic stress, red shoes syndrome, and loneliness. Current resilience models fail to fully capture and explain the complex challenge of resilience experienced by US Army veterinarians.

Impostor Syndrome

Impostor syndrome, also known as impostor phenomenon, appears in human and veterinary health care literature as the tendency to doubt one's abilities despite positive evidence to the contrary.[18] Convinced that others overestimate their talent, individuals experiencing these tendencies live in fear of being exposed as incompetent.[19] Low self-esteem and perfectionism are associated with those affected, and these traits can negatively impact their mental health. Imposter syndrome symptoms include a lack of self-confidence, depression, and generalized anxiety.[20] Although initially assumed to affect women mostly, subsequent studies found that both males and females have imposter syndrome proclivity.[10] Persistence of imposter syndrome despite success is the defining attribute of true imposter syndrome, and positive reinforcement remains ineffective for resolution. The appreciation of imposter syndrome among veterinary professionals is essential and timely, given the high prevalence among medical professionals and the knowledge that imposter syndrome correlates with poor mental health, perfectionism, neuroticism, depression, anxiety, and burnout.[10] Anecdotally, admission to this shared experience is on the rise, particularly with senior veterinary students embarking on clinical responsibilities and recent graduates in a hospital setting.

A recent international study explored the prevalence and severity of imposter syndrome in practicing veterinarians utilizing a 20-question Clance Impostor Phenomenon Scale (CIPS) plus additional demographic and work-related questions.[10] Developed in 1985, it is a 20-item test that uses a 5-point Likert scale. Overall, 68% of veterinarians surveyed met the criteria for intense impostor feelings at the time of the survey.[10] This proportion is much higher than the 20% to 50% reported in cross-sectional studies of medical practitioners and likely represents true imposter syndrome despite professional success. This study further demonstrated that veterinarians in practice for less than five years have higher odds for imposter syndrome, aligning with medicine and health professions studies. When considering the military population's entrance into active-duty service and frequent assignment transitions, imposter syndrome peaks during professional transition.

According to recent Veterinary Corps surveys, veterinarians were significantly more likely to identify moderate and frequent imposter syndrome characteristics within the US Army community than other operational specialties.[6] Females were significantly more likely to have endorsed a positive score for frequent imposter syndrome characteristics than males, consistent with studies among high-achieving individuals and medical professionals in the general population.[21] Despite outstanding academic and professional accomplishments, US Army veterinarians who experience imposter syndrome are similar to their civilian counterparts and persist in believing that they lack the talent and worthiness for their positions. Despite ample objective evidence of superior intellect and performance, significant achievements and documented successful performance do not appear to affect the impostor belief.

US Army veterinarians may question their fundamental worthiness when suffering from imposter syndrome. Through the course of on-the-job responsibilities, veterinarians often face self-doubt when called upon to make timely and critical patient care decisions. Self-doubt is especially troublesome for US Army veterinarians, who may conclude clients or subordinates would not follow orders if the veterinarian's imperfections were exposed. In the author's experience, new graduates can become so overwhelmed by poor patient outcomes that their clinical decision-making is paralyzed for weeks or months afterward. This downward spiral may translate into a collapse of clinical confidence and competence. Health care delivery may be isolating and contribute to self-doubt, resulting in the build-up of imposter syndrome over time.

Client communication presents additional challenges when a veterinarian's clinical acumen is frequently questioned. Well-meaning clients often solicit advice from family, friends, animal breeders, pet store employees, and internet resources of varying repute. Thus, when veterinarians make medical recommendations, they may receive substantial pushback from clients in a fashion that can be confrontational and sometimes disrespectful. Such interactions may threaten a veterinary health care provider's identity and self-esteem in what can become a crippling trend throughout medical practice.

Ruchika Tulshyan and Jodi Ann Burey's recent work on imposter syndrome for the Harvard Business Review revealed that the concept, as developed in the 1970s, excluded the effects of systemic racism, classism, xenophobia, and other biases.[22] With the application of imposter syndrome to the workplace, what some may consider healthy self-doubt was pathologized inappropriately, especially for women.[22] The authors concluded that the answer to overcoming imposter syndrome is not to fix individuals but to create an environment that fosters various leadership styles.[22] Such an environment requires that diversity of racial, ethnic, and gender identities be normalized as the professional model.[22]

The rise of imposter syndrome among US Army veterinarians is deeply troubling. The isolating qualities of this syndrome can potentially compromise the delivery of high-quality patient care. Whether deployed overseas or assigned to a geographically remote duty site, military veterinarians serve as the final decision-makers in times of crisis and confusion. Lack of imposter syndrome awareness and open communication on the prevalence further contributes to the abundance of myths and misunderstandings surrounding this phenomenon. Distrust of oneself contributes to the crisis through further personal isolation, lack of belonging, and perceived helplessness.

Compassion Fatigue

Researcher Charles Figley defines compassion fatigue as "the mental weariness resulting from exertion that is associated with attending to the emotional and physical pain of others."[23] Initially described in 1992 as related to the nursing profession, various studies have observed compassion fatigue across a spectrum of caregiving professions, including physicians, dentists, social workers, medical interpreters, chaplains, and veterinarians.[24]

Veterinary personnel encounter compassion fatigue as a secondary PTSD through exposure to emergency and critical care patients. A typical veterinary patient presentation involves a client rushing into the lobby, declaring that a beloved four-legged companion has been hit by a car. The staff rush to transport the gravely injured patient from the client's vehicle into the clinic. The veterinarian interfaces with the distraught client at the outset, navigating highly emotional and frenzied pleas for them to save that family member's life. Typically, the client will declare that money is of no concern, until asked to approve an estimate for care. By this point, the veterinarian has necessarily shifted attention to the patient for assessment and intervention, assuring the clients they will treat the patient as if it were their own. The swirling pressures of medical

need, financial resources, and emotional investment follow the health care provider throughout the scene. The scenario imparts a multi-faceted traumatic experience that may trigger memories, drain emotional capital, and compromise caregiving at some level. Emergency and overnight on-call responsibilities threaten to further exhaust capacity. Repetition of similar scenarios over time may leave the provider ill-suited to continue practicing with any semblance of vigor.

The development of strong emotional bonds with patients, coupled with repeated exposure to animal suffering, place US Army veterinarians at heightened risk for compassion fatigue. Daily interaction with animals and a passion for animal health and welfare drive individuals to enter the field of veterinary medicine and result in an emotional connection described as the human-animal bond. Studies demonstrate unaddressed compassion fatigue in healthcare providers results in emotional exhaustion, depression, frustration, depersonalization, a sense of loss in one's achievements, recurring nightmares or flashbacks, substance abuse or other compulsive behaviors, and lack of self-care. Notably, compassion fatigue can significantly and adversely affect patient care.[3] Veterinary staff experiencing compassion fatigue may be unable to process information and adapt as situations change, such as in a medical emergency. Compassion fatigue in animal care work environments can similarly cause a high rate of employee absenteeism or excessive worker compensation claims, high personnel turnover, lack of team cohesion, aggressive behavior among staff, the unwillingness of staff to respect rules and deadlines, increased negativity, increased mistakes, safety violations or occupational health reports, increased stress experienced by research animals, and decreased quality of animal or medical care.[25]

The wellspring of a veterinarian's heralded bedside manner is compassion. A veterinarian's uncanny ability to connect with humans and animals alike is a product of that esteemed compassion. Dipping into that resource without safeguarding the reserves is perilous. Critical to averting crisis is recognizing troubling trends and preserving measures that facilitate continued professional capabilities. Compassion fatigue consists of two components: burnout and secondary traumatic stress.

Burnout

Burnout manifests as a feeling of hopelessness at work and difficulty carrying out one's job effectively. Estimates for burnout in veterinarians range between 15% and 67%, with the risk approaching 35% in other animal care team members.[26] When coupled with anticipatory grief (ie, subconsciously preparing for the illness or death of an animal by disengaging from that animal), compassion fatigue and burnout may establish a negative feedback cycle that can erode the vital human-animal bond that veterinary caregivers feel for their patients.[26] Such conditions may further decrease compassion and empathy for patient suffering.[27] A US Army Veterinary Corps survey demonstrated reported rates of burnout as moderate (51%) and low (49%) among survey participants.[6] When considering this phenomenon, moderate reporting levels represent cause for concern. Although reported numbers appear to represent a middle-range statistic, these troubling trends will likely worsen without concerted efforts toward improvement.

