Submission for
Doctor of Medicine
(by prior publication)

Medically staffed, out of hospital critical care patient transport (Retrieval) services: Performance, Incidents and Patient outcomes

By

Dr Athanasios Flavouris
MBBS, FANZCA, FJFICM, PGDipAviatMed, PGDipEcho
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This work contains no material which has been accepted for the award of any other degree or diploma in any university or other tertiary institution and, to the best of my knowledge and belief, contains no material previously published or written by another person, except where due reference has been made in the text.

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Section 1

Background, review of literature and scope of original work
Medically staffed, out of hospital critical care patient transport (Retrieval) services: Performance, Incidents and Patient outcomes

Professional Background

My primary career has been focused upon Critical Care Medicine, particularly Intensive Care Medicine. This has been complimented by a continuous and strong interest in out of hospital emergency medical care for 30 years, initially as a St John Ambulance volunteer whilst a medical student and currently as a staff specialist in retrieval. This involvement has included all categories of clinical care within this domain as well as non clinical activities such as teaching, research and administrative roles. I have also completed post graduate, university based, training in aviation medicine.

I first undertook research within this area with a study that examined factors associated with demand for first aid services at the Royal Adelaide Agricultural and Horticultural Show. At that time there was only a small amount of such research published at an international level, and almost none at a local level.

The focus of my subsequent research has been related to describing the efficacy, the distribution of, factors influencing, quality and outcomes related to out of hospital critical care delivery. This has included distribution of First Aid skills acquisition within the population, medical support at disasters and in to a much larger extent, critical care outreach type teams, specifically hospital based medical emergency teams and out of hospital transportation of critically ill patients (medical retrieval).

I have been able to translate my training and clinical experience as an Intensive Care specialist to the out of hospital environment. This has occurred through the delivery of critical care type skills, teaching, research and quality evaluation. There are obvious similarities between these two broad domains. At that time there were as yet untapped opportunities to explore other similarities of retrieval clinical practice with those of the outreach role of hospital based Medical Emergency Teams and critical incident monitoring as they applied to critical care areas such as anaesthesia, Intensive Care and Emergency Medicine. The identification and translation of some of these similarities across to the field of out of hospital critical care (and to some extent in the reverse direction) has helped drive much of the original retrieval research presented here. The concept of the Medical Emergency Team (MET) has been another area of my research focus and has occurred in parallel to the research relating to medical retrieval. Professor Ken Hillman (University of New South Wales) has been a pioneer in developing and evaluating the Medical Emergency Team system. My participation and contribution in MET related research has occurred under his guidance. I am immensely grateful for his support and mentorship.

In summary, the research output presented here evaluates further and uniquely contributes to a better understanding of the quality, effectiveness, patient features and patient outcomes associated with medical retrieval. This research output includes clinical examples of the research topic, from which follow recommendations for improved patient care, the development of a quality tool and the foundation for the use of select clinical performance indicators within medical retrieval.
Introduction to the study area

All nations face a variety of challenges in relation to the maintenance of the equitable access of health care for their population. These challenges relate to geography, population distribution and demographics, regionalisation of specialty medical services, sustaining health facilities at remote communities, communication technology and variations in demand for services with time. For example, Australia’s population is dynamic. In 1996, 13% of the Australian population lived in rural areas, compared to 43% in 1911, 24% of the population was born overseas, 50% of population growth was due to overseas migration and the pattern of migrants has varied amongst the Australian states and the contribution by each source country over time.¹

Regionalisation, or centralisation, of complex health care is increasing. This has been driven by evidence that higher volume and centrally coordinated care improves outcome,² the increasing complexity and cost of health technology and regional policy variations.³ Examples include, improved outcome from dedicated centres to manage major trauma,⁴-⁷ cardiac, vascular and cancer surgery,⁸,⁹ acute myocardial infarction¹⁰ and stroke.¹¹ There is also evidence for the centralisation of critical care services and staffing with a reduced mortality for Intensive Care Units (ICU) with a high volume,¹²-¹⁴ and ICU staffed by specialist intensivists.¹⁵ The patterns seen with centralising critical care services may also apply to their distribution within a hospital, as patients who develop sepsis in a ward have a higher mortality than patients developing sepsis in the ICU.¹⁶ This has created challenges for areas remote to any necessary and centralised service, particularly acute or time dependent services. For example, rural mortality is proportionality greater than urban mortality,¹⁷-¹⁹ time to discovery of the rural injured patient is longer, rural medical staffing and level of training is lesser as is clinical exposure of rural based medical staff to patients with a higher severity of illness.²⁰

Interhospital Transfer Systems for the Critically Ill patient

The importance of timely and equitable access to specialty health care, variations in the distribution of health resources and distribution of the population, provided the basis for the inception and ongoing expansion, of interhospital patient transport services (IHPTS), particularly those staffed by doctors (retrieval). The intention of these services was to deliver medical services to remote locations and/or deliver the patient to the regional medical services. These services were often delivered with the use of fixed wing or rotary wing aircraft. An early example of a “flying doctor” is that of a New Zealand crew of a pilot, George Bolt, who in 1922, flew Doctor W.A. Fairclough, an ophthalmic surgeon, from Auckland to Tauranga, a distance of 150 Kms, to perform an operation. On that same day, George Bolt demonstrated what was to be the future commercial reality for aeromedical service provision. He provided to the public joy flights whilst awaiting the time of completion of surgery and departure of the doctor.²¹ The first worldwide example of a dedicated civil type service was the Royal Flying Doctor Service of Australia, founded by John Flynn and Clifford Peel in 1928. They demonstrated the importance of an extensive medical consultative communication network linking remote and centralised facilities by radio and telephone. This service was described by the Australian Prime Minister at that time as
the “greatest single contribution to the effective settlement of the far distant back country that we have witnessed in our time”.

The first dedicated critical care patient transport teams (also referred to as retrieval teams), were seen in the early 1970s. Taylor and colleagues in 1970\textsuperscript{22} describe the use of a modified hospital trolley with monitoring and resuscitation equipment for intrahospital transport of cardiac patients in Boston. The Shock Team from the Western Infirmary, Glasgow\textsuperscript{23} was established around this time, the Royal Adelaide Hospital Retrieval Service\textsuperscript{24} dates from 1974 and Stanford University’s Adult Transport Team\textsuperscript{25} from the late 1970s.

The number of critically ill patients who currently undergo interhospital transportation is not insignificant. In the United Kingdom it is estimated that 11,000 patients per year are transferred to another hospital Intensive Care Unit (ICU)\textsuperscript{26} whilst in NSW, Australia, over 6000 patients were transferred by air ambulance over a 12 month period in 2004/5.\textsuperscript{27}

Interhospital patient transport services vary in their nature, patient casemix and use of transport vehicles. The following articles are a comprehensive review of such services, including a review of Emergency Medical Services (EMS) within New South Wales and the role retrieval services as part of all other EMS and specifically, for rural trauma. These reviews provided a valuable background for the subsequent research that evolved and is presented here.
Interhospital Patient Transfer Services (IHPTS) are a unique collaboration between clinical and aviation/operational transport systems. These two papers reviewed in detail IHPTS as the applied at that time.

The utilisation of such services is driven by regional health resources, the need to maintain equity of specialty medical service delivery and geographic factors. Such factors change with time, and IHPTS must keep abreast of such changes. Assessment of earlier patient transports have identified the clinical and process benefit in terms of patient morbidity and mortality, and transport resource efficiency for specialty transport services. For any IHPTS, dedicated and efficient communication links between referral, transport and receiving facility reception is vital. When more competing tasks occur, a centralised tasking organization becomes necessary.

IHPTS may be hospital based or by independent providers. The former have the advantage of close affiliation with specialised hospital based resources whilst the latter function without competing for scarce in hospital resources. The clinical component of the IHPTS can benefit by a strong interaction with the aviation/operational component. This diversity of knowledge in terms of skill, non-clinical expertise and quality processes that results, as well as the increased complexity of patients and their casemix has seen IHPTS evolve into a unique, specialised, field of medicine. The best utilisation of such services (in terms of vehicle and clinical crew selection), the risk benefit of complex critically ill patients, equipment use and choice and the transport environment remains to be validated.

Summary and Significance of publication
These two publications were invited reviews of interhospital patient transport systems for critically ill patients. Both publications were based on a detailed review of the literature available at that time and also formed the background information for the subsequent research output. The significance of both publications are that they detail the various factors involved in interhospital transfer of critically ill patients, their risks, advantages, indications and future directions. They involved a detailed literature search and a concise review of the the relevant literature available at that time. The maximum number of references listed for one of those publications was 115. There were few prior published reviews of this topic at that time.

Published in: Intensive Care and Emergency Medicine 2001 Year Book. and the Netherlands J of Critical Care 2003;12:353-63 (Impact Factor - 0.31)

Citations: 18
**Interhospital Patient Transport Services in NSW and their role in the New South Wales Emergency Medical Services**

This paper described the system of Emergency Medical Service (EMS) in New South Wales. It examined those facets of the EMS involved in patient transport, that is ambulance, adult and paediatric retrieval and medical disaster response. It described and briefly illustrated how such services are coordinated, tasked and integrated into the planned medical response for disasters. The paper also reviewed the nature, geographical distribution, resources, training, education and research activities of the medical retrieval services.

**Summary and Significance of publication**

This publication resulted from an invitation to contribute to a series of articles describing a range of international EMS. It outlined all levels and types of interhospital patient transport services including ambulance, medical adult and medical paediatric/neonatal transportation as well as the coordination of those services.

Published in: *Resuscitation* 2003 Nov;59:165-70 (Impact Factor 2.31 (2006)).

Citations: 3

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**The challenges of delivering acute medical services to trauma patients in remote locations**

This paper reviewed the challenges for the delivery of trauma care to remote locations. The paper focused upon issues specific to the response to, and transportation from, remote locations of trauma victims. The paper reviewed the physical environment, epidemiology of rural trauma, accessing and response of Emergency Medical Services, coordination of multidisciplinary response and use of telemedicine.

**Summary and Significance of publication**

This publication resulted from an invitation to review emergency medical responses to trauma patients in remote locations. The significance of this publication is that it details the nature of and challenges for emergency medical services responding to trauma patients in remote locations. The information within this publication was derived from a concise review of the recent relevant literature available at that time. The number of references listed was 25.

Published in: 2001 *Anaesthesia, Pain, Intensive Care and Emergency Medicine Symposium Book*
Medical care is delivered in “a dynamic environment with complex interactions between disease processes, medical staff, infrastructure, equipment, policies and protocols.”32 Adverse events are not uncommon.33,34 This is particularly so for critically ill patients during interhospital patient transportation (also referred to as retrieval). Patients admitted to a tertiary referral ICU following transfer from another hospital have a high severity of illness.35 Early interhospital patient transfers documented inadequacies of patient care, an associated high morbidity,36-40 observed mortality, and higher a mortality in comparison to similar patients who were not transferred.41,42 Major physiological disturbances such as hypoxia, hypotension, missed injuries, poorly managed intravenous access, airway, ventilation, spine and limb immobilisation and communication problems were often observed.36,38-40,43 Unresolved physiological instability at the referral site, and lack of transport experience by the escorting team, where predictive of in transit adverse patient events.44-46 Death during transport however was a rare event in comparison to other adverse events. Risks associated with transportation were not only confined to patients. The early 1980’s saw a peak in accident rates amongst aeromedical emergency services of nearly 25 accidents/100,000 flight hours.47 These basic errors that were occurring and potentially contributing to problems clearly illustrated the necessity for guidelines for safe practice during transport48-51 and for staff of appropriate clinical experience and skill mix for improved patient outcome.52-54

Patients admitted to a tertiary referral ICU following transfer from another hospital have higher severity of illness measures than non transferred ICU admissions35,42 and a severity of illness that is similar to that of patients admitted to the ICU from the ward.42 Although there are cases of interhospital transfer/retrieval in which the retrieval process contributed to a positive patient outcome,55,56 and such cases are important to illustrate the benefit of retrieval, collectively the observed mortality of patients undergoing interhospital transfer exceeds their predicted mortality when compared to similar non transferred patients.42,57

The following study was designed with the intention to better document the demographics and outcome differences for critically ill patients who have undergone an interhospital transfer and admitted to an ICU. These patients were then compared with patients who had not undergone interhospital transfer, but also admitted to the ICU. This study documented the collective overall and higher than expected mortality of patients who undergone interhospital transportation. In contrast, specific cases were selected of critically ill patients were selected, based upon their unique and challenging time critical and/or life threatening conditions and unique transport challenges. These cases, described below, were used to illustrate a clear benefit from retrieval and describe the factors associated with a positive outcome.
Patient referral and transportation to a regional tertiary ICU: patient demographics, severity of illness and outcome comparison with non-transported patients

The purpose of this study was to describe and compare the demographics and hospital outcome of critically ill patients transported from peripheral hospitals to the regional tertiary referral Intensive Care Unit (ICU) with that of non transported patients admitted to that same ICU. A retrospective review of transported and non transported patients admitted to the same Intensive Care Unit was conducted. Patient demographics, disease categories, source of admission to ICU, APACHE II scores, predicted and actual hospital mortality, hospital and ICU length of stay were examined. Of all ICU admissions, 16% were transported. Transported patients had a different case mix, significantly higher severity of illness measures than patients admitted from the operating theatre, the Emergency Department and the ward, mortality and length of ICU stay. Patients admitted from the ward had severity of illness measures that most closely match that of patients admitted from another hospital. Observed mortality of transported patients with sepsis, gastro intestinal disease or bleeding, intracranial haemorrhage and post respiratory arrest was lesser than predicted whilst those with neurological disease, post cardiac arrest and overdose had a higher than predicted mortality. The importance of this paper was it verified, in a much larger sample size, that patients admitted to an ICU from another hospital have a high severity of illness. It was also one of the first papers to demonstrate a differential outcome, based upon diagnosis.

Summary and Significance of publication

This publication contributed significantly to the better understanding of outcomes for critically ill patients undergoing interhospital transfer. Although limited to a single centre, the sample size (n=460) was much greater than any previous published work. Specifically it highlighted the significance of the impact of such patients in terms of the proportion of the total of patient admissions to ICU that they contribute, their disproportionately higher severity of illness, mortality and potential costs relative to all other ICU patient admissions. It also provided a unique insight as to their similarities with patients admitted to ICU from the ward, their greater than expected hospital mortality, and how this differed according to patient casemix.

Published in: *Anaesthesia and Intensive Care* 1999; 27:385-90 (Impact Factor - 0.945). This journal was chosen as it was at that time the primary journal in Australia for Australian and New Zealand Intensive Care medical practitioners. The study was conducted within a New Zealand ICU and thus of most relevance to this readership.

Citations: 17
Aeromedical transportation during prone ventilation \textsuperscript{55} (complete publication in Section 7)

and

Reducing time to urgent surgery by transporting surgical resources to the trauma patient, prior to interhospital transfer \textsuperscript{58} (complete publication in Section 8)

These two papers describe a series of patients that were acutely ill and a high risk of interhospital transfer. Each patient reflected unique characteristics associated with patient treatment and transportation by dedicated, medically staffed teams for patient retrieval. The papers documented the specialist input in each case and the processes that led to a positive outcome. One paper\textsuperscript{55} described the first documented case of prone ventilation during interhospital transport, discussing the transport related issues and making recommendations for its’ use. The other paper\textsuperscript{58} described the utilisation of a medical retrieval service to deliver surgical expertise to patients with life threatening injuries following trauma as a peripheral hospital, lacking the required level of expertise. This paper described and discussed the important aspects of co ordination of such a response, transport related challenges, particularly with retrieval team composition, transport vehicle selection and equipment. It suggested recording the use of such a response as a quality measure within a trauma region.

Summary and Significance of publication

These publications used case illustrations to highlight direct patient benefit from retrieval and outline the factors that positively contributed to the outcomes. One publication also used the cases presented to illustrated how particular measures associated with interhospital patient transportation could be utilised as future clinical indicators of trauma system performance. It was also the intention to contrast individual patient benefit from the interhospital transfer process with that of previously documented and higher than expected collective mortality of such patients. \textsuperscript{42}

Published in: Anaesthesia and Intensive Care \textsuperscript{2003;3:675-8} (Impact Factor - 0.945) and Australian and New Zealand Journal of Surgery \textsuperscript{2007;77:241-6} (Impact Factor - 0.881) These journals were chosen as at that time they were the primary journals in Australia for Australian and New Zealand Intensive Care and trauma medical practitioners. The cases presented, all arose from within Australia and thus of most relevance to this readership.

Citations: 2\textsuperscript{55} and 1\textsuperscript{58}
Quality improvement and Interhospital Transfer Systems for the critically ill patient

Patients admitted to an ICU from the ward have delays in receiving or inadequate time critical care, prior to their admission to the ICU. Up to 50% of ward patients receive substandard care prior to admission to the ICU, 55% have documented physiological abnormalities in the 24 hours prior, and 41% of are potentially avoidable admissions to ICU. Unanticipated ICU admissions have an increased ICU and hospital mortality. These findings are qualitatively not dissimilar to patients admitted to an ICU directly from another hospital.

The concept of a Medical Emergency Team (also called Rapid Response Team) was developed so as to provide a team of multidisciplinary staff, trained in advanced critical care skills, and available for immediate response, with the purpose of delivering a timely, equitable and hospital wide, as compared to ICU centred, critical care response. Medical Emergency Teams provide a critical care based outreach service to hospital in patients, who develop acute physiological disturbance, and when necessary escort them within the hospital to the ICU or other acute care environment. The concept of a Medical Emergency Team is not dissimilar to that of retrieval teams, in that both respond to critically ill patients, in locations remote to a critical care environment and deliver advanced critical care within those locations.

Medical record review has previously been used as a tool for quality improvement. Previous studies involving a review of medical records have revealed adverse events (incidents resulting in harm to a patient) to occur in association with 10% of hospital admissions. Patients most at risk are the elderly and those receiving urgent, complex interventions. Medical record review, however, tells us little about how and why things go wrong.

Out of hospital patient transportation, or retrieval, provides an even greater challenge as it occurs within a much more complex, dynamic, unpredictable and uncontrolled setting. As outlined in earlier research, patients who undergo an out of hospital transfer have a higher severity of illness, acuity and observed mortality that exceeds their expected mortality. To date most quality assurance activities have been retrospective audits of in transit events. The limitation of such audits is that they evaluate information only from select segments of the overall patient interhospital transfer process, that is, clinical in transit events. Non clinical aspects of patient transportation often undergo a totally separate audit process. Failure to combined or examine all aspects and phases of interhospital transfer may overlook or underestimate system based antecedents. The process of inter hospital transport of critically ill patients has many interfaces, i.e. referral staff to receiving staff, referral staff to transport team, referral patient monitoring/equipment to transport patient monitoring/equipment, etc and an audit process would need to encompass all such interfaces. A possible audit tool that may address these issues, and provide insight into the particular features of out of hospital patient transportation that may impact upon patient outcome is that of incident monitoring. To date a tool that systematically examines incidents during out of hospital transportation of critically ill patients has not been described.

Incident monitoring was initially developed to reduce accidents in military aviation and is well established in commercial aviation and more recently in the critical care
areas of Anaesthesia,\textsuperscript{78-80} Intensive Care\textsuperscript{81} and Emergency Medicine. Anonymous reporting of incidents can identify, monitor and improve process quality by using corrective strategies to close the loop and through ongoing incident reporting, examine the impact of such changes. Incident reporting can be applied so that it is almost real time reporting through the use of frequent feedback of trends and accumulated incidents.

Although there is data available as to the nature and risks of interhospital patient transportation, there is very little such data available for medically staffed teams that respond to the scene of an accident. Such teams are commonly used within Australia.\textsuperscript{24,30} The process for developing an incident monitoring tool for out of hospital patient transportation began with a retrospective review of transport patient medical records and analysing unstructured free text comments, within those patient records, related to voluntarily documented adverse and positive events by transporting medical staff during patient transportation. An incident was defined as an event, which may have or did reduce the safety margin for the patient and/or retrieval team. Events were considered to be a positive event if that event actually did, or had the potential to, positively influence the outcome for the patient and/or retrieval team task.

Transport missions were categorised into those that were a scene response, that is patient was transported from the scene of an accident to a hospital, or an interhospital mission, that is the patient was transported from one hospital to another. Only patient transports that included a doctor escort were considered. Preliminary findings were presented at a peer reviewed aeromedical conference.\textsuperscript{82} The abstract is included here as the purpose of this work at that time was to generate discussion, gain a measure of support and awareness of incident monitoring in general and any further feedback.

Further studies of incidents related to scene response and patients with spinal injury were specifically analysed and reported upon. These categories were specifically selected at that time as there was very little information in the medical literature for incidents or adverse event reporting in association with scene responses and spinal patients. The choice of transport vehicles for patients with acute spinal injuries remains controversial and poorly defined\textsuperscript{83} despite known physiological consequences of transport forces,\textsuperscript{84-88} and at that time provided often robust discussion and variability in practice as to the preferred choice of mode of transportation. They also formed the foundation for some of the data elements in a planned development, and prospective evaluation of, an incident monitoring tool for retrieval.
Redefining in hospital resuscitation: the concept of the medical emergency team. *(complete publication in Section 10)*

The MET concept provides a framework for managing seriously ill and at-risk patients across an acute hospital. It is an extension of Intensive Care and Emergency Medicine, but operating outside their usual four walls. It provides a means of identifying those at-risk of serious deterioration. It provides rapid resuscitation with skilled personnel at all times and provides a means of ensuring the quality of care of the seriously ill as well as giving clinicians ownership of that data so they can adjust and improve the system as necessary.

The MET concept represents a move from the traditional doctor/patient relationship with its focus on individual wards, departments and professions to a systematic, integrated, co-ordinated and patient-focused approach to the seriously ill. Using relatively few extra resources, the MET concept may improve the outcome of the seriously ill. The MET concept represents a move away from the expensive magic bullets which have had little impact on ICU to an early intervention and preventative approach. By mobilising and rearranging existing resources in a different way, it provides the opportunity to improve patient outcome in the broader picture of managing the seriously ill across the whole hospital, rather than just in our ICUs. Both these papers review the literature, summarize the basis for, and describe, the Medical Emergency Team system.

The first article is published in: *Update in Intensive Care and Emergency Medicine Vol 35* - Evaluating Critical Care, Using Health Services Research to improve outcome. Eds Sibbald WJ and Bion JF. Springer 2000

The second article is published in *Resuscitation 2001;48:105-10.*

Citations 53  Impact Factor 2.31 (2006)
Incident monitoring during out of hospital patient transportation by medical retrieval services [published in abstract form only]

Adverse incidents were recorded in the medical records of 1251 patients who had undergone out of hospital patient transportation and positive comments in 92 records. ICU severity of illness measures, and hospital outcome were obtainable for 296 patients. Of patients with adverse incidents (N=146) their mean APACHE II score was 24.5, predicted mortality 45.8%, observed mortality 37.2% (SMR=0.82) and scene time 61.5 minutes. In comparison, patients without documented adverse events (N=144) had APACHE II of 21.5, p=0.016, predicted mortality of 37.2%, p=0.041, observed mortality 31.4% (SMR=0.84), and scene time of 55 minutes, p = 0.004. Patients with positive events (N=6) had APACHE II of 24.2, p=0.88, predicted mortality of 26.1%, p=0.041, observed mortality of 16.7% (SMR=0.64) and scene time of 51 minutes, p = 0.043.

Equipment related incidents occurred in 54% and were more frequent with fixed wing and helicopter aircraft transport vehicles. Of all adverse incidents, 45% occurred in transit (94% being equipment related), and 45% at the referral site. Of the latter, 35% involved inadequate patient treatment and 31% a delay in initiation of retrieval. For incidents with documented patient impact (N=417), 76% sustained prolonged unwanted physiological effect requiring medical intervention. Documented positive retrieval features were those that involved appropriate and timely patient preparation and/or initiation of patient retrieval.

In conclusion incident monitoring may be an applicable quality tool for out of hospital patient transportation. For transported patients, adverse events appear to be multifactorial with significant patient impact. A systematic and multifaceted approach is suggested for the improvement of the transport process of such patients.

Published in: Anaesthesia and Intensive Care 2001;29;663-4.
A description of events associated with scene response by a helicopter based medical retrieval teams

This study set out to describe events occurring during a scene response and documented by medically staffed retrieval teams.

257 patient transport records had documented events (216 incidents, 41 positive), 35.6% had multiple events. Doctor’s experience correlated with event documentation, $R^2 = 0.614$ ($P < 0.0001$). Incidents occurred more often during team dispatch, team at the scene and prior to team scene arrival. Equipment related incidents accounted for 24.3% of negative incidents. Winch incidents accounted for 12% of equipment incidents. Environmental factors contributed to 14.3% of incidents.

In conclusion, the description of events associated with a scene response can be used for quality evaluation. Both incidents and positive events should be evaluated. Future evaluation can benefit by incorporating more detailed information from a larger cross section of retrieval organizations.

This study contributed to the collective understanding of adverse events during a scene response involving a medical retrieval team. Although such teams had been in use for many years this was the first study of its’ type to collectively describe such events. It was also another example oh how incident monitoring may be applied to retrieval and the efficacy of its’ use and the potential information that could be derived from it.

Summary and Significance of publication

These publications used case illustrations to highlight direct patient benefit from retrieval and outline the factors that positively contributed to the outcomes. One publication also used the cases presented to illustrated how particular measures associated with interhospital patient transportation could be utilised as future clinical indicators of trauma system performance. It was also the intention to contrast individual patient benefit from the interhospital transfer process with that of previously documented and higher than expected collective mortality of such patients.

Published in: Injury, 2003, 34;11:847-852 (Impact Factor – 1.07) This journal was chosen because of its focus being trauma and trauma care, including pre hospital trauma care and at that time was a key journal in Australia for Australian and New Zealand Intensive Care and trauma medical practitioners. The majority of missions within this study were for trauma patients.

Citations: 1
Clinical features, patterns of referral and out of hospital transport events for patients with suspected isolated spinal injury

The principle concern for patients with suspected spinal injuries during out of hospital transportation is deterioration of neurological function as a result of patient movement. Major neurological deterioration from time of injury to time of admission to a spinal unit has been documented for 10-26% of such patients. The impact of out of hospital transportation upon patients with spinal injuries remains incompletely defined. The forces of transportation sustained by such patients are unique to the transport environment and can result in significant physiological effects. In clinical practice however patient transportation has not been shown to impact adversely on neurological function, nor has the choice of transport vehicle. The aim of this study was to describe the pattern of utilisation of a medically staffed patient transportation service by patients with suspected isolated spinal injuries who undergo transportation from a hospital or a scene and the clinical consequences of different modes of transportation.

Retrospective review of medical records for patients with suspected spinal injury assessed and escorted by medically staffed team.

196 patients had follow up for spinal injury, 61% with actual injury. Of the 196 patients, 93% involved helicopter transport, 3.5% road vehicle and 3.5% fixed wing transports. 51% were interhospital transfers. Medical team’s scene diagnostic accuracy of spinal injury was 31%. Scene medical interventions were those consistent with current paramedical skills. Of interhospital transferred patients, 19% had no injury. Cervical injuries as part of mixed injuries were the most often missed injuries. Abnormal neurological findings occurred equally amongst patients with and without spinal injury. Transport related incidents were documented for 15%. Interhospital transport patient related incidents occurred for 12% helicopter and 36% road vehicle transports, p=0.094. No transport related neurological injury or other morbidity was documented.

In conclusion, prehospital diagnosis of spinal injury, even by medical teams remains imprecise. Choice of helicopter transport, based purely upon the suspected presence of spinal injury could not be supported.

