Mortality of rapid response team patients in Australia: a multicentre study

The ANZICS-CORE MET dose investigators

ABSTRACT

Background: Most studies of the rapid response team (RRT) investigate the effect of introducing an RRT on outcomes of all hospitalised patients. Less information exists on RRT patient epidemiology, or changes in RRT call numbers with time.

Objectives: To estimate the inhospital mortality of patients subject to RRT review, the proportion of inhospital deaths reviewed by the RRT, and changes in annual RRT call numbers with time.

Method: Retrospective observational study in adult RRT-equipped Australian hospitals for up to 10 years (2000–2009).

Participants and outcome measures: Thirty-four per cent (35/102) of the Australian adult RRT-equipped hospitals provided annual hospital admissions and deaths, intensive care unit admissions and RRT calls. They also provided the number of patients reviewed by the RRT and the number of inhospital deaths in such patients.

Results: Over the study period, there were 4.91 million hospital admissions, 196 488 ICU admissions and 99 377 RRT calls. Most data arose from Victoria, New South Wales and Western Australia, and from public tertiary hospitals. Among the 27 hospitals contributing at least 4 years of data, annual RRT calls per 1000 admissions was higher in the last year compared with the first year of data submission in 23 hospitals (range of increase, 11.9%–777.4%; median, 90%; interquartile range, 40%–180%). In the remaining four hospitals, annual RRT calls per 1000 admissions were lower in the last year compared with the first year (range of decrease, – 5.5% to – 29.8%). Among the 70 924 RRT patients for whom the outcome was known, there were 17 260 deaths (24.3%). We calculate that the RRT reviewed 17 260 of 79 476 patients (21.7%) who died in hospital over the study period. In the 2008–09 financial year, there were 18 800 RRT calls for at least 14 743 patients.

Conclusions: Annual RRT calls are increasing in many Australian hospitals, and now affect more than 14 700 patients annually. Inhospital mortality of RRT patients is about 25%, and about 20% of patients who die in hospital are reviewed by the RRT. Further research is needed to understand the reason for the high inhospital mortality of RRT patients.

Crit Care Resusc 2013; 15: 273–278

Rapid response teams (RRTs) have been introduced in hospitals to identify and treat deteriorating patients. Such teams have been introduced in many countries around the world, including the United States,[1] Canada,[2] the Netherlands,[3] Brazil[4] and Sweden,[5] as well as Australia and New Zealand.[6] Most studies of RRTs have focused on what happens to the outcomes of an entire hospital population when an RRT is introduced. The most commonly studied outcomes include unexpected deaths, unplanned intensive care unit admissions and cardiac arrest rates. There is much less information on the resource implications of introducing an RRT service or the characteristics and outcome of patients who are actually reviewed by the RRT.[7]

Three single-centre studies have reported a progressive increase in the use of an RRT service with time,[8-10] but no studies exist to assess such time-related changes over several years in multiple hospitals. Other single-centre studies suggest that the inhospital mortality of adult patients subject to RRT review is about 20%[11-13] — much greater than the 11% inhospital mortality typically reported for ICU admissions in Australia.[14] If these findings were true in multiple hospitals, this would have major implications for workload and resource use (particularly for ICUs[15,16]) as well as for public health.

We conducted a retrospective observational study in 35 Australian adult hospitals to estimate the mortality of patients subject to RRT review from financial year 2000–01 to 2009–10. In addition, we assessed the broader resource implications of RRT services, by assessing the changes in annualised RRT reviews. Finally, we investigated the role of the RRT in end-of-life care, by calculating the proportion of inhospital deaths that were seen by the RRT.

Methods

We obtained ethics approval from all participating hospital research and ethics committees and from Monash University (CF10/1531 – 2010000820). The need for informed patient consent was waived by all committees. This study is part of a larger study of 39 hospitals.[15] Of these, for the present study, we excluded three paediatric hospitals and one hospital that was not able to provide data.