The Maslach Burnout Inventory (MBI) is a commonly accepted tool for assessing burnout that captures three main dimensions: "overwhelming exhaustion, feelings of cynicism and detachment from the job, and a sense of ineffectiveness and lack of accomplishment."[28] Although veterinarians may experience all three dimensions when suffering from burnout, feelings of emotional exhaustion are most associated with burnout and translate into an increased risk of developing poor mental or physical health. Moreover, the degree of exhaustion determines maladaptive coping mechanisms such as cynicism and depersonalization, leading to a lack of self-worth concerning accomplishments at work.[29]

Burnout is more than another term for work stress and differs from compassion fatigue in that there is a discernible end-state. Veterinarians experience burnout when the wellspring of caring has effectively gone dry. Once they realize they cannot muster any further caring, they find themselves wholly emotionally numb. US Army veterinarians may attribute this to the imposition of mounting changes outside their control. The Army Public Health Center houses internal corporate advisory entities for providing veterinary services that have sometimes unintentionally contributed to stress in military veterinary practice. Examples include wholesale corporate veterinary medical practice directives promoting controversial operational and personnel decisions. Likewise, public health emergencies may occur unexpectedly and force personnel to work longer hours, contributing to additional stress. Whatever the case, US Army veterinarians must contend with situations that derail "business as usual" while concurrently asking them to do more with less. When insufficient space exists to restore themselves, the consequence is akin to emotional bankruptcy. Anecdotally, US Army veterinarians tend to isolate themselves further when this occurs, often delaying the pursuit of support until they are overwhelmed. Previously engaged leaders resort to locking themselves in their offices and avoiding responsibilities because they are too painful. These individuals are often observed as simply going through the motions because they have nothing left from which to invest themselves. This resulting numbness is distinct from compassion fatigue manifesting in an observable state of defeat.

Secondary Traumatic Stress

Secondary traumatic stress in healthcare workers represents the second and equally important component of compassion fatigue. Secondary traumatic stress involves job-related, secondary exposure to highly stressful or traumatic events,

causing workers to experience extreme tension and preoccupation with suffering in the medical setting.[30] Secondary traumatic stress is also known as vicarious trauma and secondary victimization. Secondary traumatic stress can result from a single incident or cumulative daily stressful events and interfere with a person's job performance.[3] The veterinary profession is thus at an elevated risk for secondary traumatic stress associated with clinical responsibilities, particularly patient encounters.

Secondary traumatic stress is a separate phenomenon from PTSD. In general, service members constitute a high-risk population for PTSD symptoms, including nightmares or unwanted memories of the trauma, avoidance of situations that bring back memories of the trauma or trigger heightened reactions, anxiety, or depressed mood. Line of duty exposure to secondary trauma further impacts first responders, social workers, and clergy. Individuals may experience secondary PTSD when informed by reports of catastrophic events such as pandemics, natural disasters, or acts of terror. Military veterinarians, bombarded by high emotion, terrible scenes, and an inability to alleviate pain and suffering, may become mired in secondary duty-related trauma. A US Army Veterinary Corps survey demonstrated reported rates for secondary traumatic stress as moderate (22%) and low (78%).[6] Moderate reporting levels represent cause for concern despite apparent middle-range values. A heightened concern is valid, given the nature of secondary traumatic stress and its cumulative effect on health care providers.

Veterinarians are caregivers for both nonhuman animal patients and human clients, making them uniquely susceptible to secondary trauma through either relationship. The abiding presence of these multiple roles and responsibilities for the US Army veterinarian assuredly represents a predisposing factor to the acknowledged mental health crisis. Figley created the Professional Quality of Life (ProQOL) Measure, Version 5 (ProQOL-V), as a tool to measure subscales for burnout, secondary traumatic stress, and Compassion Satisfaction and provides a basis for compassion fatigue.[30] Measures such as those mentioned (Maslach and ProQOL) form a consistent approach for comparison within and across professions, as evidenced by recent military medical literature. Insight gathered through this research may benefit healthcare providers across civilian and military sectors by identifying similar mental health concerns and implementing shared solutions when applicable.

Red Shoes Syndrome

The uniquity of veterinarians and their teams transcends existing definitions, requiring an undescribed analogy. The combination of intelligence, drive, and commitment needed to perform veterinary caregiving may lead to perilous consequences, including self-harm. This threat is especially so for US Army veterinarians thrust into leadership roles from the outset of their professional careers. As previously described, veterinarians tend to rely heavily on their abilities and view themselves in perpetual competition with their peers from their time as high-performing students. As they find greater and greater success, the pattern becomes reinforced. Committed to continuing education, tireless research, and round-the-clock service to their patients and clients, veterinarians fall into an unforgiving hidden cycle of self-imposed and self-fulfilling commitment.

Social worker Dr. Susan Cohen recently coined the term "red shoes syndrome" to explain this covert activity as articulated in a recent podcast:

> *The "red shoes" comes from a story by Hans Christian Andersen.[31] The basic story is that a ballerina goes to a fair, and she sees a pair of beautiful red ballet slippers. She must have them, and we, the audience, can tell that the guy selling her these ballet slippers is up to no good. There's something very fishy about him. He's some sort of wizard. She puts on the shoes and immediately feels like the best in the world, and she is dancing as she has never danced before. She danced all through the fair; she was fantastic. She then dances into the woods and decides, you know, I think I'm a little tired. I think I'd like to go home. She tries to go home. Her mother stands in the doorway, but the shoes won't allow her to stop. So, they dance her out of town and into the next town, where she tries to stop at a church, and the priest is there with his arms out. She's trying to get to him, but the shoes force her to dance away. In the end, these enchanted shoes force her to dance until she collapses.[32]*

Red shoes syndrome manifests in US Army veterinarians when their unique talents, coupled with the military mantle of leadership, result in the profound conviction that they must always stay on the job because nobody else can manage their responsibilities as well as them.

Unfortunately, many new US Army veterinarians exhibit this troublesome tendency. These veterinarians convince themselves that if they go home, patient lives will be lost, the practice will fall into chaos and ruin, and those for whom they are responsible will feel abandoned and dejected. Supervisors render positive feedback, lauding the veterinarian's work ethic and elite skill set, unwittingly contributing to and reinforcing worrisome trends. Without more realistic feedback, these veterinarians find it excruciatingly difficult to stop doing what they are doing. This commitment becomes their identity, inexorably tied to their self-worth. Even if they recognize that this pattern has become destructive, they find it very hard to take a step back, let alone put aside their metaphorical red shoes.

Loneliness

Loneliness is a relatable condition experienced by human and veterinary health care providers, regardless of civilian or military employment. Various authors have defined loneliness as

the discrepancy between a person's desired and achieved levels of social relations. Studies have characterized loneliness as the aversive feelings of separateness, alienation, and perceived social isolation.[33] Chronic loneliness has documented deleterious effects on mental and behavioral problems, physical health, and mortality. Voluntary military service demands self-sacrifice, including freedom of choice for a physical location and social circumstance. Thus, loneliness represents a key feature for predicting mental health problems and suicide in service members.

While US Army veterinarians rarely find themselves in combat on the front lines, the small population of Veterinary Corps officers experience profound global distribution to meet high mission demand. Lone-duty sites restrict individuals from attaining peer-to-peer support and mentorship as part of their daily interactions in the workplace. Additionally, previously described hierarchical contributions pose a significant stumbling block for new personnel to generate meaningful peer connections. These factors make feelings of loneliness endemic among new military personnel, regardless of discipline and by the very nature of active-duty military service. Loneliness is more than an uncomfortable feeling because it impacts health and functioning; this condition in individuals may even spread like a contagion within organizations.