Summary and Significance of publication
This publication sought to further examine risk of patient transportation, but in a select group of patients. The use of prehospital spine immobilisation, utilising a range of devices is very much established practice, but not based upon high level of evidence. Even less so is there evidence on the preferred choice of transport vehicle. At that time, helicopter transportation was often selected in preference to a road vehicle by many clinicians involved in patient transportation. Despite there being very little evidence to justify that practices, it would have been ethically difficult to conduct a randomised study. This study utilised a retrospective review of patients with isolated spinal injuries and an incident monitoring methodology under development at that time to examine the occurrence of adverse events amongst this group of patients, across a range of transport vehicles. These findings suggest, that based upon the incidence of documented adverse events during transportation, that the choice of transport vehicle should be based on factors other than the presence or absence of an isolated spinal injury. It also documented that in the prehospital environment a spinal injury was often over diagnosed and thus contributed to the unnecessary over utilisation of a helicopter in comparison to other transport vehicles.

Published in: Injury 2001;32:569-575 (Impact Factor – 1.07) This journal was chosen because of its focus being trauma and trauma care and at that time was a key journal in Australia for Australian and New Zealand Intensive Care and trauma medical practitioners.

Citations: 1


Retrieval Incident Monitoring Study

Following on from this research output, a consultative process was undertaken to develop an incident monitoring tool for retrieval, or out of hospital patient transportation. The aim was to set up incident reporting to collect and characterise problems occurring during retrieval and to identify their associated contributing and minimising factors their actual or potential contribution to patient harm with a view to devising preventive and corrective strategies.

Four diverse organisations representing the broad spectrum of medical retrieval then participated in retrieval incident monitoring. The study set out to describe the problems that occurred during retrieval and identify their contributing factors, minimising factors and their contribution to actual or potential patient harm. This allowed for the suggesting of, and giving examples of, devising preventive and corrective strategies. This paper contributed significantly to the better understanding of adverse events during out of hospital patient transportation and the means of their prevention. The output from this paper was further utilised to develop a retrieval and pre hospital specialty incident monitoring tool that is linked to other specialty incident monitoring and a generic incident system that could be adopted for use across any service that undertakes out of hospital transportation of critically ill patients. The development of this tool is described in a section that follows.

The medical retrieval teams that conducted out of hospital patient transportation were also an integral component of a multi agency response to disasters or mass gatherings. Mass gatherings involve large gatherings of people and are associated with a higher incidence of injury and illness than would be expected from the general population. Factors such as weather, attendance numbers and duration of event have been evaluated for their impact upon demand for medical services. The infrequency of such events makes audit and quality improvement difficult. As the medical preparation for the 2000 Sydney Olympics utilised medical staff from established retrieval teams, the clinical utility of incident monitoring under development at that time was used to test its applicability at a major event. The objective being, to better identify the nature and contributing factors of medical incidents during the course of a major event.

Incident reporting has the potential to identify uncommon incidents that may otherwise go overlooked. As an illustration, a case report of patient awareness whilst receiving total intravenous anaesthesia during an interhospital transfer with a medical escort and identified through the incident monitoring study was generated. This was the first documented case of patient awareness during retrieval. It is also illustrative of how information from incident monitoring can be used to inform on a (presumed) uncommon adverse events.
Multiple casualty incidents (MCI) are infrequent events for medical systems making audit and quality improvement of the medical response difficult. Quality tools and use of such tools for improvement is necessary to ensure the design of medical systems allows the best possible response to MCI. The aim of this study was to describe the utility of incident reporting as a quality tool during the deployment of medical teams for mass gatherings and multiple casualty incidents.

Voluntary and confidential reporting of incidents by members of the medical disaster response teams during the period of medical disaster team deployment for the 2000 Sydney Olympic Games. Qualitative evaluation of reported incidents. Main outcome measures were nature of incident and associated contributing factors, minimisation factors, harm potential and comparison with the post deployment cold debrief.

53 incidents were reported. Management based decisions, poor or non-existent protocols, equipment and communication related issues were the principle contributing factors. 89% of incidents were considered preventable. Potential for harm to patients and/or team members were documented in 58% of reports, of which 76% were likely to cause at least significant harm. Of equipment incidents, personal protective equipment (33%), medical equipment (27%), provision of equipment (22%) and communication equipment (17%) predominated. Personal protective equipment (50%) was reported as the most frequent occupational health and safety incident followed by fatigue (25%). Pre-deployment planning was the most important factor for future incident impact minimisation.

Summary and Significance of publication

This study revealed that incident monitoring could be used as a quality tool in identifying incidents and their contributing factors during events involving mass gatherings. It identified a high preventability rate, in keeping with other incident monitoring studies and the importance of equipment, communications and pre deployment planning.

Published in: *Prehospital and Disaster Medicine*. 2004;19:164-8 (Impact Factor unknown) Mass gatherings and medical preparedness are of international interest, particularly for internationally recognised events such as the Olympics. This journal was chosen because of its international readership and its focus on disaster medicine.

Citations: 1
The aim of this study was to characterize incidents occurring during retrieval and to provide a basis for developing corrective strategies.

Four organizations contributed 125 reports, documenting 272 incidents; 91% of forms documented incidents as preventable. Incidents related to equipment (37%), patient care (26%), transport operations (11%), interpersonal communication (9%), planning or preparation (9%), retrieval staff (7%) and tasking (2%). Incidents occurred during patient transport to the receiving facility (26%), at patient origin (26%), during patient loading (20%), at the retrieval service base (18%) and receiving facility (9%). Contributing factors were system-based for 54% and human-based for 42%. Haste (7.5%), equipment malfunctioning (7.2%), or missing (5.5%), failure to check (5.8%) and pressure to proceed (5.2%) were the most frequent contributing factors. Harm was documented in 59% of forms with one death. Minimising factors were good crew skills/teamwork (42%), checking equipment (17%) and patient (8%), patient monitors (15%), good luck (14%) and good interpersonal communication (4%).

Incident monitoring provides sufficient insight into retrieval incidents to be a useful quality improvement tool for retrieval services. Information gathered suggested improvements in retrieval equipment design and use of alternative power sources, the use of pro forma for equipment checking, patient assessment, preparation for transportation and information transfer. Lessons from incidents in other areas applicable to retrieval should be linked for analysis with retrieval incidents.

Summary and Significance of publication

This study revealed that incident monitoring could be used as a quality tool in identifying incidents and their contributing factors during out of hospital patient transportation. It is the first study to document the use of an incident monitoring tool specifically to document and interpret incidents during out of hospital patient transportation across a number of organisations. It documents the nature of, contributing factors and impact of such events. It also identifies future potential uses of such a tool such as developing crisis management algorithms, preventative strategies and comparisons with similar incidents from other incident monitoring tools. Data from this study was subsequently used to test

Published in: Anaesthesia and Intensive Care 2006;34:228-36 (Impact Factor - 0.945). This study was conducted within the Australian environment. Although the participating organisations represented a broad spectrum of out of hospital patient transportation, the generalizability of the findings from this study have not been confirmed. As such an Australian based journal was chosen as well as one that had shown interest in other incident monitoring tools.

Citations: 1
Awareness in Retrieval Medicine: A Case Report

Awareness is the spontaneous recall of an event(s) that occurred during general anaesthesia and surgery. The incidence of awareness is approximately 0.2% of cases where neuromuscular blockers are used and half that where they are omitted. The majority of data relating to awareness is from anaesthetic practice. We report a case of awareness associated with an out of hospital transportation of a critically ill patient requiring a medical escort (retrieval). We discuss the risk factors associated with awareness during retrieval and the unique challenges for the prevention of awareness within the retrieval environment.

Summary and Significance of publication
This publication is the first to document a case of awareness during out of hospital patient transportation in a patient who had been intentionally administered general anaesthesia as part of her medical management. The article also reviews what is known in relation to awareness within other critical care settings, known risk and preventative factors and suggests how they may be applicable to out of hospital patient transportation.

Published in: Anaesthesia and Intensive Care 2006;34:678-82 (Impact Factor - 0.945). This journal was chosen because of its focus being anaesthesia and critical care and that the case report arose from an Australian setting.

Citations: 1
Narrativizing errors of care and the potential affect on reporters

Critical incident reporting is intended to enhance safety and quality of care through a reflection on ‘what was done’ as a way of intervening in ‘how things could have been done’. In part it does so by attempting to transcend professional and specialty boundaries through a narrative or (inter)personal means. Essentially a device that asks clinicians to narrativize about how the clinical work unfolds, critical incident reporting is a once organizational change device and a form of representation through which humans express their “desire for a kind of order and fullness.” This paper argues that, through engaging the reporter in sharing narratives about their work, they are faced with having to construct, confirm or contest the technical and ethical contours of who they are and what they do.

Critical incident reporting was developed in the military to understand the behaviours of fighter pilots during World War II. Psychologists wanted to understand why some trainee pilots dropped out of the flight program, and why and how others were involved in incidents and accidents. On the one hand, these studies led to recommendations regarding not just the design of cockpits and instrument panels, but also the kinds of actions performed by fighter crews. On the other hand, the focus on critical incidents enabled researchers to investigate the differences between acts that led to success versus those that led to failure, and derive conclusions from that about how people should be encouraged to act, or should be forced to act by redesigning their work environments to produce more desirable outcomes.

Critical incident reporting places an affective component on the way reporters document interpersonal experiences about ‘what happened’ and ‘what I did’. Thus, this study set out to explore the free text associated with incident reports so as to determine whether narratives in incident reports are narratives, to demonstrate the extent that the narrative discourse details the clinicians’ everyday experiences and their personal and moral feelings about these experiences and the extent that it enables or renders clinicians vulnerable, to anchoring ‘what went wrong’ and ‘what they felt’ to the broader he alth-organizational agendas of governance, practice improvement, and clinical quality and safety.
Narrativizing errors of care: Critical incident reporting in clinical practice

This paper considers the rise across acute care settings in the industrialized world of techniques that encourages clinicians to record their experiences about events they are personally involved in; that is, to share narratives about their work. The events that clinicians are increasingly expected to narrate into being are adverse events, also referred to as ‘critical incidents’. Critical incident reporting is often followed by ‘root cause analysis’: a cross-disciplinary (or ‘horizontal’) investigation into the incident, involving collecting stories about the incident from relevant parties around the organization. The narrations that constitute these critical incidents and root cause analyses render visible molecular facets of the everyday clinical work that heretofore were only discussed in closed, paperless meetings. For its part, the critical incident form further requires that incident narrations are followed by statements about consequences and implications, linking narration to a kind of organizational meta-discourse. This is in effect a transition from personal into organizational discourse, realizing a trend in contemporary organizations that centres on ‘responsibilizing’ non-managerial employees. Drawing on a study of 124 medical retrieval incident reports, the paper provides illustrations and interpretations of both the narrative and the meta-discursive dimensions of four of those critical incident reports. The paper argues that as new and complex genre critical incident reporting achieves two important objectives. First, medical clinicians express interpersonal meanings in discourse about local work problems to an audience that includes not just doctors. Second, by co-articulating self-identity (as feelings and judgments) and organizational norms in such a semi-public forum, doctors find themselves drawn into producing a discursive space where their selves are ‘organizationalized’ and organizations ‘selfed’.

A valuable section of the incident monitoring tool was a section that allowed for the reporter of the incident to use free text to report on the incident. On analysis of the reports it was noticed that a valuable and unexplored aspect to this free text was its’ emotive components. This was an as yet unexplored field. This study was unique in that it used a discourse analysis to explore these components of the free text. Such information would be valuable, in particular to out of hospital patient transportation of critically ill patients. Earlier studies presented here illustrate the potential clinical stressors that clinicians may be exposed to as they are tasked in an unpredictable manner to deal with patients with a high severity of illness and thus level of clinical intervention, within an environment more hostile to that of a hospital and in a range of transport vehicles.

Summary and Significance of publication
Incident monitoring as a quality tool has been used since the 1950s and more recently throughout a number of medical fields such as anaesthesia, hyperbaric and Intensive Care. An important component of many incident monitoring tools is the narrative written by the reporter of an incident in there own language. This is the first study to focus predominately on this free text through a discourse analysis of that narrative. It uses selected case studies from the Retrieval Incident Monitoring Study to identify emotive features within the free text and its possible significance to the reporters and the organisations they represent.

Published in: Social Science and Medicine. 2006;62:134-144 (Impact Factor – 2.75)

Citations: 1
Developing the Retrieval Healthcare Incident Type (HIT)

The Retrieval HIT was developed in conjunction with the Australian Patient Safety Foundation (APSF). The APSF non-profit independent organisation dedicated to the advancement of patient safety. The APSF provides a software tool, the Advanced Incident Management System (AIMS) to capture information from a wide variety of sources to enable de-construction and classification of incidents from near misses to sentinel events in a consistent way, so that subsequent, detailed analysis is possible. Utilising this organisation's expertise, the AIMS program and the data from the Retrieval Incident Monitoring Study, a specialty Ambulance/Retrieval HIT was developed.

AIMS is a program designed to collect, store, manage, and analyse information about things that go wrong in healthcare. The underlying information model within AIMS is based on the “Reason” model of complex system failure, our explicit representation of which is the Generic Reference Model (GRM). The GRM is the conceptual basis of the process, and provides a structured approach to drawing out all the relevant information about an incident. It forms the basis for the design of the AIMS database and underpins the overall process of collecting and classifying information.

The GRM can be represented by the following diagram. It was developed to provide a framework to define the relationships between components of the classification system and the terms which are used to describe the attributes of each of these components.

NOTE:
This figure is included on page 21 of the print copy of the thesis held in the University of Adelaide Library.
Incidents are divided into types and the GRM is used to derive a “specific incident reference model” for each incident. Each incident may be classified into one or more types. For example, an overdose of morphine in a surgical patient because of malfunction of an infusion pump, would be classified using “medication”, “therapeutic device” and “surgery” types. When an incident is classified using multiple incident types, the user needs to identify the “principal incident type” which AIMS uses to categorise the incident when generating reports (this is the incident type which most directly was responsible for any harm or potential harm).

The Generic HITs cover the types of incidents that can occur across the spectrum of activities, behaviours, equipment and factors involved in the delivery of care, in both acute and non-acute environments. Each HIT is designed to elicit comprehensive information specifically related to that type of incident. In addition to the HIT specific questions, Generic HITS also include a set of Common Questions that elicit information about human or general factors that span all incident types.

**Generic HITs**

**Clinical**
- Aggression - Aggressor
- Aggression – Victim
- Behaviour/Human Performance
- Clinical Management
- Documentation
- Falls
- Hospital acquired infection/infestation
- Medical Devices/Equipment/Property
- Medications/IV Fluids
- Nutrition
- Oxygens/Gases/Vapors
- Pressure Ulcer

**Non-Clinical**
- Accidents/Occupational Health and Safety
- Buildings/Fittings/Fixtures/Surrounds
- Organisational Management/Services
- Security

**Specialty HITs**

**Clinical**
- Anaesthesia
- Complaints
- Hyperbaric
- Intensive Care Unit
- Obstetric – foetal
- Obstetric – maternal

Specialty HITs, of which the Ambulance / Retrieval HIT is one, capture detail specific to that specialty. Illustrated below are screen shots of sections of the Ambulance / Retrieval HIT as they would appear to the user.
Understanding, planning for and benchmarking the quality of care of critically ill patients undergoing interhospital transportation

To date, studies of the outcomes of critically ill patients who undergo interhospital transport have been small, single centre studies, lacked comparable controls, confined to a specific cohort of patients or risked significant bias from confounding factors. Furthermore regional, geographical and population variability may limit the generalizability of their findings.

The scope of the research output presented above has been to identify patients undergoing interhospital transport to have a high severity of illness and hospital mortality. These findings may be as a result of health system and/or casemix dependent and/or due to the occurrence of transport associated adverse events. These adverse findings contribute to potential and actual patient harm and thus may also be potentially preventable. Earlier case illustrations have also been used that suggest the use of patient transport measures as clinical performance indicators. Based upon the findings of this prior research outlined above, the following research was undertaken and reported upon.

The first of the following papers set out to gain an understanding of the demographic and illness characteristics of critically ill patients undergoing interhospital transport so as to better assist with the future provision and accessibility of health care resources. Utilising a large dataset of patients admitted to an Australian or New Zealand Intensive Care Unit, a detailed and predefined examination of regional differences and patterns of interhospital transport was conducted so as to describe more accurately and further evaluate the factors influencing the occurrence and outcome of interhospital transport.

The second paper was a case control study that set out to explore differences in the outcomes and regional variations (amongst the states and territories of Australia and New Zealand), if any, of patients whose ICU source of admission was another acute hospital compared with similar patients admitted to the ICU from the Emergency Department. This paper further evaluated the differences in patient outcomes for different patient diagnosis.

These two papers report upon the largest published sample of patients undergoing interhospital transfer and the first to examine for differences across different geographical domains. They also provide a basis for the use of patient transport related information as potential measures of a health systems performance, system monitoring and means of quality improvement, in relation to acute health care services distribution, access and delivery.
Objective: To describe demographics, illness categories and outcomes of adult intensive care unit (ICU) patients subjected to Interhospital Transfer (IHT).

Design: Retrospective review from a bi national intensive care quality assurance dataset.

Participants and Setting: 125 Australian and New Zealand adult ICUs, 332,009 patients, 16 years and older, known hospital and ICU source of admission, between 1st January 1994 and 31st December 2003.

Results: Tertiary ICU contributed 47.9% of patients, metropolitan 20.9%, private 16.7% and rural/regional 14.5%. Patients admitted to an ICU following IHT had a high severity of illness, hospital stay, intubation rate, mortality and discharge to another hospital. Over 10 years, the proportion of IHT increased for tertiary ($R^2=0.639$, $p=0.006$) and rural/regional hospitals ($R^2=0.703$, $p=0.002$), for the diagnosis of sepsis ($R^2=0.877$, $p<0.0001$) and respiratory infection ($R^2=0.679$, $p=0.003$), decreased for trauma ($R^2=0.612$, $p=0.007$), was associated with fewer ICU admissions after elective surgery [$b = -1.47$ (CI -2.19, -0.74), $p<0.000$] and from the operating theatre [$b = -0.78$ (CI -1.46, -0.1), $p=0.025$]. IHT occurred mostly during July - October and on Friday and Saturday. There were significant variations between Australian states and territories and New Zealand.

Conclusions: IHT patients admitted to ICU have significant resource implications based upon severity of illness, hospital stay and mortality, and adversely affect the capacity for elective and OT ICU admissions. Regional differences and temporal trends have implications for planning of ICU resources and requires ongoing surveillance.

Summary and Significance of publication
This study is the first to analyse the demographics and outcomes of critically ill patients who have undergone interhospital transportation and required admission to an Intensive Care Unit across a number of different ICU and across a number of geographical regions. Prior studies have been smaller in patient numbers, single centre or single region and more diverse study population. The important findings were: higher severity of illness, mortality and hospital stay; adverse impact upon hospital elective admissions to an ICU; change in casemix of such patients over time; seasonal and weekly variations and variability according to ICU type and region. These findings have important implications for ICU planning as well as for services that are involved with out of hospital patient transportation.

Published in: *Critical Care and Resuscitation 2008;10: 90–96* (Impact Factor – not documented, but Medline listed journal). This journal was chosen because it is the primary journal for the Intensive Care community in Australia and New Zealand and so is the audience to which this study would have the maximum appeal.
Outcomes of patients admitted to tertiary intensive care units after interhospital transfer: comparison with patients admitted from emergency departments.\textsuperscript{102} (complete publication in Section 18)

**Objectives:** To compare regional variations and outcomes of inter hospital transfer (IHT) patients admitted to Intensive Care Unit (ICU) with similar patients from the Emergency Department (ED)

**Design:** Historical case control study of direct ICU admission from another hospital (DIHT) matched with ICU admission from the Emergency Department (ED group) according to age, gender, APACHE II score and diagnosis.

**Participants and Setting:** From 30 Australian and New Zealand adult tertiary ICU, 28 883 patients, 16 years and older, admitted between 1\textsuperscript{st} January 1994 and 31\textsuperscript{st} December 2003 with one of the eight most common diagnoses for IHT patients.

**Results:** Hospital mortality in the DIHT group, compared to the ED group, was greater for a diagnosis of trauma [11\% vs 5.1\% OR 2.3 (CI 1.6, 3.34)], respiratory infection [28.1\% vs 19.1\% OR 1.66 (CI 1.34, 2.05)], sepsis [38.7\% vs 28.7\% OR 1.57 (CI 1.34, 1.83)], intracranial haemorrhage [49.9\% vs 42.6\% OR 1.34 (CI 1.14, 1.58)] head injury [16.9\% vs 13.7\% OR 1.28 (CI 1.01, 1.62)], and cardiac arrest [59.3\% vs 53.2\% OR 1.28 (CI 1.06, 1.56)] but not for overdose [3.9\% vs 3.6\% OR 1.09 (CI 0.72, 1.67)] or COPD [19.8\% vs 22.5\% OR 0.85 (CI 0.63, 1.15)]. Overall the DIHT group had a greater intubation rate, ICU length of stay and discharge to another hospital.

**Conclusions:** ICU admissions from another hospital have a greater hospital mortality and length of stay, which varies for diagnosis. These differences are important considerations for resource allocation, triage, and as a measure of quality.

**Summary and Significance of publication**
This study, utilising the same dataset as the study above is the first to show that previous findings of higher than expected mortality and hospital stay for critically ill patients who have undergone interhospital transportation and required admission to an Intensive Care Unit is casemix dependent and shows regional variation. It also identified the significantly higher incidence of endotracheal intubation and mechanical ventilation amongst interhospital transferred patients in comparison to matched non transferred patients. These findings have important implications for ICU planning, for services that are involved with out of hospital patient transportation, resource allocation and the use of these indicators as quality measures for regional out of hospital patient transportation of critically ill patients.

Published in: *Critical Care and Resuscitation* 2008;10: 97–105 (Impact Factor – not documented, but Medline listed journal). This journal was chosen because it is the primary journal for the Intensive Care community in Australia and New Zealand and so is the audience to which this study would have the maximum appeal
Summary

The provision of equitable access to health care, particularly acute care remains a challenge. This challenge is often met through the provision of outreach critical care services. These services may take the form of Medical Emergency Teams responding to hospital in-patients who become acutely ill outside a hospital critical care environment (e.g., a general medical ward) or medically staffed retrieval services that respond to patients who become acutely ill in an out of hospital environment for which critical care resources are not immediately available and are delivered to the patient by a responding retrieval team. In both circumstances the intention is early recognition of the acutely ill patient, a timely response by a team with the desired critical care skills, where appropriate deliver the patient to a Critical Care environment (e.g., an Intensive Care Unit) for ongoing management and by doing so prevent potential adverse patient events.

Retrieval services are becoming increasingly important as centralisation of specialty and acute medical services is increasing. These processes involve many complex interactions, with the potential for adverse patient events. Thus it is important to better understand the nature, frequency of occurrence and patient outcomes associated with out of hospital patient transportation, particularly with critically ill patients requiring admission to an Intensive Care Unit.

This body of work, across a number of studies, showed that patients whose ICU source of admission was another hospital had a severity of illness that was higher than for other ICU admissions, had a greater than expected mortality and a mortality and hospital length of stay that exceeded that of similar patients, matched for demographics and casemix who had not undergone an interhospital transfer. These findings varied according to the diagnostic category (being stronger for trauma, respiratory illness, sepsis and intra cranial haemorrhage) and varied across geographical regions. These studies also showed that there was regional variation in the proportion of patients admitted to an ICU from another hospital, the proportion of such patients was increasing (particularly for sepsis) as well as patterns of variation based upon day of the week (highest occurrence Friday and Saturday) and month of the year (mostly July to October). They also revealed that there is a negative correlation between the proportion of patients admitted to an ICU from another hospital with the proportion of elective and post operative admissions to the ICU. This information is important in regards to planning for the provision of acute care and emergency services resources.

The interhospital transfer of critically ill patients has been previously documented to be associated with significant adverse patient events. However our understanding of these events in terms of contributing factors, preventability, potential for harm and minimizing factors has not been well documented. This body of work also showed that medical treatment may be altered based solely on the fact that a patient is undergoing retrieval. An example of this is the finding that such patients have a significantly greater likelihood of endotracheal intubation and mechanical ventilation that similar patients matched for demographics, severity of illness and diagnosis who have not undergone retrieval. Retrieval however can provide significant patient benefit, and this body of work illustrates that through the description of a number of unique and challenging cases and the retrieval specific factors that were associated with a good outcome for each of those cases.
This information points to the importance of identifying quality in retrieval practice. This body of work outlines the original development of an incident monitoring tool for retrieval, based upon existing examples of use of the incident monitoring methodology within other medical and non medical domains. Following a retrospective review and analysis of comments from retrieval patient records and consultation a tool for Retrieval Incident Monitoring was developed. An investigation of the use of Retrieval Incident Monitoring across a number of retrieval organisations and pre hospital activities, including during deployment at a major public event (2000 Sydney Olympics) was undertaken. The findings of this study showed that the majority of incidents during retrieval are preventable (91%) and that most incidents were related to problems with equipment, then patient care, and transport operations, interpersonal communication, planning or preparation, retrieval staffing and tasking. Incidents were most likely to occur during patient transport to the receiving facility, at patient origin, during patient loading and at the retrieval service base. Contributing factors were almost equally spread between those that were system and human based. Patient harm was documented in 59% as well as a death. The importance of good crew skills/teamwork was highlighted as a minimising factor to incident occurrence.

Subsequently this knowledge, experience and data was used to develop and validity a Retrieval and Ambulance Healthcare Incident Type within the generic and widely used Advanced Incident Management System (AIMS).

Finally the occurrence of retrieval can be used as a quality measure for the wider health system. Ideally, because of the findings from this body of work of an associated greater than expected mortality and hospital stay of patients undergoing retrieval, particularly for certain diagnostic categories, then a measure of the occurrence of retrieval could be used as a quality indicator of health service provision across a region. As the need for retrieval will never be negated, outcomes associated with retrieval can be measured and benchmarked across a number of regions.

In summary, in its entirety, this work has added and tested new knowledge and methods as well as value added to existing knowledge for critical care delivery in the out of hospital environment, in particularly to medical retrieval of critically ill patients admitted to an Intensive Care Unit within Australia and New Zealand. It has developed and validated the efficacy of a new quality tool for retrieval and retrieval based quality measures. It has also pointed towards new areas of future investigation particularly in relation to factors that may favourably or adversely impact upon retrieval outcomes and outcomes of patients undergoing retrieval.
References

Publications for which I have been a principle or a significant contributor to and form part of this body of work are entirely bold.
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Section 2
OPTIMAL INTERHOSPITAL TRANSPORT SYSTEMS FOR THE CRITICALLY ILL

Arthas Flabouris, MBBS, FANZCA, FFICANZCA PostGrad Dip Aviat Med.*
Ian Seppelt MBBS, BSc(Med), FANZCA, FFICANZCA#
Staff Specialists NRMA CareFlight NSW Medical Retrieval Service and Intensive Care Units, *Liverpool Hospital and #Nepean Hospital

Corresponding Author
Dr Arthas Flabouris
NRMA CareFlight
PO Box 159
Westmead 2145, New South Wales
Australia

E-mail - Arthas.Flabouris@swsahs.nsw.gov.au
Introduction

Increasingly, critically ill patients are undergoing interhospital transportation. The reason for transport is not only for higher level care, but also as consequences of the re-distribution of critical care resources. There are many transport system issues for such patients. These issues have the potential for significant patient and transport team morbidity and financial burden upon the health services. An examination of events during the patient referral process can identify referral system based problems at many levels of health care. This paper will review our current knowledge of the clinical and operational process for referral and transportation of critically ill adult patients as well as the available means of its evaluation and likely future direction.

Organisational Structure

The organisational structure for patient interhospital transport services is largely determined by the perceived clinical workload, regional population demographics, geographic features and transport related regulatory requirements.

