



## Evaluation of a Medical Emergency Team one year after implementation

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### Abstract

**Aim:** To evaluate the activity and impact of a Medical Emergency Team (MET) one year after implementation. **Setting and population:** A 700-bed District General Hospital (DGH) in Southeast England with approximately 53,500 adult admissions per annum. The population studied included all adult admissions receiving intervention by the MET during a 12-month period between 1 October 2000 and 30 September 2001. **Methods:** Analysis of the activation of the MET using both prospective and retrospectively acquired data. Routinely collected hospital data for admissions, discharges and deaths was used to compare outcomes for the 12 months before and after the introduction of the MET. **Results:** There were 136 activations of MET over 1-year. Six cases were excluded. Mean age of patients was 73 years (range 20–97 years). 40% (52/130) survived to discharge following MET intervention. Of those who died 22% (28/130) were designated ‘not for resuscitation’. Patients that died were more likely to have three or more physiological abnormalities present (odds ratio, OR 6.2, Chi-square ( $\chi^2$ )  $P = 0.004$ ) and had higher MET scores ( $P = 0.004$ ). Commonest interventions by the MET were initiation or increase of oxygen therapy or ventilatory support (80%), with or without the administration of intravenous fluids or medications. In 10% of cases, oxygen therapy was the sole intervention. One year after implementation of the MET a reduction in cardiac arrest rate and overall mortality was noted but this was not statistically significant. **Conclusion:** Often only simple interventions are only required to reverse deterioration. Initiating ‘do not attempt resuscitation’ (DNAR) decisions is a key part of MET activity. Multiple physiological abnormalities are associated with increased mortality and therefore wider and earlier application of the MET to the hospital population may save lives or expedite DNAR decisions. New systems need time to develop (“bed in”) and further research is needed to observe significant reductions in cardiac arrests and overall mortality.

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**Keywords:** MET; Evaluation; Medical Emergency Team; Cardiac arrest prevention; Intervention

### Resumo

**Objetivo:** Avaliar a actividade e impacto da Equipe Médica de Emergência (MET) após um ano de implementação. **População e local:** Hospital Geral Distrital (DGH) do Sudoeste de Inglaterra, com 700 camas e cerca de 53.500 internamentos de adultos por ano. A população estudada incluiu todos os adultos internados durante um período de 12 meses, de 1 de Outubro de 2000 a 30 de Setembro de 2001, que foram alvo de intervenção pela MET. **Métodos:** Análise da activação da MET utilizando dados recolhidos retrospectiva e prospectivamente. Utilizaram-se dados obtidos por rotina na admissão, alta e falecimento comparando resultados nos 12 meses antes e depois da introdução da MET. **Resultados:** No período de 1 ano houve 136 activações da MET. Foram excluídos 6 casos. A idade média dos doentes foi de 73 anos (intervalo de 20–97 anos). Quarenta por cento (52/130) sobreviveram até alta após intervenção pela MET. Vinte e dois por cento (28/130) dos que morreram foram assumidos como “decisão de não reanimar”. Nos doentes que morreram era maior probabilidade de ter 3 ou mais anomalias fisiológicas (odds ratio, OR 6,2, Chi-quadrado ( $\chi^2$ )  $P = 0,004$ ) e maiores scores MET ( $P = 0,004$ ). As intervenções mais comuns da MET foram iniciar ou aumentar a oxigenoterapia ou suporte ventilatório (80%), com ou sem administração de fluidos intravenosos ou medicação. Em 10% dos casos a única intervenção foi oxigenoterapia. Um ano após a implementação da MET observou-se redução da taxa de paragem cardíaca e da mortalidade global, sem significado estatístico. **Conclusão:** Com frequência são necessárias apenas intervenções simples para reverter a deterioração. A instituição de “decisão de não reanimar” (DNR) é um aspecto chave da actividade da MET. Anormalidades fisiológicas múltiplas estão associadas a maior mortalidade e, portanto, a aplicação mais precoce e mais alargada da

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MET à população hospitalar pode salvar vidas ou assumir de forma expedita uma DNR. É necessário tempo para desenvolver de novos sistemas e é necessária mais investigação para observar reduções significativas nas paragens cardíacas e na mortalidade global.

