

The timing of Rapid-Response Team activations: a multicentre international study

The Medical Emergency Team End-of-Life Care investigators

Rapid-Response Teams (RRTs) are specialised teams that review deteriorating ward patients.^{1,2} Criteria for activation are usually based on predefined derangement of vital signs. Most studies on RRTs assess the effects of implementing the service on outcomes of all hospitalised patients. Much less information exists on factors that might contribute to patients requiring RRT review. A single-centre study revealed that RRT activation was variable over the 24-hour cycle,³ and that activation was more likely when caregivers were present to detect a crisis.⁴

Litvak and Pronovost suggested that RRT review may sometimes be needed because of a triage error, when a patient is sent to a ward rather than to a monitored area.⁵ Suboptimal triage may necessitate activation of the RRT shortly after hospital admission. In line with this, the Australian Council on Healthcare Standards (ACHS) has recently published clinical indicators for hospital care, one of which relates to the number of RRT activations in the first 24 hours of hospital admission.⁶ To date, no study has specifically assessed the timing of RRT activations in relation to the day of hospital admission.

We evaluated the timing of RRT activations in seven university-affiliated hospitals; we assessed the distribution of activations in relation to the day of hospital admission, with particular focus on calls to the RRTs occurring shortly after hospital admission. We also assessed the circadian variation of calls over a 24-hour period. Finally, we assessed for differences in the demographics, call characteristics and patient outcomes for activations made early and late in the hospital stay.

Materials and methods

Study design and data collection

Ethics approval was obtained from the hospital research and ethics committees of all participating hospitals (CC01/09; 03-04-05-09; h2008/03312; QA2009/010; B-220708; 2009/469-31/4 and 370/08). The need for informed patient consent was waived by all institutions.

Details of the patient cohort have previously been described.⁷ De-identified data on RRT calls occurring over 1 month were prospectively collected in seven hospitals, using standardised case report forms (CRFs) completed primarily by RRT staff at call conclusion, or by site investigators in a minority of cases. Complete capture of

ABSTRACT

Background: Most studies of Rapid-Response Teams (RRTs) assess their effect on outcomes of all hospitalised patients. Little information exists on RRT activation patterns or why RRT calls are needed. Triage error may necessitate RRT review of ward patients shortly after hospital admission. RRT diurnal activation rates may reflect the likely frequency of caregiver visits.

Objectives: To study the timing of RRT calls in relation to time of day and day of week, and their frequency and outcomes in relation to days after hospital admission.

Methods: We prospectively studied RRT calls over 1 month in seven hospitals during 2009, collecting data on patient age, sex, admitting unit, admission source, limitations of medical therapy (LOMTs), and admission and discharge dates. We assessed the timing of RRT calls in relation to hospital admission and circadian variation; and differences in characteristics and outcomes of calls occurring early (Days 0 and 1) versus late (after Day 7) after hospital admission.

Results: There were 652 RRT calls for 518 patients. Calls were more likely on Mondays ($P=0.018$) and during work hours ($P<0.0001$) but less likely on weekends ($P=0.003$) or overnight ($P<0.001$). There were 177 early calls (27.1%) and 198 late calls (30.4%). Early calls involved younger patients (median ages, 67.5 years [early calls] v 73 years [late calls]; $P=0.01$), fewer LOMTs ($P=0.029$), and lower inhospital mortality (12.8% [early calls] v 32.3% [late calls]; $P<0.0001$). The mortality difference remained in patients without LOMTs (5.6% [early calls] v 19.6% [late calls]; $P=0.003$).

Conclusions: About one-quarter of RRT calls occurred shortly after hospital admission, and were more common when caregivers were around. Early calls may partially reflect suboptimal triage, though the associated mortality appeared low. Late calls may reflect suboptimal end-of-life care planning, and the associated mortality was high. There is a need to further assess the epidemiology of RRT calls at different phases of the hospital stay.

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calls was guaranteed by cross-referencing the hospital switchboard log.

Completed CRFs were sent to the principal investigator and manually entered into an Excel (Microsoft) spreadsheet and rechecked for accuracy. Information on the dates of

hospital admission and discharge was obtained from the hospital electronic database.

Our study represents a post-hoc analysis of the previously published study.⁷ A study design and analysis plan was approved by the management committee before commencing data analysis.