Hospital based services source their personnel and equipment from within the hospital's critical care department medical and nursing pool rostered specifically for transport duties or taken from rostered hospital duties. They have ready access to other specialised hospital clinical services and can develop the capacity to deliver specialised services (eg neurosurgical, thoracic, etc) to patients at the referral site. They can also have access a wider range of other hospital logistical support such as roster/staff pool manipulation, blood products, rapid sterilisation services and infrequently used drugs, antivenoms and antidotes.

Hospital based services can enhance the referral process through a dedicated communication line through which immediate advice can be provided and the referral response within that hospital initiated. As the complete referral process is co-ordinated through one site, quality measurements could be gathered for each phase of the referral and there is a single source of outcome data to referral sites. Such hospital services could be involved with uniform instruction of pre-transport patient care and preparation through outreach educational programs at potential receiving sites.

A process for the rapid deployment of vehicle and personnel, which includes aspects of communication, tasking, vehicle availability, safety and pre-deployment vehicle familiarisation training is essential. The latter would include on board procedures and equipment, including communication devices and those to do with vehicle safety.

Non hospital based organisations are administratively independent organisations that supply the medical and aviation crew for the purpose of transporting patients between non-affiliated facilities. They have the advantage that expertise is developed through their sole focus on safe interhospital patient transportation. This concentrated and higher volume of clinical and aviation transport exposure may have positive implications for crew performance [1] and patient safety [2]. Non hospital based patient transport services should develop links with tertiary referral hospitals for improved access to speciality medical and surgical services consultation, utilisation of hospital services such as equipment sterilisation, pharmacy and blood products as well
as in hospital educational and audit activities pertaining to the transport service activities.

Table 1 summarises the advantages and disadvantages of hospital and non-hospital based organisations.

Table 1
Comparison of Hospital and Non Hospital based interhospital patient transport services.

<table>
<thead>
<tr>
<th></th>
<th>ADVANTAGES</th>
<th>DISADVANTAGES</th>
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<tr>
<td>HOSPITAL</td>
<td>Ready pool of staff from critical care areas</td>
<td>Less concentration of numbers of patient transports</td>
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<tr>
<td>BASED</td>
<td>Sole &quot;control and command&quot; of referral process</td>
<td>Less concentration of transport medical equipment resources, and less cost efficient</td>
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<td></td>
<td>Patient preparation and management based upon familiar hospital practises</td>
<td>Clash of crew training activities and service audit processes with other hospital duties</td>
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<td></td>
<td>Ease of integration of patient into hospital services</td>
<td>Disruption to hospital workload through removal of staff for transport duties</td>
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<td></td>
<td>Patient monitor compatibility</td>
<td>Variable adherence to guidelines due to inability to provide for limited medical equipment</td>
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<tr>
<td></td>
<td>Familiarity of crew and referral staff within each region</td>
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<td></td>
<td>Access to other hospital clinical, diagnostic, therapeutic services</td>
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<td></td>
<td>On site for data collection, outcome measures and quality assessment</td>
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<tr>
<td>NON HOSPITAL</td>
<td>Concentration of expertise and skills through volume of work</td>
<td>Increased complexity of communication links between referring, transport and receiving staff</td>
</tr>
<tr>
<td>BASED</td>
<td>Development of true &quot;speciality&quot; service by concentrating on provision of transport services only</td>
<td>Medical equipment incompatibility between various sites</td>
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<tr>
<td></td>
<td>More efficient use of medical equipment, crew training opportunities</td>
<td>Patient management procedures may differ between crew and referral/receiving hospitals</td>
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<tr>
<td></td>
<td>Staff rostered solely for transport duties</td>
<td>Distant from specialised hospital clinical, diagnostic, therapeutic services</td>
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<td></td>
<td>Greater crew familiarity with transport vehicles</td>
<td>May require to maintain costly, less frequently used pharmacy items</td>
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<tr>
<td></td>
<td>Crew training and currency easier to apply and monitor</td>
<td>Data acquisition is scattered amongst more than one receiving site</td>
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<tr>
<td></td>
<td></td>
<td>Medical equipment cleaning and repair less efficient due to lower volume of work</td>
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When more than one transport service is available and/or are multi tasked, tasking is best coordinated through a central tasking authority via a dedicated communication line. This allows for prioritisation of requests and establishment of communication links between referring, transporting and receiving staff. The central tasking authority can become involved in establishment and maintenance of patient transport standards, evaluation of the critical care referral process, liaison with other services (eg ambulance and aircraft providers) as well as report to local hospital, regional area health service, state and or national health authorities and legislators.

**Medical Crew - Crew Selection, Accreditation and Training**

Studies of the interhospital transfer of critically ill patients have documented inadequacies of patient care, significant associated morbidity and observed mortality in excess of expected mortality when compared to similar patients who were not transferred [3,4]. Patients admitted to an ICU following transfer from another hospital have been shown on average to have higher severity of illness measures than similar non-transferred admissions to the same ICU. [4,5]. In recognition of these events standards for the safe conduct of out of hospital patient transportation have been developed.

Major physiological disturbances such as hypoxia, hypotension, missed injuries, intravenous access, airway, ventilation, spine and limb immobilisation and communication problems are commonly documented in transit adverse patient events. Unresolved physiological instability at the referral site, and lack of transport experience by the escorting team, are predictive of such events [6,7]. It is therefore essential that the medical team escorting the patient have the skills in monitoring, recognising and managing acute physiological disturbances associated with a broad range of patient illness, rather than staff with medical expertise limited to specific disease categories and little expertise in acute multi organ dysfunction.

Referrals from remote regional hospitals with limited resources and staff who only infrequently encounter critically ill patients provide the greatest challenge. The transporting medical staff should have the capabilities to provide to those sites at the very least an enhanced level of clinical expertise.

High level and well-practised communication skills are vital to transporting medical teams. Not only must they be familiar with the range of available communication aids but also they must develop, acutely, a rapport with potentially unfamiliar referring and receiving medical staff, patients and their relatives. They require the capacity to communicate clinical information in a clear, relevant and timely fashion. This facilitates the transfer and appropriateness of information advice that they are expected to provide to the referring, receiving and supervising staff, all of who may be at a location distant to the team and patient.

The transport environment is a more unpredictable and stressful to the inexperienced than the familiar hospital environment. The team requires a high degree of situational awareness and this is often associated with an increased clinical workload, both in terms of intensity and duration. Successful team function then becomes even more dependent upon effective interaction amongst team members, of which familiarity, communication, effective leadership and team cultural factors play a part [8].
Selection and training of patient transport medical teams must then reflect these demands. At present a disproportionate emphasis is placed upon pilot selection than medical staff selection, even though it is the latter that have the most significant influence upon outcome of patients undergoing interhospital transfer.

Medical staff should be selected based upon extensive in hospital critical care experience, a demonstrated ability to function unsupervised, communication and leadership skills, ability to safely adapt clinical practises to unique situations and to work within a variety of team structures. Training should incorporate clinical performance within the constraints of transport vehicles, medical and personal protective equipment as well as vehicle familiarisation, especially the associated communication and safety/emergency procedures (eg where applicable, helicopter underwater escape training, hypoxia awareness training).

Knowledge of and comfort within the working transport environment is also essential. Despite the wealth of information about the physical aviation environment, there is an inadequate amount of information as to the clinical consequences and significance of that environment upon the various patient pathophysiological processes. Most such information is derived and/or accumulated through clinical exposure. Therefore not only is a sound knowledge of the transport environment required, but instruction about the environment/patient interface and its clinical significance is essential for medical transport teams. Knowledge of local geography and meteorology is also important.

Familiarity with regional medical resource distribution, referral policy and procedures as well as referring and receiving senior medical staff is important. Resource distribution can be catalogued within a predeveloped database. At least an above average level of physical fitness should be required of transport team members as well as a pre deployment assessment of vision and hearing.

Team performance training should be based upon Crew Resource Management principles which incorporate effective communication skills, situational awareness, problem solving, decision making, stress recognition and management, team management, interpersonal skills, fatigue recognition and management [9]. Such training needs to be ongoing and tailored to conditions and experiences encountered within the patient transport service [10].

Familiarity and prior experience are crucial to such medical crew performance. Re accreditation of personnel should reflect clinical currency in inter hospital patient transportation, equipment familiarisation, participation in specific quality assurance activities, accuracy and completeness of documentation and participation in transport vehicle familiarisation briefings. Skills can be maintained through ongoing in hospital clinical exposure within relevant critical care environments, especially Intensive Care and Emergency Departments, clinical exercises utilising transport equipment and team scenarios supervised transports and simulator training. Attendance and participation in quality/audit activities should be mandatory.
Not all acutely ill patients require a doctor. Although out of keeping with most currently accepted guidelines for minimum standards of patient transportation, some critically ill patients can, under medical guidance, be transported by non-medical escort with no documented added morbidity or mortality [11]. On this basis hospital and non-hospital based patient transport organisations may develop a multi tiered response capability, in terms of team crew composition and resource utilisation. Such a strategy would require reliable and expert pre transport information gathering and assessment. Currently, available scoring tools to predict which patient is not at risk [12] have a low specificity and are likely to be based upon clinical judgement. Given the incidence of missed injuries and deficiencies in treatment at the referral sites, such decisions for critically ill patients should be cautiously applied after a high level of medical consideration.

**Types of Transport Vehicles and Vehicle Selection.**

For interhospital transport of the critically ill the choice is essentially road ambulances, rotary wing aircraft (helicopters) and fixed wing aircraft (dedicated air ambulances or commercial flights).

Road ambulances are readily available all over the world, but range from being an empty vehicle only, to being a sophisticated, well equipped resuscitation platform. Vehicle and patient cabin size varies according to the requirements for speed, manoeuvrability, terrain and clinical patient circumstances under which it will be utilised.

Helicopters are selected based upon the considerations of working geographical environment, cost, maintenance, single/twin engine capacity, size, noise, and IFR/non IFR capability. A twin engine aircraft has a significant margin of safety for medical work, in that it can fly on, and land after, an engine failure whereas a single engine aircraft has no option but to auto rotate into the nearest clear space. Helicopters used for long distance patient transport over wilderness areas should be twin engine. Aircraft equipped to fly under visual flight rules (VFR) conditions only is at a safety disadvantage compared to one with equipment and pilots trained to fly using instrument flight rules (IFR) when needed, either with two pilots or using an autopilot. A small, fast helicopter is manoeuvrable and able to land in tight landing areas – of advantage during urban prehospital work. Interhospital medical work is between known safe landing zones and there may be an advantage using a larger aircraft with the capacity for more than one patient. Noise is an issue for hospitals in populated areas, and there is a benefit to modern quieter helicopters designed to minimise tail rotor noise (such as fenestron rotors or NOTAR (no tail rotor) systems).

Fixed wing aircraft range from dedicated or reconfigured turbo prop or jet engine aircraft fitted out as air ambulances, to long haul commercial airliners with stretchers mounted to military aircraft designed for transport of mass casualties.

Depending upon the terrain, road vehicles are more efficient and quicker for distances of up to 50 km, helicopter transport quickest are more efficient and no as financially cheap as fixed wing aircraft within the range of 50 – 250 km, whilst fixed wing aircraft are preferred for distances beyond that.
A new aircraft, the Bell/Agusta 609 Tiltrotor, combines advantages of both rotary and fixed wing aircraft and may have a significant impact on aeromedical work in the future. It can take off from and land at a hospital helipad, and hover as a helicopter, then move its rotors into a rear thrust position for forward motion with the speed advantage of a fixed wing aircraft.

Few comparisons between different modes of transportation have been done using similar patient population groups. Patients with acute coronary syndromes can be safely transported by helicopter. Comparative studies with road transportation have not shown a survival advantage but fewer adverse cardiac events have been shown to occur during road as compared to helicopter transport [13]. Patients with a broad case mix [14,15] and more specific conditions such as hypothermia, post thrombolytic therapy, cardiogenic shock receiving complex therapy (ie. inotropes and intra aortic balloon pump) and trauma have also been safely transported. Of the latter, trauma patients are the group with the most consistent benefit. Our own (submitted in 2000, yet unpublished), and others [16], retrospective comparison of patients with spinal injuries undergoing interhospital transfer showed that no form of transportation was associated with documented exacerbation of neurological injury. Our data showed that, compared to road transport, helicopter transports were associated with fewer overall transport incidents, but a similar number of patient only related incidents.

There are only a very few specific contraindications for the available modes of transportation. There should be no patient who is “too sick to transport” provided that the patient receives appropriate in transit care and stands to benefit from the improved level of care at the receiving institution. Potential benefits to the patient from care at the receiving site rarely do not outweigh the non-insurmountable transport related risks. Choice of vehicle is mostly based upon clinical urgency, geography, weather and vehicle availability. The majority of adverse patient related events are related to clinical rather than vehicle related factors. Overall, the transport process, itself may however contribute to patient morbidity and mortality for certain patient groups [4,17], but the factors that do so are poorly defined.

**Patterns of Patient Referral, Selection and Acceptance of Clinical Transport Responsibility**

Each region should assess and document their requirements for interhospital patient transportation. Based upon this information a regional strategy should be developed and redefined as ongoing evaluation of those requirements occur.

It is important that referral process guidelines, as distinct to specific clinical patient transport related guidelines, be established. These should be designed to reduce the burden at hospitals with the least resources, which are the most likely to initiate a referral. The referring hospital staff need to only make a single call, which triggers a standardised process. This call also initiates the tasking process for the patient transport service. This single contact point can also be utilised as a source for immediate clinical advice [18].
These communication channels can be via a dedicated telephone landline, radio or Internet facilitated information transfer such as e-mail, still and/or video picture transfer. A conferencing system can be established where referring, retrieval and receiving doctors and any coordinating personnel can simultaneously be part of the one call. That way operational planning and clinical management advice [19] can proceed simultaneously. For efficiency, such communication must run according to a set protocol. This protocol should define who leads or "chairs" the conversation, minimises debate and non-directed discussions. Such communication should be recorded, protected from liability, and utilised for quality purposes. In situations where transport team dispatch is urgent, they can be dispatched while the other parties complete the exchange of information.

The receiving hospital specialist to whose care the patient is being referred, in conjunction with a senior member of the patient transport service should take joint responsibility for the process and define the indication for referral. This is a crucial step towards the timely, organised and safe transfer of the patient to an appropriate and prepared receiving hospital. All necessary assistance (eg information, personnel and equipment) for the referral site should be offered at that time. A management plan that extends into the time after the arrival of the patient at the receiving hospital should be developed at this stage. This process will provide all carers with common therapeutic objectives, simplify the clinical interaction at each patient handover point and maintain continuity of care. Time consuming interventional procedures and/or patient stabilisation would not be necessary for transporting teams if patients are adequately prepared prior to their arrival. Similarly all clinical patient information and documentation should be well known to the transporting team and prepared prior to their arrival. The role of the team is then the continuation of treatment, clinical monitoring and communication with the receiving hospital. Those responsible for the referral process should remain readily contactable in case of consultation.

Guidelines for pre transport patient preparation can be distributed for use by referring staff. Examples of such guidelines are those published by the Association of Anaesthetists of Great Britain and Ireland for serious head injured patients and those currently in use within the South Western Sydney Area Health Service, Liverpool Hospital Trauma Service for trauma referrals. The latter incorporate a dedicated phone landline, the “Trauma Hotline” [20] through which initial contact for all trauma referrals is made and a checklist pneumonic, the NEWS ABCDEFGH. This checklist is printed on the cover of a large envelope into which all referral patient documentation and radiology are enclosed. NEWS refers to the questions asked, ie Needed? Enough? Working? Secure? about Airway (plus cervical spine), Breathing, Circulation, Disability, Equipment, Family, Gastric tube, History/handover and was developed by Dr Patrick Schoettaker at the Liverpool Hospital Trauma Service (personal communication, 2000).

Proximate or remote supervision of the transport phase should be through a senior member of the patient transport service. This includes logistical and other organisational tasks and team briefing prior to departure. The means for regular and rapid communication with the transport team should be always available. The receiving hospital specialist, in conjunction with the transport service, should ensure that the appropriate resources (eg monitoring equipment, drug infusions, preparation
for investigation, operating theatres, etc) are arranged prior to the patient’s arrival at the receiving hospital. Preliminary data from the Retrieval Incident Monitoring study shows that of incidents at the receiving facility, the majority was related to deficiencies in the preparations for patient reception.

A feedback process to referral staff, at 24 hours and at time of patient hospital discharge is highly desirable. It completes the “referral process loop” for the referring medical staff and provides positive feedback for the process as a whole.

Finally, before departing the referring hospital, it must be confirmed that the patient or surrogate consents to the transport. In the USA it is now mandatory that written consent to transport be obtained [21]. In addition it must be confirmed that the transport is legal and does not violate regulatory requirements or managed care requirements. US federal legislation was passed in 1986 preventing “dumping” of uninsured patients, and this has now been amended within the Emergency Medical Treatment and Active Labor Act (EMTALA) [22].

### Medical Monitoring Equipment and Oxygen Supply

Despite guidelines for patient monitoring during transportation monitoring they are at times not consistently applied [23]. The transport environment is unforgiving to patient monitors, and few have been developed specifically for such an environment. Many organisations have developed innovative structures, such as the stretcher bridge to incorporate patient monitors into their practice. Preliminary, unpublished data from our Retrieval Incident Monitoring pilot project (Dr A. Flabouris, 2000) suggests that equipment related incidents make up 27% of all reported incidents and 35% of those are related to patient monitors. This compares to a 9% reporting of anaesthetic equipment related incidents in the Anaesthetic Incident Monitoring Study [24], of which 24% (ie. 2% of all reported incidents) were related to patient monitors.

As access to patients is may be restricted in transit, and clinical signs can be difficult to illicit a greater than usual clinical dependence is placed upon the information provided and sought from patient monitors. Within an ICU environment, monitor alarms have a 5% true positive rate for clinically significant patient events [25]. Pulse oximeters may register a false alarm for nearly 30 minutes of every hour [26]. These are significant added stressors for escorting medical teams and place further demands on the monitor’s ability to monitor accurately.

Point of care testing is a developing technology with potential for application in the out of hospital environment. Such testing can be affected by the pressure and temperature differences encountered at altitude. The impact of point of care testing upon patient benefit in a critical care area, apart from the enhancement of the medical therapeutic decision making process has not yet been established [27] and this appears to be the case on the little documentation that is available for interhospital transportation. The clinical utility of arterial blood gas analysis in transit in the presence of pulse oximetry and capnography remains to be determined.

Our data shows that even though our scene time during interhospital patient transportation is on average 50 minutes, monitor power related adverse events account
for the majority of reported equipment related adverse events. Most fixed wing aircraft operate on 12 V DC and helicopters on 12 or 28 V DC systems. Conversion of aircraft power to a suitable AC current requires the installation of an inverter, which are costly, heavy and sensitive to frequency fluctuations. DC to DC conversion to adapt to monitor battery packs and the carriage of replaceable batteries are alternative power sources. Problems with replaceable batteries include that the range in varieties, not all monitors have replaceable batteries, loss of monitoring during the battery changes and subsequent recalibration period. Replaceable batteries must be of the sealed type. A maintenance program for the recharging and restocking of batteries should be part of each service's equipment maintenance program.

Due to the current diversity of monitors, transport related monitor incompatibility problems could arise at the time of patient reception and transfer at referral and receiving hospitals. Transport services can develop a database of referral site equipment compatibilities, modify cable connections for the use with a range of monitors, or initiate a complete change of recording device, eg pressure transducers, at the time of transfer.

The adverse transport environment however does not preclude the monitoring of even sensitive physiological signals. Ultrasound and even EEG signal recording have been applied clinically. As technology develops, the configuration and capabilities of patient monitors will alter. Importantly their capabilities for the storage of recorded information, analysis, reporting and transfer of such data to and from remote sites, enabling distant real time supervision of patient care, will also improve. There will be an increasing pressure upon transferring staff, based upon current monitor deficiencies and need for more clinical information to adopt newer technology. Transport services should have an equipment evaluation process to assess equipment clinical efficacy and suitability within their operational environment. The sharing of such information amongst patient transport services adds further to current information, and encourages the development of monitors with greater specificity to the transport environment.

The most common source of medical oxygen during patient transportation is replaceable, bulky and heavy high-pressure oxygen cylinders. In our experience, reported adverse incidents in relation to the use of oxygen cylinders is rare. In Australia however there has been a serious fire and aircraft explosion in relation to the faulty installation of an on board helicopter oxygen system.

Alternatives to oxygen cylinders are on board oxygen generating systems (OBOGS), liquid oxygen and oxygen concentrators. Oxygen produced by OBOGS is via chemical, electrochemical, permeable membrane and molecular sieve technologies. They minimise the extent of logistical support required for other oxygen systems but oxygen flow is largely uncontrolled and insufficiently pressurised for most pneumatically controlled ventilators and chemical processes, once initiated are irreversible. Oxygen concentrators are impractical for transported critically ill patients as they are noisy, bulky, limited to the achievable oxygen concentration, do not supply oxygen at a medically workable pressure and require a high voltage, AC power source.
Liquid oxygen has a smaller and lighter storage capacity than similar quantities of cylinder oxygen, allows for refilling of partially empty containers and more recent devices can provide high flow oxygen at 450kPa [28], sufficient to drive most pneumatically controlled portable ventilators. Disadvantages are that resupply is not readily available at remote sites, contamination may occur during resupply, the phenomenon of temperature stratification if the container is disturbed soon after filling, the need to adequately warm the oxygen produced, they require a complex storage and delivery system than gaseous oxygen.

The challenge with the various oxygen systems is to deliver sufficient flow rates of oxygen to provide maximal non invasive ventilatory support during interhospital transport, the median time for road and helicopter vehicles in our experience, is 31(IQ 22 and 44) minutes. Gaseous oxygen is the only source of oxygen that currently meets these requirements.

**Quality Assurance**

To date most quality assurance activities have been audits of in transit clinical events. The limitation of such audits is that they examine only select segments of the overall patient interhospital transfer process, that is, clinical in transit events. Non clinical aspects of patient transportation often undergo a totally separate audit process, and if these processes are not combined or examined as a whole, system based antecedents to incidents may be overlooked or underestimated. This is important if future team training needs, through Crew Resource Management techniques, are to address quality related issues [9].

Examples of potential audit processes are confidential surveys, the use of expert non-operational observers [9], and incident monitoring. Incident monitoring is well established in commercial aviation and the critical care areas of Anesthesia, Intensive Care and Emergency Medicine. Anonymous reporting of incidents can identify, monitor and improve process quality by using corrective strategies to close the loop and through ongoing incident reporting evaluate the effect of such change. Incident reporting can be applied as almost real time reporting by frequent feedback of trends and accumulated incidents.

Other, longer term, more specific monitors, such as predetermined process indicators (eg time to initiation of referral, time to definitive care upon arrival at receiving hospital, in transit accidental extubations/loss of intravascular access, no referral hospital ICU bed availability, vehicle related refused/delayed transfers, etc) can be incorporated into quality programs across most services.

A pilot Retrieval Incident Monitoring Study in conjunction with NRMA CareFlight and the Australian Patient Safety Foundation has been underway and is nearing preliminary evaluation. Preliminary data from that study are illustrated in Figures 1,2 and 3. The figures shows that incidents occur most frequently at the referral hospital, patient and equipment related incidents are the most frequent and that moderate or greater adverse patient sequelae, as determined by the transporting team members, occurs in 26% of reported incidents.
Figure 1
Type of interhospital patient transfer incident

![Type of Interhospital Incident](image)

- Patient: 35%
- Equipment: 23%
- Non retrieval staff: 13%
- Prior to departure: 4%
- At the receiving hospital: 20%
- At the referral hospital: 52%
- Multiple: 12%
- In transit to receiving hospital: 12%
- Transport: 10%
- Procedural: 10%
- Communication systems: 6%
- Other: 3%

Figure 2
Location of interhospital patient transfer incident

![Location of Interhospital Incident](image)

- At the referral hospital: 52%
- In transit to receiving hospital: 12%
- At the receiving hospital: 20%
- Multiple: 12%
- Prior to departure: 4%
Cost

Measuring the cost benefit of a helicopter organisation used solely for interhospital transportation is difficult as the patient population who are most likely to benefit is narrow and undefined. For prehospital, scene responses, it is estimated that a helicopter service must save approximately 3 lives per year to be cost effective [29]. Although a small and possibly achievable number, 90% of transported patients are thought to not benefit directly from helicopter transfer, with obstetric emergencies, very young patients with acute respiratory problems and life threatening infections benefiting the most, in terms of life years and quality adjusted life years gained [15].

Choice of vehicle for trauma patients remains controversial and is dependent on severity of injury, with those with the highest severity of injury most likely to benefit from earlier delivery to definitive care by helicopter transport. This benefit lessens as the time delay to request for transfer increases to beyond 60 minutes [14] and is likely to reflect a different trauma patient population. Another factor that influences this finding is the quality of initial care at the referral hospital.

Regionalisation of specialty services, eg trauma, neonatal, paediatric cardiac, etc has resulted in documented reduction in patient mortality. One of the challenges of regionalisation is the equity of care for those in rural areas. The cost benefit per year of life saved through regionalisation of such services may be sufficient to fund a regional patient transport service. The community’s attitude to helicopter services is positive add express a willingness to pay through an additional taxation burden amongst residents in remote areas, when they perceive an overall community benefit and view the service as a means of maintaining equal access to health care and gain reassurance from its presence. A willingness to pay was also present when the threat of removal of such a service was suggested [30].
Some patient groups have only a marginal gain from helicopter transportation over other vehicles, such as those with cardiovascular disease, adults with infections, and intoxications [15]. The risks and potential loss of crew and patient life years as a result of accident and injury during patient transportation may negate any added benefit. The current emergency medical helicopter accident fatality rate is approximately 4 – 6 per 100 000 flight hours, with non-fatal accidents being approximately ten times greater.

In summary, there remain significant regional factors that impact upon the cost effectiveness of the various forms of interhospital patient transportation services and their evaluation is essential for the optimisation of such a services. From perspective of public policy the benefits of regionalisation needs to be balanced with the maintenance of equity of health care services provision. This must be without disadvantaging any population group or a community perception of disadvantage.

**Current Challenges and Future Trends**

The current challenge for interhospital patient transport services is to meet the higher standards and expectations that will be placed upon these services. These challenges will arise through the regionalisation of medical services, fiscal restraints, development of complex new therapeutic and/or diagnostic modalities that are costly and require unique expertise for their clinical application. The development of critical care networks and the resultant increased redistribution of patients within those networks will also have significant impact.

Fiscal restraint will result in fewer hospital based patient transport services as hospitals look less favourably at their cost implications and see the benefits of concentration of resources in stand alone organisations.

This has implications for team selection, composition, training (medical and operational), experience, supervision and accreditation as well as transport vehicle and medical equipment selection and utilisation. The interaction between medical and operational transport arms will strengthen through adoption of common outcome aims, quality-measuring tools and integrated crew resource management training. Interhospital patient transportation could justifiably expand to be a unique medical sub specialty as a result of these forces encouraging enhanced quality outcome and research.

Justification of the type of patient transport will increasingly be demanded, both in terms of patient benefit and financial implication. Validated outcome measures that are both specific to the transport service (medical and operational) and the referral process, in its entirety, needs to be developed. These can include generic ICU severity of illness measures, trauma scoring systems, generic hospital data such as DRGs, outcome, length of stay and resource utilisation or more regional specific variables.

In terms of audit and quality processes much can be learnt, borrowed and utilised from the commercial aviation industry. Incident monitoring as a quality tool has the potential to provide an assessment of the critical care referral system as a whole as well as the patient transport service. This is vital as adverse critical care system based factors have the potential to impact on the performance of the transport service.
As regional changes occur, newer regional costing and reimbursement models for each region would need to be negotiated following consultation with all the significant users. Such models should be carefully developed so that a disincentive to appropriate patient referral is not created and they sustain the viability of a quality and effective patient transport service. Geographic information systems, utilising existing mapping programs and aviation navigational aids would contribute valuable information to the patient referral patterns and future enhance such services.