Branch of service disparities accompanying diverse assignment locations, coupled with the inability of US Army veterinarians to associate with subordinate veterinary staff due to fraternization concerns, limits meaningful social engagement. The resulting social isolation may erode individual coping mechanisms for stress.[3] Previous studies determined that lower self-reported social support was associated with higher compassion fatigue.[34] Higher loneliness scores were also significantly associated with higher burnout and secondary traumatic stress.[3] One study found platoon cohesion and support, relationship satisfaction with friends, and relationship satisfaction with platoon members were protective factors for loneliness in active-duty personnel.[33] These studies spotlight the compromises and contradictions apparent in military veterinary medicine. The paucity of opportunities for camaraderie and team building across the US Army veterinary community compromises the ability of veterinary personnel to combat loneliness.

The multitude of threats to resilience encountered by US Army veterinarians have remained invisible to those outside the US Army Veterinary Corps. Shockingly, those within the community have either remained ignorant or complacent in addressing the fulminant mental health crisis that has resulted. The many-layered threats to resilience, including the occurrences of imposter syndrome, compassion fatigue, burnout, secondary traumatic stress, red shoe syndrome, and loneliness, demand immediate attention for the effective mitigation of mental health risks associated with this essential population of US Army veterinarians.

The Value of Resilience

Resilience is a multidimensional construct variously defined as "a capacity, a process, and an outcome."[35] All definitions describe a positive response to adversity, such that an individual is at least coping, if not thriving.[36] The importance of resilience hinges on the ability of US Army veterinarians to accurately appraise a stressful situation, which will promote an adaptive rather than maladaptive coping style.

In addition to the established definitions, one could argue that resilience also includes the ability to find meaning and opportunity in the face of hardship and adversity. In a study of human health care nurses working in an intensive care setting, Mealer et al[37] found that resilience is beneficial for working in potentially stressful occupations. Nurses who scored higher on a defined "resiliency" scale were less likely to suffer from occupational stress and had reduced risk of stress-related conditions such as burnout. Highly resilient nurses use positive coping skills and psychological characteristics to thrive in a stressful environment and remain satisfied with their employment for many years. The veterinary profession, likewise, is rife with stress and adversity, especially within a military setting. Fostering high levels of resilience in US Army veterinarians may prove equally protective.

In veterinary literature on resilience, Cake et al[35] highlight the pivotal role of "emotional competence" in resilience, explaining the need for a high level of emotional processing capabilities to achieve professional success. Characteristics of resilience involve personal qualities or traits such as optimism, self-confidence, level-headedness, hardiness, and resourcefulness during adversity.[29] The Connor-Davidson Resilience Scale (CD-RISC) represents the most widely used measure for this purpose and uniquely evaluates successful stress-coping ability while incorporating global aspects of resilience.[38] An available measure like the CD-RISC offers a robust tool for ensuring the continuity of resilience research and further legitimizes the value of data related to the Army's veterinary mental health crisis.

A study by Perret et al[36] referenced previously identified personal and workplace factors associated with resilience, presenting opportunities for intervention at each level, but could not determine how veterinarians most effectively develop resilience. This data reinforces personal and organizational contributions to resilience that reduce adverse mental health outcomes such as stress, burnout, and secondary traumatic stress. The authors promote interventional strategies such as resilience building and mindfulness at the individual level, emphasizing personal characteristics, talents, and skills. Workplace cultural changes, including improved boundaries between work and home life, will likely be the most impactful for the occupation.

The US Army recognizes the value of resilience to soldiers. To this end, the US Army offers Master Resilience Training (MRT) as a resilience training program within its broader Comprehensive Soldier Fitness program.[39] The US Army adopted MRT in a proactive approach to strengthening soldiers' resilience during a period of repeated, high-demand combat deployments.[40] Access later expanded to include families of soldiers and non-combat service members. The preparation component of MRT consists of five separate modules (Resilience, Building Mental Toughness, Identifying Character Strengths, Strengthening Relationships, Teaching Skills). The program has suffered from a lack of modernization and inconsistent facilitation since its inception, resulting in discontent with course offerings for annual training. Sustained complaints from veterinary personnel regarding program complacency have populated command climate surveys, sensing sessions, and other official channels. Course content appears similarly inadequate when considering the myriad of imminent threats to the resilience of US Army veterinarians.

For individuals to truly value resilience, they must believe in their ability to possess this resource. The concept of perceived resilience is important to examine how resources possessed by employees enable them to show positive adaptation following significant adversity.[41] Smith et al[42] defined perceived resilience as a belief one can show resilience when faced with adversity. Many self-reporting resilience measures assess resources that may promote resilience rather than recovery, resistance, adaptation, or thriving. The Brief Resilience Scale (BRS) has emerged as the only tool that assesses a single factor reflective of quickly recovering from adversity without confounding the concept with strategies to promote resilience. US Army Veterinary Corps surveys may consider perceived resilience as a personal resource that could predict improved functioning among military personnel following their exposure to traumatic events in the line of duty.[41]

Current Resources

Many US Army veterinarians are unfamiliar with the available resources and initiatives to improve mental health and well-being. There are existing programs to support mental health and well-being associated with the human health care field, military assets, and professional veterinary sectors. Similarly, the US Army Veterinary Corps has various efforts and initiatives to highlight the growing needs of this critical community.

Numerous parallels exist with their human health care counterparts., Many recent veterinary initiatives to support mental health and well-being have paralleled those programs that have proven successful for the human health care profession. Among physicians, organization-level interventions such as changes to workload or teamwork-focused meetings have proven most effective.[43] Ongoing courses geared toward institutional level, practice management style, effective communication, and physician-organization collaboration promote physician resilience.[44] Other strategies present in the human sector but long absent in the veterinary world include supportive professional relationships, conscious management of personal and professional boundaries, and limitation of working hours.[44]

The pandemic response has generated pervasive emotional trauma among human health care teams grappling with COVID-19 virus-associated morbidity and mortality. Grassroots innovation has fostered initiatives to help caregivers deal with resultant feelings of grief and loss through structured group therapy. One such program piloted by Rush University Medical Center in Chicago has successfully implemented concepts like self-compassion as part of a program designed to mitigate symptoms of compassion fatigue, burnout, and secondary traumatic stress incurred while attempting to save lives.[45] Entitled "Growing Forward," this program applies lessons learned from managing combat veteran experiences to assist private sector providers with resilience. Health care workers implement activities like journaling to help them acknowledge their feelings and learn healthy ways to decompress. The paucity of similar programs within the veterinary sector is likely due to individual implementation requirements, which are unlikely to manifest without institutional support and prioritization.[36]

Evidence that veterinarians in North America do not widely use the current workplace and organization-level mental health resources compounds the dearth of programs.[8] Likewise, recent US Army veterinary surveys demonstrated poor support service utilization among soldiers with recent mental health symptoms.[6] Decreases in service utilization may result from barriers and stigma to seeking care. These include fear of negative career consequences, anticipated differences in treatment by leadership, and difficulties getting time off to seek care.

Numerous military resources appear outside the formal hospital setting for mental health concerns. Beyond embedded mental health services, the emergency department of most military medical centers is available to support those with mental health crises (including substance abuse, addiction, and suicidal ideation). Other trained personnel available to military members on an installation include social workers, ombudsmen, and chaplains. For those inclined to pursue care outside of the military installation, Military OneSource represents the US Department of Defense's support network for the military community.[46] This venue offers mental health services for the entire military family with minimal reporting requirements and complete coverage through service members' existing insurance plans. The Military and Family Life Counseling Program supports service members, families, and survivors with non-medical counseling worldwide.[47] Trained to work with the military community, Military and

Family Life counselors deliver valuable face-to-face counseling services, briefings, and presentations to the military community on and off the installation. Confidential non-medical counseling addresses improving relationships at home and work, stress management, adjustment difficulties, parenting, and grief or loss support. Other agencies, such as The Defense Center of Excellence for Psychological Health and the National Suicide Prevention Lifeline, may provide further assistance as indicated.

