A Clinical Model For Health Services Research—The Medical Emergency Team

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Health Services Research (HSR) is a relatively recent discipline which describes how health care delivery occurs and the evaluation of that care. The implementation of a Medical Emergency Team (MET) is an example of a health service intervention. The aim of the MET is to extend the expertise of Intensive Care across the hospital to all at-risk patients. The MET criteria for calling are based on simple abnormalities in vital signs with an extra "worried" category to empower junior medical and nursing staff to call for help. The concept is based on early intervention and resuscitation of the seriously ill, hopefully leading to improved outcomes from intensive care and perhaps even avoiding admission to an intensive care unit. The problems of implementing major health service change and evaluating the effectiveness of that change presents a different challenge to evaluating a new drug or procedure and is approached within different research frameworks.

HEALTH SERVICES RESEARCH (HSR) is a relatively new field of inquiry, producing new knowledge about the way health services are delivered and the outcome of delivering those services.[1-2]

Research in Critical Care has, until recently, been mainly based on laboratory and clinical models. However, there are exciting possibilities as well as challenges for using HSR in Critical Care. Below is a model which demonstrates some of the challenges of using HSR in Critical Care and ways in which research methodologies associated with HSR can be used to address questions about the care of the seriously ill.

BACKGROUND

Many of the published studies in Critical Care Medicine are based on the evaluation of drugs and procedures. However, patient outcome is also associated with the health service configuration of intensive care units (ICUs) and the hospital environment in which they sit.

For example, patients with ready access to ICU resources, admitted to a 30-bed ICU in a 100-bed hospital, may have a better outcome than if their admission was delayed as a result of the hospital having a 6-bed ICU serving a 1,000-bed hospital. Patients admitted to the latter ICU would probably have severe and possibly end-stage multiorgan failure before they were deemed ill enough to deserve an intensive care bed.

Moreover, patients admitted to the hypothetical 6-bed ICU may have had delayed admission to ICU because of limited bed numbers. Many patients admitted to the ICU have suffered suboptimal treatment before their admission[3-5] and this delay contributes to a poor outcome. In some of Knaus's early work on prognostication, the delay was called "lead time bias"[6] –the authors recognized that delayed admission may affect outcome, but that in terms of the APACHE severity of illness index, it was difficult to quantify.

In patients suffering in-hospital cardiorespiratory arrest, up to 80% suffered severe physiological deterioration in the hours before their arrest.[3,7,8] Similar antecedents and deterioration in the patient's condition have been found before hospital deaths and before admission to the ICU from general wards.[3,5,9] In a wider perspective, there are reports of large numbers of potentially preventable acute hospital deaths.[10,11]

Reasons for delay in resuscitating in-hospital patients are many and include the lack of early recognition of the seriously ill; failure to engage nursing observations with a rapid medical response; failure of undergraduate and postgraduate medicine to teach advances in acute medicine; and the limitations of advanced resuscitation skills within a hospital to areas such as the ICU and Emergency Departments. These factors may have an impact on patient outcome as profound as the drugs and procedures used to treat patients in the ICU, but the level of research on these factors has been, up until now, limited.

The current system in acute hospitals for managing the seriously ill is similar to the management of serious trauma before it was standardized and

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coordinated. Up until about 15 years ago, seriously ill trauma patients were transported to the nearest hospital, and treated by relatively junior and untrained medical staff without much in the way of standardization. Nowadays, at-risk trauma patients are identified at the roadside by triage criteria; transported by trained personnel to the nearest hospital, capable of managing major trauma; a trauma team then manages care according to priorities and protocols. A similar approach to managing the seriously ill within a hospital seemed logical and the evaluation of the reconfiguration of a system designed to recognise and resuscitate patients earlier is a challenge for HSR.

Implementing Change in Health Service Delivery

In an attempt to implement such a system, the first and probably most difficult challenge was to move outside the walls of the ICU, across geographical, functional and professional silos.[12] Being Intensive Care clinicians, we have had little, if any, formal training or skills in areas such as change management, nor how to develop systems, as opposed to delivering individual patient care.

Initially we met with our clinical colleagues and presented some of our data on poor patient outcome as a result of delayed treatment and suggested we had a problem with hospital-wide patient care; at the same time trying not to offend or threaten them. We were planning to offer them a new service, based on the existing cardiac arrest team, but instituting treatment before the patient actually had an arrest. Clinicians responsible for patient care would be contacted immediately AFTER the team had resuscitated their patient, just as with a cardiac arrest team. The Medical Emergency Team (MET), as it became known, would then collaborate with the specialist-in-charge to formulate a future plan. The "carrot" was a rapid and well-informed service, operated from the ICU, without the specialist losing control of their patient: the "stick" or alternative was the prospect of compulsory and urgent attendance by the specialist-in-charge of the patient. Obviously this was an inconvenient and sometimes impossible obligation.