Future developments in health care such as telemedicine, advances in patient monitoring and therapeutic devices such as organ support technologies need to be systematically applied and evaluated in terms of clinical benefit and cost. This requires close collaboration with the operational crew and regulatory authorities.

Collaborative exchange of information between interhospital patient transport services and the possible development of performance indicators is crucial. It enables evaluation of the services, justification of their activities and may be forced upon them through legislation, if cohesive voluntary adoption does not occur.

**Conclusion**

Interhospital patient transport services are a unique collaboration between clinical and operational transport services. The utilisation of such services has received much scrutiny in the past and will receive even greater scrutiny in the future. Their role is continually changing, driven largely by the changing nature of critically ill patients, regionalisation and networking of health resources, fiscal policy, equity of health service provision, public perceptions and expectations. It is important for each regional health service to define its patient referral requirements, develop a process for such referrals, and incorporate the patient transport service within that process.

All this has significant implications as to the organisational structure of such services, including crew selection and training, medical equipment utilisation, patient selection and choice of vehicle. Strong and validated audit process will be essential to defining their ongoing function and activities.

Future collaboration between patient transport services will add strength to each service and provide a platform for more evidence based practise and guideline development. Through these processes, and increased interest and demand, the future recognition of patient transportation as a unique and important aspect of critical care medicine in terms of formal education and research status can be developed.
References


Section 3
Inter-hospital transport systems for the critically ill

A. Flavouris

1 Intensive Care Unit, Liverpool Hospital, and 2CareFlight NSW Medical Retrieval Service, Sydney Australia

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Section 4
International EMS Systems: New South Wales, Australia

S. Trevithick a,*, A. Flabouris b, G. Tall c, C.F. Webber d

a Registrar NRMA CareFlight, NSW Medical Retrieval Service, PO Box 159, Westmead 2145, NSW, Australia
b Staff Specialist NRMA CareFlight, NSW Medical Retrieval Service and Deputy Medical Director, Medical Retrieval Unit, NSW, Australia
c Medical Director, Sydney Aeromedical Retrieval Services and Deputy Medical Director, Medical Retrieval Unit, NSW, Australia
d Deputy Medical Director NETS and Paediatric Emergency Physician Sydney Children’s Hospital, Randwick, NSW, Australia

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Section 5
The challenges of delivering acute medical services to trauma patients in remote locations.

DJ Penney¹, A Flbouris² and MJA Parr³.

1 Senior Registrar in Intensive Care Medicine  
2 Consultant in Intensive Care Medicine and Lecturer, University of New South Wales  
3 Consultant in Intensive Care Medicine and Lecturer, University of New South Wales

*Intensive Care Unit*  
Liverpool Hospital  
University of New South Wales  
Locked Bag 7103  
Liverpool BC  
Sydney  
NSW 1871  
Australia
**Introduction**

Trunkey in 1983 proposed the concept of the ‘trimodal distribution of trauma deaths’, with 50% of deaths occurring immediately following an accident, 30% of deaths in the first 4 hours and 20% of deaths beyond 4 hours [1]. The concept of the 'Golden Hour' of trauma stresses the importance of early medical intervention within the first hour to prevent the organ damage that may result in later in-hospital deaths. The applicability and accuracy of these concepts has been questioned but prompt resuscitation and delivery of the severely injured patient to definitive care is a crucial determinant of improved patient outcome.

It is well established that severely injured patients have an improved chance of survival if treated in trauma centres within regionalized trauma systems [2]. A trauma centre can be defined as ‘a hospital where the medical staff have a commitment to provide 24 hour in-house cover by surgeons, anaesthesiologists and support staff to care for trauma patients’ [1]. Regionalisation ensures volume through fewer centres, a factor that is said to be associated with improved outcome (3) but may also increase the physical distance between such trauma centres and the injured in remote locations.

Thus the challenges for the delivery of trauma care to remote locations include issues related to transport vehicles, equipment, personnel performance and access.

**Physical environments**

Remote locations present differing challenges for the provision of trauma services compared to urban areas. The physical environment can be highly variable, even within the same regions. Such environments create many challenges for Emergency Medical Services (EMS). These include notification of injury, location identification and access, patient extrication, delivery of medical staff and equipment performance in extreme conditions.

Each region has its own physical characteristic in which an EMS will operate. The responding trauma system must anticipate these problems and be appropriately structured and resourced so as to counter such challenges. However a system, which works well in one region, may not be appropriate for another and so didactic system requirements are inappropriate.

**Epidemiology**

Remote locations, in terms of medical service provision, can be defined as areas where a subgroup of a population is separated from access to higher standards of service by distance or other barrier [4]. This subgroup may differ in both demographics and health
from an urban population. Regional population demographics may also vary due to temporary or seasonal population migration or seasonal physical environmental changes.

The human activities at different regions may be unique and predictable. Data gathering and analysis for each region is essential for risk assessment. For example, within the national park regions of California, the overall occurrence of nonfatal events was recorded to be 9.2 people per 100,000 visits. The majority of injuries, 70% of all nonfatal injuries, were related to musculoskeletal or soft-tissue injury, 38% of which involved the lower limbs. Overall mortality rate was 0.26 deaths per 100,000 visits, of which males accounted for 78% of deaths with heart disease, drowning and falls being the most common cause of death (5). Similar data was recorded in another survey, mortality rate 0.28 per 100,000 person-days of exposure, 80% of non fatal injuries being soft tissue injuries (6). In the latter study, 39% of all injuries and illnesses required evacuation (1.5 per 1,000 person-days of exposure).

When compared with urban statistics, similar mechanisms of injury in remote locations carry a higher mortality compared to the urban environment (7,8). Motor vehicle accidents in non-urban areas have a higher mortality, especially in children and adolescents [9].

Although injuries in such remote locations are infrequent, careful planning and individual selection prior to exposure to such environments can help limit their occurrence. Similarly injury prediction through prior regional risk assessment and use of regional databases of injury occurrences can aid with planning and prevention of future similar such injuries. Preventative and planning processes may be of greater significance for remote locations considering the challenges such environments place upon trauma systems.

**EMS system**

Effective trauma management requires a system of care to manage the patient from the injury scene all the way through to rehabilitation. Importance needs to be focused on developing the system as a whole, as weak components of the system will lead to an overall failure of the system.

**Access to EMS**

An easy, single point, rapid access and activation process is essential for all trauma systems. Education of the general public in bystander trauma care allows for the mobilisation of community resources, which can act as the first line response. As a concept this is very cheap to administer and given the current reluctance and inability of the lay public to play a role, there is real potential for a positive impact.

Most such systems however rely on a single telephone number for activation. Advancing telecommunication technology has made this service increasingly more widely available.
to remote locations, which in the past could not access such a service. Although travel
time for EMS to injured patients can be very short, time to discovery of the injured is the
greater time delay factor (10)

Transport vehicles

Primary response options are determined by factors such as distance from, and to, the site
of definitive care as well as geographical and climactic features. Motor vehicle and rotary
or fixed-wing air response are among the available options. Cost is clearly a major factor,
especially in under developed countries. There have been no studies to clearly
demonstrate one system is preferable to another in an urban environment.

For the remote location, each with it's own unique characteristics, comparative studies for
choice of vehicles is impractical. Air or ground vehicles each have their own utility and
crew capabilities. An EMS system should have recourse to several transport options in a
continuously reviewed and evolving structure. More importantly the choice of vehicle
should be made in conjunction with the choice of the transport crew as it may be the latter
rather than the vehicle itself that have the greater impact upon patient outcome (11-14).

Factors such as the transport of appropriate personnel and equipment to the patient in as
short a time as possible need to be balanced with consideration of maximal EMS crew
safety. The safety of commercial EMS helicopter activity was examined in a safety study
in 1988 in the USA where patient transport helicopters experienced twice the accident
rate than air taxis, usually night and weather related, with human error being most
frequently attributed as the cause [15]. Safety recommendations address main topics of
weather conditions, pilot staffing and workload, night operations, pilot training and
experience, equipment installation and performance standards, personnel protective
clothing and equipment, and organization and management [16].

Ground transport is also not without risks. With all transport modalities there are
important stressors, such as noise, vibration, acceleration forces, fatigue and motion
sickness and the potential therapeutic limitations imposed by the transport environment.

Ambient environmental factors such as altitude and temperature can impact upon
allowable vehicle size and performance. In all such circumstances, prior risk assessment,
with multidisciplinary input, is crucial to the success of any trauma task

Personnel

A short on-scene time with a ‘scoop and run’ approach may be contrasted to a longer
prehospital phase with a ‘stay and stabilize’ philosophy, which better describes
circumstances in remote locations for which the "run" phase is greatly exaggerated. The
latter approaches require highly trained and skilled personnel with appropriate equipment.
There is much debate over the benefit of the levels of training and skills of pre-hospital
personnel. A recent review article by Spaite et al. questioned that the primary determinant of outcome for trauma patients is the time interval from injury to the operating room, concluding studies supporting the relationship are flawed and retrospective [17]. The authors also reviewed articles for and against ALS at the scene. They examined methodologies, results and conclusions and concluded no one study exists to convincingly support one approach over another, stating that there is a desperate need for prospective, randomized controlled trials that compare ALS to basic life support prehospital care in victims of major trauma.

On-scene interventions range from simple to the sophisticated. Airway compromise and hypoxia are common at the scene of injury and result in a range of injury from irreversible brain damage and death to lesser insults that may however profoundly influencing outcome, especially in head-injured patients [18,19]. The need for intervention is clear, how much intervention and by whom is less clear. Currently even within the urban environment the benefit of pre-hospital fluid administration and advanced airway management remains controversial [20,21].

Within remote environments risks in the delivery of scene resuscitation skills is greater and the timely availability of higher level "backup" support is less likely to be available. Rural environments not only have fewer available EMS (10) but have fewer advanced trained EMS personnel, who have less trauma exposure (22).

In such circumstances a "get it right the first time" approach would necessitate the delivery of the highest allowable level of care. This may require the use of trained and experienced medical (11-14), as compared to paramedical, personnel. The latter approach would result in a greater "overtriage" rate for the level of personnel and equipment delivered to a remote location. Ultimately the acceptability of such rates need to be, based upon each regions unique environmental and injury pattern characteristics.

Emergency departments

Issues related to the availability of highly skilled hospital staff and their exposure to a sufficient volume of trauma patients apply equally to the emergency departments of smaller rural hospitals as they do to pre hospital EMS. Training, a trauma verification system and integration of smaller hospitals into a wider trauma system can have a positive impact on patient outcome, especially for patients with more severe injuries (23,24).

Coordination of trauma care

Areas, which have established regional plans to provide trauma care from the scene to rehabilitation, have achieved dramatic reduction in preventable death rates [25]. Regionalization of trauma services involves the establishment of an injury database, regional plans, the identification of barriers to change and the administrative support
necessary for the efficient functioning of such services. Reasons for failure include lack of funds, political will, lack of awareness by society and an underestimation of the resources and effort required to coordinate and integrate the system.

Coordination of trauma care in remote locations is even more challenging. The isolation of such populations, the desire to not medically disadvantage them, the infrequency of injury occurrences and the challenges of delivery of an urban equivalent system of trauma care to such regions need to be addressed. With developing technology some medical care, in terms of advice, clinical expertise and remote triage can be delivered via advanced telemedical communication. Ideally each region, based upon their unique prior risk assessment, frequency or injury occurrence and catalogue of available resources should prepare and plan it's own regional specific trauma response. An ongoing evaluation of all facets of such a response is vital as short and longer term regional variations evolve.

Conclusion

Patients injured within a remote environment will continually provide a challenge to all levels of trauma care providers. Strategies based upon detailed risk analysis and subsequent resource allocation and provision are essential for optimal service delivery. Such strategies would require continual re evaluation and refinement. Remote environments should be incorporated within, and supported by, regional trauma systems. With the advancement in current technology, such support can be increasingly provided from a distant location.

References


Section 6
Patient Referral and Transportation to a Regional Tertiary ICU: Patient Demographics, Severity of Illness and Outcome Comparison with Non-Transported Patients

A. FLABOURIS*

Intensive Care Unit, Wellington Hospital, Wellington, New Zealand


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Section 7
ARDS with Severe Hypoxia—Aeromedical Transportation During Prone Ventilation

A. FLABOURIS*, P. SCHOETTKER†, A. GARNER*
NRMA CareFlight, New South Wales Medical Retrieval and Rescue Service, Sydney, New South Wales

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Section 8
ORIGINAL ARTICLE

REducing time to urgent surgery by transporting resources to the trauma patient

Morgan P. McMonagle,*† Arthas Flabouris,*‡ Michael J. A. Parr§ and Michael Sugrue§

*NRMA CareFlight, NSW Medical Retrieval Service, †Department of Trauma Surgery, Westmead Hospital,
§Liverpool Hospital, Sydney, New South Wales, and ‡Intensive Care Unit, Royal Adelaide Hospital, Adelaide,
South Australia, Australia

by transporting resources to the trauma patient
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Section 9
A HOSPITAL-WIDE SYSTEM
FOR MANAGING THE SERIOUSLY ILL

Ken Hillman, Arthas Flabouris, Michael Parr

Intensive Care Unit, The Liverpool Hospital,
Locked Bag 7103, Liverpool BC, NSW, 1871, Australia.
INTRODUCTION

The specialty of Intensive Care Medicine has, until relatively recently, been largely practised within the four walls of the Intensive Care Unit (ICU). We are now increasingly realizing that outcome from intervention in the ICU is also determined by the level of care delivered before and after admission to the ICU. Intensive Care physicians are becoming increasingly involved in care of the seriously ill in settings other than the ICU and are participating in the establishment of systems which rapidly detect and respond to the seriously ill and which monitor and audit the quality of those systems.

EARLY MANAGEMENT OF ISCHAEMIA

Shock is described as inadequate cellular perfusion. We usually measure the extent of shock in terms of hypotension and signs of overt ischaemia to individual organs such as oliguria, decreased level of consciousness and shut down peripheries. However, these are late signs and ischaemia can also occur in the planchnic beds [1], liver [2] and even the cerebral circulation[3], despite apparently normal vital signs. Early ischaemia, even if it is seemingly minor, can lead to measurable cellular dysfunction [4]. More overt ischaemia can, of course, predispose to organ dysfunction such as acute respiratory distress syndrome (ARDS) [5], as well as multiple organ failure (MOF) [6], resulting in severe complications and death.

A common model of ischaemia occurs as a result of trauma. Ischaemia can occur soon after the traumatic event and unless detected and managed rapidly, can result in MOF and death [7]. This has focussed our attention on the importance of rapid resuscitation in the management of trauma. The organization of a system to optimize trauma management involves components
such as initial stabilization; transport to a major trauma centre; activation of a team with personnel trained in resuscitation; as well as rapid investigation and definitive treatment [8,9].

The organization of trauma management in order to rapidly correct ischaemia and hypoxia has resulted in a significant reduction in preventable deaths [10,11].

Despite our knowledge about the dangers of minor degrees of ischemia [12-15] and the beneficial impact of organized and early intervention in patients with severe trauma, there have been few other systematic attempts to organize early intervention for all at-risk patients.

While not involved in specific systems, specialized sections of a hospital ICUs, High Dependency Units (HDUs), Operating Rooms (OR) and Emergency Departments (ED) provide a 24 hour environment where at-risk patients are rapidly attended to. A combination of comprehensive monitoring and supervision by staff with expertise in the management of the seriously ill probably guarantees early recognition and rapid correction of ischemia.

However, other environments such as the general wards of hospitals may not provide that level of care [16]. Up to 80% of patients who suffer an in-hospital cardiac arrest have readily detected changes in vital signs within the eight hours preceding the arrest [17]. Other studies have suggested that up to 41% of admissions to ICUs were potentially avoidable [18] and that patients admitted from the general wards had a higher mortality than those from the OR, ED or Recovery [19].

A matched group of septic patients initially managed on the general wards had a higher mortality than those initially managed in the ICU [20]. The lack of a systematic approach to at-risk patients may explain the large numbers of potentially preventable deaths in hospital
Peter Safar, one of the pioneers of modern resuscitation, said as long ago as 1974 - “the most sophisticated intensive care often becomes unnecessarily expensive terminal care when the pre-ICU system fails” [25].

SYSTEM FAILURE IN ACUTE HOSPITALS

Why are acute hospitals, particularly the general wards, so dangerous for patients? For a start, medical practitioners are not necessarily trained as undergraduates in even the basic aspects of how to manage the seriously ill [26,27]. Nor is training in resuscitation consistent in the postgraduate period [28,29]. The exceptions may be in areas such as Anaesthetics, Intensive Care Medicine or Emergency Medicine, where formal training in all aspects of advanced resuscitation presumably occurs. It follows therefore that most hospital-based specialists are also not competent in the practice of acute medicine [30], as they do not receive formal training at an undergraduate or postgraduate level and do not have the opportunity to practice and maintain the skills they were not formally taught in the first place. This lack of training in and awareness of acute medicine is one of the factors resulting in poor systematic 24 hour cover for acute hospitals [31], despite the fact that in-hospital emergencies occur in an unpredictable fashion at any time of the day or night [32,33].

The situation is exacerbated by specialists “owning” patients. At best, “ownership” guarantees one person has responsibility for co-ordination and managing every aspect of the patient’s care. However “ownership” may also be driven by economic motives or perhaps it is simply as a result of territorialism. This means that systems that cross professional and
functional boundaries are difficult to establish, often fuelled by fear of losing “control” by the owning specialist.

The fact that there is little way of an organized system to provide 24 hour early detection and management of life-threatening emergencies, may contribute to the large number of potentially preventable cardiorespiratory arrests [17] admissions to ICU [18,19] and deaths [21-23] that occur in hospitals.

A model is described here for hospital-wide provision of emergency care 24 hours a day based on the Medical Emergency Team (MET) concept [33-35]. The system comprises early identification of at-risk patients; an emergency response based on those criteria; resuscitation by a multidisciplinary team with at least one member with formal training in all aspects of advanced resuscitation; evaluation of the effectiveness of the system; and a mechanism where all members of the hospital are educated and aware of the system and are provided with feedback as to its effectiveness in order to adjust and improve it as necessary. The system is based on a Medical Emergency Team (MET), which replaces the hospital cardiac arrest team. The model has become known as the MET, even though the “team” is only one aspect of the overall system.

THE MET CRITERIA

The MET criteria identifies a patient who is at-risk of serious deterioration and requires emergency management. Initially, over 30 criteria were used to identify at-risk patients. These have gradually been refined to 8 simple criteria (table 1), based on abnormalities of
commonly measured vital signs such as pulse rate, respiratory rate, blood pressure and level of consciousness.

The MET criteria assume all at-risk patients deteriorate in a similar way (Figure 1). Patients ultimately die of physiological abnormalities, rather than specific diagnoses or anatomical pathology. Ischemia and/or hypoxia are final common pathways, eventually leading to cardiorespiratory arrest and death. Along the way, patients respond by changes in vital signs: such as increasing or decreasing pulse and respiratory rates, either as a primary or secondary event; decreasing blood pressure; or losing consciousness. No matter whether the cause of the deterioration is disease related (eg pneumonia) or syndrome related (eg shock), deterioration is along largely predictable pathways. The aim of the MET criteria is to detect this predictable deterioration and identify at-risk patients before severe complications occur. Initially, biochemical abnormalities were also included in the criteria, but they made an otherwise simple system more complex and had a low rate of identifying at-risk patients. The adverse effects of abnormal biochemistry such as hyper and hypokalemia are usually manifested by changes in vital signs and the credibility of the MET system was being compromised by being over-called for abnormal pathology results, without adverse clinical manifestations.

Convulsion is the only diagnostic criteria remaining as part of the MET criteria. Not only are convulsions distressing for clinical staff but can predispose to immediately life-threatening sequelae such as airway compromise, hypoxia, pulmonary aspiration and permanent neurological damage [36] as well as be a marker for significant physiological disturbances.
In order to encourage staff to maintain a low threshold for calling the MET, a “worried” category was also included. Ward hospital staff normally have no system for summoning immediate medical help when they have a “feeling” that their patient is deteriorating, unless, of course, the patient actually dies, when they then can call the cardiac arrest team. The usual circumstance is that attempts are made to contact the junior medical staff of the responsible medical team. Such responses are not uncommonly delayed and attended to by otherwise busy junior staff who either lack or do not have immediately available to them the quantity and quality of resources required to manage an acute medical emergency in the ward. This situation is akin to the circumstances that existed for the management of acute trauma prior to the introduction of trauma teams and systems. The calling criteria need to be set at a low enough level to identify an appropriate population of at-risk patients (eg avoid under triage), without causing major disruption to hospital function; but not at such a high level that serious complications as a result of delay in management, would result (eg avoid over triage). Obviously it is better to err on the side of over-calling. The “worried” category empowers staff to call earlier rather than later. Our own analysis shows that 19% of patients for whom a “worried” call is made require are admitted to ICU as a result of that call.

It is important that members of the MET actively support staff who utilise the worried criteria, for being astute enough to detect serious illness at an early stage. This reinforces a culture within the hospital of concern for seriously ill and at-risk patients. At the same time, delayed calling is discouraged and cardiorespiratory arrest is seen as a potential failure of the system. In this way, the MET criteria can themselves drive a cultural change in a hospital, from one of
separate islands of care and “ownership” to a unified awareness and systematic response for to all at-risk patients.

THE MET RESPONSE

Just as the best trauma systems are designed to minimize ischemia and hypoxia, so should other systems, designed to deal with medical emergencies. In fact, one could argue it is at least as important to restore, for example, the circulating volume of a shocked patient with diabetic ketoacidosis (DKA), as it is to resuscitate a young, otherwise fit, patient with trauma. This is especially so for patients with chronic health problems who already have compromised organ function, such as cardiovascular disease and renal dysfunction. Once triage criteria for defining an at-risk patient have been agreed upon, then there must be a rapid and skilled response in order to limit organ damage.

Most trauma systems now have a trauma team with members who have skills in maintaining the airway, breathing and circulation [37]. Trauma teams now resuscitate according to up-to-date guidelines such as The Advanced Trauma Life Support (ATLS) system [38]. Participants in the trauma team are usually trained in all aspects of advanced resuscitation according to these ATLS guidelines. While the importance of early intervention in a limited number of medical emergencies such as acute myocardial infarction [39] is recognised, there is little in the way of guaranteeing personnel fully trained in advanced resuscitation at all times in every acute hospital. Even if training was adequate, there is little regard paid to the systematic provision of trained medical staff over a 24 hour period in acute hospitals. A part from the concept of the specialist “hospitalist” in North America [40], the system for caring for the
acutely ill in our hospital wards is largely based on in-house trainee medical staff or on-call specialists who may or may not be trained, or regularly actively manage critically ill patients. Whatever the level of response to a hospital emergency, it is crucial that at least one member of the team is formally trained and regularly practises in advanced resuscitation skills.

A crucial part of the MET system is to provide these trained personnel at all times. The MET system was developed at Liverpool Hospital in Sydney, Australia. Liverpool Hospital is an integral part of the South Western Sydney Area Health Service (SWSAHS) which has one 547 bed tertiary referral hospital (Liverpool Hospital), 2 rural hospitals (71 beds and 116 beds) and 3 metropolitan hospitals (183, 191 and 442 beds). Twenty-four hour medical cover varies from full-time trainees in Intensive Care Medicine in the tertiary referral hospital to general practitioner cover at a distance in one of the small rural hospitals. There are junior medical staff rotating through the metropolitan hospitals for periods from 3-12 months. In order to provide 24 hour advanced resuscitation cover that meet the needs of all hospitals, the following principles were agreed to:

- 10-15 trained staff from each hospital was necessary to provide at least one member of staff with advanced resuscitation skills covering each hospital for all shifts, allowing for leave and holidays.
- Because the training involves a 6 month self-directed learning package, only full-time staff and not staff on short term (less than 1 year) rotation could be considered for training.
As there were insufficient medical staff permanently working in hospitals at all times of day and night, nursing staff were considered for training. Nursing staff from the ED and ICU with postgraduate qualifications were preferred but not essential.

Each hospital nominated their own staff, within these guidelines for training and arranged their own rosters to cover their hospital at all times.

**TRAINING IN ADVANCED RESUSCITATION**

Medical practitioners do not have a monopoly on the skills and knowledge necessary for advanced resuscitation. In fact, Kenneth Cadman, the chief medical officer in the United Kingdom argued that a doctor’s most unique and valuable role is in diagnosis [41]. Paramedics, nursing staff and even lay people can be trained in many aspects of advanced resuscitation [42-45]. Unfortunately most so-called resuscitation training, focuses on cardiorespiratory resuscitation (CPR) [46,47]. Each hospital has its own variation of training in CPR with varying amounts of resources being allocated for training. However, the outcome from in-hospital cardiac arrest has changed little over the last 30 years and it has been estimated that its costs approximately $400,000 (US) per life saved to operate in-hospital CPR programmes [48].

Other initiatives in advanced resuscitation training include a Fundamental Critical Care Support (FCCS) programme, developed to provide basic principles of critical care and to offer guidance for decision making in the early management of the critically ill patient [49]. The course is aimed to assist the non-intensivist in the initial 24 hours of management of the critically ill patient if critical care expertise is not readily available. The course is limited in
that it concentrates more on Intensive Care Medicine, such as the ongoing need for mechanical ventilation and monitoring, rather than initial resuscitation and identification of the critically ill.

It is imperative that each acute hospital address the need to have at least one person available at all times who can practise all aspects of advanced resuscitation. This will become more important as bed numbers decrease, hospital length of stay declines and alternatives to hospital admission are explored, resulting in acute hospitals having to manage an increasing population of critically ill [56].

To complement the early warning MET criteria and, in line with the principles previously outlined, to meet the needs of each hospital in the provision of a 24 hour services for hospital emergencies, the Advanced Resuscitation Course (ARC) was established to train staff. The features of the ARC include:

- 6 month self-directed course done largely within the candidates own time.
- The theoretical content of the course is covered in a specially prepared manual (Implementation of the MET System into Your Hospital, ISBN 1875909761).
- The specialised skills associated with advanced resuscitation are taught largely within the trainee’s own hospital and include intubation, central line insertion and initial ventilatory skills, with each candidate having to perform a minimum number under supervision. The Anaesthetic Department conducts much of the teaching in the OR setting. Increasingly,
mannequins are also being used for instruction. A total of 76 skills required for the practice of advanced resuscitation, have been identified.

- A multiple choice questionnaire before and after the 6 month course, testing acute medicine knowledge. This was developed and validated by Emergency Medicine and Intensive Care specialists.

- A 3 day evaluation course is held at the end of each 6 month period which includes skill testing, tutorials and simulated emergencies. If the candidate passes, they are given their ARC certificate and permitted to practise advanced resuscitation in the own hospital.

- Ongoing education, support and recertification then becomes part of the programme.

The program is organized across the health area by one intensive care nurse and a clerical assistant. Medical staff from the tertiary hospital ICU support teaching and supervision of the course. So far 96 candidates have enrolled in the course from 5 hospitals. Of those, 60 have qualified. Forty-four of the successful candidates are nurses and 16 are medical officers.

**AUDITING THE SYSTEM**

Once a system has been established - in this case to manage seriously ill and at-risk patients throughout an acute hospital - then outcome indicators should ideally be developed to monitor that system. Not only do measurements have to be made, but the data needs to be widely distributed to those who can appropriately adjust and improve the system. This process is the basis for what is called, amongst other things, continuous quality management (CQM) [51].

Many separate departments within a hospital attempt to measure and monitor their performance. Standardized mortality ratio (SMR) is often used to estimate the quality of care
in an ICU. Predicted hospital mortality is compared with actual hospital mortality after the admission data is adjusted for factors such as casemix, age, and chronic health status [52]. Even using SMRs with data collected from ICUs, true mortality may be concealed as a result of lead time bias [53,54]. Lead time bias is related to delays or inappropriate treatment prior to admission to the ICU and the effect this would have on eventual mortality. In other words, mortality is related to factors other than the care given within the four walls of the ICU. The severity of illness on admission to the ICU may be related more to inappropriate management prior to ICU admission and therefore be testing the whole hospital system rather than simply the ICU component.