Hospitals, RRTs and datasets

Participating hospitals included five Australian hospitals (including one private hospital) and one hospital each from Canada and Sweden. All hospitals were university-affiliated and had RRTs of at least 4 years' standing. In two hospitals, the RRTs functioned to review both cardiac arrests and medical emergencies that were not cardiac arrests.

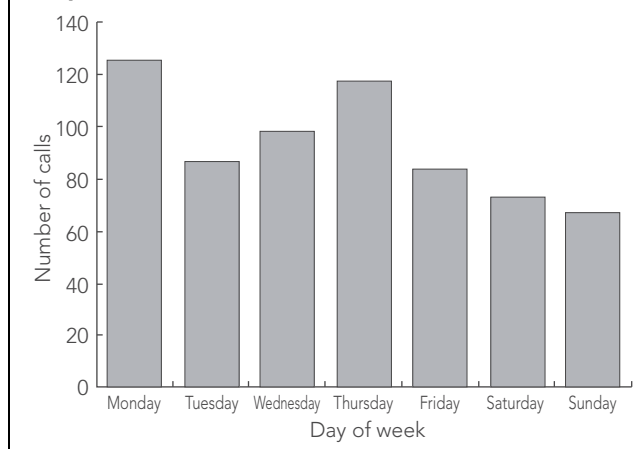
We collected information on patient demographics, including age, sex, admission source and admitting unit. The "other" category of admitting unit included units such as psychiatry, outpatients subsequently requiring unplanned hospital admission, obstetrics and gynaecology, and outpatient dialysis. Details of RRT calls included the date and time (using the 24-hour clock) of the call activation. For the purpose of this study, end-of-life care was categorised as "full care" or "limitation of medical therapy" (LOMT), which was ascertained separately before and after the call. "In-hours" was considered to include 08:00 to 18:00. We also obtained the number of admissions when the patient stayed at least overnight (excluding dialysis and same-day admissions) to permit calculation of RRT call rate (calls/1000 admissions), and to estimate the call rate in the first 24 hours, as described by the ACHS.⁶

Data analysis

To illustrate the timing of RRT call activations, we constructed histograms of RRT activation by day of the week. We also calculated the number of days between admission date and RRT activation, and constructed a histogram to illustrate the frequency with which activation of calls occurred in relation to admission. Circadian variation of activation was shown by collating the number of activations in each hourly interval. The time of hospital admission was not recorded in the original study. Thus, to examine the proportion of calls that may have occurred within 24 hours of admission,⁶ we counted calls occurring on Days 0 and 1 together.

To test for significance of rates of activations for day of week and hour of day, we compared the observed rate to the expected (average) rate for the assessed period. Finally, to explore the epidemiology of RRT calls at different times of activation, we compared the differences in baseline characteristics and outcomes for "early calls" (defined as occurring on Days 0 and 1) versus "late calls" (defined as occurring after Day 7).

Figure 1. Day of activation for 652 Rapid-Response Team calls over 1 month, in seven teaching hospitals



Statistical analysis was conducted using PASW Statistics 18.0 (SPSS). Descriptive data are shown as raw numbers and percentages of totals, and numerical data are shown as medians and interquartile ranges (IQRs). Differences in proportions were assessed using the χ^2 test (with Yates's correction for continuity) or with the Fisher exact test, and expressed as an odds ratio (OR) with 95% confidence interval. Differences in the central tendency of distributed data were assessed using the Mann-Whitney U test. Data analysis was conducted for calls (analysing admitting unit, admission source, day of the week and end-of-life care issues during the call) and for patients (analysing age, sex, hospital length-of-stay and discharge destination). A *P* value of <0.05 was taken to indicate statistical significance.