Table 1. Hospital admissions, intensive care unit admissions and total rapid response team (RRT) calls for 35 adult Australian hospitals over a 10-year period

	Hospital admissions	ICU admissions	Total RRT calls
Total number	4 914 746	196 488	99 377
ICU classification			
Metropolitan	27.1%	14.2%	16.5%
Private	9.1%	10.0%	3.3%
Rural/regional	21.0%	15.6%	12.3%
Tertiary	42.8%	60.2%	67.9%
Jurisdiction			
Australian Capital Territory	1.5%	2.4%	2.7%
New South Wales	26.1%	23.3%	25.9%
Northern Territory	0.7%	1.3%	0.2%
Queensland	11.7%	6.3%	5.1%
South Australia	8.3%	9.7%	8.5%
Tasmania	0.9%	0.7%	0.3%
Victoria	36.6%	45.6%	45.1%
Western Australia	14.1%	10.7%	12.2%
ICU level			
1	0.6%	0.8%	0.4%
2	33.6%	23.8%	19.8%
3	65.8%	75.4%	79.7%

Study infrastructure and coordination

The study was coordinated from the Australian and New Zealand Intensive Care Society Centre for Outcome and Resource Evaluation (ANZICS-CORE). A management committee (Appendix) oversaw all aspects of the study, including study design and development, obtaining funding, development, review and distribution of the study protocol and data dictionary, collation of results, query resolution with participating sites, data analysis, and manuscript writing.

Staff from the 102 adult hospitals known to have an RRT were invited to participate via email in early 2010, and the protocol and data dictionary were finalised in May 2010. At each hospital, the investigators obtained site-specific data from clinical information systems and inhouse RRT databases. These were collated into a Microsoft Excel spreadsheet, and emailed to the coordination centre. Data enquiries were handled by one or more site investigators at each hospital (Appendix).

Funding was obtained from the Australian Commission on Safety and Quality in Health Care (ACSQHC) to fund a part-time research officer, and cover partial costs at participating sites.

Data collected

At each site, the investigators obtained retrospective data for each financial year (1 July to 30 June) as aggregate numbers, collated in a Microsoft Excel spreadsheet. The 2000–01 financial year is represented by the year 2000. Only aggregate data were provided, and no individual patient data were submitted to the management committee. All sites provided identical data and a data dictionary was provided to investigators to standardise data collection. Only years where data were available for the complete financial year were included. Thus, data for each year were classified as "unavailable" if the hospital did not collect data for that year, or if data were only available for part of the year.

At each site, investigators collected data on numbers of hospital admissions lasting more than 24 hours (excluding day cases, endoscopies, same-day dialysis and chronic/rehabilitation patients), inhospital deaths in acute patients, ICU admissions and total RRT calls.

In addition to collecting data on annual RRT calls or admission numbers, we also calculated the inhospital mortality of RRT patients. To achieve this, site investigators collated data on the number of "RRT patients where the inhospital mortality was known". This group calculated the number of patients subject to RRT review by excluding repeat RRT reviews (so outcome was not counted twice), and excluding RRT calls where the inhospital outcome was not known.

Finally, site investigators collected data on "RRT call patient deaths", which was the number of patient deaths

Table 2. Comparison of site characteristics for study participants and non-participants over a 10-year period

	Non-participant	Participant	Total	*P**
Jurisdiction				
Australian Capital Territory	1 (1.5)	1 (2.9)	2 (2.0)	
New South Wales	23 (34.3)	6 (17.1)	29 (28.4)	
Northern Territory	0 (0)	1 (2.9)	1 (1.0)	
Queensland	18 (26.9)	3 (8.6)	21 (20.6)	0.07
South Australia	4 (6.0)	4 (11.4)	8 (7.8)	
Tasmania	2(3.0)	1 (2.9)	3 (2.9)	
Victoria	15 (22.4)	15 (42.9)	30 (29.4)	
Western Australia	4 (6.0)	4 (11.4)	8 (7.8)	
ICU classification				
Metropolitan	14 (20.9)	8 (22.9)	22 (21.6)	
Private	29 (43.3)	6 (17.1)	35 (34.3)	0.02
Rural/regional	16 (23.9)	10 (28.6)	26 (25.5)	
Tertiary	8 (11.9)	11 (31.4)	19 (18.6)	
Public/private				
Private	29 (43.3)	6 (17.1)	35 (34.3)	0.008
Public	38 (56.7)	29 (82.9)	67 (65.7)	
ICU level				
1	6 (9.0)	1 (2.9)	7 (6.9)	
2	33 (49.3)	16 (45.7)	49 (48.0)	0.41
3	28 (41.8)	18 (51.4)	46 (45.1)	
Total	67	35	102	