Other hospital departments and specialties may have other ways of determining the outcome of the seriously ill patients that they manage. However, there is little in the way of measurements which estimate the standard of care of the seriously ill across the whole hospital system involving various departments, functions and professions. The measurement of the standard management of trauma care from the prehospital setting to eventual outcome in the community is one of the few exceptions.

One of the few ways we have of measuring the quality of care given to the seriously ill across the whole hospital is by focusing on mortality [55]. Attempts have been made to adjust hospital death rates in order to make it a more accurate tool for measuring hospital care [56]. Random audit of patient notes have also been used to analyse hospital mortality [21-23]. These studies show that up to 27% of in-hospital deaths have been estimated to be preventable. However, the usual methodology for analyzing hospital mortality is time consuming, expensive
and of ten i nvolves c linicians s ubjective opi nion a bout p reventability.  For t hese r easons, mortality is not often systematically used as a practical tool for measuring the quality of an acute hospital.

Using the MET System to Measure Hospital Quality

The M ET s ystem le nds itself to measuring the e ffectiveness of the s ystem its elf a s w ell a s identifying potentially p reventable e vents. T he hospital-wide out come i ndicators c hosen for the M ET s ystem ar e d eaths w ithout a N ot F or R esuscitation ( NFR) or der, unanticipated admission t o t he I CU a nd c ardiorespiratory a rrest r ates ( Fig I). P atients m ay, of c ourse, develop s erious i lness a nd not s uffer a ny o f t hese c omplications. H owever, out come indicators ha ve t o b e a chievable us ing available r esources. T he i ndicators ne ed t o m ake intuitive s ense to clinicians a s w ell a s t o o th er lev els of t he h ealth s ystem. U sing de aths, unanticipated admission to ICU and cardiorenspiratory arrest rates assumes that if patients are discharged w ithout t hese s erious c omplications, t hen t he s ystem, w hile not p erfect, a t l east ensured their discharge alive from hospital, without complications serious enough to require admission to the ICU.

Use of Outcome Indicators to Indicate Potential Preventability

The presence of MET criteria which were not acted upon by initiating a MET response within the 24 hour s p rior t o t he t hree out come i ndicators m ay b e us ed a s a measure of potential reversibility of those outcome indicators. It could be, of course, that the patient did meet MET criteria and these were not recorded in the notes. A review of the patients’ notes and charts would indicate whether MET criteria had been noted and whether or not appropriate action
had been taken when the MET criteria were first recorded. Utilising this 24 hour period greatly reduces the workload needed to determine hospital outcome indicators as only the final entries in the patient’s case notes, covering the 24 hour period prior to the 3 events, have to be reviewed in any detail. Again, it is a matter of balancing available resources with objectives. Detailed interviews with staff at the time may reveal whether the patient could have fulfilled MET criteria without them being recorded. However, this is not only time-consuming but may defeat the purpose of the audit by making staff feel defensive and encouraging inaccurate answers.

**Hospital Outcome Indicators and End of Life Decisions**

The MET system is not designed to be used to resuscitate patients who are terminally ill and for whom resuscitation measures are deemed as futile. The term “do not resuscitate” (DNR) refers specifically to patients who are terminally ill and may require CPR [57]. CPR in these circumstances obviously would represent inappropriate use of resources, provide unfair hope to the patient and relatives, and in most cases, would be futile anyway. It may be equally futile to provide early resuscitation, in the form of a MET response and the associated resuscitation measures, to terminally ill patients. The MET system can help drive a systematic cultural change in acute hospitals by encouraging clinicians to make an explicit diagnosis of dying in terminally ill patients, and thus discuss the withholding of resuscitation attempts, including that of CPR, which may not be in the patient’s interest.
“Not for MET” (NF-MET) is a slightly different concept compared to “not for resuscitation” (NFR). NF-MET may imply that death is imminent and associated resuscitation measures are not indicated. Whereas NFR may imply that active management is still continuing but if it fails to the extent that cardiorespiratory arrest occurs, then CPR will not be attempted. Not all terminally ill patients need be NF-MET. It is important for each hospital to think carefully about these issues and discuss the implications of all that these terms imply and then develop their own procedures for their application. There is a perceived need that we should be more explicit, both amongst ourselves as clinicians, as well as with patients and their friends and relatives about prognosis and end of life wishes expressed by the patient. We are often reluctant to make a diagnosis of dying in the acute hospital setting.

The MET outcome indicators can be a catalyst for this process. Patients who have no NF-MET or NFR order and who have died or had a cardiorespiratory arrest can be labelled as ‘UNEXPECTED’. This label is used to flag patients for auditing purposes as well as to assist in driving debate and discussion about the appropriateness of a MET call for that particular patient.

In our experience of the MET system, the MET team often acts as the surrogate end of life decision making body. When, for example, the patient is obviously suffering a quite predictable end of life event, for which a MET is called, the MET has to negotiate with the admitting team about whether active management is appropriate in these circumstances. Often it is not. The MET system in this situation is making explicit, a decision making process.
which ideally should have occurred at an earlier time and discussed at that time with the patient and relatives.

**Summary of MET Outcome Indicators**

The 3 outcome indicators represent one dimension of an acute hospital’s quality. The indicators are relatively easy to collect and are “flagged”, indicating possible cases where management across the hospital system may have been less than optimal and opportunities for improvement possible.

<table>
<thead>
<tr>
<th>Indicator</th>
<th>Formula</th>
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<tbody>
<tr>
<td>Unexpected Deaths</td>
<td>( \text{UNEXPECTED DEATHS} = \text{TOTAL DEATHS} - \text{DEATHS WITH A DNR ORDER} )</td>
</tr>
<tr>
<td>Unexpected Cardiorespiratory Arrests</td>
<td>( \text{UNEXPECTED CARDIORESPIRATORY ARRESTS} = \text{TOTAL NUMBER OF CARDIORESPIRATORY ARRESTS} - \text{DEATHS WITH A DNR ORDER} )</td>
</tr>
<tr>
<td>Unanticipated Admissions to ICU</td>
<td>( \text{UNANTICIPATED ADMISSIONS TO ICU} = \text{ALL IN HOSPITAL ADMISSIONS TO ICU} - \text{PATIENTS ADMITTED FROM THE ED or OR} )</td>
</tr>
</tbody>
</table>
The indicators can be modified according to each hospital’s needs. By not including patients from the ED, OR, or Recovery in ‘UNANTICIPATED ADMISSION to ICU’, we are assuming that management in these environments is optimal. In other words, we are assuming that patients managed in environments which are monitored and are cared for by staff trained in advanced resuscitation should not be flagged for further audit as the system could not be improved without enormous cost anyway. The MET concept, in theory, would provide little benefit in these environments. Other outcome indicators should be used to monitor quality of care in these areas. Other sites such as High Dependency Units (HDUs) or Coronary Care Units (CCUs) may also be excluded from unanticipated admissions to ICU. In doing so, we are saying that the MET system would add little benefit to these areas and therefore including them in the audit process would achieve little. Similarly age limits can be used to define these indicators. For example, the MET system may not be appropriate for neonates.

Similarly, the MET system has not formally been developed or tested in a paediatric setting and other outcome indicators may be more appropriate.

**Completing the Quality Circle**

Much data is already demanded of clinicians and the health system. That data is often not made readily available to clinicians in an easy to understand and timely fashion. It disappears into “data gravernyards”. In order to maintain the accuracy of data and commitment of clinicians to collecting it, the data must be analysed and fed back in an easily understood fashion. The clinicians delivering health care are the main determinants of the system.
improvement. In order to improve the system, clinicians need data on how their system currently performs.

The cost of collecting the outcome indicators needs to be minimal and their impact on clinical practice, maximal. The outcome indicators used as part of the MET system are deaths, cardiorespiratory arrests and unanticipated admission to the ICU. Each potentially measures the potential effectiveness of the MET system as well as estimating dimensions of hospital quality, particularly its ability to manage the seriously ill in a systematic way.

The outcome indicators are ‘flags’. They indicate patients where the system may have operated more effectively. They do not specifically indicate which part of the system failed. That is left to individual clinicians, wards or departments to determine by examining the circumstances of the patient’s event in more detail.

As part of the MET system, data on each patient is fed back to all clinicians that they have been responsible for managing patients who have suffered a death, cardiorespiratory arrest or unanticipated admission to the ICU. Data is also provided on whether this patient had MET criteria within 24 hours of those events and whether these criteria were appropriately acted on or not. The clinician then has a measurement tool for assessing, on a system-wide basis, the management of their own patients. They also presumably have control over a large part of that system and can implement appropriate strategies to improve the system.
The data is then de-identified and aggregated as deaths without an NFR order, unanticipated ICU admissions and Cardiac Arrests. It can then be tailored for distribution to all levels of the hospital system (e.g., ward, medical team, medical service, division, etc.) so that different dimensions of quality can be estimated. The crude numbers, as well as "unexpected" and "potentially preventable" numbers, can then be examined either individually or as trends. Similarly, aggregated data on a larger scale can be examined across a whole hospital, health region or even country. Hospitals can be matched for factors such as age, casemix and ED admissions and used for benchmarking purposes.

**Accountability and Acute Hospitals.**

Accountability is increasingly becoming important in health care delivery. Until recently we only had good information on the cost of health care, with little information on the quality of care. Now the funders and users of health care are demanding more information on the quality of health care. This has made many clinicians defensive. Firstly, there is sometimes a reluctance to be more accountable. But, secondly, and as a very practical point, there are very few clinical indicators which unequivocally and accurately measure clinical practice. Data can easily be misinterpreted. Some American cities publish comparative surgical mortality in order to give consumers and health funders information about the relative standards of individual surgeons. This simplistic approach does not take into account adjusted risk factors and as a result is rejected by clinicians. Nor does it take into account the many components of a system which the admitting surgeon may not have direct control over. Nevertheless accountability and transparency can be positive agents for change and clinicians need to take the initiative in developing indicators which accurately reflect the outcome of clinical practice.
CONCLUSION

The MET concept provides a framework for managing seriously ill and at-risk patients across an acute hospital. It is an extension of Intensive Care and Emergency Medicine, but operating outside their usual four walls. It provides a means of identifying those at-risk of serious deterioration. It provides rapid resuscitation with skilled personnel at all times and provides a means of ensuring the quality of care of the seriously ill as well as giving clinicians ownership of that data so they can adjust and improve the system as necessary.

The MET concept represents a move from the traditional doctor/patient relationship with its focus on individual wards, departments and professions to a systematic, integrated, coordinated and patient-focused approach to the seriously ill. Using relatively few extra resources, the MET concept may improve the outcome of the seriously ill. The MET concept represents a move away from the expensive magic bullets which have had little impact on ICU to an early intervention and preventive approach. By mobilizing and rearranging existing resources in a different way, it provides the opportunity to improve patient outcome in the broader picture of managing the seriously ill across the whole hospital, rather than just in our ICUs.
Table 1

<table>
<thead>
<tr>
<th>MET calling criteria</th>
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<tbody>
<tr>
<td>Threatened airway</td>
</tr>
<tr>
<td>Respiratory rate &lt;5 or &gt;36</td>
</tr>
<tr>
<td>Cardiorespiratory arrest</td>
</tr>
<tr>
<td>Pulse rate &lt;40 or &gt;140</td>
</tr>
<tr>
<td>Systolic blood pressure &lt;= 90 mmHg</td>
</tr>
<tr>
<td>Seizures</td>
</tr>
<tr>
<td>Fall in GCS &gt; 2 points</td>
</tr>
<tr>
<td>Worried</td>
</tr>
</tbody>
</table>
**Figure 1** This diagram describes how any patient in an acute hospital must pass through the MET criteria and the other outcome indicators as their condition deteriorates. The MET criteria and other outcome indicators provide the basis for response as well as evaluation.

**ACUTE HOSPITAL POPULATION**

- **MET CRITERIA**
- **Real time incident Monitoring**

**UNANTICIPATED ADMISSION TO ICU FOR CARDIORESPIRATORY ARREST**

**OUTCOME INDICATORS**

- **POTENTIAL PREVENTABILITY**
  - DEFINED BY PRESENCE OF MET CRITERIA IN 24HOURS BEFORE EVENT

**DEATH**
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Section 10
Review article

Redefining in-hospital resuscitation: the concept of the medical emergency team

K. Hillman *, M. Parr, A. Flabouris, G. Bishop, A. Stewart

University of New South Wales, Intensive Care Unit, Liverpool Hospital, Sydney, Australia

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Section 11
A description of events associated with scene response by helicopter based medical retrieval teams

Arthas Flavouris*

NSW Medical Retrieval Service, CareFlight, P.O. Box 159, Westmead NSW 2145, Australia
Accepted 18 December 2002


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Section 12
Clinical features, patterns of referral and out of hospital transport events for patients with suspected isolated spinal injury

Arthas Flavouris

*CareFlight, NSW Medical Retrieval Service, PO Box 159, Westmead, NSW 2145, Australia*

Accepted 9 April 2001


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[http://dx.doi.org/10.1016/S0020-1383(01)00071-7](http://dx.doi.org/10.1016/S0020-1383(01)00071-7)
Section 13
Efficacy of Critical Incident Monitoring for Evaluating Disaster Medical Readiness and Response During the Sydney 2000 Olympic Games

Arthas Flabouris, MD, JFICM; Antony Nocera, MD, FACEM; Alan Garner, MD, FACEM

Abstract

Introduction: Multiple casualty incidents (MCI) are infrequent events for medical systems. This renders audit and quality improvement of the medical responses difficult. Quality tools and use of such tools for improvement is necessary to ensure that the design of medical systems facilitates the best possible response to MCI.

Objective: To describe the utility of incident reporting as a quality monitoring and improvement tool during the deployment of medical teams for mass gatherings and multiple casualty incidents.

Methods: Voluntary and confidential reporting of incidents was provided by members of the disaster medical response teams during the period of disaster medical team deployment for the 2000 Sydney Olympic Games. Qualitative evaluations were conducted of reported incidents. The main outcome measures included the nature of incident and associated contributing factors, minimization factors, harm potential, and comparison with the post-deployment, cold debriefings.

Results: A total of 53 incidents were reported. Management-based decisions, poor or non-existent protocols, and equipment and communication-related issues were the principal contributing factors. Eighty nine percent of the incidents were considered preventable. A potential for harm to patients and/or team members was documented in 58% of reports, of which 76% were likely to cause at least significant harm. Of equipment incidents, personal protective equipment (33%), medical equipment (27%), provision of equipment (22%), and communication equipment (17%) predominated. Personal protective equipment (50%) was reported as the most frequent occupational health and safety incident followed by fatigue (25%). Pre-deployment planning was the most important factor for future incident impact minimization.

Conclusions: Incident monitoring was efficacious as a quality tool in identifying incident contributing factors. Incident monitoring allowed for greater systems evaluation. Further evaluation of this quality tool within different disaster settings is required.


Introduction

Disasters and major multiple casualty incidents (MCI) are infrequent events for medical systems. The paucity of such events makes audit and quality improvement of the medical responses difficult. Quality improvement is necessary to ensure the design of medical systems facilitates the best possible response to such unpredictable events. Quality methods used have consisted mostly of post-event audits of unexpected incidents, or responses that deviated from the pre-event plans. In the past, such methods consisted of a post-
hours, during each of the 16 days of the Sydney Olympic Games, plus the two days prior to the Opening Ceremony. Overnight, the two teams were co-located at a third hospital on a delayed response footing. A nine-day training period preceded the deployment period. During this training period, instruction was provided to all team members including the medical and nursing commanders, as to the process of incident reporting. Incidents were defined as any event that led to, or had the potential to cause, a change in the degree of safety of either patients and/or team members. It was stressed that incident reporting did not replace any other quality assessment activities in which team members may be expected to participate. Incidents were recorded on forms that were developed in conjunction with the Australian Patient Safety Foundation for Medical Retrieval Incident Monitoring. The forms consisted of a free narrative section and sections with directed queries. Reporting of the incidents was voluntary and anonymous, with all personal identifying features excluded from subsequent analysis. Completed forms were placed in designated envelopes at each of the sites where teams were based. The forms were collected at the end of the team deployment period.

The teams’ activities during the period of incident reporting involved setting up at the two hospital sites, checking equipment, establishing communication links, developing team procedures, individual team exercises, and two occasions of team deployment. A “cold” debriefing was held two weeks post stand-down of the Sydney Olympic Disaster Medical Response Teams. At that time, each team leader provided a 10-minute verbal report of their team’s experience. Adverse issues, as highlighted by the team leaders, were collectively recorded for comparison with those documented on the Incident Report Forms.

A database specific to this study was developed. The authors collectively reviewed the free narrative section of the forms, during the period of incident reporting involved setting up at the two hospital sites, checking equipment, establishing communication links, developing team procedures, individual team exercises, and two occasions of team deployment. A “cold” debriefing was held two weeks post stand-down of the Sydney Olympic Disaster Medical Response Teams. At that time, each team leader provided a 10-minute verbal report of their team’s experience. Adverse issues, as highlighted by the team leaders, were collectively recorded for comparison with those documented on the Incident Report Forms.
Efficacy of Critical Incident Monitoring

Incident reporters deemed that 89% of all reported incidents were preventable. A potential for harm to patients and/or team members was documented in 21 (58%) reported incidents. Incidents associated with personal protective equipment were the most frequently documented equipment incidents (33%), followed by problems with medical equipment (27%), inadequate provision of equipment (22%), and communication-related equipment (17%). Personal protective equipment (50%) was reported as the most frequent occupational health and safety-related incident followed by fatigue (25%) (Figure 3). Of communication-related incidents, 20% were related directly to communication equipment, 67% to organizational-vertical and 13% to organizational-horizontal communication.

Recommendations for ways in which the incident may be better managed or prevented in the future were provided in 22 (61%) forms. These are illustrated in Figure 4. Documented factors that were considered to have minimized the incident were recorded in 10 (28%) forms. Of these, "good luck" (80%) was the predominant factor followed by team member expertise (10%) and low probability of consequence occurrence (10%).

Contributing factors that were reported by the incident monitoring methodology and those described as adverse events at the time of the Sydney Olympic Disaster Medical Response "cold" debrief, held two weeks after the teams were stood down, are listed in Table 1.

In a departmental report summarizing the health services activities, there were no reported patient- or staff-related injuries during the study period.11

**Discussion**

The results of this study indicate that the critical incident
monitoring technique is applicable as a quality improvement activity during deployment for mass gatherings. Management-based decisions, failure or absence of appropriate protocols, equipment-related and communication issues were the categories most often reported for factors contributing to incident occurrence. The prominence of management and communication incidents highlights the value of an anonymous avenue to highlight system factors that otherwise might not be noted.

For the management category, planning and poor risk assessment were the principal contributors. For communication factors, equipment alone contributed only to 20% of the problems; with the largest problem being the vertical communication within the organizational hierarchical structure. This reinforces the previous finding that while communication problems are frequently reported during major incidents, they generally are the symptomatic manifestation of an organizational error rather than a communication equipment issue.

Managerial, protocol/policy, and equipment factors were to be the most often identified factors considered amenable to mitigation. These factors also were major contributors to incident occurrence, and had substantial harm potential, emphasizing the importance of the planning and preparation phase for major incident management. Planning and testing of policy and procedures must be based upon an adequate risk assessment. Other factors to be addressed during the planning and preparation phase include equipment selection, testing and supply, communication equipment and channels, team training, level of seniority and performance, interaction with other services, and the nature and function of the managerial structure that will oversee it.

Not all of the incidents reported through incident monitoring matched those reported at the debriefing. Thus, incident monitoring may not necessarily be a replacement for the debriefing. The critical incident monitoring technique to be complimentary to the post-incident debriefing and is useful as a quality activity as it documented problems not identified using the traditional methods.

Critical incident reporting allows all personnel such as doctors, nurses, and other ancillary staff to participate and contribute to the quality improvement process. Team debriefing sessions record team-specific incidents, but fail to benefit from the enhanced analysis that arises from the greater volume of information that occurs with central collection of all of the teams’ contributions. Incident reporting potentially can capture data in real time, which otherwise may be forgotten by the time a cold debriefing is held.

Organizational debriefings, especially in large, complex systems that characterize disaster readiness, may not provide the opportunity for inclusion of all individuals. However, incident reporting is more inclusive. Anonymous reporting of incidents also allows the recording of information that otherwise may not be politically possible.

No patient- or staff-related injury was reported in relation to this event. If reportable accidents alone had been sought and analyzed, no such information would have been reported. As errors, the nature of which we seek to identify and prevent, are more likely to result in incidents as compared to accidents, performing incident monitoring will provide a greater amount of error-related information as compared to the much less frequent and thus, less often reported accident events.

Weaknesses of this study were that only the period the medical teams were on duty was included and that there was a low frequency of actual team deployment. Preparation, planning, and responding to major events is multifaceted, has multi-service input, and begins long before actual deployment. This study was limited to the
medical and nursing component of that response, and other emergency services that are administered separately were not included.

Similar incidents to those reported here also have been cited in reports on previous major incidents. These included poor or non-existent appropriate protocols or insufficient training that resulted in teams working in inappropriate environments, inadequate personal protective equipment, inadequate transport arrangements and communications. This suggests some commonality with other types of events, and that the technique may have external validity. This should be confirmed by utilization of the technique in other incident types.

Conclusion

Incident monitoring methodology can be applied to multiple casualty incidents and mass gatherings, and is qualitatively similar and complimentary to the traditional post-incident debriefings. Central collation of reported incidents has unique advantages for the identification and development of quality improvement measures and monitoring of systems improvements. It also may better identify system-based incident contributors. Consideration should be given to broader testing of this methodology within a variety of disaster medical settings. As disasters occur infrequently, this would be achieved best through international collaboration.

Acknowledgement

We acknowledge the contribution made by the Australian Patient Safety Foundation in the development and printing of forms for the Retrieval Medicine Incident Monitoring Study, on which the forms used in this study were largely based. Also, we acknowledge the members of the NSW Health Disaster Medical Response Teams that contributed to the documented incidents that form the basis of this study.

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Section 14
Incidents During Out-of-Hospital Patient Transportation

A Flabouris; W B Runciman; B Levings

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Section 15
Awareness in Retrieval Medicine

J. GIBSON*, A. FLABOURIS†

NRMA Careflight, Westmead, Sydney, New South Wales, Australia

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Section 16
Narrativizing errors of care: Critical incident reporting in clinical practice

Rick Iedema*, Arthas Flabouris, Susan Grant, Christine Jorm

Centre for Clinical Governance Research, School of Public Health and Community Medicine,
The University of New South Wales, Sydney 2052 NSW, Australia
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Section 17
Observational study of patients admitted to intensive care units in Australia and New Zealand after interhospital transfer

Dr Arthas Flabouris
Staff Specialist, Intensive Care Unit, Royal Adelaide Hospital, Adelaide South Australia
Clinical Senior Lecturer, Department of Anaesthesia and Intensive Care, University of Adelaide, South Australia

Associate Professor Graeme K Hart
Deputy Director Intensive Care, Austin Hospital, Melbourne Victoria
Clinical Director Austin Centre for Applied Clinical Informatics, Melbourne Victoria
Chair ANZICS Database Management Committee, Melbourne Victoria

Carol George
Project Manager, ANZICS Adult Patient Database, Melbourne, Victoria

Corresponding Author
Dr Arthas Flabouris
Royal Adelaide Hospital, Intensive Care Unit
North Terrace
Adelaide, South Australia, 5001

Email - Arthas.Flabouris@health.sa.gov.au
Phone – 08 82224000
Abstract

Objective: To describe the demographics, illness categories and outcomes of adult intensive care unit (ICU) patients who underwent interhospital transfer (IHT).

Design: Retrospective review of data from the Australian and New Zealand Intensive Care Society Adult Patient Database (ANZICS APD), a binational intensive-care quality-assurance dataset.

Participants and setting: 332,009 patients from 125 Australian and New Zealand adult ICUs, who were aged 16 years or older, and had a known hospital and ICU source of admission between 1 January 1994 and 31 December 2003.

Results: Tertiary ICUs contributed 47.9% of patients, metropolitan 20.9%, private 16.7% and rural/regional 14.5%. Patients admitted to an ICU after IHT had more severe illness, longer hospital stay, and a higher intubation rate, mortality and rate of discharge to another hospital. Over 10 years, the proportion of IHTs increased for rural/regional ($R^2 = 0.639; P = 0.006$) and tertiary ($R^2 = 0.703; P = 0.002$) hospitals, and for the diagnoses of sepsis ($R^2 = 0.877; P < 0.001$) and respiratory infection ($R^2 = 0.679, P = 0.003$); decreased for trauma ($R^2 = 0.612; P = 0.007$); and was associated with fewer ICU admissions after elective surgery ($\beta = \sim 1.47; 95\% CI, \sim 2.19$ to $\sim 0.74; P < 0.001$) and from the operating theatre ($\beta = \sim 0.78; 95\% CI; \sim 1.46$ to $\sim 0.1; P = 0.03$). IHT was most common during July–October and on Fridays and Saturdays. There were significant variations between Australian states and territories and New Zealand.

Conclusions: Patients admitted to an ICU after IHT have significant resource implications based on their severity of illness, hospital stay and mortality, and adversely affect ICU capacity for elective and operating theatre admissions. Regional differences and temporal trends have implications for planning of ICU resources and require ongoing surveillance.

Introduction

The centralisation of complex health care is increasing, partly because of the need for expensive and complex technology, and partly because of evidence that high-volume, centrally coordinated care improves patient outcomes. For example, improved outcomes have been seen at dedicated centres for major trauma, cardiac, vascular and cancer surgery, and acute myocardial infarction. There is also evidence supporting the centralisation of critical care services, with reduced mortality seen in high-volume intensive care units staffed by specialist intensivists.

Centralisation of health care raises the problem of equity of access, and may increase the need for interhospital transfer (IHT), as patients in hospitals remote from central services must be referred and transported to hospitals that can provide the requisite service. This has the potential to delay treatment and increase morbidity and mortality. The risk is likely to be greatest for critically ill patients, because of their greater illness severity and support requirements. In addition, critically ill patients are sometimes transferred between hospitals because the referring site has insufficient resources to deliver care it is competent to deliver, not because of a need for higher-level care.
An understanding of the demographic and illness characteristics of patients who undergo IHT may assist with planning future provision and accessibility of health care resources. Comparisons of regional differences and patterns of IHT may provide a basis for evaluating factors that influence the occurrence and outcome of IHT. The aim of this study was to describe the patient and illness demographics and outcomes for adult intensive care patients who underwent IHT from within Australia or New Zealand.

Methods

The study was a retrospective review of data from the Australian and New Zealand Intensive Care Society Adult Patient Database (ANZICS APD). This quality-assurance dataset collects de-identified data on adult patients admitted to participating Australian and New Zealand ICUs. Patients were included in the analysis if they were aged 16 years or older, admitted between 1st January 1994 and 31st December 2003, had known hospital and ICU source of admission, and known ICU and hospital outcome. Patients whose hospital source of admission was a chronic care facility were excluded.

Not all Australian and New Zealand ICUs contributed data to the database. In 2003, participation was 60% overall, 78% for Australian ICUs, and 37% for New Zealand ICUs. Data from individual ICUs that began contributing part way through a calendar year were excluded if the number of admissions they contributed in that year was less than 10% of the number in the following year.

Variables analysed were age, sex, hospital and ICU source of admission, APACHE II score, predicted risk of death and diagnostic category, intubation (endotracheal intubation within the first 24 hours of ICU admission), date of hospital and ICU admission, and hospital outcome. Details of the receiving ICU type (rural, metropolitan, tertiary or private) and location (Australian states or territories or New Zealand) were also sought.