Results

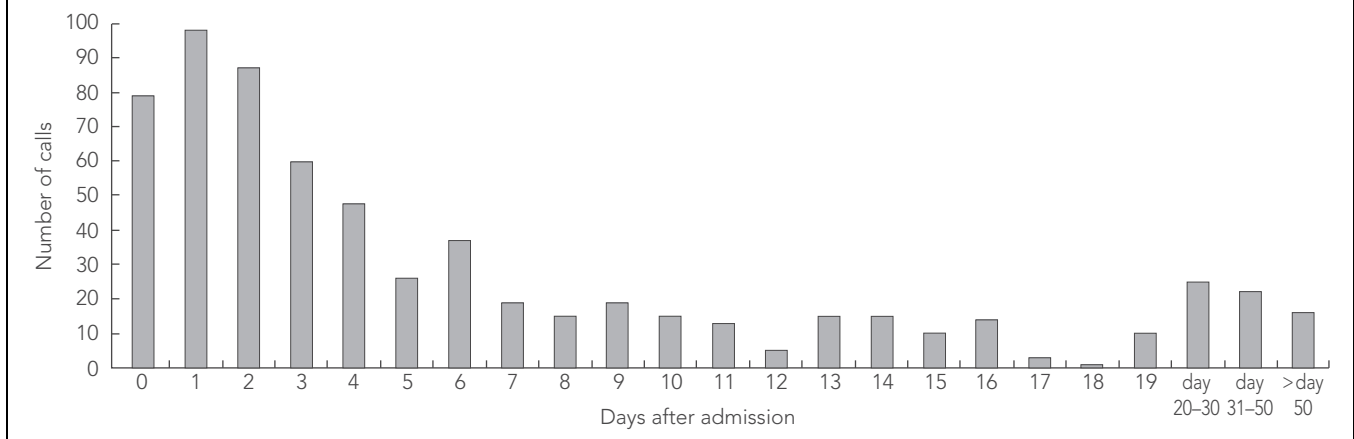
Details of RRT calls overall

Over 1 month, there were 652 calls in seven hospitals (range, 33–155 calls; median, 108 calls; IQR, 47–101 calls). The number of calls per day in each hospital ranged from 0–14, with a median of three calls and an IQR of one to four calls per hospital per day. These 652 calls occurred in 518 patients, and their median hospital length-of-stay was 14 days (IQR, 6–27 days). The admitting unit was designated medical for 375 patients (57.5%), surgical for 213 patients (32.7%), and "other" for 64 patients (9.8%). The median RRT call rate was 42.1 calls/1000 admissions (IQR, 22.6–58.2 calls/1000 admissions).

Timing of RRT calls by day of week

Calls were not evenly distributed over the days of the week (Figure 1). The expected daily rate of RRT activation calls

Figure 2. Activation of 652 Rapid-Response Team calls over 1 month, in seven teaching hospitals, by day after admission



was $652 \div 7$, or 93 calls/day. Compared with the expected daily rate, calls were more likely to occur on Mondays (125 calls; OR, 1.42; 95% CI, 1.06–1.91; $P=0.018$), with a trend for increased calls on Thursdays (118 calls; OR, 1.33; 95% CI, 0.99–1.78; $P=0.062$). In contrast, calls were less likely to occur on Sundays (67 calls; OR, 0.69; 95% CI, 0.49–0.96; $P=0.027$), or weekends (140 calls made vs 186 calls expected; OR, 0.68; 95% CI, 0.53–0.88; $P=0.003$).

Timing of RRT calls by day of admission

The median time between admission and RRT activation was 4 days (IQR, 1–10 days). Of the 652 calls, 454 (69.6%) occurred between Days 0 and 7 (Figure 2). There were 177 calls (27.1%) on the day of or the day after admission (Days 0 and 1). The proportion of early calls ranged from 20% to 36.4% between the seven hospitals (median, 28.7%; IQR, 23.4%–31.0%). The median call rate for calls occurring on Days 0 and 1 was 12.1 calls/1000 admissions (IQR, 6.5–15.3 calls/1000 admissions). There were 277 calls (IQR, 42.5%) between Days 2 and 7, and 198 calls (IQR, 30.4%) after Day 7 (Table 1).

There were several statistically significant differences between the characteristics and outcomes of calls occurring early (Days 0 and 1) compared with those occurring late (after Day 7) (Table 1 and Table 2). Early calls were more likely to occur for younger patients, were less likely to occur on the weekend, and were less likely to be triggered by hypoxaemia, compared with late calls (19/177 [10.7%] v 37/198 [18.7%]; OR, 0.52; 95% CI, 0.29–0.94; $P=0.044$). There were no other statistically significant differences between the RRT call criteria for early versus late calls.

