# Effects of a medical emergency team on reduction of incidence of and mortality from unexpected cardiac arrests in hospital: preliminary study

Michael D Buist, Gaye E Moore, Stephen A Bernard, Bruce P Waxman, Jeremy N Anderson, Tuan V Nguyen

ELPS

*The full version of this article appears on bmj.com*


## Abstract

**Objectives** To determine whether earlier clinical intervention by a medical emergency team prompted by clinical instability in a patient could reduce the incidence of and mortality from unexpected cardiac arrest in hospital.

**Design** A non-randomised, population based study before (1996) and after (1999) introduction of the medical emergency team.

**Setting** 300 bed tertiary referral teaching hospital.

**Participants** All patients admitted to the hospital in 1996 (n=19 317) and 1999 (n=22 847).

**Interventions** Medical emergency team (two doctors and one senior intensive care nurse) attended clinically unstable patients immediately with resuscitation drugs, fluid, and equipment. Response activated by the bedside nurse or doctor according to predefined criteria.

**Main outcome measures** Incidence and outcome of unexpected cardiac arrest.

**Results** The incidence of unexpected cardiac arrest was 3.77 per 1000 hospital admissions (73 cases) in 1996 (before intervention) and 2.05 per 1000 admissions (47 cases) in 1999 (after intervention), with mortality being 77% (56 patients) and 55% (26 patients), respectively. After adjustment for case mix the intervention was associated with a 50% reduction in the incidence of unexpected cardiac arrest (odds ratio 0.50, 95% confidence interval 0.35 to 0.73).

**Conclusions** In clinically unstable inpatients early intervention by a medical emergency team significantly reduces the incidence of and mortality from unexpected cardiac arrest in hospital.


## Introduction

Unexpected cardiac arrest is one of the more serious and clinically important adverse events that occurs in hospital patients. Despite the availability of cardiac arrest teams and advances in cardiopulmonary resuscitation the risk of death from such an event has remained largely static at 50-80%.[1 2]

Unexpected cardiac arrests in hospital are usually preceded by signs of clinical instability.[3 4] In a pilot study we noted that 112 (76%) patients with unexpected cardiac arrest or unplanned admission to intensive care had deterioration in the airway, circulation, or respiratory system for at least one hour (median 6.5 hours, range 0-432 hours) before their index event.[5] Furthermore, these patients were often reviewed (median twice, range 0-13) by junior medical staff during the documented period of clinical instability. Despite this the hospital mortality for these patients was 62%.

Such patients should receive better assessment either for aggressive resuscitation and management or for clear institution of "do not resuscitate" orders with palliative care. A medical emergency team has been proposed as a pre-emptive response system to manage these patients.[5 6] In this system when clinical observations reach certain predefined critical limits the primary care nurse or medical officer calls for the team, which responds immediately. The team in our hospital comprises a medical registrar, an intensive care registrar, and a senior intensive care nurse and is equipped with resuscitation drugs, fluids, and equipment.

## Methods

We carried out a non-randomised investigation in which the incidence of and mortality from cardiac arrest were recorded in inpatients in a single hospital over two 12 month periods: before (1996) and after (1999) the implementation of the intervention.

### Implementation of the system

In 1996 Dandenong Hospital had a "traditional" system of response to clinically unstable patients. The nurse would observe and document the instability, a call would then be made to the most junior member of the medical team, who would attend the patient, review the problem, and institute treatment. If the patient's condition continued to be unstable, the junior medical officer would seek advice from the next most senior member of the medical team concerned with the patient's management (in our hospital, the specialty registrar). The treatment review cycle could then be repeated, often with referrals to other specialist services. Occasionally, these cycles were further repeated when the consultant reviewed the case and different teams of on-call doctors became involved.