Descriptive statistical methods were used for patient and illness demographics. Results were presented as means and 95% confidence intervals. Statistical significance was set at P < 0.05. Associations between variables and hospital or ICU admission source were examined using Pearson’s correlation coefficient after testing for linearity, $X^2$ tests for categorical data, and a linear regression model for yearly temporal trends over the study period. All analyses were performed using SPSS version 11.0.4 statistical software (SPSS, Chicago, Ill, USA). Standardised mortality ratio (SMR) was defined as the ratio of observed to predicted deaths by APACHE II; 95% confidence intervals for SMR were calculated according to the ANZICS APD methodology.

Results

Over the 10-year period 1994–2003, the ANZICS APD recorded 356,455 patients aged 16 years or over from 125 ICUs. Of these patients, 332,009 (93.1%) had a recorded hospital and ICU source of admission and outcome and were not admitted from a chronic care facility.
The 125 ICUs that contributed data were classified as tertiary (47.9% of admissions), metropolitan (20.9%), private (16.7%) and rural/regional ICU (14.5%). Of the 125, 14% contributed to each year, and 10% for any one year, of the 10-year study period. The average contribution was 5.5 years. No Tasmanian ICUs contributed in 1994, and no New Zealand ICUs in 2000.

Epidemiology

Patients who were transferred from another acute hospital had more severe illness, longer ICU and hospital stay, and higher mortality and SMR than patients admitted to hospital from home (Table 1). Patients admitted to the ICU from a ward or another hospital had the highest APACHE II scores, SMR and hospital mortality. Patients admitted to the ICU after IHT were younger than patients admitted from the ward and otherwise similar, but were more likely to be intubated.

Most IHT patients were admitted directly to the ICU (44.2%), while 25.8% were admitted via the operating theatre, 17.2% via the emergency department (ED), 11.6% via a ward and 1.3% via another ICU within the same hospital. IHT patients were also more likely to be discharged to another hospital (Table 1). This pattern varied according to ICU type. Tertiary ICUs had the highest proportion of patients whose hospital and ICU source of admission was another hospital (23.3% and 10.2%, respectively), followed by rural/regional (19.4% and 5.9%), metropolitan (12% and 6.7%) and private (10.7% and 5.1%) ($P < 0.001$). Patients from a rural/regional ICU were most likely to be discharged to another hospital ICU (6.1%) or another hospital (15.5%) compared with patients from a tertiary ICU (0.7% and 8.5%), a metropolitan ICU (1.9% and 8.2%) or a private ICU (1.2% and 4.6%) ($P < 0.001$).

Table 2 shows the most common diagnostic categories for patients whose hospital source of admission was another hospital, by ICU type. Sepsis and gastrointestinal disorders were common to all ICU types, with trauma being more common in tertiary ICUs, overdose in metropolitan ICUs, and coronary artery disease in rural/regional ICUs.

Impact of IHT patients

The proportion of admissions to an ICU after IHT showed an inverse relationship with ICU admissions from the operating theatre ($\beta = -0.78$ [95% CI, $-1.46$ to $-0.1$, $P = 0.03$]), and the ED ($\beta = 0.63$ [95% CI, $-1.26$ to $-0.01$, $P = 0.047$]) and with admissions after elective surgery ($\beta = 1.47$ [95% CI, $-2.19$ to $-0.74$, $P < 0.001$]), but a positive relationship with admissions from the ward ($\beta = 0.37$ [95% CI, 0.18 to 0.57], $P < 0.001$). The proportion of ICU admissions from the ED was also inversely related to admissions from the operating theatre ($\beta = -0.96$ [95% CI, $-1.06$ to $-0.87$, $P < 0.001$]).

Trends for IHT patients

The proportion of IHT patients increased significantly over the 10-year study period ($R^2 = 0.567$, $P = 0.01$), but only for rural/regional and tertiary ICUs ($R^2 = 0.639$, $P = 0.006$; and $R^2 = 0.703$, $P = 0.002$; respectively). The proportion of patients admitted directly to an ICU from another hospital remained virtually unchanged ($R^2 = 0.042$, $P = 0.35$), regardless of the type of ICU. Of the diagnostic categories for IHT patients, only sepsis ($R^2 = 0.877$, $P < 0.001$) and respiratory infection ($R^2 = 0.679$, $P = 0.003$) increased significantly over the study period, while gastrointestinal disorders decreased ($R^2 = 0.569$, $P = 0.01$). This pattern was similar for IHT
patients admitted directly to an ICU, with the addition of an increase in renal disorders ($R^2 = 0.817, P < 0.001$) and a decrease in trauma ($R^2 = 0.612, P = 0.007$).

The incidence of IHTs was greatest during the months July to October (Figure 1) and on the days Friday and Saturday (Figure 2).

Geographic variations

There were regional differences in the pattern of IHT (Figure 3), the disposition of patients on admission to hospital (Figure 4) and the predominance of diagnostic categories (Table 3 and Table 4). Western Australia had the highest proportion of admissions whose hospital admission source was another hospital, and South Australia had the highest proportion whose ICU source was another hospital. Sepsis was more common in WA, New South Wales, SA, the Northern Territory and the Australian Capital Territory, intracranial haemorrhage and head injury in New Zealand, Tasmania and NT, and overdose in Victoria and Queensland. Head trauma, sepsis and intracranial haemorrhage were the most common diagnoses of intubated patients admitted directly to a tertiary ICU after IHT (Table 4).

The proportion of patients whose hospital source of admission was another hospital increased over the study period for all regions, but the increase was statistically significant only in NSW ($R^2 = 0.767, P = 0.02$), SA ($R^2 = 0.933, P = 0.03$), Tasmania ($R^2 = 0.940, P = 0.01$) and WA ($R^2 = 0.675, P = 0.045$).

Discussion

We found that adults admitted to an Australian or NZ ICU after IHT have more severe illness, longer hospital and ICU stay, and higher SMR, hospital mortality and likelihood of discharge to another hospital compared with patients admitted to an ICU from other sources, with the exception of those from a ward. Over the 10-year study period, the proportion of such patients increased significantly for tertiary and rural/regional ICUs and for the common diagnostic categories of sepsis and respiratory infection.

For receiving hospitals, IHT patients are likely to place a high burden on resources, based on their greater severity of illness, longer stay and likelihood of intubation within the first 24 hours of ICU admission. Generally, most Australian and NZ ICUs operate as “closed” ICUs, with admissions being triaged by qualified intensivists who are responsible for the allocation of the limited, locally available ICU resources. Requests for IHT directly to an ICU can be triaged and planned before the patient’s arrival. Our study suggests that IHT patients are placing an increasing and unexpected demand on ICU services through bypassing the typical opportunity for ICU triage and being admitted indirectly to the ICU, via the operating theatre, ED or ward. The urgency of these admissions reduces the opportunity to plan and apportion fixed ICU resources, and may explain the inverse relationship identified in this study between ICU admissions after IHT and elective and operating theatre ICU admissions, and the positive relationship with ward ICU admissions.

These events have the greatest impact for tertiary and rural/regional ICUs, which had a high proportion of IHT patients. Such hospitals are likely to be acting as regional “hubs”, providing a relatively higher level of service, with obligations to receive patients referred to them. This may
reduce their ability to deal with elective and surgical caseloads.

Rural/regional hospitals were most likely to receive patients from, and discharge them to, another hospital. Potentially, these patients would be exposed to additional risk from yet another IHT. Tertiary ICUs had a similar high proportion of IHTs, but were least likely to discharge patients directly to another hospital. The study was limited by lack of data on the indication for IHT.

Sepsis was a common diagnosis among IHT patients and increased in incidence over the study period. This is consistent with the findings of another large national dataset, from the United Kingdom. Respiratory infection and renal disorders also increased, while gastrointestinal disorders and trauma decreased. The data were insufficient to explain these findings. The decrease in trauma admissions direct to an ICU after IHT may be explained by increased adherence to trauma bypass protocols and direct admissions to major trauma centres. Rural/regional ICUs had a higher proportion of patients with coronary artery disease, reflecting the fact that they often combine a general ICU and coronary care unit.

Patients with a diagnosis of overdose or cardiac arrest would usually not be expected to require specialised intensive care or other medical services, yet were a common category of IHT to a tertiary ICU. This finding is likely to reflect insufficient intensive care resources in the referring hospital as the sole indication for transfer. Under such circumstances, patients are exposed to the significant risks of IHT for possibly little additional direct patient benefit. Resource and health policy variations across the Australian states and territories and for NZ, as well as geography, population density and the presence and capacity of local patient transport (retrieval) services may account for the regional variations noted in this study. It is also possible that a proportion of these patients were from hospitals that lacked an ICU, as data about the referring hospital and indication for transfer were not available. The breadth of the observed diagnostic categories among IHT patients suggests a complex mixture of indications for IHT, which require future evaluation.

IHTs peaked during the winter months of July to October and on the days Friday and Saturday. The predominance of IHT patients, with their associated more severe illness, during winter and on a weekend may reflect constraints on system capacity and has implications for the capacity of receiving ICU and retrieval services to provide timely review by senior medical staff. Time to first contact of a critically ill patient with a senior critical care physician may be directly related to patient morbidity.

Although IHT may contribute to a positive patient outcome in some cases, our study supports previous findings that IHT patients overall have a higher than expected mortality and longer hospital stay. The explanations are likely to be complex and may relate to adverse effects during IHT, timeliness of referral and transportation, level of patient escort, efficacy of treatment at the referring hospital or a failure of ICU triage at the time of referral. It is likely that the risks and benefits of IHT are not equivalent across all diagnostic groups. In contrast, other studies have shown a benefit from centralisation of certain health services. However, those studies were confined to a single diagnosis, and the contribution of IHT patients to the study outcome was not clearly identified. There is evidence that the proportion of IHTs can affect an ICU’s measures of quality, but the impact of IHT on the measurable outcomes of centralisation
of health services across a range of specific diagnoses remains ill defined and requires further investigation.

The nature, frequency, disposition after hospital admission and 10-year trend of IHT varied across the regions examined. IHT has the potential to be used as a quality measure for delivery of critical care and other medical services within a particular region. For example, rural/regional hospitals had a rate of IHT comparable to that of tertiary hospitals, but a higher rate of discharges to another hospital. Tertiary ICUs in NZ, Queensland and Tasmania had a relatively higher proportion of direct admissions of IHT patients with head trauma compared with Victoria and WA. IHT could also be used to monitor the impact of changes to access to regional medical services over time. It is difficult to foresee the circumstances in which IHT would never be needed, especially within the diverse geopolitical regions of the Australian states and territories and NZ. Indeed, high-level IHT services should be seen as essential to any centralisation of health care resources and expertise.

This study relied on the strength of a large, standardised bi-national dataset of ICU admissions from multiple, unselected, centres throughout Australia and NZ that voluntarily contribute data. In 2003, the dataset captured 78% and 37% of admissions to Australian and NZ ICUs, respectively. The dataset is of high quality based on established criteria. Weaknesses of this study were that it was retrospective; it did not include all Australian and NZ ICUs and thus the full potential pool of IHT patients, so that patient demographics, source of admission and casemix of the study population may not have been representative of the true ICU patient population; and no information was available on the indication for IHT or physical process of transport. The findings also cannot be used to establish causal relationships. Ideally, such datasets would have added value if they included unique patient identifiers allowing tracking of individual patients, and if they were linked to other datasets (such as trauma datasets).

In summary, this study based on a large binational dataset found that ICU patients admitted after IHT have a high severity of illness, hospital mortality and hospital stay. IHT patients may adversely affect ICU capacity for elective and operating theatre admissions. Regional differences and temporal trends have implications for planning of ICU resources and require ongoing surveillance. Future studies are needed to identify the causal effects of the different factors involved in the referral and transport process.
References


Figure 1. Proportion of IHT, whose ICU or hospital source of admission was another hospital by month.
Figure 2. Proportion of IHT, where ICU or hospital source of admission was another hospital by day of the week

- ICU source is other Hospital
- Hospital source is other hospital
Figure 3. Proportion of IHT, whose ICU or hospital source of admission was another hospital by each region.
Figure 4. Disposition of patients whose hospital source of admission was another hospital.
Table 1. Demographic characteristics and outcomes of patients recorded in the ANZICS APD, 1994–2003, with a known source of hospital and ICU admission*

<table>
<thead>
<tr>
<th></th>
<th>Hospital admission source</th>
<th>ICU admission source</th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Home</td>
<td>Other acute hospital</td>
<td>Operating theatre</td>
<td>Emergency Department</td>
<td>Ward</td>
<td>Other acute hospital</td>
</tr>
<tr>
<td>No. of patients</td>
<td>268 156</td>
<td>63 853</td>
<td>154 102</td>
<td>92 012</td>
<td>54 109</td>
<td>28 780</td>
</tr>
<tr>
<td>Age (years)†</td>
<td>60.1 (60–60.2)</td>
<td>57.1 (57–57.3)</td>
<td>62.7 (62.6–62.8)</td>
<td>54.1 (54–54.2)</td>
<td>63 (62.3–63.2)</td>
<td>55.7 (55.4–55.9)</td>
</tr>
<tr>
<td>Male sex (%)</td>
<td>60.4%</td>
<td>59.2%</td>
<td>63.7%</td>
<td>57.6%</td>
<td>55.8%</td>
<td>56.8%</td>
</tr>
<tr>
<td>Intubated (%)†</td>
<td>46.3%</td>
<td>62.3%</td>
<td>55.5%</td>
<td>40.2%</td>
<td>39.8%</td>
<td>67.1%</td>
</tr>
<tr>
<td>APACHE II score†</td>
<td>14.9 (14.8–14.9)</td>
<td>17.4 (17.3–17.5)</td>
<td>13.1 (13.1–13.2)</td>
<td>15.4 (15.3–15.4)</td>
<td>19 (19–19.1)</td>
<td>18.2 (18.1–18.3)</td>
</tr>
<tr>
<td>APACHE II risk of death†</td>
<td>0.21 (0.21–0.21)</td>
<td>0.28 (0.28–0.28)</td>
<td>0.15 (0.15–0.15)</td>
<td>0.22 (0.22–0.23)</td>
<td>0.33 (0.33–0.33)</td>
<td>0.31 (0.30–0.31)</td>
</tr>
<tr>
<td>SMR†</td>
<td>0.68 (0.67–0.69)</td>
<td>0.75 (0.74–0.77)</td>
<td>0.51 (0.50–0.52)</td>
<td>0.75 (0.73–0.76)</td>
<td>0.94 (0.92–0.96)</td>
<td>0.78 (0.76–0.80)</td>
</tr>
<tr>
<td>No. of patients for SMR calculation (% of total no.)</td>
<td>225 752 (84.2%)</td>
<td>53 800 (88.8%)</td>
<td>114 443 (74.3%)</td>
<td>87 339 (94.9%)</td>
<td>50 596 (93.5%)</td>
<td>27 472 (95.5%)</td>
</tr>
<tr>
<td>ICU length of stay (days)†</td>
<td>3.4 (3.4–3.4)</td>
<td>5.1 (5.0–5.1)</td>
<td>3 (3.0–3.0)</td>
<td>3.4 (3.4–3.4)</td>
<td>4.9 (4.9–5.0)</td>
<td>5.4 (5.3–5.5)</td>
</tr>
<tr>
<td>Pre-ICU hospital stay (days)†</td>
<td>3.4 (3.3–3.4)</td>
<td>2.6 (2.5–2.7)</td>
<td>3.52 (3.5–3.6)</td>
<td>0.7 (0.6–0.8)</td>
<td>8 (7.8–8.1)</td>
<td></td>
</tr>
<tr>
<td>Hospital length of stay (days)†</td>
<td>17.5 (17.4–17.6)</td>
<td>19.5 (19.2–19.7)</td>
<td>19.2 (19.1–19.4)</td>
<td>11.8 (11.6–11.9)</td>
<td>26.4 (26.1–26.7)</td>
<td>15.6 (15.3–15.9)</td>
</tr>
<tr>
<td>Discharge to another hospital (%)†</td>
<td>7.5%</td>
<td>22.3%</td>
<td>6.0%</td>
<td>12.1%</td>
<td>10.7%</td>
<td>26.6%</td>
</tr>
<tr>
<td>Hospital mortality (%)†</td>
<td>14.0%</td>
<td>21.1%</td>
<td>7.6%</td>
<td>16.7%</td>
<td>31.1%</td>
<td>23.6%</td>
</tr>
</tbody>
</table>

ANZICS APD = Australian and New Zealand Intensive Care Society Adult Patient Database. SMR = standardised mortality ratio.

* Values are mean and 95% CI unless otherwise indicated. † P < 0.001 for both hospital and ICU source of admission.

Patients whose ICU source of admission is “another ICU same hospital” have been omitted from the table.
Table 2. The 20 most common APACHE II diagnostic categories at the time of ICU admission, as a percentage of all patients whose hospital source of admission was another hospital, by ICU type

<table>
<thead>
<tr>
<th>APACHE II diagnostic category</th>
<th>Metropolitan</th>
<th>Private</th>
<th>Rural/regional</th>
<th>Tertiary</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sepsis</td>
<td>8.69</td>
<td>5.66</td>
<td>7.46</td>
<td>6.86</td>
<td>7.09</td>
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<tr>
<td>Gastrointestinal other</td>
<td>5.88</td>
<td>4.90</td>
<td>7.06</td>
<td>5.01</td>
<td>5.43</td>
</tr>
<tr>
<td>Drug overdose</td>
<td>9.58</td>
<td>3.62</td>
<td>5.39</td>
<td>4.29</td>
<td>5.13</td>
</tr>
<tr>
<td>Respiratory infection</td>
<td>5.81</td>
<td>4.55</td>
<td>5.30</td>
<td>4.29</td>
<td>4.67</td>
</tr>
<tr>
<td>Respiratory other</td>
<td>4.42</td>
<td>4.50</td>
<td>4.47</td>
<td>4.43</td>
<td>4.44</td>
</tr>
<tr>
<td>Head-only trauma</td>
<td>2.35</td>
<td>1.42</td>
<td>2.60</td>
<td>5.53</td>
<td>4.26</td>
</tr>
<tr>
<td>Intracranial haemorrhage</td>
<td>2.14</td>
<td>2.66</td>
<td>1.97</td>
<td>5.20</td>
<td>4.05</td>
</tr>
<tr>
<td>Neurological other</td>
<td>3.45</td>
<td>3.40</td>
<td>2.93</td>
<td>4.10</td>
<td>3.77</td>
</tr>
<tr>
<td>Cardiovascular other</td>
<td>2.35</td>
<td>5.29</td>
<td>6.21</td>
<td>3.17</td>
<td>3.71</td>
</tr>
<tr>
<td>Post cardiac arrest</td>
<td>4.92</td>
<td>2.92</td>
<td>3.46</td>
<td>3.57</td>
<td>3.68</td>
</tr>
<tr>
<td>Multiple trauma</td>
<td>2.20</td>
<td>1.58</td>
<td>3.04</td>
<td>4.47</td>
<td>3.66</td>
</tr>
<tr>
<td>Postoperative gastrointestinal perforation/obstruction</td>
<td>4.64</td>
<td>3.17</td>
<td>6.22</td>
<td>2.46</td>
<td>3.39</td>
</tr>
<tr>
<td>Postoperative intracranial haemorrhage</td>
<td>1.10</td>
<td>2.00</td>
<td>0.30</td>
<td>3.95</td>
<td>2.82</td>
</tr>
<tr>
<td>Renal other</td>
<td>3.60</td>
<td>2.24</td>
<td>3.66</td>
<td>2.43</td>
<td>2.76</td>
</tr>
<tr>
<td>Postoperative peripheral vascular disease</td>
<td>2.76</td>
<td>2.22</td>
<td>2.18</td>
<td>2.84</td>
<td>2.67</td>
</tr>
<tr>
<td>Chronic obstructive pulmonary disease</td>
<td>4.42</td>
<td>1.45</td>
<td>2.39</td>
<td>2.08</td>
<td>2.39</td>
</tr>
<tr>
<td>Postoperative multiple trauma</td>
<td>2.37</td>
<td>1.54</td>
<td>2.68</td>
<td>2.36</td>
<td>2.33</td>
</tr>
<tr>
<td>Coronary artery disease</td>
<td>1.62</td>
<td>2.70</td>
<td>6.36</td>
<td>0.95</td>
<td>2.01</td>
</tr>
<tr>
<td>Cardiogenic shock</td>
<td>1.86</td>
<td>1.80</td>
<td>1.26</td>
<td>2.14</td>
<td>1.94</td>
</tr>
<tr>
<td>Seizure disorder</td>
<td>2.02</td>
<td>1.17</td>
<td>1.67</td>
<td>1.80</td>
<td>1.75</td>
</tr>
</tbody>
</table>

*P* < 0.001 across all ICU types and diagnostic categories listed.
Table 3. The 10 most common APACHE II diagnostic categories, as a percentage of all patients whose ICU source of admission was another hospital, by

<table>
<thead>
<tr>
<th>Diagnostic category</th>
<th>WA</th>
<th>VIC</th>
<th>TAS</th>
<th>SA</th>
<th>QLD</th>
<th>NZ</th>
<th>NT</th>
<th>NSW</th>
<th>ACT</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sepsis</td>
<td>11.13</td>
<td>7.92</td>
<td>9.00</td>
<td>9.34</td>
<td>7.39</td>
<td>8.32</td>
<td>24.39</td>
<td>9.07</td>
<td>10.69</td>
<td>8.84</td>
</tr>
<tr>
<td>Drug overdose</td>
<td>9.81</td>
<td>9.97</td>
<td>1.36</td>
<td>8.35</td>
<td>9.95</td>
<td>2.14</td>
<td>1.63</td>
<td>8.11</td>
<td>5.34</td>
<td>8.46</td>
</tr>
<tr>
<td>Respiratory infection</td>
<td>7.83</td>
<td>6.52</td>
<td>5.06</td>
<td>8.03</td>
<td>5.51</td>
<td>3.78</td>
<td>7.59</td>
<td>6.21</td>
<td>7.63</td>
<td>6.39</td>
</tr>
<tr>
<td>Intracranial, subdural or subarachnoid haemorrhage</td>
<td>5.52</td>
<td>3.97</td>
<td>11.71</td>
<td>5.80</td>
<td>6.74</td>
<td>12.61</td>
<td>4.07</td>
<td>5.43</td>
<td>10.11</td>
<td>5.85</td>
</tr>
<tr>
<td>Head-only trauma</td>
<td>2.31</td>
<td>2.52</td>
<td>10.23</td>
<td>6.35</td>
<td>8.97</td>
<td>14.00</td>
<td>3.79</td>
<td>4.71</td>
<td>5.34</td>
<td>5.52</td>
</tr>
<tr>
<td>Gastrointestinal other</td>
<td>1.32</td>
<td>5.92</td>
<td>5.80</td>
<td>5.74</td>
<td>4.66</td>
<td>6.56</td>
<td>4.34</td>
<td>5.87</td>
<td>6.68</td>
<td>5.46</td>
</tr>
<tr>
<td>Post cardiac arrest</td>
<td>4.12</td>
<td>5.60</td>
<td>1.48</td>
<td>5.97</td>
<td>4.49</td>
<td>3.91</td>
<td>4.07</td>
<td>6.07</td>
<td>8.02</td>
<td>5.40</td>
</tr>
<tr>
<td>Multiple trauma</td>
<td>3.71</td>
<td>4.60</td>
<td>2.34</td>
<td>4.64</td>
<td>7.56</td>
<td>6.81</td>
<td>2.98</td>
<td>3.79</td>
<td>2.29</td>
<td>4.76</td>
</tr>
<tr>
<td>Neurological other</td>
<td>3.22</td>
<td>3.76</td>
<td>4.93</td>
<td>4.44</td>
<td>4.25</td>
<td>6.43</td>
<td>4.61</td>
<td>5.50</td>
<td>4.58</td>
<td>4.64</td>
</tr>
<tr>
<td>Respiratory other</td>
<td>5.19</td>
<td>3.98</td>
<td>3.70</td>
<td>3.25</td>
<td>4.19</td>
<td>4.54</td>
<td>5.96</td>
<td>4.41</td>
<td>2.67</td>
<td>4.14</td>
</tr>
</tbody>
</table>

WA = Western Australia. VIC = Victoria. TAS = Tasmania. SA = South Australia. QLD = Queensland. NZ = New Zealand. NT = Northern Territory. NSW = New South Wales. ACT = Australian Capital Territory. \( P < 0.001 \) across all regions.
Table 4. The 10 most common APACHE II diagnostic categories, as a percentage of all patients whose ICU source of admission was another hospital and who were intubated, by region*

<table>
<thead>
<tr>
<th>Diagnostic categories</th>
<th>ACT</th>
<th>NSW</th>
<th>NT†</th>
<th>NZ</th>
<th>QLD</th>
<th>SA</th>
<th>TAS</th>
<th>VIC</th>
<th>WA</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Head-only trauma</td>
<td>5.88</td>
<td>7.37</td>
<td>5.63</td>
<td>19.59</td>
<td>13.73</td>
<td>7.59</td>
<td>19.29</td>
<td>4.85</td>
<td>3.12</td>
<td>8.76</td>
</tr>
<tr>
<td>Sepsis</td>
<td>11.03</td>
<td>8.79</td>
<td>27.71</td>
<td>7.74</td>
<td>7.20</td>
<td>8.94</td>
<td>9.32</td>
<td>7.39</td>
<td>7.02</td>
<td>8.32</td>
</tr>
<tr>
<td>Intracranial haemorrhage</td>
<td>10.54</td>
<td>7.74</td>
<td>3.90</td>
<td>18.91</td>
<td>7.15</td>
<td>6.66</td>
<td>20.58</td>
<td>9.94</td>
<td>4.09</td>
<td>8.32</td>
</tr>
<tr>
<td>Drug overdose</td>
<td>6.13</td>
<td>7.22</td>
<td>2.60</td>
<td>1.59</td>
<td>10.44</td>
<td>9.78</td>
<td>0.64</td>
<td>6.06</td>
<td>12.28</td>
<td>8.00</td>
</tr>
<tr>
<td>Post cardiac arrest</td>
<td>10.29</td>
<td>6.89</td>
<td>6.06</td>
<td>4.10</td>
<td>5.49</td>
<td>7.05</td>
<td>2.25</td>
<td>5.58</td>
<td>4.29</td>
<td>6.29</td>
</tr>
<tr>
<td>Respiratory infection</td>
<td>8.09</td>
<td>6.42</td>
<td>8.23</td>
<td>4.56</td>
<td>5.82</td>
<td>7.36</td>
<td>5.47</td>
<td>3.82</td>
<td>6.43</td>
<td>6.13</td>
</tr>
<tr>
<td>Multiple trauma</td>
<td>1.23</td>
<td>4.75</td>
<td>3.03</td>
<td>6.61</td>
<td>10.11</td>
<td>5.08</td>
<td>3.22</td>
<td>8.18</td>
<td>1.56</td>
<td>6.04</td>
</tr>
<tr>
<td>Neurological other</td>
<td>4.90</td>
<td>6.05</td>
<td>5.19</td>
<td>7.06</td>
<td>5.20</td>
<td>4.39</td>
<td>5.14</td>
<td>5.52</td>
<td>3.90</td>
<td>5.38</td>
</tr>
<tr>
<td>Gastrointestinal other</td>
<td>4.90</td>
<td>6.05</td>
<td>3.03</td>
<td>5.24</td>
<td>3.24</td>
<td>4.97</td>
<td>4.18</td>
<td>5.64</td>
<td>2.14</td>
<td>5.00</td>
</tr>
<tr>
<td>Respiratory other</td>
<td>2.94</td>
<td>4.00</td>
<td>4.76</td>
<td>4.33</td>
<td>3.49</td>
<td>2.62</td>
<td>2.57</td>
<td>4.00</td>
<td>6.82</td>
<td>3.68</td>
</tr>
</tbody>
</table>

ACT = Australian Capital Territory. NSW = New South Wales. NZ = New Zealand. NT = Northern Territory. QLD = Queensland. SA = South Australia. TAS = Tasmania. VIC = Victoria. WA = Western Australia. * P < 0.001 across all regions. † For the NT, hospital type was metropolitan.
Section 18
Outcomes of patients admitted to tertiary intensive care units after interhospital transfer: comparison with patients admitted from emergency departments.

