ABSTRACT
Introduction: Navy physical therapists (PTs) have been a part of ship’s company aboard Aircraft Carriers since 2002 due to musculoskeletal injuries being the number one cause of lost duty time and disability. This article describes a decade of physical therapy services provided aboard aircraft carriers. Materials and Methods: A retrospective survey was conducted to evaluate the types of services provided, volume of workload, value of services provided, and impact of PTs on operational readiness for personnel aboard Naval aircraft carriers. Thirty-four reports documenting workload from PTs stationed onboard aircraft carriers were collected during the first decade of permanent PT assignment to aircraft carriers. Results: This report quantifies a 10-yr period of physical therapy services (PT and PT Technician) in providing musculoskeletal care within the carrier strike group and adds to existing literature demonstrating a high demand for musculoskeletal care in operational platforms. A collective total of 144,211 encounters were reported during the 10-yr period. The number of initial evaluations performed by the PT averaged 1,448 per assigned tour. The average number of follow-up appointments performed by the PT per tour was 1,440. The average number of treatment appointments per tour provided by the PT and PT technician combined was 1,888. The average number of visits per patient, including the initial evaluation, was 3.3. Sixty-five percent (65%) of the workload occurred while deployed or out to sea during training periods. It was estimated that 213 medical evacuations were averted over the 10-yr period. There were no reports of adverse events or quality of care reviews related to the care provided by the PT and/or PT technician. Access to early PT intervention aboard aircraft carriers was associated with a better utilization ratio (lower average number of visits per condition) than has been reported in prior studies and suggests an effective utilization of medical personnel resources. Conclusions: The impact of Navy PTs serving afloat highlights the importance of sustaining these billets and indicates the potential benefit of additional billet establishment to support operational platforms with high volumes of musculoskeletal injury. Access to early PT intervention can prevent and rehabilitate injuries among operational forces, promote human performance optimization, increase readiness during war and peace time efforts, and accelerate rehabilitation from neuromusculoskeletal injuries. With the establishment of Electronic Health Records within all carrier medical groups a repeat study may provide additional detail related to musculoskeletal injuries to guide medical planners to staff sea-based operational platforms most effectively to care for the greatest source of battle and disease non-battle injuries and related disability in the military.

INTRODUCTION
U.S. Navy physical therapists (PTs) were first deployed on carriers in 1996 and 1997 to perform pilot studies to determine the impact of PTs on mitigating musculoskeletal injuries and expediting return to full duty following sustaining of injuries. These trial deployments proved successful in providing prompt evaluation of acute, subacute and chronic musculoskeletal conditions, providing work-site ergonomic and injury prevention guidance and subsequently reduced lost workdays and medical evacuations (MEDEVACs). The early success of physical therapy services led to establishment of billeting for one PT and one PT Technician (Hospital Corpsman Navy Enlisted Classification 8466) as part of ship’s company aboard each carrier beginning in the fall of 1998. The billeting and staffing roll-out process led to all carriers having the routine manning of one PT and one PT Technician by 2002. While onboard, PTs provided direct access evaluation, diagnosis, and management of acute and chronic neuromusculoskeletal injuries and dysfunction for the Carrier Strike Group (CSG). Patients were provided with individualized services to restore function, improve mobility, and relieve pain in attempt to prevent or mitigate development of chronic symptoms and future physical disability. As licensed independent providers, PTs hold an array of clinical privileges that facilitate efficiency in early evaluation and management (Table 1). PTs also design injury prevention and human performance optimization (strength and conditioning) training programs. In addition to their primary functions, PTs may serve...
in additional roles such as Assistant Medical Department Head, Health Promotion and Wellness Programs Officer, Sick Call Coordinator, Medical Training Team Leader, Command Watch Officer, Command Fitness Leader, and Mass Casualty Training Team Leader.

The purpose of this paper is to summarize clinical productivity and additional details of the clinical services provided by carrier-based PTs during the initial decade of PT assignment as a regular part of a CSG. The investigators asked PTs, who served on Nimitz class carrier, to abstract from existing administrative records, information on clinician productivity, integration of physical therapy services onboard ship, PT workload and impact of physical therapy services on operational readiness.