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*Palavras chave:* MET; Avaliação; Equipe Médica de Emergência; Prevenção da paragem cardíaca; Intervenção

## Resumen

*Objetivo:* Evaluar la actividad e impacto de un equipo de emergencias medicas (MET) un año después de su implementación. *Ambiente y población:* Un hospital general de 700 camas en un distrito en el Sureste de Inglaterra, con aproximadamente 53500 admisiones de adultos por año. La población estudiada incluyó a todas las admisiones de adultos que recibieron intervenciones por el MET durante un período de 12 meses entre Octubre 1 del año 2000 y Septiembre 30 del 2001. *Métodos:* Análisis de la activación del MET usando datos adquiridos retrospectivamente y prospectivamente. Se usaron los datos recogidos rutinariamente durante la admisión, altas y muertes para comparar resultados en los 12 meses antes y después de la introducción del MET. *Resultados:* En un año se activó el MET 136 veces. Se excluyeron 6 casos. La edad media de los pacientes fue de 73 años (rango de 20–97 años). 40% (52/130) sobrevivieron al alta después de la intervención del MET. De aquellos que murieron 22% (28/130) estaban designados 'no para resucitación'. Los pacientes que murieron tenían mas probabilidad de tener presentes tres o mas anomalías fisiológicas (odds ratio, OR 6.2, Chi cuadrado( $\chi^2$ )  $P = 0.004$ ) y tenían puntajes de MET mas altos ( $P = 0.004$ ). Las intervenciones mas comunes por el MET fueron la iniciación o aumento de oxigenoterapia o apoyo ventilatorio (80%), con o sin administración de fluidos intravenosos o medicaciones. En el 10% de los casos, la oxigeno terapia fue la única intervención. Un año después de la implementación de el MET se notó una disminución en la tasa de paros cardíacos y en la mortalidad general, pero esta no fue estadísticamente significativa. *Conclusión:* Frecuentemente bastan intervenciones muy simples para revertir el deterioro. El iniciar las decisiones de no intentar reanimación (DNAR) es una parte clave de la actividad de MET. Las múltiples anomalías fisiológicas están asociadas con mortalidad aumentada y por lo tanto aplicación mas amplia y precoz del MET a la población del hospital puede salvar vidas o hacer mas expedita las decisiones de DNAR. Los nuevos sistemas necesitan tiempo para desarrollarse ('camas adentro') y se necesita ulterior investigación para observar reducciones significativas en los paros cardíacos y en la mortalidad general.

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*Palabras clave:* MET; Evaluación; Equipo de emergencias médicas; Prevención del paro cardíaco; Intervención

## 1. Introduction

Adverse events in hospital [1–3] resulting in avoidable critical deterioration and cardiac arrest carry a heavy human and financial burden [4,5] and have provided the rationale for developing acute response teams [6–10]. Within the United Kingdom, acute response teams fall broadly into Medical Emergency Teams (MET) or outreach teams. Both have UK Department of Health (DoH) support as part of a strategy to improve the management of critically ill patients [11–14]. To date little published work is available evaluating the role and impact of a MET.

This paper reports findings from research evaluating a unique MET system [7] following its introduction to a District General Hospital (DGH) in the southeast of England. The main reasons for MET activation, interventions required and impact on survival post-MET intervention are discussed.

## 2. Methodology

### 2.1. Setting and population

A 700-bed DGH (six intensive care unit, five high dependency unit, and four coronary care units beds) with a catchment population of 365,000 and approximately 53,500 adult admissions per annum. The study population included all adult admissions receiving intervention from the MET

during a 12-month period between 1 October 2000 to 30 September 2001.

### 2.2. Data collection

Activation of the MET were identified from the hospital's switchboard log and cross-referenced with a prospective record of activations maintained by the primary author. As a further measure to ensure the capture of all activations of the MET, the hospital's Resuscitation Officer (NC) was also consulted.

Each case was reviewed in detail using both prospective and retrospective data. Prospective data consisted of information collated by the MET staff at the time of call. Retrospective data consisted of information obtained from patients' medical and nursing notes to determine events leading to activation of the MET.

### 2.3. Inclusion criteria

All intentional MET activations for patients who were not in cardiac arrest at the time of call were included in the evaluation.