Dr Arthas Flabouris
Staff Specialist, Intensive Care Unit, Royal Adelaide Hospital, Adelaide South Australia
Clinical Senior Lecturer, Department of Anaesthesia and Intensive Care, University of Adelaide, South Australia

Associate Professor Graeme K Hart
Deputy Director Intensive Care, Austin Hospital, Melbourne Victoria
Clinical Director Austin Centre for Applied Clinical Informatics, Melbourne Victoria
Chair ANZICS Database Management Committee, Melbourne Victoria

Carol George
Project Manager, ANZICS Adult Patient Database, Melbourne, Victoria

Corresponding Author
Dr Arthas Flabouris
Royal Adelaide Hospital, Intensive Care Unit
North Tce
Adelaide, South Australia, 5001

Email - Arthas.Flabouris@health.sa.gov.au
Phone – 08 82224000
Abstract

Objectives: To compare outcomes of patients admitted to tertiary-level intensive care units after interhospital transfer (IHT) with those of similar patients admitted from the emergency department (ED).

Design: Historical case–control study using data from the Australian and New Zealand Intensive Care Society Adult Patient Database (ANZICS APD), a quality-assurance dataset.

Participants and setting: 28 882 patients aged 16 years or older admitted to an adult tertiary ICU in Australia or New Zealand between 1 January 1994 and 31 December 2003 with one of the eight most common diagnoses for IHT patients. Patients admitted directly to the ICU from another hospital (DIHT group) \((n = 9203)\) were matched by age, sex, APACHE II score and diagnosis with non IHT patients admitted from the ED (ED group).

Results: Hospital mortality was higher in the DIHT group than in the ED group for patients with a diagnosis of multiple trauma (11.0% v 5.1%; odds ratio [OR], 2.3; 95% CI, 1.6–3.34), respiratory infection (28.1% v 19.1%; OR, 1.66; 95% CI, 1.34–2.05), sepsis (38.7% v 28.7%; OR, 1.57; 95% CI, 1.34–1.83), intracranial haemorrhage (49.9% v 42.6%; OR, 1.34; 95% CI, 1.14–1.58), head injury alone (16.9% v 13.7%; OR, 1.28; 95% CI, 1.01–1.62), and cardiac arrest (59.3% v 53.2%; OR, 1.28; 95% CI, 1.06–1.56), but not overdose (3.9% v 3.6%; OR, 1.09; (95% CI, 0.72–1.67) or chronic obstructive pulmonary disease (19.8% v 22.5%; OR, 0.85; 95% CI, 0.63–1.15). Overall, the DIHT group had a higher intubation rate, longer ICU stay and higher rate of discharge to another hospital.

Conclusions: Patients admitted to an ICU from another hospital have higher hospital mortality and longer stay than those admitted from the ED, with the differences varying between diagnoses. These differences are important considerations for resource allocation and triage, and as a measure of quality.
Introduction

A significant number of critically ill patients undergo interhospital transfer (IHT). In the United Kingdom, it is estimated that 11,000 patients per year are transferred to another hospital intensive care unit. A significant proportion of IHTs occur solely because of insufficient resources, rather than the need to access a specific service not available at the referring hospital. In metropolitan Victoria, 10% of patients referred to a public hospital ICU were unable to be admitted to the ICU of first choice, and 60% of those patients (equivalent to almost two patients per day) undergo acute IHT.

To date, studies of the outcomes of critically ill patients who undergo IHT have been small, single-centre studies, lacked comparable controls, and were confined to a specific cohort of patients or risked significant bias from confounding factors. Furthermore, regional, geographical and population variability may limit the generalisability of their findings.

Using a large dataset of adult intensive care patients, we conducted a case–control study of patients whose ICU source of admission was another acute hospital, and explored differences in their outcomes compared with those of similar ICU patients admitted from the emergency department (ED). We also explored regional variations among Australian states and territories and New Zealand.

Methods

The study used data from the Australian and New Zealand Intensive Care Society Adult Patient Database (ANZICS APD), which contains de-identified data on patients admitted to participating ICUs in Australia and New Zealand. Not all ICUs contribute data. In 2003, the participation rate was 60% overall, 78% for Australian ICUs, and 37% for NZ ICUs.

Patients were selected using the criteria: age 16 years or older; admission to a tertiary-level ICU between 1 January 1994 and 31 December 2003; hospital source of admission either “another acute hospital” or “home”; and ICU source of admission either an “ED” or “another acute hospital”.

The data sought were patient age, sex, hospital and ICU source of admission, APACHE II score, APACHE II-derived risk of death (ROD), APACHE II diagnostic category, intubation (endotracheal intubation within the first 24 hour s of ICU admission), date of hospital and ICU admission, ICU and hospital outcomes, and ICU location (Australian states and territories and New Zealand). Patients whose hospital or ICU source of admission was another hospital (referring) ICU were included in the category “another a cute hospital”. The dataset did not record the type of other acute hospital (referring), the location within that hospital from which the patient was transferred (eg, ward, emergency department or operating theatre) or treatment at that hospital. The Northern Territory was excluded as there was no participating ICU.

Patients were selected from the eight most common non-operative diagnostic categories for patients admitted to a tertiary ICU directly from another acute hospital: chronic obstructive pulmonary disease (COPD), respiratory infection, sepsis, post-cardiac arrest, multiple trauma with or without head injury (“multiple trauma”), head injury alone, no-n- traumatic intracranial haemorrhage (ICH) and overdose. These categories were chosen as they collectively constituted just over 50% of all diagnoses after excluding postoperative, “undefined” and “other” diagnostic categories.
Patients were classified as “direct IHT” (DIHT; transferred from another hospital and admitted directly to the ICU) or “ED” (not transferred from another hospital and admitted to the ICU directly from the ED). Patients from the DIHT group were matched with patients from the ED group based on age, sex, APACHE II score and diagnosis. The latter variables were combined into a unique string code for matching. The DIHT group was then compared with matched patients from the ED group.

Outcome measures were ICU and hospital length of stay (LOS), hospital outcome, and standardised mortality ratio (SMR; the ratio of observed to predicted death by APACHE II).

Descriptive statistical methods were used for patient and illness demographics. Results were presented as mean and 95% confidence interval or median and interquartile range (IQR; 25% to 75% quartile). Statistical significance was set for the outcome measures (hospital outcome and stay) at $P < 0.01$, and for patient demographics to ascertain strength of matching (age, APACHE II score and R OD, and intubation) and diagnostic group comparisons (day of week, month, year, and region) at $P < 0.05$. Comparisons between groups were examined using the $t$ test and ANOVA for normally distributed data, Kruskal–Wallis test for non-parametric data, $\chi^2$ test for categorical data, and a linear regression model for temporal trends over the study period. Length of stay was analysed using the Kaplan–Meier technique, and comparisons with a log rank test. Analyses were performed using SPSS version 11.0.4 statistical software (SPSS, Chicago, Ill, USA).

Results

For the period 1994–2003, the ANZICS APD recorded 356,455 patients aged 16 years or older, from 125 ICUs. Figure 1 shows the derivation of the study population. A total of 28,883 patients were from one of the eight selected diagnostic categories: 9,203 (31.9%) were admitted directly from another hospital (DIHT group), including 863 (9.4% of the DIHT group) transferred from another hospital ICU; and 19,679 (68.1%) were admitted from the ED. These patients formed the basis for all further analyses.

Among the ICU patients admitted from the ED, 2,846 (14.5%) arrived in the ED after IHT. These patients had similar age, severity of illness, and predicted and observed hospital mortality, but significantly longer ICU and hospital stay, a higher rate of intubation and discharge to another hospital compared with non-IHT patients admitted to the ICU from the ED (Table 1). Patients admitted to the ICU from the ED with head injury alone were the most likely to have arrived in the ED after IHT (26.9%), followed by patients with multiple trauma (23.1%), ICH (17.3%), sepsis (15.4%), respiratory infection (12.6%), COPD (12.4%), post-cardiac arrest (13.6%) and overdose (6.4%).

Patients from the DIHT group and IHT patients admitted to the ICU via the ED had significantly higher rates of intubation overall (Table 1), and for all diagnostic categories ($P < 0.001$) except post-cardiac arrest in comparison with non-IHT ICU admissions from the ED. Post-cardiac arrest patients had the highest overall rates of intubation (> 90%) (Figure 2).

New South Wales contributed 32.2% of all patients analysed, South Australia 18.1%, Victoria 17.4%, Queensland 14.8%, Australian Capital Territory 5.6%, New Zealand 4.5%, and Western Australia 3.1%. Over the study period, mortality decreased significantly for both the DIHT and ED group for patients with respiratory infection ($R^2 = 0.563$, $P = 0.01$, and $R^2 = 0.857$, $P < 0.001$, respectively) and intracranial haemorrhage ($R^2 = 0.426$, $P = 0.04$, and $R^2 = 0.560$, $P = 0.01$), and for the ED group for those with sepsis ($R^2 = 0.436$, $P = 0.04$).
Table 2 compares the demographics of patients in the DIHT and ED groups. There was no significant difference between the ED groups for the admitting day of the week or month of the year, except for overdose patients within the ED group, who had a lower proportion of admissions on a Friday and Saturday. Table 2 also compares patients from the DIHT group who could not be matched with a patient from the ED group. Unmatched patients with COPD, respiratory infection, post-cardiac arrest and ICH had less severe illness, while patients with sepsis, multiple trauma, head injury alone and overdose were older and had more severe illness than patients from the DIHT group who could be matched.

Outcomes of matched patients from the DIHT and ED groups are compared in Table 3. Patients from the DIHT group with diagnoses of COPD, respiratory infection, sepsis, multiple trauma and head injury alone had significantly longer ICU stays. DIHT patients with multiple trauma and head injury alone had longer hospital stays, those with ICH and cardiac arrest had shorter stays, and there was no difference in stay for those with COPD, respiratory infection, sepsis and overdose. Hospital mortality and SMR in the DIHT groups were higher across all diagnostic categories, other than COPD, but statistically significantly only for patients with respiratory infection, sepsis, multiple trauma and ICH. DIHT patients with multiple trauma, when compared with similar ED patients, had the highest odds ratio for mortality.

Table 4 shows patient age, severity of illness and hospital mortality for all patients in the DIHT group by region and diagnosis. Patient age, APACHE II score and predicted ROD varied significantly among the regions for all diagnoses other than COPD, post-cardiac arrest and head injury alone. There was significant regional variation for hospital mortality for the diagnostic categories of sepsis, multiple trauma and ICH.

Discussion

This study compared the outcomes of patients admitted directly to an Australian or New Zealand tertiary level ICU after IHT with outcomes of similar patients admitted from the ED. Patients from the DIHT group with a diagnosis of respiratory infection, sepsis, post-cardiac arrest, multiple trauma, head injury alone or ICH had significantly higher mortality than similar patients from the ED group. Overall IHT patients, with few exceptions, were more likely to have undergone endotracheal intubation, to have longer ICU and hospital stay, and to be discharged to another hospital.

Outcome differences between the DIHT and the ED groups varied according to diagnosis, being most significant for patients with major trauma and of non-measurable impact for patients with COPD or overdose. The diagnostic groups selected were the eight most common for tertiary ICU patients admitted from another hospital. Previous studies have also shown increased morbidity and mortality for IHT patients, 9,10 and suggested that this effect may be prominent for certain diagnostic groups.

Our finding regarding trauma patients might be expected as patients with major trauma who are not admitted directly to a major trauma centre, may have delayed, or suboptimal, definitive treatment and have a comparatively higher mortality than similar patients from an IHT patient admitted directly to an ICU. However, in our study, IHT trauma patients were specifically trauma patients not admitted directly from the scene of an accident to a tertiary hospital and underwent an IHT with direct admission to an ICU. If time was a critical outcome determinant for the seven patients, the time would suggest there may be an additional contribution to mortality associated with an IHT patient admitted directly to an ICU compared with a non-IHT patient admitted from the ED. Observational studies have shown that time to acceptance after referral is shorter for an ED than for an ICU. Treatment of certain conditions in
higher-volume, specialty-staffed ICUs, early goal-directed resuscitation and delays in discharge to a hospital inpatient bed from the ED are all factors that can influence patient outcome positively or negatively. These factors may, in part, explain our findings.

Patients in the DIHT group had a higher intubation rate than similar patients in the ED group across all diagnostic groups except post-cardiac arrest. The difference for the post-cardiac arrest group may not have reached statistical significance because of the high overall rate of tracheal intubation in that group. Similarly, ICU patients admitted via the ED after IHT, although younger and with a similar severity of illness to non-IHT patients admitted from the ED, also had a higher intubation rate and longer ICU and hospital stay. Intubation in our study was defined as intubation within the first 24 hours of ICU admission. We found that IHT patients had a higher risk of intubation, either before ICU admission, associated with or in preparation for transportation, and after ICU admission.

Influences on patient management during IHT include the need to guard against the physical consequences of transport, the restrictions of different transport platforms, duration of travel and expertise of patient escorts. Institution of invasive ventilatory support is frequently advocated to mitigate the risk of clinical deterioration during IHT but carries its own risks, particularly the loss of the advantages of non-invasive ventilation—a technique which has significant limitations in the typical transport environment. The extent to which the transport process itself contributed to the adverse outcomes identified in our study could not be determined. However, adverse events are not infrequent during IHT and contribute to preventable adverse patient consequences.

This study also highlighted significant regional variations in age of patients, severity of illness and hospital outcome, particularly for patients with sepsis, respiratory infection, multiple trauma and ICH. These findings may be explained by geographical differences, and variations in resources and patient selection, referral and transport processes. Data on these variables were not available to us; they should be examined in future studies as they may be important to building models of IHT associated with better patient outcomes.

A strength of this study was the use of the large standardised national dataset of ICU admissions across many centres. This dataset is of high quality using when assessed against established criteria. Its size allowed selection of a larger sample of control cases, using stronger matching criteria and more diagnostic categories than in previous studies, in an area of study where it would be difficult to conduct prospective, multicentre randomised control studies.

Weaknesses of our study were that we could not examine specific factors such as the appropriateness of patient intervention before and during IHT, distortion of illness severity measures caused by lead-time bias or bias resulting from patient selection for transportation (eg, “too unstable to transfer”, “not likely to survive” or “no ICU bed transfer”). The last may explain the selection for IHT of patients for whom similar ED patients could not be identified. Although the study population was large it did not draw from all Australian and New Zealand ICUs, and may not necessarily be representative of the entire IHT population. Changes in mortality across the diagnostic categories over the 10-year study period were similar for both study groups, other than a small difference for sepsis, and unlikely to have influenced the study’s outcome comparisons. Finally, hospital mortality of IHT patients may have been underestimated as these patients were more likely to be discharged to another hospital, where length of stay and outcome were not measured.

Our findings are significant for the planning, funding and equitable distribution of health services. For
countries such as Australia and New Zealand, access to tertiary health resources is influenced by geography, population distribution, hospital volume and resource allocation. Transport services for acutely ill patients are essential for bringing either distant resources to the patient or the patient to the resources. IHT patients have disproportionately higher resource implications for receiving hospitals because of their increased ICU and hospital stays. This impact varies according to diagnostic category and particularly affects IHT patients with multiple trauma and head injury, who not only had longer ICU and hospital stays but also, unlike other IHT patients, were no more likely to be discharged to another hospital than non-IHT patients. Patients with sepsis had a longer ICU stay, and those with ICH a longer hospital stay. Thus, receiving hospitals most likely to be financially disadvantaged by IHT patients are those which are designated to receive trauma patients and have a higher-level ICU or specialist neurosurgical services. These findings suggest that the nature and number of IHTs should be a determinant for funding and allocation of critical care resources. The disproportionately higher mortality of D IHT patients and the presence of regional variability highlight the importance of monitoring and evaluating IHT as a quality measure of any regional health service, particularly as it may be related solely to insufficient resources at the referring location. Measures that may prevent an IHT or, if it is not preventable, minimise the adverse consequences should be thoroughly evaluated and may be generalisable across regions. Examples of such measures include quality tools, such as incident monitoring, resource reallocation to areas with a high level of IHT activity, IHT supervision by senior experienced clinicians, use of transfer checklists, and telemedicine.

In summary, Australia and New Zealand IHT patients admitted directly to a tertiary-level ICU with multiple and head trauma, sepsis, respiratory infections, post-cardiac arrest and intracranial haemorrhage have higher intubation rates and hospital mortality, and longer stays than matched non-IHT patients admitted directly from the ED. There were regional variations for patient demographics, severity of illness and outcome. The occurrence of IHT should be monitored and reported as part of a regional health quality measure. Further evaluations of patient referral and transport factors and their relative contribution to patient outcomes would help tailor interventions to improve the appropriateness of IHT and patient outcome.
References


11. Cooper DJ, McDermott FT, Cordner SM, Tremayne AB. Quality assessment of the management of road traffic fatalities at a level 1 trauma centre compared with other hospitals in Victoria, Australia. J Trauma 1998;45:772-779.


18. Chalfin, Donald B., Trzeciak, Stephen, Likourezos, Antonios, Baumann, Brigitte M., Dellinger, R Phillip; Impact of delayed transfer of critically ill patients from the emergency department to the intensive care unit; Critical care Medicine; Volume 35(6), June 2007, pp 1477-1483.


Patients, age 16 years or older admitted to an Australian or New Zealand Intensive Care Unit 1st January 1994 to 31st December 2003 (n=356 455)

Excluded - Hospital or ICU source of admission missing
n= 24 446 (6.9%)

Admitted to a Tertiary level Intensive Care Unit
n= 158 938 (47.9%)

Excluded – Source of ICU admission is the Operating Theatre, another ICU in the same hospital, chronic care facility or Ward
n = 104 953 (66%)

Intensive Care Unit Source of admission is the Emergency Department or another acute hospital
n = 53 985 (34%)

Excluded – Post operative diagnosis and diagnosis of “other” or “undefined”
n = 13 050 (24.2%)

Diagnostic Category is Non Operative
n = 40 925 (75.8%)

Excluded, missing values – Hospital outcome, n = 130 (0.4%)

Diagnostic Category is
Chronic Obstructive Pulmonary Disease
Respiratory Infection
Sepsis
Post Cardiac Arrest
Multiple Trauma (not post operative)
Head Injury (not post operative)
Intracranial Haemorrhage (not post operative)
Overdose
n = 28 882 (53.1%)
Figure 2. Intubation rates for IHT patients admitted to ICU via the ED and for patients in the DIHT and ED groups. Intubation rates varied significantly for all categories (p < 0.000), except cardiac arrest (p=0.173). From other hospital via ED, n=2846, Direct from other hospital (DIHT), n=9203, From ED (non IHT), n=16833
Table 1. Patient demographics, severity of illness and outcome measures according to tertiary intensive care unit source of admission

<table>
<thead>
<tr>
<th></th>
<th>ICU source of admission</th>
<th>Direct from other hospital (DIHT)</th>
<th>From emergency department (ED)</th>
<th>From other hospital via ED</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number</td>
<td></td>
<td>9203</td>
<td>16833</td>
<td>2846</td>
</tr>
<tr>
<td>Male sex</td>
<td></td>
<td>59.8%</td>
<td>60.8%</td>
<td>62.1%</td>
</tr>
<tr>
<td>Age in years (95% CI)</td>
<td></td>
<td>51.1 (50.7–51.5)</td>
<td>49.8 (49.5–50.1)</td>
<td>49.2 (48.5–50)</td>
</tr>
<tr>
<td>APACHE II score (95% CI)</td>
<td></td>
<td>18.8 (18.6–18.9)</td>
<td>16.7 (16.6–16.8)</td>
<td>16.7 (16.3–17)</td>
</tr>
<tr>
<td>Predicted risk of death (95% CI)</td>
<td></td>
<td>0.33 (0.32–0.33)</td>
<td>0.26 (0.26–0.26)</td>
<td>0.27 (0.26–0.28)</td>
</tr>
<tr>
<td>ICU stay in days* (IQR)</td>
<td></td>
<td>3 (1–8)</td>
<td>2 (1–4)</td>
<td>3 (1–7)</td>
</tr>
<tr>
<td>Hospital stay in days* (IQR)</td>
<td></td>
<td>9 (3–23)</td>
<td>7 (2–16)</td>
<td>10 (3–23)</td>
</tr>
<tr>
<td>Intubated*</td>
<td></td>
<td>81%</td>
<td>64%</td>
<td>70.6%</td>
</tr>
<tr>
<td>Hospital mortality*</td>
<td></td>
<td>27.9%</td>
<td>23.8%</td>
<td>24.4%</td>
</tr>
<tr>
<td>Discharge to other hospital*</td>
<td></td>
<td>25.3%</td>
<td>8.7%</td>
<td>14%</td>
</tr>
</tbody>
</table>

IQR = interquartile range. * P < 0.001 for comparisons across the DIHT, ED and other hospital via ED groups
<table>
<thead>
<tr>
<th>Diagnostic category</th>
<th>Number</th>
<th>Age (years) (95% CI)</th>
<th>Male sex</th>
<th>APACHE II score (95% CI)</th>
<th>Risk of death (95% CI)*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chronic obstructive pulmonary disease</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>DIHT group</td>
<td>519</td>
<td>66.4 (65.6–67.2)</td>
<td>52.4%</td>
<td>20.3 (19.7–20.9)</td>
<td>0.31 (0.30–0.33)</td>
</tr>
<tr>
<td>ED group</td>
<td>519</td>
<td>66.4 (65.6–67.2)</td>
<td>52.4%</td>
<td>19.7 (19.2–20.2)</td>
<td>0.29 (0.28–0.31)</td>
</tr>
<tr>
<td>Unmatched DIHT group</td>
<td>31</td>
<td>57.1 (52.3–61.9)</td>
<td>54.8%</td>
<td>13.7 (10.6–16.9)</td>
<td>0.19 (0.11–0.26)</td>
</tr>
<tr>
<td>Respiratory infection</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>DIHT group</td>
<td>954</td>
<td>58.4 (57.3–59.5)</td>
<td>61.1%</td>
<td>20.7 (20.2–21.3)</td>
<td>0.40 (0.38–0.41)</td>
</tr>
<tr>
<td>ED group</td>
<td>954</td>
<td>58.5 (57.4–59.6)</td>
<td>61.1%</td>
<td>20.6 (20.1–21.1)</td>
<td>0.40 (0.38–0.41)</td>
</tr>
<tr>
<td>Unmatched DIHT group</td>
<td>80</td>
<td>57.3 (53.4–61.3)</td>
<td>35%</td>
<td>16.4 (14.5–18.4)</td>
<td>0.29 (0.24–0.34)</td>
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<td>DIHT group</td>
<td>1420</td>
<td>58.7 (57.8–59.6)</td>
<td>53.8%</td>
<td>24.4 (23.9–24.9)</td>
<td>0.53 (0.51–0.54)</td>
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<tr>
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<td>58.5 (57.7–59.4)</td>
<td>53.8%</td>
<td>23.7 (23.3–24.2)</td>
<td>0.51 (0.50–0.53)</td>
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<tr>
<td>Unmatched DIHT group</td>
<td>49</td>
<td>64.9 (60.7–69)</td>
<td>34.7%</td>
<td>11.5 (10.5–12.4)</td>
<td>0.16 (0.14–0.18)</td>
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<td>Cardiac arrest</td>
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<td>DIHT group</td>
<td>816</td>
<td>63.2 (62.2–64.3)</td>
<td>62.4%</td>
<td>25.3 (24.7–25.9)</td>
<td>0.61 (0.59–0.62)</td>
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<tr>
<td>ED group</td>
<td>816</td>
<td>63.4 (62.4–64.4)</td>
<td>62.4%</td>
<td>24.8 (24.2–25.4)</td>
<td>0.60 (0.58–0.62)</td>
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<tr>
<td>Unmatched DIHT group</td>
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<td>57.7 (52–63.3)</td>
<td>39.1%</td>
<td>11.1 (9.7–12.5)</td>
<td>0.20 (0.17–0.23)</td>
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<tr>
<td>DIHT group</td>
<td>864</td>
<td>41.0 (39.8–42.3)</td>
<td>78.0%</td>
<td>12.9 (12.4–13.4)</td>
<td>0.09 (0.08–0.09)</td>
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<tr>
<td>ED group</td>
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<td>41.0 (39.8–42.3)</td>
<td>78.0%</td>
<td>12.7 (12.2–13.2)</td>
<td>0.08 (0.08–0.09)</td>
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<td>75</td>
<td>55.4 (51.9–59)</td>
<td>34.7%</td>
<td>21.3 (19.6–23)</td>
<td>0.21 (0.17–0.25)</td>
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<tr>
<td>DIHT</td>
<td>1097</td>
<td>35.8 (34.8–36.9)</td>
<td>79.2%</td>
<td>15.5 (15.1–16.0)</td>
<td>0.19 (0.18–0.20)</td>
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<td>ED group</td>
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<td>36.4 (35.3–37.3)</td>
<td>79.2%</td>
<td>15.6 (15.2–16.1)</td>
<td>0.20 (0.19–0.21)</td>
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<td>Unmatched DIHT group</td>
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<td>68.7 (65.1–72.3)</td>
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<td>0.22 (0.14–0.29)</td>
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<td>Intracranial haemorrhage</td>
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<tr>
<td>DIHT</td>
<td>1158</td>
<td>55.3 (54.5–56.2)</td>
<td>50.8%</td>
<td>20.4 (19.9–20.8)</td>
<td>0.54 (0.52–0.55)</td>
</tr>
<tr>
<td>ED group</td>
<td>1158</td>
<td>55.4 (54.6–56.3)</td>
<td>50.8%</td>
<td>20.2 (19.7–20.6)</td>
<td>0.53 (0.52–0.55)</td>
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<td>Unmatched DIHT group</td>
<td>134</td>
<td>55.1 (51.8–58.4)</td>
<td>46.3%</td>
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<td>0.31 (0.28–0.33)</td>
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<tr>
<td>Overdose</td>
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</tr>
<tr>
<td>DIHT group</td>
<td>1209</td>
<td>37.7 (36.9–38.5)</td>
<td>53.3%</td>
<td>13.2 (12.7–13.6)</td>
<td>0.01 (0.013–0.017)</td>
</tr>
<tr>
<td>ED group</td>
<td>1209</td>
<td>37.7 (36.9–38.5)</td>
<td>53.3%</td>
<td>13.0 (12.6–13.5)</td>
<td>0.01 (0.012–0.015)</td>
</tr>
<tr>
<td>Unmatched DIHT group</td>
<td>37</td>
<td>71.3 (69–73.7)</td>
<td>59.5%</td>
<td>18.4 (15.3–21.4)</td>
<td>0.037 (0.014–0.060)</td>
</tr>
</tbody>
</table>

* Based on APACHE II.
Table 3. Hospital and ICU length of stay, outcome and standardised mortality ratio compared between the DIHT and matched ED groups