**METHODS**

**Data Sources**

Data for this analysis came from routine quarterly clinical productivity reports and quality of care reviews. To facilitate the collection of these data, the investigators asked the PTs from each carrier to record these data using an abstract form (Supplementary Table). The abstracting form was distributed to all PTs who served onboard Nimitz class carrier during the first decade of permanent PT assignment. The form asked the PTs to abstract data related to the following areas of professional services provided and related impact:

- **Productivity**: expressed in terms of number of patient encounters, broken down by new evaluations, follow up evaluations, and treatment sessions.
- **Integration**: expressed as whether the PT duplicated services from other medical department personnel, or whether the PT represented a unique specialty care provider without which the services offered by the PT would not otherwise be available to the patient. Additionally, respondents were asked to report on special tests and supplemental privileges (e.g., imaging, laboratory studies, electromyography (EMG), nerve conduction studies (NCS) medication, casting and splinting) utilized by PTs using a four-point response scale (never, rarely, occasionally, frequent).

- **Workload**: respondents reported on command collateral duties during time at sea, and the percent of the work day spent on patient care versus collateral duties.

- **Medical evacuation**: The impact of permanent billeted PTs on the number of MEDEVACs was reported as the number of MEDEVACs saved because of musculoskeletal conditions. Respondents were asked to report the number of musculoskeletal MEDEVACs experienced prior to PT staffing onboard ship, and again for the period of time after PT staffing was onboard ship. Finally, the respective Force Surgeon for Commander Naval Air Forces and the Navy Physical Therapy Specialty Leader were queried for reports of adverse events or quality of care reviews related to cases involving use of onboard physical therapy services.

Numeric data are tabulated and summarized using descriptive statistics (N, mean (X), and median (M)). This is a descriptive report; no specific statistical comparisons are reported.

The Institutional Review Board at Naval Medical Center, San Diego, CA, USA was consulted and provided a determination that this was a quality improvement project, not a human subject research project.

**RESULTS**

Forty-five PTs were asked to abstract data for the survey. Of the 45 candidates, 34 returned data (77% response rate), documenting workload from PTs and PT technicians. The time period covered by the reports varied, ranged from 6 to 38 mo (X = 21.6 mo, median (M) = 24 mo), indicative of the variable duration in which the PT was assigned to the aircraft carrier.

**Productivity**

A collective total of 144,211 encounters were reported during the 10-yr period (Table II). Of the 34 reports received, 14 reports provided comprehensive breakdown of the number of initial (new) evaluations, number of follow-up evaluations, and number of treatment sessions. The other (20) reports provided total number of visits with 6 providing only the total number of visits, 14 providing total volume along with volume of new evaluations, follow-up evaluations, and/or treatment sessions but not all 3. The average workload was 203 patient visits per month.

The number of initial evaluations performed by the PT averaged 1,448 (M = 1,144) per assigned tour. The average number of follow-up appointments performed by the PT per tour was 1,440 (M = 700). The average number of treatment appointments per tour provided by the PT and PT technician.
combined was 1,888 ($M = 1,675$). The average number of visits per patient, including the initial evaluation, was 3.3. Sixty-five percent (65%) of the workload occurred while deployed or out to sea during training periods. The breakdown of appointment types (Fig. 1) indicates a nearly equal number of initial evaluations (38%) in comparison to the number of total treatment sessions (41%).