### 2.4. Definitions

In-hospital cardiac arrest was defined as a loss of spontaneous circulation that occurred in any setting within the

hospital and where resuscitation was attempted. Hospital ‘admissions’ referred to adults (>15 years) admitted to all areas of the hospital excluding day care units and the emergency department (ED). Coronary care, intensive care, the high dependency unit and the operating theatre were all defined as high dependency areas. Survival was defined as to hospital discharge or to 6 weeks after intervention by the MET (after Utstein criteria) [15].

### 2.5. Statistical analysis

Data was analysed using the Statistical Package for Social Sciences (SPSS) V10.0. Proportions, counts or rates were compared using Z-test (for manual calculation) or Pearson Chi-square ( $\chi^2$ ) [16]. Where the frequency in any of the cells of a  $2 \times 2$  table fell below five, Fisher’s exact test was applied [17]. Continuous data was compared using Student’s *t*-test [18]. When there was concern regarding the normal distribution of continuous data, the Mann–Whitney *U*-test was used [16,18]. A ‘*P*’ value of less than 0.05 was considered statistically significant and a 95% confidence interval (CI) calculated where indicated [18]. For a measure of risk the relative risk (RR) or odds ratio (OR) and its 95% CI were calculated.

### 2.6. Ethical approval

Ethical approval was obtained from the North West Surrey Local Research and Ethics Committee. Data extracted from medical records was stored in a computerised database conforming to the DoH Data Protection Act [19].

## 3. Results

### 3.1. Inclusions

One hundred and thirty-six MET activations were identified over the study period and 130 patients were included in the preliminary analysis.

### 3.2. Exclusions

The six exclusions included two calls made in error, and three patients who were in cardiac arrest when the call was made (the cardiac arrest team should have been summoned); one case was lost to follow-up.

### 3.3. Demographics

The mean age of the patients was 73 years (median 76 years, range 20–97 years), and 44% (57/130) of the patients were male.

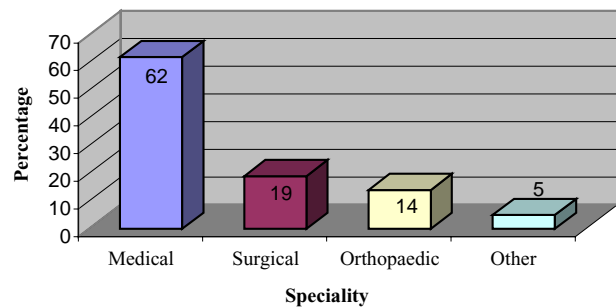


Fig. 1. Medical Emergency Team activation by speciality presented as a percentage of 130 calls. The 5% of calls not assigned to a speciality (other) include two calls to outpatients, two to the hospital lift area, one to pharmacy, and one to the hospitals main entrance (surgical patients include: general surgery, ENT and urology).

### 3.4. Distribution of calls

Fig. 1 outlines the distribution of MET calls across the hospital.

### 3.5. Factors present preceding MET activation

Nurses initiated 83% (108/130) of calls, doctors 15% (20/130) and professions allied to medicine 2% (2/130). Changes in physiology present in the hours prior to MET activation are outlined in Table 1. The main interventions by MET are given in Table 2.

### 3.6. Time of day, day of week

Calls for MET were evenly distributed throughout the day/night and across weekdays and weekend days.

Table 1

Factors present prior to MET activation (many patients had multiple factors present).

Factor	Frequency (%)
Glasgow coma score $\leq 13$	75 (58.1)
Fall in oxygen saturation $<95\%$	75 (58.1)
Increased respiratory rate $>20$	70 (54.3)
Decrease SBP <sup>a</sup> $<100$ mmHg	62 (48.1)
Increased pulse $>90$	57 (44.2)
Abnormal blood results	56 (43.4)
Decrease pulse $<60$	20 (15.5)
Reduced urine output $<20$ mls/h	18 (14.0)
Increase in SBP <sup>a</sup> by $>30$ mmHg	16 (12.4)
Reduced respiratory rate $<12$	14 (10.9)
Collapse	14 (10.9)
Chest pain	11 (8.5)
Anxious/agitated	10 (7.8)
Fitting	8 (6.2)
Decrease temperature $<35^\circ\text{C}$	7 (5.4)
Increased temperature $>38.4^\circ\text{C}$	6 (4.7)
Concern of relative	4 (3.1)
Abdominal pain	1 (0.8)

<sup>a</sup> SBP: systolic blood pressure.

