

Focus On....Managing Health Services Support to Military Operations.

Casualty Estimation

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Abstract

This is the third in a series of monographs that examine some of the principles and factors involved in managing health services support to military operations. This paper will consider casualty estimation and the link between historical evidence and prospective forecasting of demand for medical resources. First, the paper will consider the purpose of casualty estimation at each level in the chain of command. Next, a review of the historical uses of casualty estimation will be provided along with consideration of the methodological approaches to casualty estimation. The link between historical evidence and future planning will be demonstrated. Finally, the paper will show how casualty estimation is used within the medical planning process.

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'Every " G " officer very naturally hopes that his battle is going to be successful, and this is liable to induce him to give an estimate of a somewhat optimistic character. It is a well-known fact that an unsuccessful attack is a very expensive affair, and it behoves us, therefore, to bear this in mind, as, although we too anticipate a happy issue to the battle, it will not do for us to be unprepared to deal with the price that has to be paid for an attack which has failed.(1)'

Introduction

This is the third in a series of monographs that examine some of the principles and factors involved in managing health services support to military operations. The second paper discussed the principles of medical planning with specific consideration of the formal planning tool called the 'Estimate'. This paper will consider casualty estimation and the link between historical evidence and prospective forecasting of demand for medical resources. First, the paper will consider the purpose of casualty estimation at each level in the chain of command. Next, a review of the historical uses of casualty estimation will be provided along with consideration of the methodological approaches to casualty estimation. The link between historical evidence and future planning will be demonstrated. Finally, the paper will show how casualty estimation is used within the medical planning process. Because the actual data used for current casualty estimation is classified and is therefore not suitable for mainstream publication, this paper will illustrate the process using data from previously published papers.

Purpose of Casualty Estimation

Military casualties from personnel attrition can be divided into the categories shown at Table 1. The casualty rate is typically expressed as the number of casualties per population at risk (PAR) by time period of exposure. Casualty estimation is the application of casualty ratios derived from prior historical analysis to a PAR to predict personnel attrition from future military activity. Military medical services are concerned with the evacuation and treatment of WIA, BS, D and NBI.

Table 1 Categorisation of Casualties.

| | |
|----------------------------|------|
| Killed-in-Action | KIA |
| Captured/Missing-in-Action | CMIA |
| Wounded-in-Action | WIA |
| Battle Stress | BS |
| Disease | D |
| Non-Battle Injury | NBI |

It is important to consider the purpose of casualty estimation in order to set the framework for developing the methodology for new tools and to understand how to interpret the results. The purpose depends on the level in the chain of command in which the estimate will be used. For example, at the Ministry of Defence policy level, casualty

estimation influences defence planning, force design, and manning requirements. Casualty estimation determines the size of the military medical organisation required to support military forces against agreed defence planning assumptions and scenarios. It also influences the balance between regular and reserve medical forces and the range of clinical specialities required to support expected casualty rates and types. For operations, at the strategic level, casualty estimation determines the allocation of medical resources to a specific campaign, confirms capacity in the strategic aeromedical evacuation (STRATEVAC) system and the national receiving system, allocates hospitals to locations in theatre, and determines the requirement for specialist medical capabilities in theatre. At the operational level, the casualty estimate determines the requirement for medical capability and capacity over the period of the campaign design. This confirms the location of evacuation and forward hospitals, the capacity of the in-theatre medical evacuation system and the demand for specific medical logistic commodities such as blood products and medical gases. The tactical casualty estimate predicts the numbers of casualties for each engagement, thus assigning tactical medical units and determining the opening times of forward medical facilities including Role 2 Light Manoeuvre units.

Historical Background

Prior to the Great War, the casualty estimate in British military medical doctrine was that described by an Austrian General, Cron. His formula was based upon a study of casualties in European warfare in the 19th century (1). Cron estimated that only three-fifths of the total force would be engaged in actual fighting, the remaining two-fifths

consisting of reserves and ancillary services in the rear. Further, he estimated that 10 percent of those engaged would suffer casualties; thus the total number of casualties from a force would be 10 percent of three-fifths, or 6 percent. Experience from the Great War showed that 26.19 percent of all casualties were killed, missing or taken prisoner. Of the wounded, 30 percent would be walking wounded and 70 percent sitting or lying down. The percentage of the force for whom hospital bed cover was provided was subject to wide fluctuation, depending on the circumstances of the individual campaign ranging from 4% in France to 25% in East Africa. In addition, a number of hospital beds equating to approximately 8% of the strength of troops in France and Flanders, were set aside for casualties in UK from that theatre (2).