Our first research involved defining the characteristics of an at-risk patient or the calling criteria for the MET. We started with over 30 criteria and eventually reduced it to 8 (Table 1). These criteria are measured or observed by attending nursing staff even in the most basic general ward of the smallest acute hospital. Interestingly, the "worried" criterion became the most accessible tool for the junior medical and nursing staff, who were now empowered to call a MET whenever they were concerned about a patient. Nursing staff, in particular, often commented, that before the introduction of the MET, when they were "just not happy with a patient." However, they had no way of negotiating with a rigid medical hierarchy in order to convey those concerns.

Table 1. MET Calling Criteria

Airway	Threatened
Breathing	All respiratory arrests
	Respiratory rate <5 breaths/min
	Respiratory rate >36 breaths/min
Circulation	All cardiac arrests
	Pulse rate <40 breaths/min
	Pulse rate >140 breaths/min
	Systolic blood pressure <90 mm Hg
Neurology	Sudden fall in level of consciousness (Fall in GCS of >2 points)
	Repeated or prolonged seizures.
Other	Any patient who you are seriously worried about that does not fit the above criteria.

The MET was similar to the usual referral pattern in a hospital: when one specialist asks another for an opinion. However, the referral response had to be within minutes not days, as the patient was at-risk of serious complications or death. Therefore, the usual formal written request and delays were circumvented by a direct MET call to Intensive Care staff–the same mechanism and response time, used to call a cardiac arrest team.

Changing the culture of the whole organisation was essential as this was a hospital-wide system potentially involving all staff. Members of the MET were asked not to abuse nursing staff because they had called earlier than everyone was accustomed and before the patient had arrested or died. As with any formal consultation between hospital clinicians, they had to thank the staff for being alert enough to call on their expertise early in order to optimize the patient's outcome. The same questions came up all the time–such as "won't this system de-skill staff in the wards"; to which we replied, "the staff in the wards was never formally skilled in managing all aspects of acute resuscitation." Intensive Care Medicine is a new and sepa-

Table 2. MET Outcome Indicators

Unexpected deaths	=	All deaths − NFR patients
Unexpected cardiac arrests	=	All cardiac arrests − NFR patients
Unanticipated ICU admissions	=	All ICU admissions- (ED + OR referrals)

NOTE. Potentially preventable event = Those patients in the above 3 categories where a MET criteria was present within 24 hours of the event but where a MET call did not occur.

Abbreviations: NFR, not for resuscitation; ICU, intensive care unit; ED, emergency department; OR, operating rooms.

rate specialty, which in some countries requires 5 years of postgraduate training to become a specialist. It has its own societies, textbooks and journals. Just because many of us managed the seriously ill on the wards when we were junior doctors, it did not necessarily follow that we had the appropriate training and skills.

The Health Service gradually changed. Acceptance, especially by nursing staff at the bedside, was universal. Junior medical and nursing staff had access to a rapid response team for patients that they were concerned about.

MONITORING THE HEALTH SERVICE CHANGE

To reinforce the robustness and sustainability of the MET concept, a system for monitoring its effectiveness was instituted.[13] We believed the key was to collect information that would empower direct health deliverers to monitor and change their own system. At the same time it had to avoid any implication of checking or controlling.

We developed 3 major outcome indicators that would monitor the effectiveness of the MET system: cardiac arrests; deaths; and admissions to the ICU (Table 2). The major aim of the MET system was to prevent these serious complications. The clinical notes were examined for any mention of a not-for resuscitation (NFR) order in all patients who had died or suffered a cardiorespiratory arrest. Data on these patients were analysed separately, as the MET system was not designed to intervene in terminally ill patients.

For patients admitted to the ICU, we excluded all patients who came from an environment where they were already being monitored in a "ideal" way, in terms of staff and equipment. For example, the patients in operating rooms (OR) and Emergency Departments (EDs) were excluded as they would not potentially benefit from a MET system and this left mainly patients from general wards who were classified as "*unanticipated admission to the ICU*."

Patients who had suffered a death, cardiac arrest or who were considered an unanticipated admission to the ICU, were then considered "*potentially preventable*" if there were any MET criteria (Table 1) in the clinical notes within 24 hours of any of the 3 events, but where NO MET call had occurred.