Patients for whom an RRT call was made early in their admission were less likely to be categorised as LOMT

before and after the call, had a markedly shorter hospital length-of-stay, were more likely to be discharged home and were less likely to die than patients for whom an RRT call was made after Day 7 of their admission (Table 2). Thus, 21/164 (12.8%) patients for whom an RRT call was made on Days 0 or 1 died in hospital compared with 51/158 (32.3%) who had an RRT review after Day 7 (OR, 0.31; 95% CI, 0.18–0.53; $P<0.0001$). When patients ascertained as non-LOMT were considered separately, 7/124 (5.6%) who had an RRT review on Day 0 or Day 1 died in hospital, versus 19.6% (19/97) who had an RRT review after Day 7 (OR, 0.25; 95% CI, 0.13–0.62; $P=0.003$).

Circadian variation of RRT calls

Activation of RRT calls was not uniform over the 24-hour cycle (Figure 3). The average hourly activation of calls was 27 calls/hour (652/24). Calls were more likely during working hours (08:00–18:00) than in the evening (18:01–24:00), and least likely overnight (00:01–7:59). Thus, during working hours, there were 376 calls (57.7%) compared with 272 expected calls (OR, 1.90; 95% CI, 1.53–2.47; $P<0.0001$), and, overnight, there were 123 calls (18.9% of calls) compared with 217 expected calls (OR, 0.47; 95% CI, 0.36–0.60; $P<0.001$). During the evenings, the observed number of calls (153 [23.5%]) was similar to the number expected over the time period (163; $P=0.52$).

Discussion

Summary

In our study of 652 RRT calls occurring over 1 month in seven hospitals and three countries, we found that about one-quarter of all calls occurred on the day of or the day

Table 1. Differences in baseline characteristics and nature of RRT calls, between early versus late calls, among 652 RRT activations

Characteristic	Early RRT call (Day 0 or 1)	Late RRT call (after Day 7)	P
No. of calls (% of all calls)	177 (27.1%)	198 (30.4%)	NA
Patients subject to review	164	158	NA
Age median (years) (interquartile range)	67.5 (47.0–78.0)	73.0 (56.8–81.0)	0.01
Male (%)	88 (53.7%)	81 (51.3%)	0.75
Admitting unit (n) (%)			
Medical	96 (54.2%)	120 (60.6%)	0.011
Surgical	52 (29.4%)	65 (32.8%)	
Other	29 (16.4%)	13 (6.6%)	
Admission source (n) (%)			
Home	156 (88.1%)	175 (88.4%)	0.329
Nursing home	14 (7.9%)	9 (4.5%)	
Other hospital	2 (1.1%)	5 (2.5%)	
Supported accommodation	5 (2.8%)	9 (4.5%)	
Day of call (n) (%)			
Monday	34 (19.2%)	25 (12.6%)	0.010
Tuesday	27 (15.3%)	20 (10.1%)	
Wednesday	33 (18.6%)	32 (16.2%)	
Thursday	21 (11.9%)	32 (16.2%)	
Friday	30 (16.9%)	31 (15.7%)	
Saturday	23 (13.0%)	26 (13.1%)	
Sunday	9 (5.1%)	32 (16.2%)	
Weekend	32 (18.1%)	58 (29.3%)	0.011
Out-of-hours calls (n) (%)	89 (52.5%)	100 (50.5%)	0.694
Reason for call (n) (%)			
Threatened airway	0	4 (2.1%)	0.13
Hypoxia	19 (10.7%)	37 (18.7%)	0.044
Increased respiratory rate	28 (15.8%)	37 (18.7%)	0.55
Decreased respiratory rate	1 (0.6%)	0	0.47
Noisy breathing	4 (2.3%)	9 (4.5%)	0.26
Hypotension	46 (26.0%)	36 (18.2%)	0.09
Decreased heart rate	6 (3.4%)	7 (3.5%)	1.0
Increased heart rate	23 (13.0%)	32 (16.2%)	0.47
Altered conscious state	33 (18.6%)	44 (22.2%)	0.47
Seizure	4 (2.3%)	1 (0.5%)	0.19
Cardiorespiratory arrest	2 (1.1%)	5 (2.5%)	0.45
Worried	45 (25.4%)	47 (23.7%)	0.80

RRT = Rapid-Response Team. NA = not applicable.

after admission. Calls were less common on weekends and infrequent out of working hours, particularly overnight. We found differences in the epidemiology of RRT calls at different phases of the hospital stay.