Departments of Intensive Care and Surgery, Dandenong Hospital, Dandenong, VIC 3175, Australia

Michael D Buist *director of intensive care unit*

Gaye E Moore *research nurse*

Stephen A Bernard *deputy director of intensive care unit*

Bruce P Waxman *surgical programme director*

Monash University Institute of Public Health,

Jeremy N Anderson *associate professor*

University of New South Wales Department of Anaesthetics, Emergency Medicine and Critical Care,

Tuan V Nguyen *senior fellow*

Correspondence to: M Buist acmdbuist@bigpond.com

*BMJ* 2002;324:387–90

**Criteria for calling medical emergency team**

**Airway**
Respiratory distress
Threatened airway

**Breathing**
Respiratory rate >30/min
Respiratory rate <6/min
$SaO_2$ <90% on oxygen
Difficulty speaking

**Circulation**
Blood pressure <90 mm Hg despite treatment
Pulse rate >130/min

**Neurology**
Any unexplained decrease in consciousness
Agitation or delirium
Repeated or prolonged seizures

**Other**
Concern about patient
Uncontrolled pain
Failure to respond to treatment
Unable to obtain prompt assistance

We gradually introduced the medical emergency team into the hospital from 1997, using previously reported criteria.[7] Initial implementation was only partially successful as the number of calls was low.[5] We thought this was because junior medical staff were reluctant to broach the "traditional" system of management and nursing staff were reluctant to respond against doctors' orders.

In 1999 we implemented a formal education and audit process directed at junior medical staff and nursing staff after the employment of a full time research nurse. The education process included interactive audiovisual presentations to hospital staff in small groups, attachment to all staff identification badges of the criteria for calling the medical emergency team, and strategic placement of posters throughout the hospital. All calls made to the team in the previous week were reviewed weekly. Staff who were involved in the more important events as identified by the audit were debriefed. Additionally, publication in 1999 of data from our pilot study in 1997 further emphasised the problem of the management of clinically unstable patients in hospital.[5] During 1997-9 we altered and simplified the criteria for calling the team in response to feedback from primary care nurses and junior medical officers (see box).[5] The team was not called to the emergency department, operating theatres, or intensive care and coronary care units.

### Data collection

We collected data from 1 January to 31 December 1996 (before the intervention) and from 1 January to 31 December 1999 (after the intervention) (figure).

For each cardiac arrest call made during the study periods we recorded demographic data, source, reason, date for admission to hospital, and data necessary for calculating the various severity scores. We reviewed data for completeness by cross referencing documented records of cardiac arrest calls made by the hospital telephone switchboard operators and reviewing all medical records for that year with a discharge code that included the words "cardiac arrest". We adopted a working definition of cardiac arrest—namely, that a staff member was so concerned about a patient that they made a cardiac arrest call, regardless of whether the patient was actually having a cardiac arrest.

## Results

### Hospital admissions

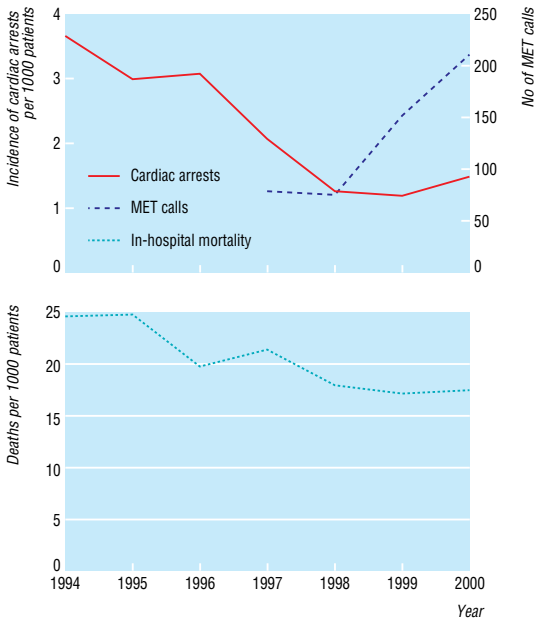
From 1996 to 1999 the number of hospital admissions increased by 14%, from 25 194 before the intervention to 28 801 after the intervention. Because there were multiple admissions during the study period the actual number of patients increased by 18%, from 19 317 in 1996 to 22 847 in 1999.