ICU = intensive care unit. * Significance, < 0.05.

among the group of "RRT patients where the inhospital mortality was known". Mortality in RRT patients was estimated by dividing the number of deaths by the number of RRT patients where this outcome measure was known.

Data analysis and statistics

We present descriptive statistics as crude numbers and percentage of totals, and distributions are presented as median and interquartile range (IQR). Details on hospital admissions, ICU admissions and total RRT calls are presented as aggregate data, and according to hospital type, jurisdiction of Australia, and College of Intensive Care Medicine level (1, 2 or 3).[14]

Annual RRT reviews were presented as RRT calls per 1000 admissions. We present the range, median and IQR for call numbers overall. Additionally, in hospitals that contributed data for at least four consecutive years, we plot the trend for annual RRT calls per 1000 admissions versus year since implementation, and describe changes in annual RRT reviews by comparing calls per 1000 admissions in the last versus the first year of data submitted.

Inhospital mortality was derived by dividing deaths over admissions for years where both data were available, and are expressed as a percentage. RRT call patient mortality was obtained by dividing RRT call patient deaths by the number of RRT patients where the inhospital mortality was known (also expressed as a percentage).

Statistical analysis was performed using SAS version 9.2 (SAS Institute). Comparison of proportions was performed using χ^2 tests for equal proportion with Yates' continuity correction, and a two-sided $P < 0.05$ was taken to indicate statistical significance.

Results

Details of overall cohort

At the time of study enrolment, 102 adult hospitals were known to have an RRT and, of these, 35 (34.3%) participated in the study. Based on the known RRT start date at each hospital, data were available for 198 of 270 (73.3%) possible years. In the 2000–01 financial year, five sites contributed data, and this increased to 35 sites in the 2008–09 financial year.

Overall, there were 4.91 million hospital admissions, 196 488 ICU admissions, and 99 377 RRT calls (Table 1). Most data arose from hospitals in Victoria, New South Wales and Western Australia, and from level 2 and 3 ICUs (Table 1 and Table 2). Participating sites were more likely to be public and tertiary level hospitals (Table 2).

Change in annualised RRT reviews

The annualised RRT reviews varied almost 53-fold, from 1.35 per 1000 admissions in a rural/regional hospital in 2007–08, to 71.32 per 1000 admissions in a tertiary-level hospital in 2009–10. The median number of RRT reviews was 14.0 (IQR, 8.0–30.0) calls per 1000 admissions.

Among the 35 participating sites, 27 contributed at least 4 years of data (Figure 1). Among these 27 hospitals, in 23 hospitals, the annualised number of RRT reviews per 1000 admissions was higher in the last year compared with the first year of data submission (range of increase, 11.9%–777.4%; median, 90%; IQR, 40%–180%). In the remaining four hospitals, the annualised number of RRT reviews per 1000 admissions was lower in the last year

compared with the first year (range of decrease, – 5.5% to – 29.8%).