**Integration**

Twelve respondents indicated there were no other medical staff aboard the ship with specialty training or interest in providing care for Sailors with orthopedic injuries. An equal number of respondents reported there were additional medical staff that provided various types of care for orthopedic conditions. The most common additional musculoskeletal care assets were Hospital Corpsmen (General Duty Corpsmen, Orthopedic Technician, Radiology Technician, Surgical Technician, and Independent Duty Corpsmen) that provided casting and splinting services aboard the carrier. The training to perform casting and/or splinting services was received at the MTF prior to deployment in 33% of reports while the other reports indicated the training was performed aboard the carrier by qualified staff (e.g., Orthopedic Technician, PT Technician, or PT). Eight respondents indicated additional care of musculoskeletal injuries was provided by one or more personnel with the following specialty training: Physician Assistants (three reports), General Medical Officer (one report), Flight Surgeon (two reports), Flight Surgeon (one report), and Doctor of Osteopathy (three reports). Seven reports indicated that other medical staff, despite expressed interest in providing care for musculoskeletal injuries, were fully engaged with non-musculoskeletal care demands.

Additionally, ancillary ships attached to the CSG cruise with organic medical assets, usually in the form of an Independent Duty Corpsman (IDC). The IDC routinely consults with carrier medical staff, to include the PT, for advice on current cases. In rare instances, patients will be flown via helicopter to the carrier, or carrier medical staff may be flown to ancillary ships, to provide on-site diagnosis, treatment and/or a management plan recommendation.

As neuromusculoskeletal subject matter experts onboard the carrier, PTs encounter complex conditions (i.e., fractures, dislocations, ruptures, nerve injury, etc.) via direct access through sick call or referral/consultation as part of the embedded medical team. While aboard the carrier, medical staff often have the ability to consult telephonically, or via email with shore-based specialty services such as orthopedic and neurological surgeons to discuss management of complex cases. Numerous case examples were provided via the abstracting form indicating multi-disciplinary collaboration among members of the carrier medical department as well as tele-medicine consultation and collaboration with specialty care services from regional military treatment facilities.

The reported frequency of clinical privileges utilized (question six in the Supplementary Table) varied with the exception of ordering radiographs (RAD) and prescribing medications (MEDS) such as non-steroidal anti-inflammatory drugs (NSAIDs) or analgesics which were reported as utilized “frequently” (78% RAD, 74% MEDS) or “occasionally” (22% RAD, 26% MEDS) in all reports. Casting/splinting was the third most utilized service with 74% of reports indicating occasional or frequent use. Services such as MRI and EMG/NCV testing required referral to external (non-carrier) medical resources. Referral for MRI utilization was variable with 22% never, 11% rarely, 48% occasionally, and 19% frequently. The least utilized services were referral for EMG/NCV, laboratory tests, and wound care which were reported as never or rarely provided (88%, 88%, and 78%, respectively).

**Workload**

Ninety-six percent of PTs reported that 75–95% of their work day was devoted to patient care, with one report indicating a period of 50% of time for direct patient care in order to fulfill emergent medical department needs and serve as the medical administrative officer. Time devoted to medical department collateral duties ranged from <5% to 10% in all
but the aforementioned case. Command collateral duties were reported to necessitate <5–15% of reporting PTs work day. Those command duties requiring the greatest amount of time were command fitness leader and health promotion officer.

Medical Evacuation
All reports indicated that PTs assigned to aircraft carriers frequently managed musculoskeletal conditions (i.e., fractures involving the extremities or spine, joint dislocations, acute radiculopathy/herniated disc, tendon ruptures, and lacerations) that would often result in emergency consultation at a local acute care facility if pier side. Numerous reports also indicated examples of service members, with some of the aforementioned conditions, that were allowed to deploy based upon the availability of physical therapy services, that would have been placed on limited duty were such services not available. There were also multiple reports of service members having orthopedic surgery (i.e., anterior cruciate ligament reconstruction, pectoralis major repair, clavicle fracture open reduction and internal fixation, etc.) and being cleared to return to the ship while deployed knowing physical therapy services were available. Such retained and returned to ship personnel resources are further indications of the impact of physical therapy services. In addition to numerous musculoskeletal conditions, there were multiple reports of Sailors with non-musculoskeletal conditions being initially evaluated by the PT and subsequently referred to carrier medical staff (i.e., physicians, physician assistant, clinical psychologist,) for further work-up. Such conditions included pyelonephritis/nephrolithiasis, myocardial infarction, transient ischemic attack, and multiple sclerosis.