When we used the number of admissions as sampling units we found a significant difference in the types of admissions between the two periods. For instance, the number of admissions from the emergency department increased from 52% in 1996 to 59% in 1999. Similarly, "planned admissions" increased from 17% in 1996 to 21% in 1999.

### Incidence and predictors of cardiac arrest calls

In the two periods there were 73 and 47 unexpected cardiac arrest calls respectively, giving incidences of 3.77 and 2.05 per 1000 patients ($P<0.001$). Mortality was 56/73 (77%) before the intervention and 26/47 (55%) after the intervention (difference significant at $P<0.001$) (table 1). There was no significant difference in the actual reasons for the call between the two periods.

We considered the following factors in a multiple logistic regression model: presence of the medical emergency team (odds ratio 0.52, 95% confidence interval 0.36 to 0.74); age ≥65 years (8.1, 5.3 to 12.2); admission to emergency department (2.7, 1.7 to 4.5); male patients (1.5, 1.1 to 2.2); and same day admission (0.36, 0.2 to 0.6) were all significantly associated with the risk of cardiac arrest (table 2). After adjustment for these factors the odds ratio for cardiac arrest with the medical emergency team in place was 0.50 (0.35 to 0.73).




Incidence of cardiac arrests, number of calls to medical emergency team (MET), and in-hospital mortality between 1994 and 2000

**Table 1** Hospital mortality, incidence of cardiac arrest, and mortality from cardiac arrest before (1996) and after (1999) implementation of medical emergency team

| | Before intervention | After intervention |
|---|---|---|
| Hospital deaths: | | |
| No of deaths | 380 | 393 |
| Rate per 1000 patients | 19.67 | 17.20* |
| Cardiac arrest: | | |
| No of cardiac arrests | 73 | 47 |
| Rate per 1000 patients | 3.77 | 2.05* |
| No (%) of deaths | 56 (76.7) | 26 (55.3)* |
| Unplanned admissions to intensive care: | | |
| No of admissions | 45 | 78 |
| Rate per 1000 patients | 2.3 | 3.4 |
| No (%) of deaths | 15 (33.3) | 23 (29.5) |

*Significant difference before and after intervention, P<0.001.

**Table 2** Independent predictors of cardiac arrest: multivariate analysis

| Risk factor | Unit | Coefficient (SE) | Odds ratio (95% CI) |
|---|---|---|---|
| MET | Yes | –0.66 (0.185) | 0.52 (0.36 to 0.74) |
| Age ⩾65 years | Yes | 2.09 (0.212) | 8.07 (5.32 to 12.2) |
| Sex | Males | 0.41 (0.183) | 1.51 (1.05 to 2.16) |
| Emergency admission | Yes | 1.01 (0.259) | 2.73 (1.65 to 4.54) |
| Same day admission | Yes | –1.02 (0.223) | 0.36 (0.23 to 0.56) |

MET=medical emergency team.

### Distribution of calls for medical emergency team

During 1999 the team was called out 152 times for 124 patients; 21 patients had more than one call. Among the patients, 40 died. Two patients died during the team visit; 13 were allocated "do not resuscitate" orders during the team visit and subsequently died; 14 died during or after admission to intensive care or the coronary care unit; and 11 died in hospital in circumstances unrelated to the medical emergency team call. The mean age of the 124 patients was 60 (SD 17.4) years. Half of the calls originated from the general medical wards, followed by general surgery (26%), orthopaedic surgery (6%), cardiology (4%), and thoracic surgery (4%). Almost all calls were made by nurses (84%) or junior medical officers (15%).

## Discussion

We found that early intervention by a medical emergency team reduced the incidence of unexpected cardiac arrest in hospital by about half. Furthermore, the subsequent mortality was reduced from 77% to 55% after the system had been introduced. In our hospital, this was a reduction in mortality by two patients per thousand hospital admissions.

