Civilian-Military Trauma Partnerships and the Visiting Surgeon Model for Maintaining Medical Readiness

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OBJECTIVE: The main objective of this paper is to create a model to predict the amount of trauma experience at a level 1 trauma center a visiting surgeon can expect to obtain with near certainty, in a specific amount of time, to maintain trauma skills.

DESIGN: The trauma database of level 1 trauma center (Saint Louis University Hospital, a military civilian partnership site) was examined to identify all urgent trauma cases between 1 October 2015 and 30 September 2017. Using retrospective data, a prospective hypothesis of a mixture of various case exposures a visiting surgeon may experience was made using Monte Carlo statistical methods, various probabilities for wartime relevant specialties were examined.

SETTING: Saint Louis University Hospital, a level 1 trauma and tertiary referral center.

PARTICIPANTS: Trauma patients between the dates October 1, 2015 and September 30, 2017 that underwent an operation at Saint Louis University Hospital.

RESULTS: Orthopedics and general/trauma surgery had the largest number of urgent trauma cases with an average daily amount of 1.03 and 0.49 cases, respectively. Using Monte Carlo methods, various scenarios and probabilities were tabulated. For example, a general surgeon on shift for 10 days could expect to experience 4.9 (95% confidence interval 1-11) urgent cases or a visiting surgeon would require twenty-six 24-hour shifts in the summer to have a 95% certainty to experience at least 10 cases.

CONCLUSIONS: Other than for orthopedics, prolonged training timelines would be required to expose a visiting surgeon to multiple operative trauma cases. Though a specific number of cases to achieve "readiness" is undefined, a visiting-surgeon model may be unacceptable if a large number of cases are required prior to military deployment. This predictive model could be extrapolated to other centers and assist in identifying adequate settings and durations of trauma training sites. (J Surg Ed 76:738−744. Published by Elsevier Inc. on behalf of Association of Program Directors in Surgery.)

KEY WORDS: Readiness, Training, Trauma, Military-Civilian Partnerships

COMPETENCIES: Systems-Based Practice

INTRODUCTION

Military medicine, in general, has 2 distinctly different environments in which it operates: a low-acuity, elective civilian environment and a trauma-centric operational environment. The deployed environment is heavily focused on trauma, acute resuscitation, damage control surgery, and medical evacuation of patients. This is substantially different from most civilian centers, where the focus is heavily weighted toward elective surgical procedures. With the management of military treatment facilities transitioning to the leadership of the Defense Health Agency, a current initiative within the Department of Defense and supported by Congressional mandate, a focus for the military branches is now maintaining operational readiness and addressing potential training gaps.[1,2]

There is ongoing debate within the military leadership regarding how best to supplement stateside, elective, general surgery practices outside of trauma centers with trauma experience, and how to best prepare surgeons for a deployed environment. What is

Funding: This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

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1931-7204/$30.00
https://doi.org/10.1016/j.jsurg.2018.10.008

generally agreed upon is that current operative volumes and trauma exposure in the civilian nontrauma setting is inadequate to maintain operational readiness.[3-6] This is currently addressed differently by each service, and often by each local Command, through various readiness training programs as well as military-civilian partnerships.

A component of trauma readiness is operative exposure and operative decision making. A predictive model would be of great benefit in targeting optimal training locations and creating timelines for training for surgeons that need trauma experience. If a predictive model were shown to be accurate and repeatable, it could answer questions like: does an institution have enough operative trauma volume to support a training program? How long does a training program need to be? While hands on surgical experience would not be the sole factor to judge trauma training programs for surgeons, it may serve as a surrogate for or as an important factor in conjunction with other critical factors such as trauma activations, critical care experience, case review, and didactic opportunity.[7]

The Center for the Sustainment of Trauma and Readiness Skills (C-STARS) is one of the few established programs in the United States Air Force where surgeons, and surgical team members, can get hands-on exposure to operative trauma, trauma resuscitation, and "high stakes" trauma decision making. There are currently 3 designated C-STARS locations in Saint Louis, Baltimore, and Cincinnati which are affiliated with local academic trauma centers. The C-STARS model consists of a civilian-military partnership, where active-duty medical personnel are embedded within civilian systems in order to support a trauma-specific training pipeline to provide trauma experience to those lacking it. Various experience levels, specialties of providers, and support personnel come to receive trauma training and exposure. This includes didactic training as well as hands on patient care, to include trauma evaluations, resuscitation, operative exposure, and technical skills such as setting up rapid infusers and placing tourniquets over a period of 12 days at the St. Louis C-STARS location. The goal of this curriculum is to ensure military personnel are prepared to perform trauma-related tasks in a war zone.