Based upon input from the reporting PTs and associated medical staff, it was estimated that 213 emergency MEDEVACs were averted over the 10-yr period. There were no reports of adverse events or quality of care reviews related to the care provided by the PTs and/or PT technicians.

DISCUSSION
The primary mission of the Military Health System is to provide healthcare to active duty members, retirees, and eligible family members while also enhancing readiness and protecting the health of U.S. Armed Forces. With neuromusculoskeletal injuries being one of the largest detractors from military readiness and causes of disability in the military, it is essential to identify optimal manning of medical staff to provide a high level of support for forward deployed service members. In order to continuously maintain national strategic goals, CSGs are on station and on call 24 h a day, 365 d a year, often operating autonomously in locations beyond the reach for air assets. The dynamic nature, mission, complexity, and sheer number of personnel of the CSG mission poses significant inherent risk to a higher rate of musculoskeletal injuries. To support CSGs in these autonomous environments, its personnel must operate at high levels of medical readiness. This requires medical staff capability to independently and rapidly respond to common and life-threatening injury, while safely returning injured personnel to full duty as quickly as possible.

Military PTs in all branches of service have established a track record of providing high quality evidence based neuromusculoskeletal care to U.S. Military personnel and beneficiaries. Similar to the Army and Air Force, Navy PTs have provided service in peace and wartime in unique and remote world-wide environments ashore and afloat. Clinical settings for Navy PTs span numerous types of healthcare environments from Recruit Training Centers (e.g., Recruit Training Command, Chicago, IL, USA and Marine Corps Recruit Depot, San Diego, CA, USA), Branch Health Clinics, major military treatment facilities, Navy and Marine Corps Special Warfare training units and teams (e.g., SEALS, Explosive Ordinance Disposal, Marine Corps Special Forces, Riverine Coastal units, etc.), Naval Hospital ships, and CSGs.

Establishment of PTs aboard aircraft carriers was the first enterprise-wide alignment of subspecialty musculoskeletal care services to the “deck-plates” to optimize outcomes by way of efficient access to evidence based medical care. In early 1998, the U.S. Navy was the first branch of service to permanently assign PTs to operational units. Over the past decade, built upon by the impact of PTs serving in Operation Iraqi Freedom and Operation Enduring Freedom, all branches of services now have some component of organic physical therapy assets assigned to their operational forces.

Licensed independent providers with expertise in evaluation and management of musculoskeletal injuries are integral due to the volume of such injuries, the negative impact on readiness, and potential for development of chronic pain and/or disability. Prior to the PT pilo studies in 1996 and 1997, Sailors’ access to care for specialty musculoskeletal services (i.e., Occupational Therapy, Orthopedic Surgeon, Physical Therapy, or Sports Medicine Physician) most often required referral and transit to a fixed Medical Treatment Facility (MTF) and could take days or weeks until care was initiated. Full-time assignment of PTs to the aircraft carrier enabled same day access to care regardless of ship’s location. An added benefit of full-time assignment to the ship was the immediate access to specialty care while pier side that saved significant lost work hours previously required for transit to and from the MTFs. With approximately 35% (50,473) of the physical therapy related visits occurring pier side this is an estimated time savings of 75,710 man-hours that would have been lost in transit (1.5 h per appointment) for MTF related appointments.

The aircraft carrier medical setting involved most patients seeing the PT by way of direct access, without prior evaluation or referral from another healthcare provider. This method of providing care for musculoskeletal injuries has been proven to be a safe and efficient means to expedite return to full duty in military personnel and has also been
demonstrated as cost-effective, with improved outcomes, in the civilian care sector (nationally and internationally).\textsuperscript{12} The PTs reported inter-disciplinary teamwork was common among the medical staff along with frequent utilization of supplemental privileges by the PT. Previous reports have also indicated the benefits of PTs in the inter-disciplinary medical team\textsuperscript{9,13,14} the competency of PTs in managing musculoskeletal conditions\textsuperscript{15} and their effectiveness in ordering imaging studies.\textsuperscript{16} The 34 respondents (PTs) assigned to the aircraft carriers had clinical experience ranging from 3 to 15 yr of orthopedic physical therapy practice. Seventy-one percent of the PTs had additional post-professional board certification in specialty areas of orthopedics, sports, or clinical electrophysiology.