World War I figures suggested that the average daily admission to hospital from non-battle casualties (Disease and Non-Battle Injury – DNBI) was 0.3% of the force. Experience in World War II indicated that this figure was too high, and that it might be reduced in temperate climates to 0.15 percent of the force or a daily admission rate to medical units of 1.5 per 1,000. Further, approximately one-third of these admissions were not transferred to general hospitals, as they were retained in forward medical units until recovery. The total requirement of hospital bed cover for non-battle casualties was, therefore, based on a daily admission rate of 0.1 per cent daily admissions to general hospitals, or 1 per 1,000. The experience from WWII further established that the average duration of stay in hospital of the non-battle casualty was approximately 20 days. Thus, after WWII a recommended estimate for the hospital bed cover percentage required for non-battle casualties was to multiply the daily admission rate by the average number of days

in hospital, *i.e.* 20 per 1,000 or 2 percent. It was necessary to add a dispersion factor of 20 percent to allow a proportion of the authorized beds to be packed for shipment or moved within the theatre, and for the separation of sick and wounded of various types in hospital wards.

The doyens of post-WW2 casualty estimation are Trevor Dupuy (3) and George Kuhn (4) both of whom developed algorithms for casualty estimation based on historical data. Dupuy analysed several hundred individual tactical engagements to develop a formula based on a number of 'factors' that influenced the personnel casualty rate. Kuhn's work used a series of analyses examining casualty statistics from World War 2, the Korean War, the Arab-Israeli Wars of 1967 and 1973 and US Army wargames. These were combined into predictive algorithms based on force sizes, time period and operational scenarios in conventional warfighting against matched military forces. The study was focussed at the divisional level because this size of formation was the main unit of manoeuvre for US and NATO operational planning in the 1980s and 1990s. Kuhn's data has been incorporated into a number of electronic planning tools to support the medical planning process.

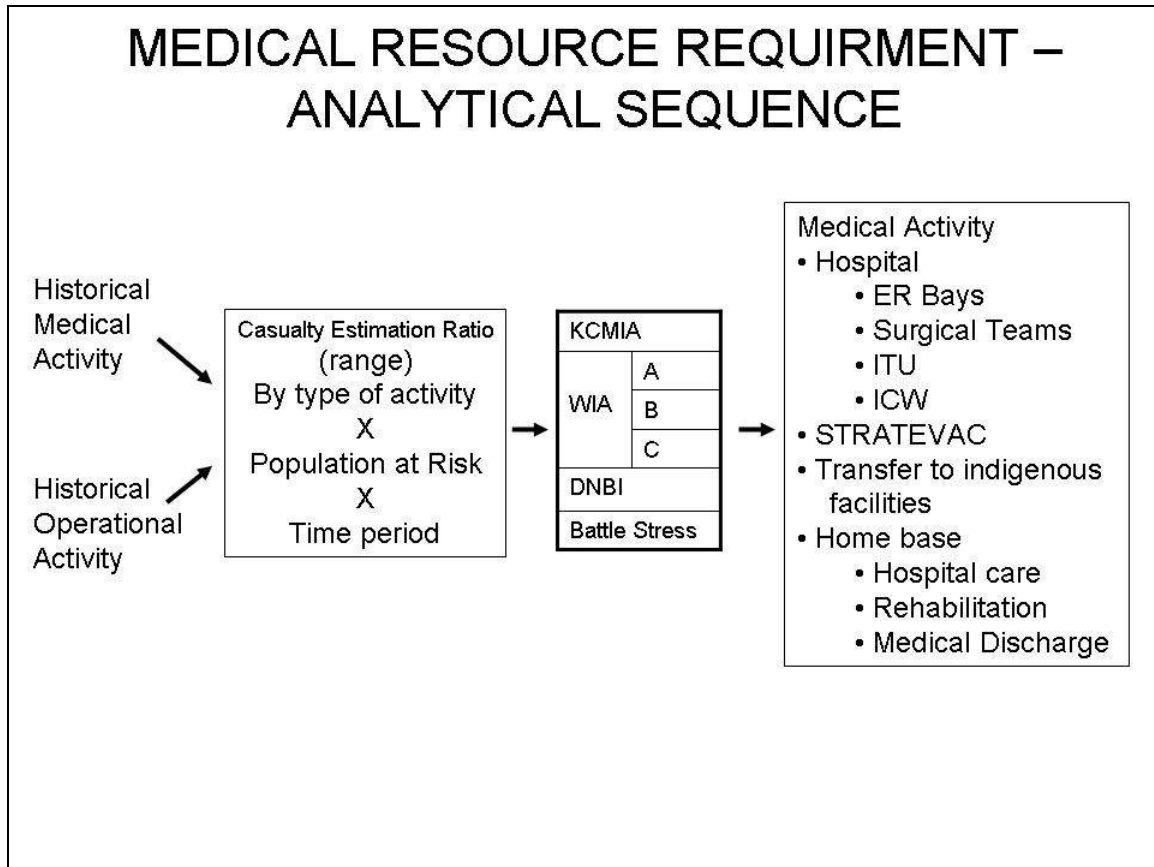
The first paper in this series showed how the nature of current operations is substantially different from the type of warfare that the UK Armed Forces were designed to fight. Many of the assumptions that underpinned the organisation and structure of the UK Defence Medical Services were based upon the Cold War casualty planning tools. The basic unit of manoeuvre has shrunk from the division to the battalion or company (5).