Table 2  
Main interventions by MET

Intervention by MET	Frequency (%)	Comments
Made DNAR <24 h of MET call	32 (24.6)	Some patients received active intervention despite being made DNAR
Oxygen and intravenous fluid	32 (24.6)	Suitable for House Officer/specialist nurse initiation
Oxygen and medication	29 (22.3)	Suitable for House Officer/specialist nurse initiation
Airway, breathing and circulatory support	31 (23.8)	Requiring ventilation or suffering cardiac arrest <5 min of MET call
Oxygen only	13 (10.0)	Suitable for House Officer/specialist nurse initiation
Medication only	6 (4.6)	Suitable for House Officer/specialist nurse initiation
Intravenous fluid only	1 (0.8)	Suitable for specialist nurse initiation/suitable for House Officer/specialist nurse initiation
No intervention required	1 (0.8)	
Other/not specified	2 (1.5)	

### 3.7. Outcome following intervention by MET ( $n = 130$ )

Table 3 outlines the outcomes for patients following MET intervention.

The mean age of survivors was 69 years versus 75 years for those who died, and this difference is significant ( $t$ -test:  $P = 0.04$ , 95% CI for the difference of 6.2 is 0.4–12.9). Patients who died were six times more likely to have three or more physiological abnormalities present than those who survived (OR 6.2, 95% CI 2.4–16.3) ( $\chi^2 P = 0.004$ ), and had significantly higher MET scores (12.5 versus 10.7) ( $t$ -test:  $P = 0.004$ , 95% CI for the difference of 1.8 in MET scores was 0.6–3.0). The timing of deaths is outlined in Fig. 2.

### 3.8. MET utilisation and outcome

Despite being older, surgical patients appear more likely to survive than medical patients (OR 1.3, 95% CI 0.8–2.1) and also were more likely to be transferred to a high dependency area after intervention by the MET (OR 1.3, 95% CI 0.8–2.2). Surgical patients MET scores were lower, but not significantly so. Post high-dependency care surgical patients

Table 3  
Outcome following MET intervention

Disposal	Frequency	Comments
Remained in same clinical area	76/130 (58.5)	42% of these patients were made DNAR
Transferred to a higher care area, including one patient transferred to a medical ward from a surgical area	34/98 (34.7) of patients receiving active management	11% to ICU 9% to HDU 5% to A&E 2% to CCU
DNAR decision	32/130 (24.6)	88% died in hospital
Died despite MET intervention	50/130 (38.5)	
Survived to discharge	52/130 (40.0)	Includes four patients made DNAR

Values in parentheses are percentages.

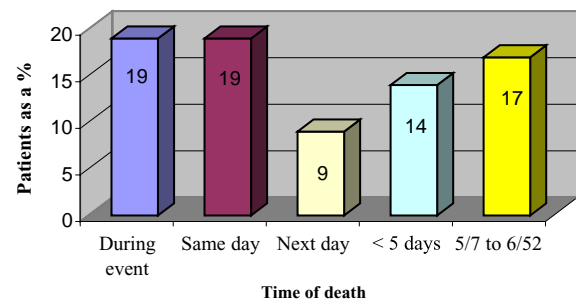


Fig. 2. Timing of deaths during or following MET intervention ( $n = 78$ ).

were almost four times more likely to survive than medical patients (OR 3.5, 95% CI 1.6–7.8).

### 3.9. The impact of MET on unexpected cardiac arrests and overall hospital deaths

There were 20.0 deaths per 1000 admissions (2.0%) with a cardiac arrest rate of 2.6/1000 admissions, and a 'do not attempt resuscitation' (DNAR) rate of 87.1% for the year prior to MET introduction. The year following MET introduction there were 19.7 deaths per 1000 admissions (1.97%) with a cardiac arrest rate of 2.4/1000 admissions, and a DNAR rate of 87.6%. The differences were not significant.

## 4. Discussion

The distribution of MET calls at the project site was similar to other studies with medical patients receiving the majority of MET calls [10,20,21]. However, the average age of patients was significantly higher than noted elsewhere, and the potential impact of age is discussed further.