To quantify a likely C-STARS experience for surgeons and create a method to assess future surgical trauma readiness programs a retrospective review of the C-STARS affiliated trauma program at Saint Louis University Hospital was conducted. Ideally, from these data, a predictive model could be created allowing for a standardized analysis of the military training paradigm, assist in gauging the effectiveness of military-civilian partnerships, as well as identify opportunities for improving trauma training programs in general.

MATERIALS AND METHODS

Institutional Review Board approval was obtained allowing for a retrospective review of the Saint Louis University Hospital Trauma Registry. Trauma data for the last 2 years, from October 1, 2015 to September 30, 2017, was collected. Items searched included arrival date, date of operation, operating service, and injury severity score.

The most applicable cases were determined *a priori*. The civilian trauma scenario that best reflects the austere battlefield surgeon's primary responsibility is the trauma scenario where the patient is injured and requires an urgent operation. This is based on these authors' personal experiences over multiple deployments, and is also described in the literature.[3-7] An urgent operation, for the purposes of this study, was defined as an operation that occurred within one calendar day of admission.

In addition, we defined a representative sample for future predictions as 2 years, 731 days, of data. We also assumed that future cases per day are independent and identically distributed according to the cases per day that we have observed. Based on these definitions, data for future cases per day were simulated and the various statistics were estimated. We made the initial decision that 10 operative trauma cases as mandated by Accreditation Council for Graduate Medical Education for general surgery graduation can be considered an initial target, but acknowledge other amounts may be more appropriate.[8] A definition of an adequate number of cases for a general surgeon to be "proficient" in trauma is undefined, and in general there is little data to answer this question. Given the lack of a definition and consensus, several separate volume scenarios were analyzed: competency = exposure to 'X' cases per year, where 'X' = 5, 10, 15, or, 20 cases, respectively. With these definitions in place, a retrospective but recent convenience sample including the previous 2 years of urgent trauma cases was evaluated.

For various scenarios, Monte Carlo resampling methods were used to calculate the most probable number of urgent cases that would be experienced for a set number of shifts, and likewise, for a set number of cases, various number requirements for days on shift were calculated. Monte Carlo methods were chosen given their ability to provide a numerical solution for a problem that does not have a readily available analytical solution. For each combination of specialty and number of shifts, the observed data was resampled with replacement 70,000 times to estimate a bootstrap sampling distribution for the number of cases that a surgeon would be exposed to during the course of the shifts. This bootstrap sampling distribution was used to construct bootstrap estimates of confidence intervals (CI). Assumptions were tested in the following way. A curve was fit to the total number of cases per day, and it appeared that summer months may have more cases and winter months may have fewer cases per day. To test seasonality, the data was split into meteorological winter, spring, summer, and fall. A permutation test using Pearson's chi-squared statistic was run on general surgery/trauma, neurosurgery, and orthopedics separately. General surgery/trauma was found to have statistically significant seasonal variations ($p = 0.00005$), while neurosurgery ($p = 0.89565$) and orthopedics ($p = 0.41565$) was not. The simulations for general surgery/trauma were run again to take into account the seasonal variance. A day of week dependency was also tested using a permutation test with Pearson's chi-squared statistic, and day of week was found to be related to cases per day ($p = 0.0229$). This was not taken into account in the analysis. Visiting surgeons traveling across the country, would not be able to selectively choose only specific days to work.