Unexpected cardiac arrest is a serious and clinically important adverse event that carries a high mortality.[1 2] Such an event is often preceded by signs of physiological deterioration,[3–5] which indicates that it is often neither a sudden nor unpredictable event. Early intervention when a patient shows signs of clinical instability could reduce the incidence of cardiac arrest and hence mortality.

Critically ill patients may be identified by clinical signs of dysfunction of the airway, breathing, or circulation. In our hospital the "traditional" system of management of these patients was hierarchical and depended on the skill, experience, judgment, and timely involvement of relevant staff members. These factors varied considerably and resulted in a poorly standardised and unstructured approach.[5] Early intervention should prevent further deterioration to the point that a cardiac arrest call is made. Our observed reduction in calls and associated mortality is consistent with that conjecture.

The implementation of the response system required considerable cultural change throughout the hospital with an education programme and audit process, which could explain some of the observed effects. On the other hand, the potential effect could have been underestimated. During the early phase of implementation junior medical and nursing staff seemed unwilling to broach the traditional system of referral. There were probably still unexpected cardiac arrest calls and unplanned admissions to intensive care that could have been prevented by better use of the medical emergency team.

The new system may simply have transferred mortality associated with cardiac arrest calls to mortality that occurred at other times and other places. While two patients died during the team visit and 14 patients died after admission to intensive care or coronary care, these events did not fully account for the overall reduction in mortality. Nevertheless, even if this effect contributed to the entire reduction in the frequency of calls the team's response still allows for a more considered approach to the patient's management than the chaos that is often inevitable with a cardiac arrest call. Calls to the medical emergency team often resulted in discussion with the patient's consultant and a decision to implement on a "do not resuscitate" order with palliative care. This occurred in 17 patients, of whom 13 died.

### Strengths and limitations

The use of two discontinuous time points could mean that the observed reduction in cardiac arrest calls could have resulted from a "natural regression" due to medical progress, or at worst, random fluctuation. This seems unlikely because data from 1994 to 2000 show that the incidence of cardiac arrests fell immediately. During the same period, the mortality in hospital also fell. When we analysed the data with a generalised linear model (for example, Poisson regression) the negative trend was significant at $P < 0.0001$ for both cardiac arrests and mortality.

The improvement in mortality could also be an indirect effect, unrelated to the medical emergency team—namely, the Hawthorne effect.[8] The research project had a high profile within the hospital, and the authors' concerns were well known. Publication of preliminary results highlighted issues regarding delivery of service and became a focus for improvement in patient care.[5] Also the employment of a full time research nurse to facilitate the implementation of the system may have improved the ward management of patients with clinical instability. The working relationship of the team nurse may also have altered patterns of referral to the team and hence, conceivably, mortality.

Nevertheless, irrespective of whether the 50% reduction in cardiac arrest was brought about by the team itself or activities associated with the implementation of the system, our results show that an early inter-

**What is already known on this topic**

In most studies mortality from unexpected cardiac arrest in hospital exceeds 50%

Such events are usually preceded by signs of clinical deterioration in the hours before cardiac arrest

**What this study adds**

Early intervention by a medical emergency team significantly reduced the incidence of and mortality from unexpected cardiac arrest in hospital

vention based on well defined criteria of clinical instability, together with a system of support, ongoing education, and performance feedback to the primary caregivers, can significantly reduce the incidence of and mortality from cardiac arrest in hospital.

We thank Mary Draper from the Department of Human Services, Victoria, for the department's financial support and her enthusiasm for the project. We also thank the staff of Dandenong Hospital, who have made the commitment to better quality care for all our patients.

Contributors: See bmj.com.

Funding: Department of Human Services.

Competing interests: None declared.