Data on all 3 adverse events and whether they were considered potentially preventable is then sent to all clinicians involved in the direct care of the patient. No further action is taken by the MET System. It is left entirely in the hands of the clinicians to review their own system, examine the possible reasons for delayed resuscitation and hopefully implement improved systems. The data is de-identified and aggregated and given to Departments and Divisions within the hospital as well as the Hospital Executive. The data is also used as a quality outcome tool which is monitored every month, with data being presented in such a way that it can be compared to information in the same period of the previous month and year.

The monitoring and feedback of information related to these 3 serious patient outcomes reinforces the aim of the MET System as well as providing a tool for clinicians to improve their own system.

The words "unexpected," "unanticipated," and "potentially preventable" are deliberately chosen as "loaded" words to attract attention of clinicians responsible for patient care.

An unexpected result of introducing a MET system was the increased number of patients designated with a formal "NFR" order. Perhaps this occurred in order to avoid the numbers of "unexpected" and "unanticipated" cases, as patients with explicit "NFR" orders in the clinical notes of patients excluded from further analysis. This has now been taken one step further in some patients where they are designated "not for MET" or "NF-MET." In many cases NF-MET is a way of making a diagnosis of dying, whereas NFR infers that everything is being done, but in the event of a cardiac arrest, resuscitation would not occur. Thus, the implementation of a new system facilitated discussion for further change in clinical practise and new opportunities for research.

EVALUATING HEALTH SERVICE CHANGE

Research in health services is different from other forms of clinical research, where the intervention is often a new drug or procedure: HSR evaluates a new and sometimes complex system. The development of a new service is somewhat akin to the development of the new drug, eg, chemical development, animal experiments, and various phases of human experiments. In the case of evaluating the MET System, we initially evaluated various components such as the validity of the criteria and the impact on the institution and patients.[14-16] We studied the antecedents to serious events,[3,9] followed by a prospective study comparing a MET hospital against control hospitals.[3] The development of the MET system was similar to the development phase of a new drug, followed by the final testing in a clinical environment. Initial studies have shown a significant decrease in deaths, cardiorespiratory arrests and unexpected admissions to the ICU.[3,8]

Given the limitations of the before-after and the nonrandomised controlled trial design involving very few hospitals, we are now embarking on a multicenter cluster controlled study throughout Australia to study the effect of a MET intervention. The study is supported by the national research body–National Health and Medical Research Council (NHMRC) as well as State and Commonwealth Governments and co-ordinated by the Simpson Centre for Health Services Research and the Clinical Trials Group (CTG) of the Australian and New Zealand Intensive Care Society (ANZICS).

The framework for sample size determination was based on incidence rates of cardiac arrests, deaths and admissions to the ICU from general hospital wards; average hospital admission rates; and assuming a reduction of 30% in the 3 primary outcomes. A stratified block randomization based primarily on hospital status (eg, tertiary referral) was used, with bed numbers in each hospital as a blocking factor.

The cluster randomization methodology lends itself to testing health system interventions across institutions where individual patient randomization is not possible. There are also new and interesting challenges. For example, the implementation strategy for the MET system was standardized for the purposes of the study. However, it is not possible to standardize the factors that make some organizational cultures more receptive to change than others. It is also difficult to measure the culture of an organization and relate it to the success or otherwise of implementing a new hospital-wide system such as the MET concept. These challenges touch on the differences between effectiveness and efficacy in evaluating interventions. Future HSR may help us to understand factors that may influence generalisability of health interventions.

IMPLICATIONS OF HSR FOR CRITICAL CARE

The research we are conducting in regard to the MET is conceptualised and driven by clinicians. Even if health administrators could conceive of a system such as the MET, they would be unlikely to succeed in implementing it.

While clinicians are the key to this type of HSR, we have learnt to respect and rely on the skills of other researchers, such as social scientists, linguistic experts and medical anthropologists, looking at the cultural aspects of implementation of the system; health informatics experts advising us on how to effectively market information; and high level statisticians, designing complex research methodology.

Research in Intensive Care to find the Holy Grail in the form of a chemical "magical bullet" will obviously still occur. However re-engineering the way we deliver our care can also potentially improve patient outcomes. Data from initial studies on the MET, indicate that we may potentially prevent thousands of patients dying, having cardiac arrests and being admitted to ICUs. These are not, the sometimes marginal improvements, that we often see with some new drugs. If the MET System was a drug it may, even at this early stage in its evaluation, be the subject of major stock market speculation.