Table 2. Differences in outcomes of early versus late calls among 652 Rapid-Response Team activations

Outcome	Early call (Day 0 or 1)	Late call (after Day 7)	P
EOLC issues (n) (%)			
LOMT before call	30 (16.9%)	52 (26.3%)	0.029
LOMT after call	45 (25.4%)	71 (35.9%)	0.029
Hospital stay (days) (IQR)	7 (3–14)	29 (18–55.5)	<0.0001
Death/discharge (n) (%)			
Died	21 (12.8%)	51 (32.3%)	<0.0001
Home	113 (68.9%)	59 (37.3%)	
Rehabilitation/other hospital	19 (11.6%)	36 (22.8%)	
Nursing home	7 (4.3%)	8 (5.1%)	
Supported accommodation	3 (1.8%)	4 (2.5%)	
Unknown	1 (0.6%)	0	
Non-LOMT mortality (deaths/non-LOMT patients) (%)	7/124 (5.6%)	19/97 (19.6%)	0.003
LOMT-related mortality (deaths/LOMT patients) (%)	14/40 (35%)	32/61 (52.5%)	0.13

EOLC = end-of-life care. LOMT = limitation of medical therapy. IQR = interquartile range.

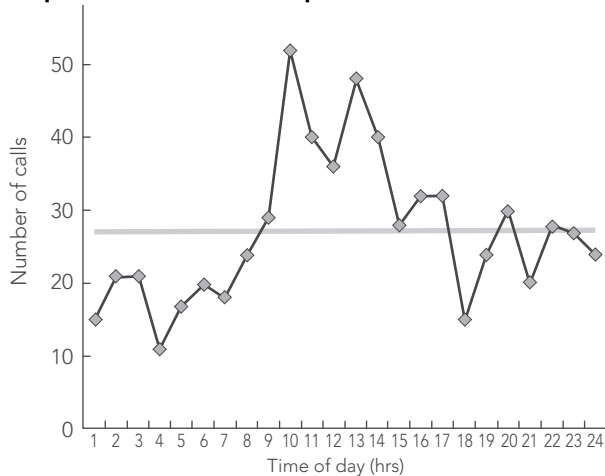
Interpretation and comparison with other studies

To our knowledge, no study has previously assessed the distribution of RRT call activations in relation to time of hospital admission. Litvak and Pronovost have suggested that RRT review may sometimes be needed because of a triage error; for example, if a patient is sent to a ward rather than a more closely monitored area.⁵ Our findings provide indirect support for this. Patients subject to early RRT calls were younger, had fewer LOMTs, stayed in hospital for a relatively short period and were more likely to be discharged home. Combined, these findings suggest that the intent of the treating clinicians for these patients was typically for full care.

An early requirement for RRT review of a patient transferred to the ward may also reflect misplacement due to a lack of capacity in more closely monitored areas.⁵ Also, an initially stable patient may deteriorate after transfer to a ward, despite adequate clinical care and appropriate triage.⁵ Importantly, the inhospital mortality of patients without an LOMT who were subject to an RRT call on Day 0 or 1 was only 5.6%, which was considerably lower than the overall cohort mortality.

In contrast, RRT calls occurring late in the hospital stay were more likely to be for older patients, to occur on the weekend, and more often involved an LOMT. They occurred

Figure 3. Circadian variation of 652 Rapid-Response Team calls over 1 month, in seven teaching hospitals, over a 24-hour period



Straight grey line = average expected calls over 24-hour period.

in patients who stayed in hospital for a long time (one-quarter stayed longer than 55 days), were more likely to die in hospital and half as likely to go home. In the case of late RRT calls, even patients without an LOMT at the time of RRT review had an inhospital mortality of 19.6%. Combined, these findings suggest that RRT calls occurring after Day 7 often involve patients with end-of-life care issues, or for whom active therapy is not effective. Other studies have also shown that the RRT may be involved in end-of-life care,⁸⁻¹⁰ particularly in patients who have been in hospital for a long time.⁹

We found that RRT activations were more common during the day and least frequent overnight. Other studies have also shown that activation of the RRT is less common overnight.^{3,11,12} Unlike a previous single-centre study,³ we did not find a large peak of activations around evening nursing handover (20:00–21:00).