1 Peatfield RC, Sillett RW, Taylor D, McNicol MW. Survival after cardiac arrest in hospital. *Lancet* 1977;i:1223-5.
2 Bedell SE, Delbanco TL, Cook EF, Epstein FH. Survival after cardiopulmonary resuscitation in the hospital. *N Engl J Med* 1983;309:569-76.
3 Schein RM, Hazday N, Pena M, Rubens BH, Sprung CL. Clinical antecedents to in-hospital-cardiopulmonary arrest. *Chest* 1990;98:1388-92.
4 Franklin C, Mathew J. Developing strategies to prevent inhospital cardiac arrest: analyzing responses of physicians and nurses in the hours before the event. *Crit Care Med* 1994;22:244-7.
5 Buist MD, Jarmolowski E, Burton PR, Bernard SA, Waxman BP, Anderson J. Recognising clinical instability in hospital patients before cardiac arrest or unplanned admission to intensive care. A pilot study in a tertiary-care hospital. *Med J Aust* 1999;171:22-5.
6 Hourihan F, Bishop G, Hillman KM, Daffurn K, Lee A. The medial emergency team: a new strategy to identify and intervene in high risk patients. *Clin Intensive Care* 1995;6:269-72.
7 Lee A, Bishop G, Hillman KM, Daffurn K. The medical emergency team. *Anaesth Intensive Care* 1995;23:183-6.
8 Campbell JP, Maxey VA, Watson WA. The Hawthorne effect: implications for pre hospital research. *Ann Emerg Med* 1995;26:590-4.

*(Accepted 20 September 2001)*

ELPS

*The full version of this article appears on bmj.com*

# Risk adjustment for hospital use using social security data: cross sectional small area analysis

Roy A Carr-Hill, James Q Jamison, Dermot O'Reilly, Michael R Stevenson, James Reid, Barry Merriman

Centre for Health Economics, University of York, York YO10 5DD
Roy A Carr-Hill *professor*

Health and Social Care Research Unit, Queen's University Belfast, Institute of Clinical Science, Belfast BT12 6BJ
James Q Jamison *director*
Dermot O'Reilly *deputy director*
Michael R Stevenson *statistician*
Barry Merriman *research associate*

Northern Ireland Cancer Registry, Queen's University Belfast
James Reid *epidemiologist*

Correspondence to: J Q Jamison, Centre for Social Research, Queen's University Belfast, Belfast BT7 1NN
j.jamison@qub.ac.uk

*BMJ* 2002;324:390–2

## Abstract

**Objectives** To identify demographic and socioeconomic determinants of need for acute hospital treatment at small area level. To establish whether there is a relation between poverty and use of inpatient services. To devise a risk adjustment formula for distributing public funds for hospital services using, as far as possible, variables that can be updated between censuses.

**Design** Cross sectional analysis. Spatial interactive modelling was used to quantify the proximity of the population to health service facilities. Two stage weighted least squares regression was used to model use against supply of hospital and community services and a wide range of potential needs drivers including health, socioeconomic census variables, uptake of income support and family credit, and religious denomination.

**Setting** Northern Ireland.

**Main outcome measure** Intensity of use of inpatient services.

**Results** After endogeneity of supply and use was taken into account, a statistical model was produced that predicted use based on five variables: income support, family credit, elderly people living alone, all ages standardised mortality ratio, and low birth weight. The main effect of the formula produced is to move resources from urban to rural areas.

**Conclusions** This work has produced a population risk adjustment formula for acute hospital treatment in which four of the five variables can be updated annually rather than relying on census derived data. Inclusion of the social security data makes a substantial difference to the model and to the results produced by the formula.

## Introduction

The 1990s saw an increase in managed care in the United States and western Europe.[1 2] This change was partly in response to growing awareness of the inescapable scarcity of healthcare resources in almost all countries in the Organisation for Economic Cooperation and Development.[3] Various market style approaches to reforming health care have also been tried to help contain costs.[4 5] At the same time many countries have been trying to improve funding mechanisms so that the whole population has equal access to care—for example, Canada,[6 7] Germany,[8] the Netherlands,[9] the United Kingdom,[10] and the United States.[11]

Methods for adjusting funding according to need (risk adjustment) have probably been most carefully studied in the United Kingdom. Equity of funding has been a recurring preoccupation of NHS policymakers and analysts for at least 20 years. There has been periodic and sometimes acrimonious debate[12] about how best to use available morbidity and socioeconomic data