Inhospital mortality of hospital admissions and patients subject to RRT review

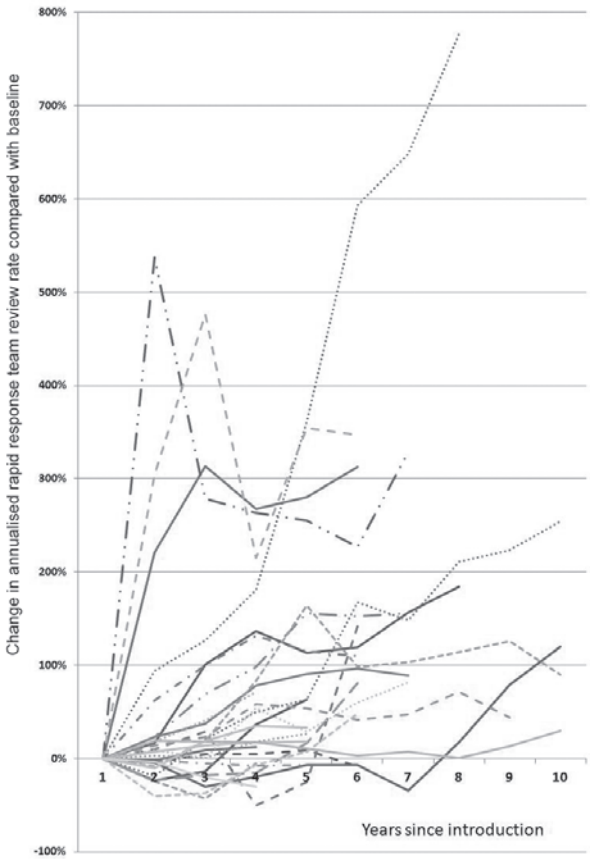
Over the 10-year period, there were 4 818 277 hospital admissions where the inhospital mortality was known; among these, there were 79 476 deaths (1.6%). Among the 99 377 RRT calls, there were 70 924 RRT patients for whom the outcome was known; among these, there were 17 260 deaths (24.3%).

As there were 79 476 hospital deaths and 17 260 RRT-related deaths, we calculate that the RRT services reviewed 21.7% of the patients who died in the participating hospitals over the 10-year study period.

Details of data from the 2008–09 financial year

In the 2008–09 financial year, all 35 hospitals contributed data. During the year, there were 862 886 hospital admissions, 33 842 ICU admissions and 18 800 RRT calls. Among the 14 743 RRT patients for whom the outcome was known, there were 3305 deaths (22.4%). In the 2008–09 financial year, the RRT reviewed at least 3305/13 611 (24.3%) of all patients who died in hospital.

Figure 1. Percentage change in annualised rapid response team review rate compared with baseline for 27 hospitals contributing at least 4 years of continuous data



Discussion

We studied 35 RRT-equipped Australian adult hospitals over a 10-year period. We found that in 23 hospitals there was an increase in annual RRT calls after adjusting for hospital admissions. We further found that the mortality of RRT patients was around 24%, and that the RRT reviewed about one in five of all hospital deaths. As these findings now affect more than 14 000 patients annually, they have important public health implications.

Our findings suggest that patients reviewed by the RRT are at increased risk of death, with inhospital mortality greater than the 11% typically reported for ICU admissions in Australia[14] but less than the 80% mortality seen in patients who suffer cardiac arrest.[17,18] It is likely that many of the patients subject to RRT review had limitations of medical therapy and do-not-resuscitate orders. A previously published multicentre study has shown that RRT patients with limitations of medical therapy have an inhospital mortality of about 50%.[19]

Other studies have also shown high mortality in adult patients subject to RRT review, ranging from 23.6% to 31.8%.[11-13,19] The mortality presented here (24.3%) is very similar to that seen in a recently published seven-hospital multinational prospective observational study (23.6%).[19] It is also similar to that of patients urgently admitted to the ICU from the ward.[20]

Our findings suggest that RRT reviews are increasing in a substantial number of hospitals and now involve more than 14 000 patients in Australia every year. As the study hospitals represented here comprise about a third of adult RRT-equipped hospitals, it is highly likely that this number is substantially larger.