<table>
<thead>
<tr>
<th>Diagnostic category</th>
<th>Number</th>
<th>ICU stay (days) (IQR)</th>
<th>Hospital stay (days) (IQR)</th>
<th>Hospital mortality</th>
<th>Odds ratio (95% CI)*</th>
<th>Discharged to another hospital</th>
<th>Standardised mortality ratio</th>
</tr>
</thead>
<tbody>
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<td><strong>Chronic obstructive pulmonary disease</strong></td>
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<td></td>
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<tr>
<td>DIHT group</td>
<td>519</td>
<td>4 (2–8)</td>
<td>12 (7–19)</td>
<td>19.8%</td>
<td>0.85 (0.63–1.15)</td>
<td>28.3%</td>
<td>0.64 (0.60–0.66)</td>
</tr>
<tr>
<td>ED group</td>
<td>519</td>
<td>3 (1–7)</td>
<td>10 (6–17)</td>
<td>22.5%</td>
<td></td>
<td>10.8%</td>
<td>0.78 (0.73–0.80)</td>
</tr>
<tr>
<td><em>p</em></td>
<td>&lt; 0.001</td>
<td>0.05</td>
<td>0.29</td>
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<tr>
<td><strong>Respiratory infection</strong></td>
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</tr>
<tr>
<td>DIHT group</td>
<td>954</td>
<td>7 (3–12.5)</td>
<td>15 (8–25)</td>
<td>28.1%</td>
<td>1.66 (1.34–2.05)</td>
<td>25.5%</td>
<td>0.70 (0.69–0.74)</td>
</tr>
<tr>
<td>ED group</td>
<td>954</td>
<td>5 (2–11)</td>
<td>13 (7–24)</td>
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<td></td>
<td>6.3%</td>
<td>0.48 (0.47–0.50)</td>
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<tr>
<td><em>p</em></td>
<td>&lt; 0.001</td>
<td>0.92</td>
<td>&lt; 0.001</td>
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<tr>
<td><strong>Sepsis</strong></td>
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</tr>
<tr>
<td>DIHT group</td>
<td>1420</td>
<td>5 (2–11)</td>
<td>12 (4–27)</td>
<td>38.7%</td>
<td>1.57 (1.34–1.83)</td>
<td>25.1%</td>
<td>0.73 (0.72–0.76)</td>
</tr>
<tr>
<td>ED group</td>
<td>1420</td>
<td>3 (1–8)</td>
<td>14 (8–24)</td>
<td>28.7%</td>
<td></td>
<td>12.5%</td>
<td>0.56 (0.54–0.57)</td>
</tr>
<tr>
<td><em>p</em></td>
<td>&lt; 0.001</td>
<td>0.54</td>
<td>&lt; 0.001</td>
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<td><strong>Post-cardiac arrest</strong></td>
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<tr>
<td>DIHT group</td>
<td>816</td>
<td>2 (1–4)</td>
<td>4 (2–11)</td>
<td>59.3%</td>
<td>1.28 (1.06–1.56)</td>
<td>14.1%</td>
<td>0.97 (0.96–1.01)</td>
</tr>
<tr>
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<td>816</td>
<td>2 (1–5)</td>
<td>7 (3.5–15)</td>
<td>53.2%</td>
<td></td>
<td>12.8%</td>
<td>0.87 (0.86–0.92)</td>
</tr>
<tr>
<td><em>p</em></td>
<td>0.045</td>
<td>&lt; 0.001</td>
<td>0.01</td>
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<td><strong>Multiple trauma</strong></td>
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<tr>
<td>DIHT group</td>
<td>864</td>
<td>4 (1–11)</td>
<td>17 (7–44)</td>
<td>11.0%</td>
<td>2.3 (1.6–3.34)</td>
<td>26.3%</td>
<td>1.22 (1.21–1.38)</td>
</tr>
<tr>
<td>ED group</td>
<td>864</td>
<td>2 (1–6)</td>
<td>6 (1–20)</td>
<td>5.1%</td>
<td></td>
<td>34.1%</td>
<td>0.64 (0.57–0.66)</td>
</tr>
<tr>
<td><em>p</em></td>
<td>&lt; 0.001</td>
<td>&lt; 0.001</td>
<td>&lt; 0.001</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Head injury</strong></td>
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<td></td>
</tr>
<tr>
<td>DIHT group</td>
<td>1097</td>
<td>3 (1–8)</td>
<td>13 (5–27.5)</td>
<td>16.9%</td>
<td>1.28 (1.01–1.62)</td>
<td>32.1%</td>
<td>0.89 (0.85–0.94)</td>
</tr>
<tr>
<td>ED group</td>
<td>1097</td>
<td>3 (1–7)</td>
<td>10 (2–26)</td>
<td>13.7%</td>
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<td>27.0%</td>
<td>0.69 (0.65–0.72)</td>
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<tr>
<td><em>p</em></td>
<td>0.001</td>
<td>&lt; 0.001</td>
<td>0.04</td>
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<tr>
<td>DIHT group</td>
<td>1158</td>
<td>2 (1–6)</td>
<td>7 (2–23)</td>
<td>49.9%</td>
<td>1.34 (1.14–1.58)</td>
<td>21.7%</td>
<td>0.92 (0.91–0.96)</td>
</tr>
<tr>
<td>ED group</td>
<td>1158</td>
<td>2 (1–6)</td>
<td>10 (2–25)</td>
<td>42.6%</td>
<td></td>
<td>16.9%</td>
<td>0.80 (0.77–0.82)</td>
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<tr>
<td><em>p</em></td>
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<tr>
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<td>1 (1–2)</td>
<td>3 (1–6)</td>
<td>3.9%</td>
<td>1.09 (0.72–1.67)</td>
<td>26.4%</td>
<td>2.6 (2.3–3.0)</td>
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<tr>
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<td>1 (1–2)</td>
<td>2 (1–5)</td>
<td>3.6%</td>
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<td>38.8%</td>
<td>2.8 (2.4–3.0)</td>
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<td><em>p</em></td>
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<td>0.96</td>
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</table>

DIHT = direct interhospital transfer (patients admitted directly to intensive care unit after transfer from another hospital). ED = emergency department. QR = interquartile range. OR = odds ratio for mortality, DIHT group versus ED group. *p* values – refer to comparison of DIHT and ED groups.
Table 5. Patient demographics, severity of illness and hospital outcome for all patients within the DIHT group by location and diagnosis.

<table>
<thead>
<tr>
<th>ACT</th>
<th>NSW</th>
<th>NZ</th>
<th>QLD</th>
<th>SA</th>
<th>TAS</th>
<th>VIC</th>
<th>WA</th>
</tr>
</thead>
<tbody>
<tr>
<td>COPD</td>
<td>p=0.631</td>
<td>p=0.460</td>
<td>p=0.471</td>
<td>p=0.507</td>
<td></td>
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<tr>
<td>Respiratory Infection</td>
<td>169</td>
<td>167</td>
<td>13</td>
<td>199</td>
<td>12</td>
<td>58</td>
<td>38</td>
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<tr>
<td>Sepsis</td>
<td>55</td>
<td>547</td>
<td>53</td>
<td>233</td>
<td>19</td>
<td>104</td>
<td>89</td>
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<tr>
<td>Cardiac Arrest</td>
<td>57</td>
<td>260</td>
<td>21.5%</td>
<td>12</td>
<td>20</td>
<td>166</td>
<td>7.0%</td>
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<tr>
<td>Multiple Trauma</td>
<td>12</td>
<td>281</td>
<td>43</td>
<td>341</td>
<td>12</td>
<td>196</td>
<td>43</td>
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</table>

<table>
<thead>
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<th>ACT</th>
<th>NSW</th>
<th>NZ</th>
<th>QLD</th>
<th>SA</th>
<th>TAS</th>
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<th>WA</th>
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<tbody>
<tr>
<td>COPD</td>
<td>p=0.631</td>
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<td>233</td>
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<td>Cardiac Arrest</td>
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<td>22</td>
<td>136</td>
<td>8</td>
<td>196</td>
<td>46</td>
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<td>341</td>
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<td>Median (Min, Max)</td>
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<td>Head Injury</td>
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<td>28</td>
<td>36.4 (30.6, 42.1)</td>
<td>0.040</td>
<td>12.5 (9.9, 15.1)</td>
<td>0.13</td>
<td>14.3%</td>
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<td>373</td>
<td>37.3 (35.6, 39.1)</td>
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<td>15.0 (14.1, 15.8)</td>
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<td>16.6%</td>
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<td>92</td>
<td>34.2 (30.6, 37.8)</td>
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<td>15.7 (14.3, 17.2)</td>
<td>0.19</td>
<td>21.7%</td>
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<td>384</td>
<td>36.5 (34.7, 38.3)</td>
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<td>15.9 (15.1, 16.6)</td>
<td>0.20</td>
<td>15.4%</td>
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<td>34.4 (32.0, 36.9)</td>
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<td>16.2 (15.0, 17.3)</td>
<td>0.21</td>
<td>20.7%</td>
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<td>67</td>
<td>36.6 (32.4, 40.8)</td>
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<td>15.9 (14.3, 17.5)</td>
<td>0.19</td>
<td>11.9%</td>
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<td>87</td>
<td>42.4 (38.3, 46.4)</td>
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<td>15.5 (13.7, 17.3)</td>
<td>0.19</td>
<td>17.2%</td>
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<tr>
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<td>37.4 (30.9, 43.9)</td>
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<td>14.3 (11.5, 17.1)</td>
<td>0.16</td>
<td>14.8%</td>
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</tr>
<tr>
<td></td>
<td>53</td>
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<td>16.7 (14.6, 18.8)</td>
<td>0.50</td>
<td>45.3%</td>
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<td>445</td>
<td>57.5 (56.2, 59.0)</td>
<td>0.002</td>
<td>19.4 (18.6, 20.1)</td>
<td>0.49</td>
<td>50.6%</td>
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<td>93</td>
<td>50.0 (46.8, 53.2)</td>
<td>0.001</td>
<td>18.8 (17.2, 20.4)</td>
<td>0.49</td>
<td>43.0%</td>
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<tr>
<td></td>
<td>256</td>
<td>53.9 (52.0, 55.7)</td>
<td></td>
<td>19.0 (17.9, 20.1)</td>
<td>0.49</td>
<td>35.5%</td>
<td></td>
</tr>
<tr>
<td></td>
<td>192</td>
<td>54.2 (51.9, 56.6)</td>
<td></td>
<td>20.5 (19.3, 21.7)</td>
<td>0.54</td>
<td>58.9%</td>
<td></td>
</tr>
<tr>
<td></td>
<td>76</td>
<td>54.7 (51.2, 58.2)</td>
<td></td>
<td>19.4 (17.8, 21.0)</td>
<td>0.51</td>
<td>36.8%</td>
<td></td>
</tr>
<tr>
<td></td>
<td>171</td>
<td>55.0 (52.7, 57.3)</td>
<td></td>
<td>21.6 (20.5, 22.7)</td>
<td>0.58</td>
<td>48.0%</td>
<td></td>
</tr>
<tr>
<td></td>
<td>64</td>
<td>54.8 (50.8, 58.8)</td>
<td></td>
<td>18.6 (17.1, 20.1)</td>
<td>0.48</td>
<td>39.1%</td>
<td></td>
</tr>
<tr>
<td>Overdose</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>28</td>
<td>42.1 (35.8, 48.4)</td>
<td>&lt;0.000</td>
<td>10.8 (7.9, 13.8)</td>
<td>0.02</td>
<td>7.1%</td>
<td></td>
</tr>
<tr>
<td></td>
<td>390</td>
<td>41.2 (39.7, 42.9)</td>
<td>&lt;0.000</td>
<td>13.5 (12.7, 14.3)</td>
<td>0.02</td>
<td>3.6%</td>
<td></td>
</tr>
<tr>
<td></td>
<td>12</td>
<td>34.1 (24.4, 43.8)</td>
<td>0.235</td>
<td>10.6 (4.6, 16.5)</td>
<td>0.01</td>
<td>0%</td>
<td></td>
</tr>
<tr>
<td></td>
<td>313</td>
<td>36.3 (34.9, 37.8)</td>
<td>0.820</td>
<td>10.8 (10.0, 11.6)</td>
<td>0.01</td>
<td>2.9%</td>
<td></td>
</tr>
<tr>
<td></td>
<td>282</td>
<td>39.2 (37.4, 40.9)</td>
<td></td>
<td>15.5 (14.6, 16.5)</td>
<td>0.02</td>
<td>4.6%</td>
<td></td>
</tr>
<tr>
<td></td>
<td>4</td>
<td>38.7 (28.4, 48.9)</td>
<td></td>
<td>15.0 (1.0, 33.0)</td>
<td>0.03</td>
<td>0%</td>
<td></td>
</tr>
<tr>
<td></td>
<td>140</td>
<td>38.5 (36.0, 41.1)</td>
<td></td>
<td>13.5 (12.3, 14.8)</td>
<td>0.02</td>
<td>5.0%</td>
<td></td>
</tr>
<tr>
<td></td>
<td>117</td>
<td>34.9 (32.8, 37.0)</td>
<td></td>
<td>14.5 (13.3, 15.7)</td>
<td>0.01</td>
<td>5.1%</td>
<td></td>
</tr>
</tbody>
</table>
Section 19
CURRICULUM VITAE

Dr Athanasios (Arthas) Flabouris
MBBS, FANZCA, FJFICM, PGDipAviatMed, PGDipEcho

CONTACT DETAILS

ADDRESS :

DATE OF BIRTH :

TELEPHONE :

E-MAIL: Arthas.Flabouris@health.sa.gov.au

LANGUAGES : English - spoken and written
Greek - spoken and written

EDUCATION

1985 Bachelor of Medicine, Bachelor of Surgery, University of Adelaide,
1988 Basic and Advanced Training course in Diving and Hyperbaric Medicine.
Oct 1990 & 1998 Early Management in Severe Trauma Course
1994 Fellow Australian and New Zealand College of Anaesthetist
1994 - 1998 Postgraduate Diploma in Aviation Medicine, University of Otago
1996 Fellow of the Faculty of Intensive Care Australian and New Zealand College of Anaesthetist (FFICANZCA) later to be the Joint Faculty of Intensive Care Medicine (FJFICM)
1997 & 2004 Major Incident Medical Management and Support Course
2004 Postgraduate Diploma in Perioperative and Critical Care Echocardiography, University of Melbourne
2005 Major Incident Medical Management and Support Instructor’s course
PREVIOUS EMPLOYMENT / PROFESSIONAL EXPERIENCE

1986 - 1991 Lecturer and Examiner (Basic and Advance Life Support) for the St John Ambulance Service South Australia

1984 - May 1996 Medical Officer for the St John Ambulance Australia Operations Branch, South Australia. Duties included: lecturing, examining, curriculum and protocol development for basic and advance First Aid and ALS, administrative and participatory activities for major public events. Medical Officer in the First Intervention Vehicles for the Australian Grand Prix over a number of occasions


Aug 1993 - Jan 1995 Intensive Care Registrar, Royal Adelaide Hospital

Feb 1995 - Jan 1996 Paediatric Intensive Care Registrar, Adelaide Women's and Children's Hospital

Feb 1996 – July 1996 Coronary Care Unit Registrar, Flinders Medical Centre

July 1996 – Jan 1997 Clinical Fellow in Retrieval Medicine at NSW Medical Retrieval Services, Care Flight

July 1996 – Jan 1997 Locum Staff Specialist in Intensive Care, Nepean Hospital, New South Wales

Feb 1997 – Jan 1998 Staff Specialist in Intensive Care and Anaesthesia, Intensive Care Unit, Wellington Hospital, Wellington, New Zealand. Conjoint appointment with the University of Otago, Wellington Medical School.

Feb 1997 – Jan 1998 Medical Director for The Life Flight Trust Air Ambulance and Rescue Service, Wellington, New Zealand. Provided medical oversight to the activities of that retrieval service, including training of medical, nursing and paramedical staff, staff at referring rural hospitals and other emergency services, in particular Maritime Search and Rescue. Reported to the Board of the Life Flight Trust. This position provided a unique opportunity to interact closely with the aviation component of retrieval to deal with circumstances unique to the local changing and challenging environment.

May 1999 & 2001 Participation in NSW Fire Ambulance Urban Search And Rescue training exercise and NSW Fire Brigade Heat Appreciation and Breathing Apparatus training sessions. Also prepared and gave presentation on related clinical topics to the course linked to that training.
Sept 2000 Medical Team leader, NSW Department of Health Disaster Response Team at the 2000 Sydney Olympic Games

Feb 1998 – Sept 2003 Staff Specialist (0.8 Full Time Equivalent (FTE)) and Supervisor of Training in Intensive Care at the Liverpool Health Service, NSW. Conjoint appointment with the University of NSW, Medical School. Involved with all aspects of clinical intensive care, management responsibilities to the ICU, particularly registrar recruitment, training and evaluation, quality and research. Also to hospital Trauma Committee.

Feb 1998 – Sept 2003. Staff Specialist (0.8 Full Time Equivalent (FTE)) and Supervisor of Training in Intensive Care (0.25 FTE) at the NRMA Care Flight, NSW Medical Retrieval Service, Sydney, NSW. Involved with many aspects of retrieval including search and rescue, primary scene response, interhospital and missions to mass casualties. Responsible for registrar recruitment, training and evaluation, quality, data management, research and service accreditation for training by the Australian and New Zealand College of Anaesthetists, Faculty of Intensive care and College of Emergency Medicine.

April 2001 – Sept 2003. Deputy Medical Director within the NSW Medical Retrieval Unit. Member of the NSW State Retrieval Committee, retrieval clinical representative to the NSW Health Critical Care Telemedicine Research Project Working group and the NSW Trauma Death Review Committee. Responsible for triage of requests for patient transport (including medical and nurse only patient transports), ICU “bed finding” and bed availability role, determination of appropriateness of retrieval requests, timely allocation and tasking of required retrieval and assets (some assets shared by both adult and paediatric retrieval as well as rural based assets), pre transport and in transit clinical advice and support, in particular to rural and remote medical, nursing and paramedical staff, inter organisational communication and co-ordination of such communication using a recorded conference call system and dispute resolution in relation to retrieval activity across the state of NSW and the ACT.

July 1998 - Present Evacuation Consultant for Customer Care Travel Assistance, CoverMore Insurance. Responsibilities involve remote on call consultation to overseas travellers who become sick or injured. Involves remote patient clinical evaluation, evaluation of appropriateness of local health facilities organisation of medical evacuation where applicable.

Oct 2003 - Present Staff Specialist, Intensive Care Unit, Royal Adelaide Hospital and the Royal Adelaide Hospital MediFlight, Medical Retrieval Service Clinical Senior Lecturer, Department of Anaesthesia and Intensive Care, University of Adelaide. Involved with all aspects of clinical intensive
care, management responsibilities to the ICU, audit, quality, research and educational activities. Also to hospital Trauma Committee and Medical Emergency Response Management Committee. Involved retrieval medicine, including scene, interhospital and mass casualty responses. University involvement includes membership on the Year 2 Medicine Curriculum and Examination Committee, Facilitator for Year 5 and Year 6 placements and assessments in Intensive Care, Year 5 Examination setting workshops.

OTHER CURRENT CLINICAL AND ACADEMIC RESPONSIBILITIES

Member of the Joint Faculty of Intensive Care Medicine Fellowship Examination committee. Examiner for the Fellowship examination.

Deputy Chairperson of the Joint Faculty of Intensive Care Medicine Primary Examination committee. Examiner for the Primary examination.

Chair of the Royal Australasian College of Surgeons Trauma Verification Committee.

Faculty of Intensive Care and Australian and New Zealand College of Anaesthetist representative to the Royal Australasian College of Surgeons, Trauma Committee.

Member of the Adelaide University Medical School Year 2 Curriculum Committee

RESEARCH PROJECTS COMPLETED AND IN PROGRESS

Degeling PJ, Iedema RAM, Hillman KM, Flabouris A, Dickson H. A project to develop interventions to overcome the limits of medicine in managing the dying process in acute care hospitals Conjoint project between the Centre for Hospital Management and Information Systems Research University of New South Wales, the Simpson Centre for Hospital Innovations and the Liverpool Health Service. [http://www.med.unsw.edu.au/clingov/Manage.htm](http://www.med.unsw.edu.au/clingov/Manage.htm) ARC grant approval (C001 06896) of $210 K

ANZICS Clinical Trials Group and the Simpson Centre for Health Services Research Innovation. **MERIT - Medical Early Response Intervention and Therapy : a cluster randomised control clinical trial.** Member of the study Management Team. Provided many project updates at the twice yearly ANZICS Clinical Trials Group meetings. Project received approval for a NHMRC grant for $525 K in November 2001 (application ID number 209578).

Chief Investigator for the project **Pilot Retrieval Incident Monitoring Study.** Australian Rotary and Research Foundation grant of $11K. Following on from this project, development of the Patient Safety International AIMS Pre Hospital and Retrieval Healthcare Incident Type classification for incident monitoring within the pre hospital and retrieval environment.

Liverpool Hospital Brain Injury Rehabilitation Unit & Liverpool Hospital Intensive Care Unit. **The value of Intensive Care Unit (ICU) assessments in long-term outcome of brain injury patients**
Design of concept, patent of and prototype development of a non invasive ventilatory device for out of hospital patient transportation. Support from Unisearch (now NewSouth Innovations Pty Ltd) on behalf of the University of New South Wales, Sydney, Australia.

Analysis of data from the Australian and New Zealand Intensive Care Society Adult Patient database for the description of the number and nature of interhospital patient transfers that are admitted to participating ICUs and their comparison with non transferred, emergency, admissions. Conjoint project with the ANZICS ARCCR.

Chief Investigator for the project Review of Retrieval Services for the Critically Ill in Australia and New Zealand. Project in conjunction with the Australian and New Zealand Intensive Care Society Critical Care Resources Committee. Funding of $ 60 K from the Intensive Care Foundation (2004). Conjoint project with the ANZICS Research Centre for Critical Care Resources.

In conjunction with the School of Psychology, University of Adelaide, a study of organisational culture & its relationship to patient safety & quality improvement within health care. Specifically focused on investigating organizational culture as it relates Intensive Care practice in relation to withdrawal of therapy and patient handover. Part of research thesis of Stacey Panozzo.

In conjunction with investigators from the School of Nursing and Midwifery, Flinders University, Investigator for the project entitled Improving triage and scene assessment in Road Trauma: A pilot study. Awaiting outcome of Motor Accident Commission grant application.

Principle Investigator at the Royal Adelaide Hospital for the ANZICS Clinical Trials Group RENAL study.

Investigator for the following projects at the Royal Adelaide Hospital –

Impact of Key Performance Indicators of the Medical Emergency Team system to reduce serious adverse events.

Evaluation of the effect of Emergency Department length of stay on hospital morbidity and mortality for critically ill patients.

RELEVANT PUBLICATIONS / PRESENTATIONS

PUBLICATIONS – Original Research


2. Flabouris A "Ethnicity and proficiency in English as factors affecting Community CPR instruction attendance" Resuscitation 1996;32:95-103


32. Cretikos M, Chen J, Hillman K, Bellomo R, Finfer S, Flabouris A, and the MERIT study investigators. The effectiveness of MET system implementation and factors associated with the
level of MET utilisation during the MERIT study. Critical Care & Resuscitation. 2007;9:206-12

33. Chen J, Bellomo R, Flabouris A, Hillman K, Finfer SR and the MERIT study investigators. Relationship between Pre-emptive Emergency Team Activity and Serious Adverse Events - A Post-hoc Analysis of the MERIT Study Data. Accepted for publication in Critical Care Medicine


40. Chen J, Flabouris A, Bellomo R, Hillman K, Finfer S and The MERIT Study Investigators. The Medical Emergency Team System and Not-for-Resuscitation Orders: Results from the MERIT Study. Accepted by the journal Resuscitation

41. Chen J, Hillman K, Bellomo R, Flabouris A, Finfer S, Cretikos M and the MERIT study investigators for the Simpson Centre and the ANZICS Clinical Trials Group The Impact of Introducing Medical Emergency Teams on the Documentations of Vital Signs. Accepted for publication by Resuscitation

PUBLICATIONS – Invited Reviews


7. Contributor to the Handbook of Trauma Care, The Liverpool Hospital Trauma Manual 6th Ed. The following chapters “Primary survey” “Adjuncts to Primary survey” “MAST suit removal” and “Arterial lines”


**PRESENTATIONS – Original work**

(when multiple authors, presenting author is underlined)

1. Flabouris A. "Teaching Cardiopulmonary Resuscitation in a Multicultural Society" at the Spark of Life International Conference on Cardiopulmonary Resuscitation, April 1993 Melbourne, Australia

2. Flabouris A "Cardiac Arrests, where are the First Aiders and what influence does age have?" Presented at the Spark of Life International Conference on Cardiopulmonary Resuscitation, Sept 1996

3. Flabouris A "Who are our public First Aiders?" Presented at the Spark of Life International Conference on Cardiopulmonary Resuscitation, Sept 1996

4. Flabouris A, Myburgh J "The Diagnostic Utility of the Open Lung Biopsy in Patients Requiring Mechanical Ventilation" Presented at the 21st ANZICS meeting held in Melbourne, October 1996
5. Flabouris A. “The Referral and Transportation of Patients to a Tertiary ICU - Patient Demographics, Severity of Illness and a Measure of Selective Increased Mortality” Presentation at the International Society of Aeromedical Services Conference in Sydney, November 1997


12. Flabouris A “Diagnosis of the Dying Patient” Presentation at the Acute Hospital Outcome Indicators Session of the Health Outcomes for the Nation: Best Bets and Best Buys Conference. Aug 2000, Canberra, Australia

13. Flabouris A “Critical Incidents in Retrieval and Disaster Medicine” Presentation at the ANZCA and FICANZCA Combined Scientific Meeting 2001, May, Hong Kong

14. Flabouris A “The Nature and impact of adverse and positive incidents occurring during interhospital patient transportation” Presentation at the ANZCA and FICANZCA Combined Scientific Meeting 2001, May, Hong Kong


16. Sugrue M, Armours S, Flabouris A, Giles A. The feasibility and implementation of a multi-disciplinary, web-inclusive trauma orientation and evaluation package at a major trauma service and teaching hospital. Presented at the 2001 RACS Congress, Canberra, Australia


19. Flabouris A, Hart G. “Interhospital patient transfers admitted to ICU - Demographics and Outcomes” Oral and poster presentation at the Australian and New Zealand Intensive Care Society Annual Scientific Meeting, Hobart, Tasmania, October 2006

20. Flabouris A, Hart G. “Interhospital patient transfers admitted to ICU - Regional variation and trends over time” Oral and poster presentation at the Australian and New Zealand Intensive Care Society Annual Scientific Meeting, Hobart, Tasmania, October 2006


PRESENTATIONS - Invited


2. Chairperson for the Symposium session “Resuscitation in Disasters” at the 10th World Congress in Disaster and Emergency Medicine, in Mainz, Germany, September 1997

3. Flabouris A. “Interhospital Transportation of patients with Spinal Injuries” Presentation at the SWAN VII Trauma Seminar, Liverpool, NSW, August 1999
4. Flabouris A “Independent Lung Ventilation in the ICU for Trauma Patients” Presentation at the SWAN VIII Trauma Seminar, Liverpool, NSW, August 1999


18. Flabouris A. “Assessing the role of Medical Retrieval in Catastrophic Injury” presentation at the Catastrophic Injury Conference, 26th November 2002, Sydney, NSW


22. Flavouris A. Medical Retrieval as part of the mass casualty response. Invited presentation at the Australian Institute of Medical Scientists 2008 National Scientific Meeting. 14th Oct 2008, Melbourne, Australia

OTHER INSTRUCTIONAL COURSES ATTENDED


Hewlett Packard Trans Oesophageal Echocardiogram Course. Sydney, June 1998


NSW Health selection technique for divisional directors (June 2000)

SWASAHS Grievance and discipline workshop (Nov 2000)

SWASAHS Child Protection Training workshop (Aug 2001)

Teaching on the run. LEAP. Adelaide April 2005

Introduction to expert witness training programme. LEAP Adelaide. May 2005

Australian Centre For Clinical Leadership; Strategic Thinking enhancement Program for Specialists (STEPS) STEPS for Leadership Workshop, Gold Coast, Queensland, November 2006

PERSONAL INTERESTS

Soccer – playing for the Comets Soccer Club, Amateur and Masters League. Also coaching junior soccer (holder of Football Federation South Australia Junior, Youth and Youth Goalkeeper Soccer licence).

Camping and bushwalking

Generally, supporting an active family.