The nature of the threat is substantially different with the improvised explosive device (IED) and small-unit direct and indirect fire being the greatest cause of casualties rather than massed indirect fire (6). The population entitled to military medical care (PAR) in current conflicts in Iraq and Afghanistan has been extended to include multi-national forces, international civilians, indigenous security forces and local national civilians. As an example, the UK Field Hospitals operating in Iraq provided care for Iraqi combat casualties, Iraqi civilians and Iraqi children in the accident and emergency department (7,8) and provided surgery in an emergency to these patients (9,10). In Afghanistan, the DMS hospital in Camp Bastion in Helmand province has cared for detainees, Afghan security force and civilian casualties as well as NATO casualties (11). The demand and expectation of medical care for each casualty is substantially greater, resulting in a far higher consumption of medical resources per casualty than previously anticipated (12). There has also been a commensurate increase in casualty survival (13). Because of this contemporary operational environment, there is a requirement to fundamentally review the methodology and datasets that support casualty estimation for current medical planning processes.

Determining Casualty Ratios for Casualty Estimation and the Medical Resource Requirement

The analytical sequence to determine a casualty ratio for casualty estimation and the Medical Resource Requirement used by previous authors is still valid and is summarised in Figure 1.

Figure 1 – Medical Resource Requirement – Analytical Sequence



Historical medical activity is matched to historical operational activity and this is used to determine the ratio for casualties for each PAR from each type of military activity over time. If available, it is important to use historical data from a recent conflict that is similar in enemy, terrain, weather, and other factors. The number of casualties from individual events is likely to have a range that has a positively skewed distribution i.e. smaller

numbers occur more frequently than larger numbers around the mean. For this reason, the mean is an inappropriate summary statistic as it is unacceptable for the casualty numbers to exceed the capacity of the medical plan on 50% of occasions. One approach is to use centiles – commonly 75th, 80th or 90th – with an assumption that the result would approximate the probability of actual casualty numbers from future events. Another approach is to evaluate the variation in the available data, and calculate confidence intervals as a measure of statistical probability.

The determination of PAR is one of the hardest elements of this process. For military personnel, the risk of becoming a casualty is highly dependant on the nature of an individual's military employment and period at risk. Clearly a staff officer is considerably safer than an Improvised Explosive Device (IED) disposal officer. At the operational level, the PAR may be 'smoothed' and based on the overall military population. The definition of the military PAR requires considerably greater refinement at the tactical level. The risk may also vary according to the evolution of the combatants' tactics, techniques and procedures as illustrated by the increasing lethality of IEDs (14). This becomes even more problematic when considering populations for whom the PAR is impossible to calculate such as civilians. Based on historical data, a relationship may be determined for civilian casualties compared to those military casualties for whom a PAR is easily defined and therefore a prediction can be made based on the relationship between these populations.

The sequence described above covers the methodology for the determination of casualty ratios to be applied as a predictor for future casualty numbers from operational activities that were similar to the historical types in the analysis. The next stage in medical planning is to determine the medical resource requirement to care for these casualties. First, the causative agent, or type of munition, should be considered. The causative agent determines the type and anatomical location of injuries and provides data on the range of clinical specialties required to care for WIA. Indirect fire has been the leading cause of injury in conventional military operations (15), however, the IED is currently the leading cause in Counter-Insurgency Operations. IEDs cause a significant number of multiply injured casualties requiring complex multi-disciplinary surgical interventions, primarily on extremities. The introduction of body armour has increased survival by reducing lethal central torso injuries.