Study strengths and limitations

Ours is the first international multicentre study to analyse the timing of RRT activations. We used simple and standardised data collection tools, prospective data collection, and a prospective analysis plan. Our study revealed details of the patterns of RRT calls and therefore of deteriorating hospitalised patients.

Our study also had a number of important limitations. We did not collect data about times of hospital admission, and thus details of early RRT calls provide only an approximation of the number of RRT calls occurring in the first 24 hours of admission. We did not analyse interventions that occurred during the RRT call, or implementation of LOMTs by the

Appendix 1. Medical Emergency Team End-of-Life Care investigators and responsibilities

Chair

Concept and design; protocol and case report form development; data access, analysis and statistics; responsibility for findings:

- Daryl Jones

Management and writing committee

Review of all aspects of study:

- Daryl Jones, Rinaldo Bellomo and Graeme K Hart

Site investigators

Oversight of the study in each site,* including ethics submission and data collation and submission to the primary investigator:

- Alberta Hospital:† Ambica Parma, RT Noel Gibney, Sean M Bagshaw
- The Alfred Hospital: Gaurav Bhatia, Tim Leong
- Austin Health: Daryl Jones, Glenn Eastwood, Leah Peck
- Cabrini Hospital: Jonathon Barret, Tracey Bucknall
- Liverpool Hospital, New South Wales: Ken Hillman, Michael Parr
- Karolinska University Hospital:‡ Gabriella Jäderling, David Konrad
- The Northern Hospital: Andrew Casamento, Andrea Doric, Cathryn Street, Graeme Duke

Data collectors

Completion of case report forms at each study site:*

- Alberta Hospital:† Ambica Parma, Sean M Bagshaw
- The Alfred Hospital: Gaurav Bhatia, Julie Barbeti
- Austin Health: John Prowle, David Crosby, Elisa Licari, K J Farley, Marco Fedi, Chun Fong, Rafidah Atan
- Cabrini Hospital: Rasa Ruseckaite
- Liverpool Hospital, NSW: Matthew MacPartin, Jayne Stevenson
- Karolinska University Hospital:‡ Gabriella Jäderling, Åsa Bengtsson
- The Northern Hospital: Angaj Ghosh, Christelle Botha, Melissa Kaufmann, Neil MacDonald

* Unless specified, sites are in Victoria, Australia. † Edmonton, Canada.

‡ Stockholm, Sweden.

admitting unit that might have occurred in the days following the call. We could not comment on the proportion of patients who required admission to a critical care area shortly after RRT review, which might further support or refute the hypothesis that early calls represent suboptimal triage and placement. Finally, we were not able to comment on factors contributing to the high mortality of patients subject to RRT review after Day 7 but who were apparently for full active care.

Implications

Differences in the epidemiology of early and late RRT calls may guide further research and understanding of the reasons for RRT calls. Thus, for early RRT calls, it may be possible to assess patients for objective physiological instability or other markers of increased risk in the emergency

department or postoperative recovery area. In such studies, it will be important to discriminate between patient instability present in these areas and instability that develops after arrival to the ward.

Prevention of RRT calls occurring late in the hospital stay may involve strategies addressing advance care planning, improving the clarity of the management plan (particularly in relation to expectations of treatment), and improved delivery of palliative care in cases where comfort care only is indicated.

The relative paucity of RRT activations on weekends and overnight is in keeping with DeVita's comment that "the more care givers that visit a patient, the more likely they are to detect patient deteriorations".⁴ Thus, staff numbers, rounding, overall vigilance and measurement of vital signs may all be expected to be lower on the weekend and overnight, leading to lower rates of detection of deterioration. The call peak on Mondays may suggest that patient deterioration was only detected after arrival of the "home team" after the weekend. These findings have important implications for the detection of crises⁴ and subsequent escalation of patient care. Use of electronic capture of vital signs may improve the escalation of care in deteriorating patients.¹³

Future research

There is a need to assess the antecedents to early RRT calls to better understand the severity of illness and presence of objective signs of deterioration in the period before transfer to the ward. In patients subject to RRT review later in their hospital stay, further clarification of end-of-life care issues may be desirable. Finally, it would be useful to study the effects of improved patient monitoring (including automated electronic monitoring systems) on the incidence of RRT activations overnight and over weekends.

Competing interests

None declared.

Author details

The Medical Emergency Team End-of-Life Care investigators (individuals are listed in Appendix 1)

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