Prior analysis of MTF-based physical therapy care indicated an average number of visits of 8.8 per patient for referral based care (K. Hodapp, unpublished data). The resultant average savings of over five visits per patient further demonstrate the benefits of early access to physical therapy care also reported by others.\textsuperscript{12,13,17} This reduction in visits per patient may partially be attributed to Sailors aboard the carrier having, in general, a higher level of medical readiness than some of the patients receiving care at the MTF. However, it should be noted that the average number of visits per patient on the carrier was significantly less than each of the studies analyzed in a recent systematic review of direct access physical therapy care.\textsuperscript{12}

Additional cost savings attributed to avoidance of MEDEVACs may also be a key benefit of adding PTs to the CSG medical staff. While only 20 respondents maintained data related to MEDEVACs, it was reported that there were 213 MEDEVACs averted by the medical care provided by the PT. Calculating a total cost value of evacuating, or replacing, a service member from a forward deployed environment let alone in austere sea-based environments has not been documented. Devising a methodology for such cost is beyond the scope of this article and the authors would argue, not only are the factors involved numerous and individual to each case, many factors cannot truly be estimated. Additionally, the variability and expanse of world-wide deployable locations of Naval sea-based units which vary year to year based on operational focus and world-wide events would make for variable cost estimations. Ultimately, meticulous planning goes into the precise number of Sailors and Marines required to execute forward deployed operations and the loss of even one service member for 1 d can impact mission readiness and accomplishment.

This manuscript is the first to report musculoskeletal care data across multiple operational Navy platforms over the course of a decade. While this analysis included over 144,000 encounters for musculoskeletal injury it should be recognized that additional musculoskeletal injuries were likely evaluated by other medical staff or not reported by Sailors. Capturing all outpatient injury data with ships at sea nearly 50% of the time was challenging and burdensome without an automated electronic health record (EHR). There was thus no comprehensive tracking mechanism for musculoskeletal injuries in the shipboard environment that covered the wide range of repetitive, overuse injuries (i.e., shoulder pain/impingement) to traumatic injuries (i.e., fracture caused by operating machinery). While occupational injuries causing traumatic injuries or significant lost work hours are commonly reported to the Navy Safety Office, the more common musculoskeletal injuries without identifiable antecedent trauma, deemed to be overuse, cumulative trauma, or insidious onset are unlikely to be reported as an occupational injury. Additionally, under-reporting of musculoskeletal injuries has been recognized in military populations.\textsuperscript{18} Although research has indicated PTs functioning as physician extenders for deployment related musculoskeletal care resulted in a 97% return to duty rate\textsuperscript{9} our survey did not specifically query for return to duty rates nor the amount of musculoskeletal care provided by non-PT medical staff. The non-availability of data preceding PT billeting aboard carriers to serve as a comparison with encounter volume or medical evacuation volume are further limitations of this report.

**CONCLUSION**

This report quantifies a 10-yr period of physical therapy services (PT and PT Technician) in providing musculoskeletal care within the CSG and adds to existing literature demonstrating a high demand for musculoskeletal care in operational platforms. Access to early PT intervention aboard aircraft carriers was associated with a better utilization ratio (lower average number of visits per condition) than has been reported in prior studies\textsuperscript{11} and suggests an effective utilization of medical personnel resources. With the establishment of electronic health records within all carrier medical groups a repeat analysis may provide additional detail related to musculoskeletal injuries to guide medical planners to staff sea-based operational platforms most effectively to care for the greatest source of battle and disease non-battle injuries and related disability in the military.

**ACKNOWLEDGMENT**

Special appreciation is extended to Rudi Hiebert, ScM, for providing input on data reporting and manuscript development.

**SUPPLEMENTARY MATERIAL**

Supplementary material is available at Military Medicine online.

**REFERENCES**