In addition to the categorisation of personnel casualties by causation; wounded, battle injury, casualties may also be categorised by severity. One such classification might be by triage score (T1, T2 or T3) or urgency for medical evacuation (16) (this will be covered in more detail in the paper on control and co-ordination of medical evacuation). Clinical coding systems such as Injury Severity Score (ISS) or Abbreviated Injury Scale (AIS) may be useful but are primarily designed for the assessment of severely injured civilian casualties rather than the whole casualty population presenting to military field hospitals (17).

Having identified the individual PAR and the distribution of clinical severity for casualties in each population, the next element of the analysis is to determine the utilisation of medical capabilities for these groups from historical medical records. This analysis should be based upon each element of the patient care pathway from advanced first aid at the scene of an incident to completion of rehabilitation.

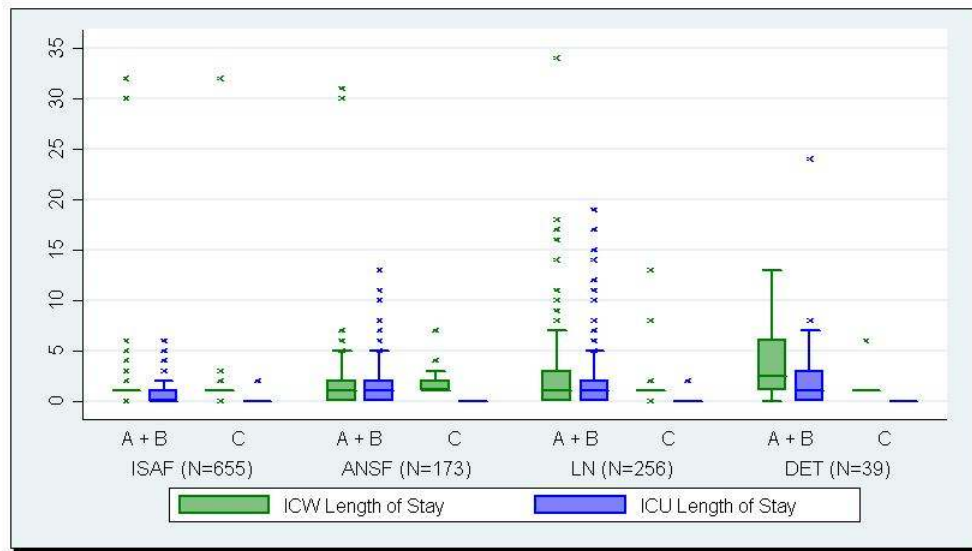
The hospital requirement is a critical element of medical resource planning. Casualty estimate driven medical requirements should consider the number of emergency department (ED) bays required to assess and resuscitate the most severely injured casualties (T1) and the patient surgical throughput. Non-urgent T2 and T3 patients may be considered to be capable of waiting and are therefore 'second in line' for ED bays. Planning data from WWII recommended that each surgeon (by inference, each surgical team) could deal with 12 Priority 1 and 2 cases in each 24 hour period (18). However, more recent experience (and expectations) has shown that the proportion of severely injured casualties with complex orthopaedic injuries has increased, as has the numbers requiring more than one surgical procedure as part of primary surgery (19). Thus, the minimum surgical capability must be based upon a collection of individuals (surgeons, anaesthetists and support staff) who can undertake the full range of damage control techniques (12). Whilst such a team can work for 12 hours in every 24, this must include pre-operative assessment and post-operative management and so the total number of surgical hours they can work is less than 12. On this basis a new surgical resource planning tool is required for current medical planning. The number of hospital beds to

include intensive care unit (ICU) and intermediate care ward (ICW) beds should also be considered in the medical requirements.

The length of stay (LOS) in hospital beds will vary according to patient type and the Theatre Holding Policy. International military casualties are likely to be aeromedically evacuated out of theatre rapidly. Indigenous casualties (detainees, military or civilian) will remain in-theatre and so their LOS will depend on the ability of the indigenous medical system to take over their care. The number of ICU beds is likely to be the critical 'rate-limiting' medical capability as this is the least well-developed aspect of indigenous hospital care (20). The LOS per category of casualty for ICU and ICW beds is likely to be significantly skewed again requiring an alternative to the mean as the appropriate summary statistic (21). This is illustrated in Figure 2 (22).