### 4.1. Reasons for activating MET

The main physiological changes resulting in MET activation were changes in conscious level, respiratory rate, oxygen saturation, blood pressure or/and heart rate. Abnormal respiratory rate and reduced level of consciousness have been found to be particularly important predictors of

impending deterioration [9,20,22,23]. Whilst these factors have been found to be sensitive for deterioration, they are not specific in isolation, as up to a third of patients with isolated abnormal physiology do not require intensive care intervention and survive to hospital discharge [7,24].

Multiple physiological abnormalities are a better indication of potential irreversible deterioration. Death was significantly more common for those with greater than two physiological abnormalities. Smith and Wood [25] support this finding, observing that those patients with multiple physiological abnormalities rarely survive to hospital discharge if allowed to deteriorate to cardiac arrest. The importance of ‘routine monitoring’ of patients vital signs to ensure early detection of deterioration is reiterated.

#### 4.2. Interventions by MET

The main interventions by the MET were changes in, or commencement of, oxygen therapy, ventilatory support—with or without the administration of intravenous fluids or medications. The high incidence of patients requiring changes in oxygen therapy or ventilatory support is not unique to this research site. An Australian study evaluating a MET [20] noted that over 80% of patients required oxygen or ventilatory support and one third required intravenous fluids or blood. A similar finding occurring in hospitals so far apart implies a global clinical and staff education problem.

For 10% of patients the *only* intervention by MET was the initiation of oxygen therapy, a task that ward staff could initiate. More advanced measures such as initiating i.v. fluids are within the capability of more senior nurses and could be administered under Patient Group Protocols [12]. Such patients may still require medical assessment and intervention, but have a potentially better outcome if treatment is initiated earlier.

Almost a quarter of patients were designated DNAR following MET intervention (within 24 h), following consultation with the patients’ team. Buist et al. [10] reported 14% of patients designated DNAR after MET intervention, however differences in calculation methods make direct comparison unreliable. The high incidence of DNAR decisions is not necessarily a negative outcome following MET intervention [26]. The activation of cardiac arrest teams to clearly futile resuscitation attempts serves no clinical benefit and often results in an undignified death for the patient. However, the survival to discharge of four patients after DNAR designation confirms that DNAR should not preclude active treatment.

In 24% (32/130) of MET calls, the patient deteriorated to cardiac arrest within 5 min of the initial call. Survival to discharge following cardiac arrest for this group was less than 5%, which is in-line with the outcome associated with ward-based cardiac arrest [6]. In the vast majority of these patients, multiple physiological abnormalities were present (three or more) in the hours before MET intervention indicating that the team could have been activated

earlier. This highlights the importance of continued training within any site using an acute response team to ensure that staff-at-the bedside are mindful of the importance of early intervention. At the research site additional clinical courses have been introduced to better prepare staff for medical and surgical emergencies [27,28].

#### 4.3. Timing of MET activation

No trends were associated with the activation of MET in relation to time of day or days of the week. Although the demand for MET does not usually exceed 3 to 4 calls per week the distribution of calls confirms the need to permanently staff the MET.

#### 4.4. Survival

Survival to discharge following MET intervention was lower at the project site than reported in other studies. Reasons for this are multi-factorial. The average age of patients at the project site was significantly older (73 years versus 55–61 years) than in other studies [9,10,20–23], and advancing age is associated with increased mortality following cardiac arrest [29]. Other confounding factors include severity of illness, selection of cohort, MET activation delay and differing calculation methods.

Potentially the two most important factors influencing survival are the use of critical care resources and delay in MET activation. It was noted by both Goldhill et al. [22] and Buist et al. [10] that survival was associated with higher rates of intensive care unit admission following acute response team intervention.

Critical care use may be an important factor in determining the overall impact of an acute response team on the hospital population. We were unable to demonstrate statistically significant reductions in either cardiac arrest calls or in overall hospital mortality 1-year following the introduction of MET, although absolute reductions were noted, 10 and 16, respectively. Only two published studies claim a statistically significant reduction in cardiac arrest rate and/or hospital mortality [10,30]. In the first study, a reduced cardiac arrest rate was associated with a 50% increase in ICU admissions [10] whilst in the second, the overall impact on ICU activity was less clear [30].

Our research demonstrates that acute response systems require time to ‘bed in’. Daffurn et al. [31] found that even 2 years after introduction of the MET 9% of nurses were still unaware of the MET and only half of them knew where the MET guideline book was located. The experiences of Daffurn et al. [31] highlight the importance of continued staff training following the introduction of a MET system.