Professional organizations have recognized the need to educate the veterinary community on mental health resources and have generated outreach communications and active programs for this purpose. The American Veterinary Medical Association (AVMA) is the leading advocate for the veterinary profession within the United States. Representing more than 97 000 members, the AVMA aspires to "protect, promote, and advance the needs of all veterinarians and those they serve." Through their proposed commitment to "advance the shared interests, values, and goals of AVMA members," the organization has investigated mental health trends and generated a variety of avenues to address stated problems.[48] Some of their initiatives include advocating self-care for veterinary professionals, promoting the use of ProQOL assessments for personal and work-related experiences, socializing a workplace well-being certification program, providing continued education for the management of compassion fatigue, and prioritizing suicide prevention training through the Question-Persuade-Refer (QPR) Institute.[49]

In addition to the AVMA's well-being resources for veterinary professionals, there has been a rise in non-profit organizations offering education, support, and resources. Various 501(C)3 non-profit organizations, such as "Not One More Vet," facilitate robust programs to assist veterinary team members through multiple pathways.[50] Crisis numbers, peer support forums, and crisis assistance grants contribute to these support networks. Veterinary mental health initiatives, such as "The Shanti Project," offer empathetic and supportive spaces where veterinary professionals can gather to understand how each other navigates similar challenges.[51] Some rely on volunteer and community support, while others employ trained professionals as group facilitators. Associated virtual venues match veterinary professionals with licensed therapists for professional online counseling. Funding, insurance coverage, and terms differ by organization. The emerging presence of these resources underscores the mental health crisis in the veterinary profession.

Another commonly accessed organization designed to support the veterinary profession is the Veterinary Information Network (VIN).[52] VIN's goals include bringing together veterinarians worldwide as colleagues. VIN's online community provides instant access to vast amounts of up-to-date veterinary information, offering instant access to "breaking news" affecting the veterinary profession, connecting veterinarians to colleagues with specialized knowledge and skills, and empowering the profession by sharing knowledge and ideas.[52] Members of the VIN community enjoy unlimited access to an extensive medical database, a wealth of practice management resources, online continuing education courses, live discussion sessions moderated by experts and specialists on a wide variety of topics, and a supportive community of colleagues. VIN access is limited to a paid membership subscription; however, various affiliated subgroups offer further professional support, including the VIN Foundation. A 501(c)(3) non-profit, the VIN Foundation exists to "better serve animal and humankind by ensuring veterinary professionals have the tools, confidence, and support to thrive."[53] Within this subgroup exists a unique forum titled Vets4Vets. Therein is a confidential support group for veterinarians that aims to help colleagues with "tough work situations, difficult school circumstances, stress, depression, emotional unrest, physical challenges, addiction, or…if you just need to talk to somebody." [54] Vets4Vets does not claim to be a replacement for individual or local support, nor does the group provide mental health diagnosis or treatment. The service does offer a unique peer-to-peer and collaborative support venue for the veterinary community at no charge and with anonymity.

The US Army Veterinary Corps has launched similar support initiatives for the military community. The Junior Officer Council represents a critical component of the US Army veterinary community that offers young veterinarians a unique voice and career influence. Delegates are representatives of each US Army Public Health Command, combatant commands, Defense Health Agency, the Medical Center of Excellence, research and development, deployable units, Special Operations forces, and food safety warrant officers. Junior officers are elected as delegates following nominations by their peers. Each delegate serves for twelve months after assuming the role, representing their constituency to JOC leadership. JOC delegates liaise with senior Veterinary Corps leadership, presenting concerns and sharing feedback gathered from the position. Delegates also disseminate relevant information and poll their constituents about various issues on behalf of the JOC. The Veterinary Corps chief answers concerns and questions from the JOC and communicates with JOC leadership regularly. Peer-to-peer support, shared experience, and a priceless sense of belonging make the JOC a valuable mental health resource for US Army veterinarians.

The Veterinary Corps recognizes that developing junior officers is crucial to the long-term effectiveness and vitality of the organization and directly supports the Army Medical Department and School strategic priority of force development. To this end, the corps chief has initiated a formal mentorship program. This mentorship program introduces a novel approach to mentoring that integrates the concepts of voluntary formal mentorship with diverse, innovative systems. This

initiative espouses a culture that supports integrative mentorship and junior officer development through an active program that seeks to benefit the organization, the mentor, and the protégé. The predictive value of senior mentorship and the broader professional perspective of more experienced officers offer US Army veterinarians important developmental and general well-being cues.

A Resource for Cultural Change

Dr. Susan Cohen has poignantly observed that "People who chose to be veterinarians…do so because they want to care for animals. However, they often fail to include themselves in the caregiving. That failure undermines the rationale for an animal-oriented career. How can someone care for pets [and animals] unless that person is healthy?"[55] Acknowledging the mental health crisis within the US Army Veterinary Service is essential to changing the deeply flawed ideology of doing business as individuals. Existing resources require revision to address this immediate need. A lack of urgency may otherwise doom the US Army Veterinary Corps to hemorrhage its lifeblood of talent. Senior leaders must embrace and mobilize a more holistic and interconnected community vision.

A targeted human medical literature review reveals the importance of both modeling and explicitly teaching professional competencies.[56] Conceptually, this allows organizations like the US Army Veterinary Corps and associated mentors to actively promote a culture of well-being and resilience among their students and mentees. A cultural shift in the profession is needed to build awareness of the importance of veterinarian well-being, and military leaders are in a unique position to model well-being and provide a workplace environment in which individual officers can thrive.[36] Previous research in civilian practice has demonstrated the potential to improve the mental health of the veterinary community through management skills training and increased employee participation in decision-making, combined with decreased work hours and improved work-home boundaries.[57]

Prevailing trends and recent US Army veterinary survey results prompted the corps chief's office to develop VETfit, an opportunity for cultural change within this community. The VETfit program targets veterinary personnel early and often at various touchpoints (professional military education opportunities) to discuss workplace and career concerns.[6] The program would also seek to maximize these opportunities to encourage seeking support if needed while offering support to fellow US Army veterinary personnel. The Walter Reed Army Institute of Research's (WRAIR) Research Transition Office developed the resulting curriculum with support from the US Army Office of the Surgeon General. VETfit offers a two-hour training for US Army veterinarians designed to provide them with the skills, concepts, and techniques to help maintain personal well-being and excel in the line of duty. Derived from a similar curriculum of resilience skills for medical staff called MEDfit, the program addresses the unique stressors and challenges that US Army veterinary personnel encounter through the course of their duties as identified through the Millennium Cohort Study.[4]

VETfit provides US Army veterinary personnel with the tools to maintain optimal functioning and well-being.[40] Instructors typically deliver instruction virtually or for up to 25 veterinary personnel groups in a classroom setting. The program begins with a review of the unique psychological stressors affecting veterinary personnel and how these stressors can contribute to burnout, compassion fatigue, and social isolation. Participants identify indicators of suboptimal and optimal functioning through deliberate self-assessments. The concept of self-care emerges as a necessary solution for individuals experiencing these tendencies. Within this arena are skills training for compassion regulation (eg, mindfulness), maintaining boundaries (eg, breaks; mottos), community support and leadership, as well as the investment in self (eg, sleep; self-care routine). The curriculum culminates with instruction on knowing when and how to seek professional mental health services as a skill for self-care. Ready and Resilient Performance Centers (R2PCs) located on major domestic and overseas installations facilitate the curriculum. The US Army Veterinary Corps has incorporated the delivery of VETfit into the Veterinary Senior Captain Development Course and small pilot groups across the enterprise.

Available literature identifies individual and organizational factors contributing to the erosion of resilience in veterinarians. The resources available to reduce adverse mental health outcomes such as burnout and secondary traumatic stress require attention and further investment.

Interventional strategies such as resilience building may be helpful at the individual level but should be proactive rather than reactive. Workplace cultural changes are necessary to improve boundaries between professional and personal life. Significant institutional collaboration and cooperation will facilitate lifecycle changes and support.

Recommendations

Creating social and physical environments that enrich US Army veterinarians' health, well-being, and resilience is paramount as solutions to the mental health crisis are developed. Considerations given to physical, emotional, and psychological health are critical to medical providers' ability to protect those entrusted to their care. Beyond the clinical competencies in peril are military veterinary professional development, productivity, and job satisfaction. Developing resilience in US Army veterinary personnel requires that individuals experience pride and joy in their work while effectively coping with stressors both in and out of the workplace. Self-care and team-care are critical responsibilities of all veterinary care team personnel. These well-being skills require education,

practice, and prioritization in the workplace. All members of the team share responsibility for the well-being of one another and the creation of a positive, healthy work environment. Restoring a veterinary caregiver's sense of purpose in their professional work will benefit personal resilience and performance quality. This section introduces recommendations for education and training, support services, chain of command influence, sharing lessons learned, a novel mental health measure, potential enforcement options, relieving administrative burden, and pursuing future studies applicable to US Army veterinary personnel. Creating and maintaining a culture supportive of self-care and team-care will provide a foundation for US Army veterinary personnel to grow personally and professionally throughout their careers.