Figure 2

DISTRIBUTION OF ISAF HOSPITAL LENGTH OF STAY BY POPULATION



Source: US Joint Theatre Trauma Registry

ISAF = International Security Assistance Force
 ANSF = Afghan Security Forces
 LN = Local Nationals
 DET = Detainees
 Categories of severity for MEDEVAC A>B.C

The approach to matching medical resources to predicted casualties may vary depending on the purpose of the medical planning. Long term planning may allow for a determination of the size and location of medical facilities, training, and manning requirements. Planning in preparation for a particular operation or surge rarely provides the time and resources for major changes to existing medical assets and policies. However, the same planning process can provide vital information to determine if short-term changes would be needed in scheduling STRATEVAC missions, available medical supplies and staffing patterns. A publication by Parker describes additional requirements such as consumption by type of patient of blood products, medical gases and laboratory investigations that should be considered based on the casualty estimate (12). Similar

analyses are required to determine the medical capabilities and patient capacities for the STRATEVAC system, the UK receiving hospitals and the rehabilitation system. Overall, this section has described the methodology for obtaining a casualty estimate and application of this estimate in the determination of medical resource requirements per type of patient presenting at medical units.

Uses of Casualty Estimation and Medical Resource Planning within the Medical Planning Process

NATO medical doctrine explains the use of the casualty estimate ratios described above in the medical planning process in the following steps (23):

1. Determine the PAR, either by organisational group eg. battalion, brigade, or by Force Element e.g. Counter-IED, Freedom of Movement or by type of patient e.g. international military forces, indigenous security forces, non-combatants, civilians
2. Estimate the rate – apply casualty estimate ratios to PAR (appropriate to type of force, engagements and other factors)
3. Estimate the profile – relative proportions of casualty types – KCMIA, WIA, CBRN, Battle Stress, DNBI and also by clinical severity – Cat A, B, C and clinical type – neurology, eyes, burns, general (abdominal or thoracic cavity) surgery, limbs (orthopaedic)

4. Estimate the flow – synchronisation of operational activity to casualty production

5. Estimate the medical resource demand, MEDEVAC, TACEVAC, STRATEVAC, patient hand-off, ED bays, surgical hours (surgical teams), ICU beds, ICW beds, medical imaging (x-ray, CT, USS), laboratory support (blood products, diagnostic capabilities), medical logistics (medical gases, medical consumables). The actual capacity requirement should be set as a percentage greater than the predicted demand as the plan should not assume full occupancy of medical units. This reserve is required to accommodate fluctuations in casualty flow and to absorb a major incident by regulation of casualties across the medical evacuation system.

6. Determine the location and opening period for key medical facilities (likely to be Role 2 and Role 3 units).

7. Determine the capacity and capability for medical evacuation platforms to move patients to and from medical facilities.

One final element of medical requirement planning is to set the Theatre Holding Policy (THP) as this is directly related to the hospital bed requirement in the theatre of operations. The shorter the THP the greater the numbers needing evacuation from theatre and the lower the return-to-duty rate, but lower numbers of hospital beds are required in theatre. Disease casualties have a higher return to duty rate and shorter duration of

hospital admission than injured casualties in the absence of a formal holding policy (24). Prior to widespread availability of aeromedical evacuation, it was usually more economical to provide hospital accommodation in the theatres of operations that were a long distance from UK sufficient to hold sick and wounded for a period of 120 days or longer. When operations took place within a short distance of the UK, *e.g.*, in NW Europe, it was be found more suitable to adopt a shorter holding policy. Current holding polices are usually short, 7 days or less, in order to reduce the number of surgical teams (only doing primary surgery), ICU and ICW beds required in-theatre. This does mean, however, that some patients with short-term, remedial conditions may be evacuated to the home base rather than enabled to return to duty with the deployed force. The THP needs to be plotted over time as each 'days worth' of patients will accrue until evacuation and so there will be a cumulative number of patients in medical facilities that balances the inflow from the casualty estimate, the THP and the STRATEVAC outflow.

This sequence provides a forecast of the numbers of patients requiring each element of medical care in the medical evacuation system. These figures are then converted into specific types of medical unit and set the timing and location for each. This product is released as the medical plan within OPlans, OpORDs or FragOs. Finally the product can be used to monitor the number of patients admitted per day during operations and to forecast whether there will be sufficient medical capacity based on the previous days' utilisation and predicted number of casualties.

Summary

This paper provides a summary of the analytical process to determine ratios from historical evidence to support Casualty Estimation and Medical Resource Requirement planning. It then explains how these ratios are used to inform the medical planning process to determine the capabilities and capacities required of the military medical system. The next paper will examine the control and co-ordination of medical evacuation.

Word count: 4161

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