HSR is an exciting and relatively new area of Critical Care Research, where we are challenged to reallocate existing resources and redesign ways of delivering health care and evaluating the impact, using different methodologies and working with others who have different and complimentary skills.

REFERENCES

1. Lomas J: Health Services Research: A domain where disciplines and decision makers meet, in Sibbald WJ, Bion JF (eds): Evaluating Critical Care. Using Health Services Research to Improve Quality. Berlin, Springer Verlag, 2001, pp 6-19

2. Navarro V: Health services research: What is it? Int J Health Serv Plan Admin Eval 23:1-13, 1993

3. Bristow PJ, Hillman KM, Chey T, et al: Rates of in-hospital arrests, deaths and intensive care admissions: The effect of a medical emergency team. Med J Aust 173:236-240, 2000

4. Goldhill DR, Sumner A: Outcome of intensive care patients in a group of British Intensive Care Units. Crit Care Med 26:1337-1345, 1998

5. McQuillan P, Pilkington S, Allan A, et al: Confidential inquiry into quality of care before admission to an intensive care. Brit Med J 316:1853-1858, 1998

6. Dragsted L, Jorgensen J, Jenmsen N-H: Interhospital comparisons of patient outcome from intensive care: Importance of lead-time bias. Crit Care Med 17:418-422, 1989

7. Schein RM, Hazday N, Pena M, et al: Clinical antecedents to in-hospital cardiopulmonary arrest. Chest 98:1388-1392, 1990

8. Buist M, Moore G, Bernard S, et al: Effects of a medical emergency team on reduction of incidence and mortality from unexpected cardiac arrests: Preliminary study. BMJ 324:387-390, 2002

9. Hillman KM, Bristow PJ, Chey T, et al: Antecedents to hospital deaths. Internal Med J 31:343-348, 2001

10. Brennan TA, Leape LL, Laird NM, et al: Incidence of adverse events and negligence in hospitalized patients: Result of the Harvard Medical Practice Study I. N Engl J Med 324: 370-376, 1991

11. Wilson R M, Runciman WB, Gibbert RW, et al: The quality in Australian Health Care Study. Med J Aust 163:458-471, 1995

12. Hillman K, Bishop G, Bristow P: Expanding the role of intensive care medicine, in Vincent J-L (ed): 1996 Yearbook of Intensive Care, Emergency and Emergency Medicine. Berlin, Springer-Verlag, 1996, pp 833-841

13. Hillman K, Alexandrou E, Flabouris M, et al: Clinical outcome indicators in acute hospital medicine. Clin Intensive Care 11:89-94, 2000

14. Lee A, Bishop G, Hillman KM, Daffurn K: The medical emergency team. Anaesth Intensive Care 23:183-186, 1995

15. Hourihan F, Bishop G, Hillman KM, et al: The medical emergency team: A new strategy to identify and intervene in high risk patients. Clin Intensive Care 6:269-272, 1995

16. Hillman KM, Bishop G, Lee A, et al: Identifying the general ward patient at high risk of cardiac arrest. Clin Intensive Care 7:242-243, 1996

COMMENTARY

Health Services Research and the Medical Emergency Team—A Multidimensional Perspective of Effectiveness

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Professor Hillman and colleagues advocate for the concept of The Medical Emergency Team (MET) as a way to improve patient outcomes that result from delayed critical care treatment, and demonstrate how health services research is driven directly by issues encountered in clinical practices. In effect, the MET responds to an increasingly complex and severely ill population of hospitalized patients by moving critical care from a structurally isolated area to the hospital ward. Hillman et al provide a compelling description of how a systematic approach to critical care outreach decreases adverse outcomes and improves the effectiveness of care.

One of the most salient issues identified by Hillman et al is the challenge of conducting health services research in an organizational context. As suggested, utilization of a multicenter cluster randomization methodology has the potential to overcome the limitations of the nonrandomized control trial. However, as noted, this methodology also poses a number of challenges, which will not come as a surprise to anyone trying to conduct health services research today. The MET evaluation focuses on effectiveness of the intervention (MET) at the level of patient outcomes (cardiac arrest, deaths, admissions to the ICU). The researchers are to be applauded for responding to the need for earlier identification and response to patients who are at risk for deterioration. While the authors do not provide information on the costs associated with implementing an outreach service, the potential to reduce overall costs makes "intuitive sense."

However, we may need to go beyond mortality and adverse events to fully evaluate the linkage between the structure and process of critical care and patient outcomes.[1] Several other factors might be assessed. First, Professor Hillman and colleagues touch on the relationship between organi-

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