Education and Training

Continuing education and training programs are essential to this resilience effort. Existing resources offer value, but platforms like the MRT curriculum must be modernized to rekindle interest and attention. The Veterinary Corps must encourage all veterinary care team members, military and civilian, to attend MRT training. Master Resiliency trainers who understand the uniquity of the US Army veterinary mission set may enhance the overall training experience. Leaders should provide examples for discussion relevant to the veterinary care team and military medical workplace. Complementing this concept requires an expansion of the VETfit curriculum.[40] The authors recommend components of the VETfit program be integrated throughout the FYGVE program to provide interns with self-care, team-care, mindfulness, and stress management tools.[58] Expansion of this program into the FYGVE curriculum establishes a foundation for learning throughout their US Army veterinary careers. Interns can then take these learned tools and resources to their subsequent assignments, sharing them with other military and civilian animal care personnel.

Sustainment modules developed to accompany future Professional Military Education touchpoints will further cement resilience building. Likewise, coordination with the US Army Resilience Directorate for a complimentary curriculum tailored to military veterinary personnel may reinforce the unity of effort to mitigate the identified mental health crisis. For continuity purposes, developing similar training to target animal care specialists and civilian animal technicians should follow pilot implementation as described.

Further prioritization for these programs requires the support of the US Army Medical Department and would benefit from central alignment under the US Army Training and Doctrine Command.

Support Services

A robust support network is necessary to support military veterinary mental health and resilience. Social relationships and camaraderie are vital components. Encouraging participation in the Veterinary Corps Mentorship Program (mentors and protégés) is a solid starting point. Likewise, involvement and familiarity with the Junior Officer Council as an advocate agency are helpful. Active membership in professional organizations and conference attendance fosters professional development and increased competence through networking opportunities, peer-to-peer interactions, and mentorship. However valuable, these groups lack the counseling expertise available through mental health professionals, and their hierarchical structure may be intimidating for US Army veterinarians seeking support.

With known mental health concerns in the population, US Army veterinary personnel must have knowledge of and access to mental health support services. Services should target soldiers aged 18 to 29, as junior officers represented by the top end of this range were significantly more likely to report symptoms above the threshold for psychological distress in recent Veterinary Corps surveys.[6] Their status as early career professionals or their transition into the US Army may contribute to this distress. The survey population reported individuals feared that seeking mental health care could negatively impact their careers. They also expressed concern regarding stigma from colleagues and peers. Therefore, leaders should prioritize education on the impact of stigma among their subordinates to promote open dialogue across all leadership channels during professional development and mandatory training at all ranks. Anecdotally, supervisors have reported improved work performance in general from those individuals who have engaged in some form of mental health support services.

Increasing awareness of the euthanasia mission among support personnel (eg, mental health providers and chaplains) would allow for a better understanding of US Army veterinarians' work and enhance support of their mission. Training content should include psychological and euthanasia distress related to the military veterinary mission, common positive and negative coping reactions, and sources of formal and informal support (eg, peers, leaders, and mental health providers). Engaging mental health clinicians and support staff to be sensitive to the implications of euthanasia as an occupational stressor will help clinicians better treat and interact with soldiers who experience distress related to euthanasia and offer effective coping strategies.

Chain of Command Influence

Key leaders appointed to steward military veterinary assets require targeted education and preparation to provide best the guidance and supervision needed for mission accomplishment and safeguarding of their personnel. Military chain of command and non-commissioned officer support channels must acknowledge the importance of individual physical and mental health measures to resilience. These leaders have a tremendous influence on their soldiers'

well-being. Ensuring all personnel are aware of resources is critical and involves educating non-veterinary commanders regarding mental health concerns threatening US Army veterinarians' resilience. Awareness and education could be achieved through the Army Medical Department and School Pre-Command Course, which incorporates a rotation with the Army Veterinary Services offering veterinary-specific briefings. This unique opportunity provides access to incoming brigade and battalion commanders taking charge of veterinary assets and personnel. Informed leadership could then disseminate resources to their population through various venues (counseling, physical displays of contact information, etc.). The chain of command must continuously review access to confidential, affordable mental health assessment, counseling, and treatment. Promoting access to urgent and emergent care as available 24 hours a day, seven days a week, for DOD employees is an organizational responsibility. Leaders must ensure that their assigned veterinary personnel always have adequate access to mental health care.

Given the stigma associated with securing individual mental health care, alternative support groups may represent a valuable alternative. Those non-profit organizations offer education, support, and resources and may be more palatable to some. Although most of these organizations do not provide mental health diagnoses or treatment, they offer anonymity and a psychologically safe place for veterinarians to explore their feelings. Confidential support groups harness years of experience helping colleagues overcome the challenges facing veterinary team members and, most importantly, impart the wisdom that nobody needs to weather adversity alone. A sense of connection can be lifesaving for military veterinary caregivers.

Sharing Lessons Learned

The process of sharing resources and lessons learned among future leaders bears further attention when considering resilience. A universally accepted method for information distribution appears lacking from many pre-command curriculums. One author benefitted from serving under a supervisor who modeled an effective means for leadership communication referred to as "Green Tab" meetings, referencing the historical form of uniform marking that identified leaders in command of combat echelons. These monthly meetings brought together command teams in a closed forum that promoted the candid and judgment-free exchange of lessons learned. These interfaces built great trust across the chain of command in all directions. Parties became familiar with one another's triumphs and tribulations in an environment seldom afforded to those construed as competing with one another for ratings. However, this experience appears to be the exception rather than the norm based on related queries among peers in various commands.

Without a directed, effective communication model, the risk of losing or ignoring valuable mental health resource knowledge looms excruciatingly high. For instance, a command team must be cognizant of and comfortable with implementing command-directed behavioral health evaluations in urgent and emergent scenarios to engage mental health professionals. Obtaining information about a soldier's mental health status and fitness for duty can be the difference between life and death. The need for resilience knowledge sharing throughout the military community is paramount. This gap is particularly salient considering the stigma sometimes associated with pursuing mental health care, as evidenced by studies cited in this paper. Individual preference for self-management and belief that care works have likewise influenced the affected individual's pursuit of mental health services.[59] Reconceptualizing mental health care to meet US Army veterinarians where they are at, rather than trying to change everyone's attitudes toward care, is an important consideration.

Novel Mental Health Assessment Measure

The mental health crisis among US Army veterinarians likely requires more than the resilience solutions proposed above to stem the rising tide. A novel mental health assessment geared specifically toward veterinary health care providers is consequently merited and must provide improved access to care for those in need. Viewing healthcare providers as a distinct performance population requiring occupationally related support places them in the company of pilots requiring flight physicals or first responders checking in with mental health professionals following disaster response. Before bringing civilian veterinarians into the military, individuals should undergo a modified or tailored assessment.

Other military professions have already merited inclusion in the more comprehensive Personnel Reliability Assurance Program, commonly known as the Personnel Reliability Program (PRP), as authorized by DOD Instruction 5210.42.[60] The PRP constitutes a US Department of Defense security, medical and psychological evaluation program designed to permit only the most trustworthy individuals to have access to nuclear weapons (NPRP), chemical weapons (CPRP), and biological weapons (BPRP). This program aims to ensure that each person who performs duties associated with the selected professions meets and maintains the highest possible reliability standards. Determining whether a person qualifies to work in a PRP position includes initial hiring and continuing evaluations once the person is employed. This evaluation contains medical tests and an extensive background investigation.

Some of the standards and requirements to determine if an individual is suitable for the PRP include the following:

- physical competence, mental alertness, and technical proficiency commensurate with duty requirements;

- evidence of dependability in accepting responsibilities and effectively performing in an approved manner;
- flexibility in adjusting to changes in the working environment;
- evidence of reasonable social adjustment;
- emotional stability and ability to exercise sound judgment in meeting adverse or emergencies; and
- positive attitude toward their duties and the PRP.