Using the before mentioned bootstrap estimate of the appropriate sampling distributions, various scenarios were contemplated such as "How many days would a surgeon be on call to experience 5 urgent cases?" or "If a surgeon was on call twenty 24-hour periods, how many cases would he be expected to experience?" For scenarios hypothesizing a number of shifts, the likely number of cases along with 95% CI were listed. For scenarios requiring a pre-set number of cases and asking how many days were required, estimates were made to include a 95% CI. The number of days required was determined to be the number at which the minimum number of a one-sided 95% CI was the pre-set number of cases.

RESULTS

The total number of urgent, operative cases within respective specialties was tabulated (Table 1). The largest number of cases were done by orthopedics with an average daily rate of 1.03 cases a day followed by general surgery/trauma at 0.49 cases a day. After this, the numbers dramatically decreased with specialties such as neurosurgery, otolaryngology, ophthalmology, etc., and were not considered further. To serve as a frame of reference, the mean injury severity scale for all trauma patients undergoing an operation in a warzone between October 1, 2015 to September 30, 2017 was acquired from the military's Joint Trauma System and was found to be 12.55. The mean injury severity scale for general surgery patients undergoing an urgent operation at Saint Louis University Hospital was 20.18 and for orthopedics, 9.44.

After tabulating the total number of urgent cases, the cases were segregated by specialty, including General Surgery, orthopedics, neurosurgery, plastics, etc. Detailed analysis for general surgery/trauma, orthopedics, and neurosurgery was done given they were the top 3 specialties by volume requiring urgent surgical intervention. Neurosurgery was included as a representative for the specialties with infrequent urgent cases. For individual specialties and with the previous assumptions in mind, a probability of participating in an urgent trauma case was calculated for a various number of possible 24-hour shifts a surgeon would have to be in order to reach a minimal level of trauma exposure. As mentioned, for each combination of specialty and number of shifts, the observed data was resampled with replacement 70,000 times to estimate a sampling distribution for the number of cases that a surgeon would be exposed to during the course of the shifts. The simulation was repeated with consistent results.

The data was tested for uniformity with respect to day of week and season. It was found that the total number of urgent operative cases were not evenly distributed with respect to day of week ($p = 0.0229$). A 7-day moving average of total number of urgent

TABLE 1. Overview of Trauma Data From Saint Louis University Hospital, Representing a Two Year Data Set. An Example to Aid in Understanding the Section Listing Number of Days With Specific Numbers of Specialty Trauma Cases: Over Two Years There were 491 Days With 0 Urgent General Cases

Data Overview	
Total Number of Trauma Activations	4753
Total Number of Urgent Cases over two years	1495
Total Number of Urgent General Surgery/Trauma Cases	360
Mean Injury Severity Score	20.18
Total Number of Urgent Orthopedics Cases	752
Mean Injury Severity Score	9.44
Total Number of Urgent Neurosurgery Cases	96
Total Number of Urgent Vascular Surgery Cases	77
Total Number of Urgent Plastic Surgery Cases	52
Total Number of Other Urgent Cases	158

operative cases was plotted, and some seasonality was observed (Peak in July and low in December). A permutation test using Pearson's chi-squared statistic was run on general surgery/trauma, neurosurgery, and orthopedics separately. General surgery/trauma was found to have statistically significant seasonal variations ($p = .00005$), while neurosurgery ($p = 0.89565$) and orthopedics ($p = 0.41565$) did not. For this reason, the sampling distributions for trauma were created by resampling by season in addition to simple resampling. The results for the nonseasonally effected specialties are tabulated in Table 2 and general/trauma surgery given in Table 3. The nonseasonal adjusted results were also compared to the true percentage of consecutive days on shifts, which would have resulted in the minimum number of occurrences of the various types of events, with consistent results in all cases.