Nine percent of patients were judged admissions to an inappropriate clinical area. The majority were medical patients admitted to surgical wards. However, the overall number of inappropriate admissions was reduced when compared to our original study [6].

Table 4  
Changes within the research site since the completion of this research

Increase in critical care beds	Two additional ICU beds (33%) Four additional CCU beds (50% increase)
Increase in specialist ward-based beds	Twelve CCU step-down beds (100% increase) Five level 1 surgical wards (100% increase) Thirty-two beds Medical Assessment Unit (100% increase)
Specialist staff	Four additional full-time ICU consultants Three additional ICU fellows (Registrar level) Consultant physician appointment for MAU One critical care educator/facilitator for ward-based support Ward/department based practise development nurses Nurse consultant for resuscitation & emergency care One additional Resuscitation Officer
Staff empowerment	Ward-based group directive protocols to include oxygen therapy
Training/education/audit	Ongoing audit of MET calls
System improvement	Reduction in medical out-lying patients
Specialist teams	ICU critical care out-reach (12.5 h per day, 7 days per week) Acute pain round by nurse/anaesthetic consultant Night nurse practitioner service (12.5 h per day, 7 days per week)
To be introduced by end of 2003	Increased A&E capacity Introduction of ALS course
Under review	Two level 1 beds within the private patients' unit Additional in-hospital acute medical beds (number undecided) Additional ICU/out-reach, MAU and A&E consultant appointments

Our research suggests that adding MET to a hospital's existing acute response system (the cardiac arrest team) requires additional resources. The 130 MET activations combined with a similar number of cardiac arrest team activations has increased the workload of those staff who would otherwise attend just cardiac arrest calls. The perceived benefits of this additional activity may be purely qualitative until a system is well established.

Since completion of this research a number of additional strategies have been introduced within the host hospital to strengthen the quality of care delivered (Table 4). Of particular importance is the increase in critical care beds and the development of an ICU outreach service; this uses the MET scoring tool and compliments the MET system.

## 5. Conclusion

As a result of our experience, a number of suggestions are made to improve the introduction and uptake of an MET system (Table 5). Medical Emergency Teams may not be the panacea for all system failures within a busy DGH, but rather should form part of a wider strategy that aims to reduce unexpected critical deterioration, raise clinical awareness and improve the quality of care delivered. Continued training after implementation of the MET is essential to ensure staff remain vigilant and aware of the need for early intervention in order to avert irreversible deterioration. Simple supportive measures initiated by nursing staff, such as

Table 5  
Suggestions for improving the delivery of care by the MET

Pilot the MET criteria on one or two wards to identify potential problem areas and help establish a baseline
Establish a MET steering group early to provide strategic direction
Introduce ward-based cascade trainers improve uptake and ownership
Early and continuing multi-disciplinary staff education is paramount
Continuous highlighting of the importance of early intervention
Continuous audit and feedback

the administration of oxygen therapy and intravenous fluids, may also improve outcome for some patients.

One year's data after the introduction of the MET suggests that the quality of life and death for many individuals has been positively affected. Anecdotal evidence suggests a continuing supportive attitude amongst staff regarding the impact of a MET system on the quality of care delivered in non-acute areas. Further research is required to evaluate the impact of the MET over time.

## References

- [1] Barach P, Small SD. Reporting and preventing medical mishaps: lessons from non-medical near miss reporting systems. *BMJ* 2000;320:759–63.
- [2] Jarman B. The quality of care in hospitals. *J RCP Lond* 2000;34:75–91.
- [3] Vincent C, Neale G, Woloshynowych M. Adverse events in British hospitals: preliminary retrospective record review. *BMJ* 2001;322:517–9.