The DOD screens for potentially disqualifying information including, but not limited to, a person's physical, mental, and emotional status. Conduct or character exhibited both on- and off-duty and at any time during employment, which may cast doubt on an individual's ability or reliability to perform professional duties, is also considered.

Modeling an assessment program after the PRP could help ensure the US Army veterinary workforce is reliable, effective, and competent to perform their essential mission. Such implementation, beginning with the recruiting process, would send the message that the military veterinary profession cares about its prospective providers and those entrusted to their care. Building requirements into the Health Professions Scholarship Program, FYGVE, and Long Term Health Education and Training programs would inexorably tie scholarship criteria to fitness for duty.[58 61]

Adapting well-being checks like those observed in the Victory Wellness program, 1st Infantry Division/Fort Riley (1ID/FRKS), offers an alternative approach.[62] This program, supported by WRAIR, incorporates mandated annual counseling sessions with Military and Family Life counselors (MFLCs) lasting approximately 30 to 45 minutes with documentation absent from any official record. The goals are to promote personal resilience and development, demystify the counseling process, and potentially decrease stigma. The Victory Wellness program, staffed exclusively by MFLCs, avoids adding caseload to the military medical system. Most importantly, this program offers prioritized access to care for participating personnel. Professional and personal benefits demonstrated by this program evidence the utility of such a systematized approach to resilience.

A recommended bi-annual system of periodic assessment would signify a commitment to US Army veterinarians' ongoing health and welfare. These touchpoints would necessarily go beyond the predominantly self-evaluative components of the Periodic Health Assessment. Face-to-face evaluations with social workers or other mental health care providers are necessary to achieve a professional pause, realistic feedback, and human connection for veterinary caregivers. MFLCs could be recruited for this purpose following veterinary-specific familiarization and training.

Another route for support could involve implementing social workers for this purpose, which would align with other military medical resources. Embedding social workers within veterinary units would offer a force multiplier effect. These professionals typically assist active military service members and veterans with social, emotional, and familial challenges. Social workers further assist with common mental health conditions, including isolation, anxiety, insomnia, PTSD, and depression. Military social workers help their clients address these issues through individual and family counseling, resource navigation services, education, and the development of programs and initiatives to serve military professionals and their families.

Incorporating social workers or counselors into the FYGVE program for early career professionals as part of the process for their development should be considered. Trust in leadership and program buy-in requires mental health care professionals to be accessible and familiar with associated working conditions for veterinary personnel. A dependable presence is critical to overcoming the stigma of pursuing mental health care. Like the MFLC model, engaged social workers could also meet with US Army veterinarians outside the military medical system.

Enforcement Options

Proposed novel assessment program results incorporated under existing credentialing and privileging enforcement guidelines under the Defense Health Agency Procedures Manual (DHA-PM 6025.13) would afford immediate action.[63] Clinical privileges could be suspended if US Army veterinarians fail to meet fitness for duty standards. Denials would identify a military veterinarian's failure to meet established threshold criteria for providing clinical veterinary care resulting from their compromised condition. Communication between the health care provider and chain of command would articulate evidence of any conduct that could adversely affect the health and welfare of a patient or assigned personnel. The US Army Veterinary Corps maintains a clinical credentialing program managed by 64F series US Army Veterinary Clinical Medicine Officers. Programs are not currently synched, but with the transition of DOD military medical assets under Defense Health Agency, the opportunity for this change exists. Suspension of security clearances under the Military Health System is an option based on mental health criteria, generally impacting credentialing status as defined under human health care provider standards. Any further consideration for enforcement implementation requires future collaboration between the offices of the US Army Veterinary Corps Chief and Surgeon General. Reducing the stigma of pursuing mental health support demands the withholding of any punitive actions when US Army veterinarians courageously seek care for a mental health crisis. Rather, leadership interventions should accompany failure to self-report or when veterinary caregivers neglect available resources, jeopardizing their mission and assigned personnel. Punitive actions will worsen the current situation worse and will not achieve the desired results if employed without considering individual circumstances and mental health status.

Reducing Administrative Burden

A targeted effort towards reducing the many occupational stressors reported by the survey population is already underway by the US Army Veterinary Corps. This Veterinary Corps task force should revisit policies and procedures that may help to reduce the burden of administrative tasks to maximize efficiencies for enhanced productivity.[6] Mitigation strategies must acknowledge the source of stress and remedy the impact appropriately. The Global Veterinary Medical Practice, as the corporate body for the US Army Veterinary Service, should reorganize or reengineer administrative tasks for efficiency and utility under the existing corporate construct and prioritize those tasks of greatest concern (eg, clerical support).

Future Studies

The continued collection of data related to US Army veterinarians' resilience, needs, interventions, and efficacy remains paramount to combating the stated mental health crisis. Future US Army Veterinary Corps surveys should incorporate appropriate indices and scales as referenced previously (CD-RISC, BRS, CIPS, MBI) for each threat to resilience. Further studies should also incorporate gender differences and variable needs given the higher ratio of females represented in the veterinary profession.

Conclusion

Resilience is a key concept that fundamentally contributes to the well-being of veterinary care providers within the military. The US Army Veterinary Service should leverage existing resources and explore innovative solutions to mitigate the crisis by addressing resilience threats, such as impostor syndrome, Compassion Fatigue, Burnout, Secondary Traumatic Stress, Red Shoe Syndrome, and loneliness. Effective programs must incorporate flexibility for ongoing shifts in the internal and external environment navigated by US Army veterinary professionals and improve access to mental health care. The imminent threats to resilience in the US Army veterinary population contribute significantly to the mental health crisis. Recommendations proposed provide a practical and comprehensive means to ameliorate these complex hazards and ultimately strengthen individual and organizational resilience for this critical service group.

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First Year Graduate Veterinary Education Program: Experiential Learning and Mentorship

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Abstract

The US Army Veterinary Corps First Year Graduate Veterinary Education (FYGVE) program provides Veterinary Corps Officers with mentored, experiential learning to hone the knowledge, skills, and behaviors required to excel across the broad Army Veterinary Services mission. In 2019, the FYGVE Futures Working Group established a FYGVE Competency Framework providing a five-domain structure of aggregated military and veterinary competencies to facilitate execution of the program. This article details the development of the framework and supporting standardized program elements that deliver mentored experiential learning.

Keywords: First Year Graduate Veterinary Education, Army Veterinary Service, Experiential Learning, Veterinary Corps

Introduction

The United States Army Veterinary Corps (VC) requires agile and adaptive Veterinary Corps Officers (VCOs) to protect the Warfighter and support the National Military Strategy through provision of military veterinary services. Military veterinary services are comprised of veterinary medical and surgical care, food safety and defense, veterinary preventive medicine, and biomedical research and development. The globally dispersed mission of the VC supports all Services and Components of the Department of Defense (DoD).

A VCO's initial transition from veterinary school to the complex responsibilities of the dual professional, the Army Officer and Doctor of Veterinary Medicine, is challenging for new graduates. Adapting to a military lifestyle, along with new responsibilities for soldier welfare, patient care, expanded technical skills and knowledge, and team leadership, adds additional stressors during an already vulnerable transition period. Veterinary school curricula do not adequately prepare newly accessioned VCOs for the diverse mission requirements they encounter early in their assignments as Field Service Veterinary Officers (Area of Concentration 64A). New VCOs are frequently assigned to execute their broad mission set from a single veterinarian duty site hundreds of miles away from their chain of command. This separation is considerably beyond what is expected of most newly accessioned Army Medical Department (AMEDD) officers who work alongside their chain of command and peer groups. Therefore, the VC must be prepared to not only effectively mentor its junior VCOs, but also utilize experiential learning to ensure confidence and competence in conducting the unique VC mission in isolated environments.