DISCUSSION

Surgeons are highly trained physicians that are crucial for the care of wounded personnel on a battlefield. In a peacetime posture, however, they will rarely encounter the kind of trauma and conditions that they are expected to encounter on a battlefield at military treatment facilities. In order to maintain trauma skills, military surgeons are sent across the country to readiness programs such as C-STARS to maintain their trauma readiness. We are calling travel to another

TABLE 2. Various Scenarios for Different Combinations of 24-Hour Shifts and Expected Urgent Trauma Cases for Specialties Without Season Variation. For Number of 24-Hour Shifts, The Most Likely Number Along With the 95% Confidence Interval is Included. For Scenarios Involving Number of Case

Number of 24-Hour Shifts	**Orthopedics**	**Neurosurgery**
	Most Likely Number of Urgent Cases that Can be Expected (95% Confidence Interval)	
5	5.0 (1-10)	0.7 (0-3)
10	9.9 (4-17)	1.3 (0-4)
12	11.9 (6-19)	1.6 (0-5)
20	19.8 (12-29)	2.6 (0-6)
Minimum Number of Cases	*24-hr Shifts Resulting in a 95% Certainty of Experiencing At Least the Stated Minimum Number of Cases*	
5	10	73
10	16	123
20	29	217

TABLE 3. Various Scenarios for Different Combinations of 24-Hour Shifts and Expected General Surgery/Trauma Cases. For Number of 24-Hour Shifts, the Most Likely Number Along With the 95% Confidence Interval is Included for Each Season. For Scenarios Involving Number of Cases, the Number of Days Resulting in a 95% Confidence Interval With a Minimum Equal to the Number of Required Cases is Listed for Each Season

Number of 24-Hour Shifts	**General Surgery/Trauma** ***Most Likely Number of Urgent Cases That Can be Expected (95% Confidence Interval)***			
	Winter	**Spring**	**Summer**	**Fall**
5	1 (0-4)	3 (0-7)	3 (0-9)	2 (0-7)
10	2 (0-6)	5 (1-11)	7 (1-14)	4 (1-11)
12	3 (0-7)	6 (2-13)	8 (2-16)	5 (1-12)
20	5 (1-10)	11 (5-19)	13 (5-24)	9 (3-18)
Minimum Number of Cases	*24-hr Shifts Resulting in a 95% Certainty of Experiencing At Least the Stated Minimum Number of Cases*			
5	40	18	16	22
10	67	30	26	37
20	118	52	45	64

institution to maintain readiness the "visiting surgeon model." While civilian trauma is not identical to battlefield trauma, it is likely the closest equivalent that can be provided outside of real battlefield casualty care. To get a civilian trauma experience to prepare for future trauma, where should it occur and how long should the course be? These questions are critical to create training and readiness opportunities that are both worthwhile and logistically possible. Using the predictive model in this study at trauma institutions, these questions can be answered.

Based on the data analysis from this study, a visiting surgeon would have to be at the studied trauma center a lengthy amount of time to experience a near guaranteed number of cases. The specialty best suited to using a visiting surgeon model may be orthopedics due to the higher volumes of operative trauma exposure; however, even this results in CIs that are incredibly wide. If a guaranteed number of cases are not required, the model may work better, but disparate experiences between groups would have to be accepted, undermining the whole notion of a standardized readiness requirement. In addition, these results also do not account for practical requirements such as rest. While a surgeon conceivably could be on call for multiple consecutive 24-hour shifts, it would not be tolerated nor practical. A more sustainable model, for example a shift every other day, would result in a doubling of the days necessary. For military physicians that will have duties at their home station, a 70-day trip to have a 95% expectation to experience 10 cases likely represents an excessive burden.

While an urgent civilian trauma case where efficiency of the team and attaining hemorrhage control takes priority is likely the best approximation of warzone battlefield trauma care, it is unknown if this is absolutely required. In the United States, a General surgery residency program requires a total of 850 cases over a 5-year period, and of those cases, 10 must be operative trauma.[7] This trauma number seems small, and may be, but is considered enough in totality with their other surgical experience to perform trauma. Many of the procedures a surgeon would do in a battlefield trauma situation (i.e., stapling off bowel, mobilizing organs, etc.) are routinely done in elective settings. The difference from the elective scenario includes the urgent nature of high stakes decision making, multiple injuries, degree of shock, and psychological factors. The extent these other factors associated with otherwise identical operative maneuvers would impact surgeon performance is at this time unknown, and it may be that a broad experience in general surgical procedures would result in adequate trauma performance. What is known is significant trauma nominally on par with that seen on the battlefield is rarely seen in the United States by surgeons in US-based military treatment facilities lacking trauma, and over time skills degrade.[9] While trauma services operate in the areas of the body general surgeons typically operate, they require a skillset that includes a speed and efficiency that other disciplines within general surgery generally lack.[10,11] Without any practice, it can be assumed that skills decrease, with some battlefield evidence supporting this theory.[12]