- [4] Gwinnutt CL, Columb M, Harris R. Outcome after cardiac arrest in adults in UK hospitals: effect of the 1997 guidelines. *Resuscitation* 2000;47:125–35.
- [5] Gage H, Kenward G, Hodgetts TJ, Castle N, Ineson N, Sheikh L. Health system costs of in-hospital cardiac arrest. *Resuscitation* 2002;54:139–46.
- [6] Hodgetts TJ, Kenward G, Vlachonikolis IG, et al. Incidence, location and reasons for avoidable in-hospital cardiac arrest in a district general hospital. *Resuscitation* 2002;54:115–23.
- [7] Hodgetts TJ, Kenward G, Vlachonikolis IG, Payne S, Castle N. The identification of risk factors for cardiac arrest and formulation of activation criteria to alert a Medical Emergency Team. *Resuscitation* 2002;54:125–31.
- [8] Goldhill DR. The critically ill: following your MEWS. *Quart J Med* 2001;94:507–10.
- [9] Lee A, Bishop G, Hillman KM, Daffurn K. The Medical Emergency Team. *Anaesth Intensive Care* 1995;23:183–6.
- [10] Buist MD, Moore GE, Bernard SA, Waxman BP, Anderson JN, Nguyen TV. Effects of a medical emergency team on reduction of incidence of and mortality from unexpected cardiac arrests in hospital: preliminary study. *BMJ* 2002;324:387–90.
- [11] Department of Health. A first class service. Quality in the new NHS. London: DoH; 1998.
- [12] Department of Health. An organisation with a memory. In: Report of an expert group on learning from adverse events in the NHS chaired by the Chief Medical Officer. London: DoH; 2000.
- [13] Department of Health. The NHS plan—a plan for investment. A plan for reform. London: DoH; 2000.
- [14] Department of Health. Comprehensive critical care. A review of adult critical care services. London: DoH; 2000.
- [15] Cummins RO, Chamberlain D, Hazinski MS. Recommended guidelines for reviewing and conducting research on in-hospital resuscitation: the in-hospital Utstein style. *Respir Care* 1998;43:33–62.
- [16] Swinscow TDV. Statistics at Square One. London: BMJ Books; 1996.
- [17] Daly LE, Bourke GJ. Interpretation and uses of medical statistics. Abingdon: Blackwell Science; 2000.
- [18] Altman D. Practical statistics for medical research. London: Chapman and Hall; 1991.
- [19] Department of Health. Data protection act. Protection and use of patient information. Accessed online at <http://www.doh.gov.uk/dpa98/index.htm>.
- [20] Hourihan F, Bishop G, Hillman KM, Daffurn K, Lee A. The Medical Emergency Team: a new strategy to identify and intervene in high-risk patients. *Clin Intensive Care* 1995;6:269–72.
- [21] Daly FF, Sidney KL, Fatovich DM. The Medical Emergency Team (MET): a model for the district general hospital. *Aust N Z J Med* 1998;28:795–8.
- [22] Goldhill DR, Worthington L, Mulcahy A, Tarling M, Sumner A. The patient-at-risk team: identifying and managing seriously ill ward patients. *Anaesthesia* 1999;54:853–60.
- [23] Salamonson Y, Kariyawasam A, van Heere B, O'Connor C. The evolutionary process of Medical Emergency Team (MET) implementation: reduction in unanticipated ICU transfers. *Resuscitation* 2001;49:135–41.
- [24] Fieselmann JF, Hendryx MS, Helms CM, Wakefield DS. Respiratory rate predicts cardiopulmonary arrest for internal medicine patients. *J Gen Internal Med* 1993;8:354–60.
- [25] Smith AF, Wood J. Can some in-hospital cardiac arrests be prevented? A prospective survey. *Resuscitation* 1998;37:133–7.
- [26] Parr M, Bishop G, Hillman K, Daffurn K, Thebridge C. Predicting in-hospital cardiac arrest. *Resuscitation* 1998;38:199.
- [27] Smith GB, Osgood VM, Crane S. An ALERT course development group. ALERT—a multiprofessional training course in the care of the acutely ill adult patient. *Resuscitation* 2002;52:281–6.
- [28] Care of the Critically Ill Surgical Patient Course (CCRISP). Accessed online at [http://www.rcseng.ac.uk/courses/display\\_course.html](http://www.rcseng.ac.uk/courses/display_course.html).
- [29] Huang C, Chen W, Ma M, Chang W, Lai C, Lee Y. Factors influencing the outcomes after in-hospital resuscitation in Taiwan. *Resuscitation* 2002;53:265–70.
- [30] Bellomo R, Goldsmith D, Uchino S, et al. A prospective before-and-after trial of a medical emergency team. *Med J Aust* 2003;179:283–7.
- [31] Daffurn K, Lee A, Hillman KA, Bishop GF, Bauman A. Do nurses know when to summon emergency assistance? *Intensive Crit Care Nurs* 1994;10:115–20.