In 2009, the Army Surgeon General approved a pilot implementation of the FYGVE program. The program was established as a one-year professional program "to better prepare its junior Veterinary Corps Officers for the rigors of military service" by bridging the knowledge gap between veterinary school and a VCO's first Army assignment.[1] The FYGVE program addresses the educational gap between what VCOs learn in their professional schooling and military-specific subject areas such as medical treatment and management of military working animals, veterinary business practices and personnel management, zoonotic disease prevention and control, commercial sanitary audits and stability operations in austere environments.[1]

A veterinarian's transition from the classroom into practice is an especially stressful time; professional skills such as confidence and self-efficacy, recognizing one's own limits, and decision-making skills are critical for new veterinarians during this period.[2] Mentorship is crucially important to professional development of new graduates as they navigate this transition

period.[3,4] FYGVE affords newly accessioned VCOs this critical mentorship during a much-needed opportunity to hone their knowledge, skills, and behaviors (KSB) to ensure they are competent and confident prior to arrival at their first post-FYGVE duty site.

With its focus on addressing the aforementioned educational gap combined with ensuring appropriate mentorship, the FYGVE program prepares VCOs to succeed and overcome the challenges of geographic dispersion and recent graduation from veterinary school with limited practical skills. This article details the development of an FYGVE Competency Framework to support standardized FYGVE program elements providing mentored experiential learning.

Background

The FYGVE program, now in its thirteenth year, has trained 326 new VCOs in requisite competencies for operating in a complex and uncertain environment. These competencies originally focused on three broad areas required of an entry-level VCO (animal medicine, veterinary public health, and leadership). Each of the seven sites (Figure 1) is staffed with two board certified cadre who provide mentored training to approximately six VCOs each year. Cadre include one VCO with specialized training in veterinary preventive medicine (Veterinary Preventive Medicine (64B) Officer) and one VCO with residency training in clinical medicine (Veterinary Clinical Medicine (64F) Officer). Two civilian Animal Health Technicians and one non-commissioned officer round out the team of instructors.

In late 2019, the Veterinary Corps Chief directed establishment of a FYGVE Futures Working Group (FFWG) to operationalize FYGVE, preparing VCOs to "face the tactical challenges of Multi-Domain Battle against near-peer adversaries in an uncertain and complex security environment of increasing instability and conflict."[5 (2)] The FFWG worked to improve and standardize program elements to achieve this objective, despite variability across program sites. Variability is inherent to the program as newly accessed VCOs enter the Army from over 50 American Veterinary Medical Association (AVMA) Council on Education-accredited colleges of veterinary medicine with different curricula and are then assigned to a one of seven FYGVE sites.[6] Each FYGVE site has a wide variety of resources unique to the location (eg, co-located deployable veterinary units, varying installation missions and different cadre specialties and experience levels).

Figure 1. The seven sites of the FYGVE program.

The FFWG focused on outcome-oriented, experiential learning strategies to develop competent, adaptive, and critical thinking VCOs just before the coronavirus (COVID-19) pandemic occurred. These efforts continued despite widespread public health restrictions that also disrupted conventional academic veterinary medicine programs. Concurrently, future VCOs completing veterinary school as part of the Health Professional Scholarship Program experienced major disruptions to conventional academic programs due to pandemic restrictions. Historically hands-on learning experiences in anatomy labs and clinical rotations were transitioned to virtual experiences. The FFWG characterized this gap in hands-on experience as a risk to the desired end state of clinically confident and competent VCOs, confirming the need for mentorship and standardization of experiential learning in the FYGVE year. To mitigate this risk, the FFWG examined competency-based approaches through the lens of US Army Training and Doctrine Command (TRADOC) Regulation 350-70, *Army Learning Policy and Systems*[7] and veterinary professional organizations including AVMA and Association of American Veterinary Medical Colleges (AAVMC).

Outcome-Oriented, Competency-Based Experiential Learning

An outcome-oriented program designed around the hallmarks of the Army Learning Model - "quality, relevant and effective learning experiences," is paramount to FYGVE transitioning new Army veterinarians from the classroom to officers executing operational missions.[7 (24)] The Military Veterinary Center (VETCEN), food facilities (installation and commercial), and garrison stakeholders provide FYGVE sites with a real-world mission set and learning environment. At these sites, FYGVE Captains experience daily exposures that support their overall readiness to perform the VC mission. This experiential learning offers a critical linkage between an individual's education, work, and personal competency development, while fostering critical thinking and initiative.[8]

Competency-based medical education (CBME) shapes medical education to ensure the learner achieves competencies within a structured framework that represents the interrelated and purposeful competencies required to meet patient and stakeholder expectations of performance.[9]CBME was first introduced in 1978 and gained momentum in the mid-1990's.[9] The AAVMC Competency-Based Veterinary Education (CBVE) Working Group published a CBVE Framework for the veterinary

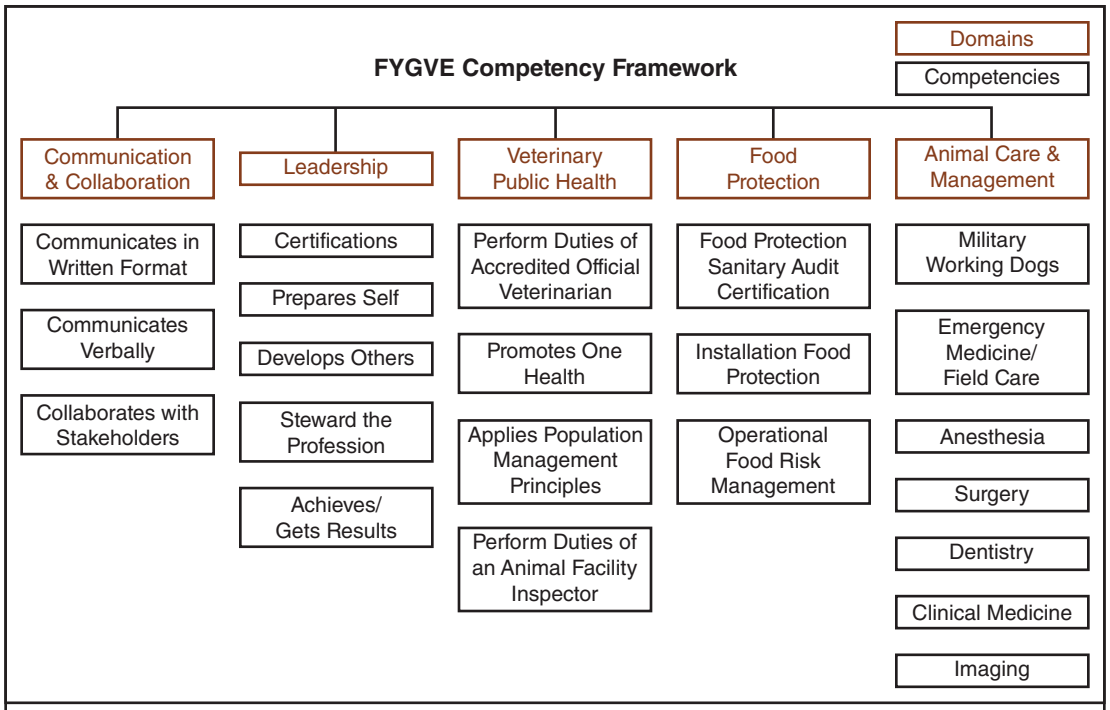

Figure 2. FYGVE Competency Framework of five domains.

profession in 2018.[10] By tailoring learning to experiences that facilitate sequential development of increasing levels of responsibility while progressing toward the desired competency outcomes, the FYGVE curriculum allows active engagement in learner-centered education and assessment.

The FFWG merged educational theory from the Army Learning Model and the relatively new CBVE Framework to establish a FYGVE Competency Framework of five domains (Figure 2) and 22 aggregated military and veterinary competencies. These 22 competencies represent a collection of observable KSBs. Sub-competencies then deliver granularity that is tailored to outcomes focused on VC mission requirements for 64As. Emphasizing real-world, learner-centered experiences, each competency and sub-competency has relevant exposures, including Individual Critical Tasks and Veterinary Corps Chief Readiness Targets.[11] Officers guide their readiness growth through tracking and personal reflection on each exposure (Figure 3). Cadre also utilize the tool to provide professional development counseling.

The FFWG developed this framework to transfer the required KSBs from the institutional environment of veterinary school to the operational environment of the military. It also expanded the original three broad-focus areas required of an entry-level VCO to five domains of competency: communication and collaboration, leadership, veterinary public health, food protection, and animal care and medicine. While each domain is necessary to build a comprehensive foundation to support a competent and confident VCO, the intentional separation of domains within the framework serves as an illustration of each essential component.