While operative trauma exposure may serve as a means of assessing a surgical training program for visiting surgeons, numbers of trauma cases alone should not be the sole way to judge a program. Large civilian institutions have many other benefits other than trauma cases that can be a benefit to the military including facilities and assets such as simulations, cadavers, nonoperative trauma resuscitations and complex nontraumatic cases. These assets can make military-civilian partnerships significantly valuable beyond the trauma experience themselves and for a whole host of various military personnel beyond surgeons alone. In addition, this study illuminates the quantity of the most applicable cases that a civilian-military partnership can provide; however, it does not illuminate the quality of the experience for the military surgeon. While a military surgeon can visit and participate in the care of civilian patients, a visiting provider, unfortunately, is often relegated to a junior position to the local staff surgeons and their residents/fellows. This results in experience that may likely be less hands-on and more auditory and visual. Without a means of assessing the general surgeon's competence in making decisions and performing operations, the experience lacks the ability to truly evaluate competency of surgeons. If temporary surgical assignments at trauma centers are routinely pursued to maintain trauma skills, close attention to the relationship the visiting surgeon has with patients and local staff will need to be given to ensure adequate involvement of the visiting surgeon. A trauma program that can provide high quality opportunities for critical decision-making in determining surgical need and operative planning, even if less cases are predicted, should be considered in a favorable light. Military-civilian partnerships should be considered in totality, but a general expectation that a surgeon can make a short visit at any trauma institution and have a guaranteed chance of experiencing and surgically intervening directly on a large number of applicable traumatic injuries should be met with skepticism.

This study does have weaknesses, namely the assumption of true randomness of traumas and the attempt to predict the future with data from the past. The inherent nature of trauma is largely unpredictable. A host of things can change in any local population or trauma system that can alter the future quantity of urgent trauma cases. With more data, a seasonal affect could be identified with specialties such as orthopedics and neurosurgery, however, the further back the data goes, it may be less reflective of the present conditions of a given area. Also, this is a single institution's data. There may be other trauma systems with a much higher quantity of urgent trauma cases and potentially less seasonal variation that can reduce the number of expected call days required for participation in cases. Ultimately, this study does provide some hint at what can be expected with a visiting surgeon model for maintaining surgical competency and provides a model for judging potential military-civilian partnerships and programs.

CONCLUSIONS

Visiting general surgeons to St. Louis are likely to require at least twenty-six 24-hour shifts to have a 95% chance of experiencing at least 10 trauma cases in peak season. Orthopedics is much lower. If a visiting surgeon model is used and St. Louis's results are common across multiple trauma centers, this suggests that a program mandating a specified number of trauma cases for anything other than orthopedics will be difficult to implement and would be logistically extraordinarily difficult.

This is a sole institution's trauma experience; other institutions may have more or less operative trauma. If a visiting surgeon model requiring urgent trauma operations to establish deployment readiness is used, analysis of the case volume that reflects the expectations on the battlefield should be conducted at a proposed military-civilian partnership hospital using this model. This model will allow estimations of the length and suitability of the site. Military surgeons should be expected to go to the institutions that provide the most experience in the shortest amount of time in order to responsibly allocate resources.

ACKNOWLEDGMENTS

The opinions and/or assertions contained herein are solely those of the authors and should not be construed as reflecting those of the U.S. Air Force, Department of Defense, or the Federal Government.

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SUPPLEMENTARY DATA

Supplementary data associated with this article can be found in the online version at https://doi.org/10.1016/j.jsurg.2018.10.008.