Competency Domains

Effective communication and collaboration underpin successful execution of all aspects of the VC mission. The communication and collaboration domain emphasizes the importance of competent communicators creating a shared understanding of topics for diverse audiences through three competencies: communicates in a written form, communicates verbally, and collaborates with stakeholders. Briefing VC capabilities to senior leaders outside the VC and delivering a professional presentation are among exposure requirements for FYGVE Captains that support the "communicates verbally" competency. Additionally, the FYGVE Captains demonstrate their ability to communicate in written form through a clear and appropriate style. They are also afforded opportunities to collaborate with a complement of stakeholders internally, externally and across a range of veterinary services.

The leadership domain also permeates all aspects of a VCO's role. One challenge for the FYGVE curriculum is identifying appropriate exposures for FYGVE Captains to gain leadership experience while they are not able to supervise Soldiers or Civilians. Instead, each week a Captain is assigned the role of Peer Leader. This officer serves as the "Officer in Charge" for the daily execution of the FYGVE mission and

their peers' performance. Regardless of their rotations or other obligations, this additional duty provides realistic leader development experiential learning beyond scenario-based and didactic officer professional development opportunities. In addition, it provides direct exposure to crucial conversations as both a leader and follower.

The animal care and management domain is most familiar to FYGVE Captains upon program entry due to the establishment of a strong clinical foundation during veterinary school. Throughout the year they build confidence in their veterinary medical knowledge and skills through mentored repetitions of preventive medicine, sick-call, surgical, and emergency exposures. Mastery of triage and emergency patient management such as performing thoracocentesis, point of care ultrasound, treating hypovolemic shock, and abdominal surgery are key to preparing new veterinarians to treat patients in austere environments.

The veterinary public health domain emphasizes veterinarians' role in promoting healthy environments through an integrated, unifying a One Health approach to zoonotic and infectious disease control, human-animal bond, mitigating transboundary disease risk and antimicrobial stewardship. In contrast to Animal Care and Management, incoming VCOs typically lack knowledge required for veterinary public health; this is likely a result of variability across veterinary school curricula.

While food safety also incorporates a One Health approach, the food protection domain was intentionally separated from the Veterinary Public Health domain due to the unique and specific exposures required to ensure VCOs are ready to perform this important mission. Another domain with less initial familiarity for most VCOs, this domain exposes VCOs to food safety and defense as they evaluate commodities for both unintentional and intentional threats. In addition to gaining Commercial Food Protection Auditor Certification through mentored auditing of least five commercial establishments, VCOs work closely with Food Safety Warrant Officers (640A) and Veterinary Food Inspection Specialists (68R) to evaluate installation facilities, operational rations, and sampling for laboratory testing.

FYGVE Program Elements

The framework's exposures are delivered by the FYGVE program elements consisting of initial weeks, rotational weeks, and collective training. Throughout the year, sites execute these elements intended to support the standardization of FYGVE Captain development.

The four initial weeks, designed to orient and evaluate, include an orientation week, a VS / food and public health week and two weeks of initial clinical competency assessment. During this period, FYGVE Captains gain familiarization with the overall program, the installation and mission, their cadre, and peers. During the clinical competency assessment, clinical cadre train, assess, and verify VCOs have adequate clinical skills to provide patient care without direct supervision and can properly document their findings in the electronic medical record.

Following the initial weeks, the core program is executed through rotational weeks emphasizing the following VC mission experiences: animal medicine; veterinary public health and food protection; and mission oversight. During rotational weeks, FYGVE Captains spend 35-39 weeks reinforcing knowledge and skills. Each academic year begins with rotations scheduled by the cadre. In the final third of the year, as VCOs progress toward attaining the desired competency outcomes, personal development plans drive the rotations. A peer leader is responsible for coordination and execution of the weekly schedule. Competencies are trained during all rotations, but rotations do not directly align with the five competency domains. FYGVE Captains spend more than 50% of their rotational weeks in animal medicine, 25% in veterinary public health and food protection, and 25% in mission oversight. Mission oversight weeks are dedicated to developing leadership skills, communication, and an understanding of VC mission execution.

After having opportunities to rotate through mission oversight weeks, each VCO refines their skill set during an attending clinic week. The attending clinic week acclimates FYGVE Captains to a site with a mission, staffing, and capabilities comparable to where they may be assigned after FYGVE. The FYGVE Captain is typically scheduled to conduct this week while simultaneously backfilling the Public Health Activity mission during an assigned VCO's absence. Occurring later in the year, and consistent with continuing natural progression, VCOs gain confidence in their ability to perform independently during this experience. Additionally, it affords opportunities for the FYGVE Captains to observe and discuss the site's mission execution and make mental comparisons to their FYGVE location's mission as they develop their leadership vision for the future.

The FFWG's goal of standardization had the greatest impact on the collective training element. Collective training brings together FYGVE Captains and cadre from across the seven locations and includes monthly virtual training, as well as three in-person collective weeks. Virtual training delivers pre-determined sub-competency topics that are either stand alone or support an aspect of knowledge required to execute in-person collective weeks. Collective weeks are resource-intensive and integrate relevant workshops, practical exercises, and scenarios that improve discussion, collaboration, and problem-solving skills needed for operational adaptability. Each collective week brings all FYGVE Captains and cadre together and provides valuable networking opportunities and delivers a standardized experience around a theme – veterinary services; military working dog medicine; and stakeholder communication and collaboration. VCOs from host sites lead the week's

scheduling, guest speaker invitations, venue and billeting coordination, and fiscal commitments, providing an additional experiential learning opportunity to gain leadership exposures.

Limitations

FYGVE is an experiential and mentorship-focused program rather than purely instructional, therefore effectiveness and impact are difficult to quantify beyond anecdotal surveys. An informal 2022 VC Junior Officer Council survey of both current and former FYGVE Captains reported the benefits of resourced, high-impact group training, camaraderie with other captains, and access to resources from other FYGVE participants and mentors as major successes of the program, supporting these less tangibly measured program outcomes. The program is reviewed annually to identify gaps, refine initiatives, and enhance execution. Moving forward, an assessment, monitoring, and evaluation effort is under development to establish improved and enduring methods to measure program effectiveness. This effort will also validate the implementation of competency-based experiential learning produces the desired, ready Field Service Veterinarians.

Conclusion

The FYGVE program was originally established to address a gap between the KSBs obtained through standard veterinary education and those required for a VCO to independently execute the VC mission. The ongoing transition and challenges of the veterinary profession combined with the complex threat landscape further dictate the crucial need for the VC to invest in mentored experiential learning for junior VCOs. Executed through FYGVE Competency Framework and standardized program elements, the FYGVE program facilitates successful career transitions while supporting the development of graduates who are prepared to excel as competent and confident VCOs in their first post-FYGVE assignment.

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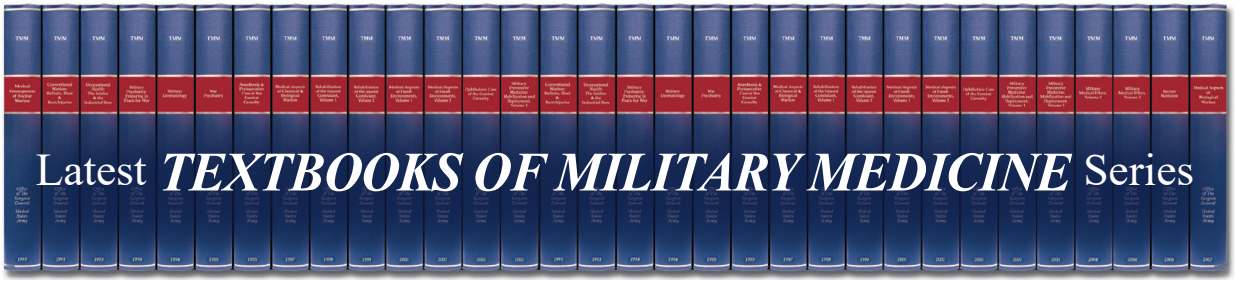

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