Given the high inhospital mortality of patients subject to RRT review, our findings suggest that novel strategies are required to prevent patients deteriorating before RRT criteria are fulfilled, and to optimise the outcome of patients reviewed by the RRT. If part of the mortality is related to not-for-resuscitation orders, then there is a need for systematic improvements of ward-based end-of-life care. As only a quarter of these hospitals are specifically funded to provide such services,[15] our findings also suggest there may be a need to better resource RRTs. Finally, as RRT patients represent a large proportion of ICU workload and are subject to high inhospital mortality, there may also be a need to develop centralised databases

for RRT calls similar to that performed for ICU admissions in Australia and New Zealand.[21]

Our study has a number of strengths. It involved 35 hospitals, a 10-year inception period, and examined and compared the outcomes of more than 4.8 million hospital admissions and 70 000 RRT call patients. It is the largest multicentre study to demonstrate high inhospital mortality in RRT patients. It involved the collection of simple aggregate data sets, use of a data dictionary to standardise data collection, and data queries to optimise data quality.

Despite these strengths, our study has important limitations, including its retrospective design, single-country representation, incomplete data sets, low participation rate, and disproportionate representation from limited jurisdictions and large teaching hospitals. Thus, we cannot comment on the details of the breakdown of the relative numbers of repeat RRT calls and patients for whom the outcome was not known. Despite these limitations, the overall RRT call mortality observed accords well with a recently published multinational prospective observational study[19] and a single centre study from Sweden.[5]

A further limitation was our inability to provide explanations for the high mortality, the timing of death in relation to RRT review, and inability to comment on the proportion of patients subject to end-of-life care and the impact of these factors on RRT patient mortality. We were also not able to comment on factors contributing to the variability of annual RRT rates between hospitals, including local cultural factors, differences in maturation effects, release of guidelines and published studies on the RRT.

Further research is required to better elucidate the epidemiology of patients reviewed by the RRT in order to identify patient, disease and system factors that may contribute to a patient needing RRT review, which can be addressed to improve patient outcomes. Importantly, strategies need to be developed to prevent deterioration in the period before RRT review. In addition, the findings of our study require confirmation in similar studies from other countries.

Our study suggests that RRT calls are increasing in number in many adult Australian hospitals. Further studies are required to identify patient, disease and system factors that contribute to the high mortality of RRT patients, and to develop strategies to reduce it. In addition, improved resources are likely to be required to treat this at-risk group of patients.

Acknowledgement

Funding for this study was provided by the ACSQHC. The funder had no role in the conception, design, conduct, analysis or writing phases of the study.

Competing interests

Daryl Jones received a research grant from the ACSQHC for RRT research in 39 Australian hospitals, and consultancy fees from Eastern Health. Rinaldo Bellomo works as a paid consultant for Philips Medical Systems in the development of monitoring technology for general wards.

Author details

The ANZICS-CORE MET dose investigators
Correspondence: Daryl.Jones@austin.org.au

References

1 Steel AC, Reynolds SF. The growth of rapid response systems. *Jt Comm J Qual Patient Saf* 2008; 34: 489-95.
2 Lobos AT, Costello J, Gilleland J, et al. An implementation strategy for a multicentre pediatric rapid response system in Ontario. *Jt Comm J Qual Patient Saf* 2010; 36: 271-80.
3 Ludikhuize J, Hamming A, de Jonge E, Fikkers BG. Rapid response systems in The Netherlands. *Jt Comm J Qual Patient Saf* 2011; 37: 138-44.
4 Boniatti MM, Azzolini N, da Fonseca DL, et al. Prognostic value of the calling criteria in patients receiving a medical emergency team review. *Resuscitation* 2010; 81: 667-70.
5 Jäderling G, Calzavacca P, Bell M, et al. The deteriorating ward patient: a Swedish-Australian comparison. *Intensive Care Med* 2011; 37: 1000-5.
6 Jones D, George C, Bellomo R, et al. Introduction of Medical Emergency Teams in Australia and New Zealand: a multi-centre study. *Crit Care* 2008; 12: R46.
7 DeVita M. Medical emergency teams: deciphering clues to crises in hospitals. *Crit Care* 2005; 9: 325-6.
8 Jones D, Bates S, Warrillow S, et al. Effect of an education programme on the utilization of a medical emergency team in a teaching hospital. *Intern Med J* 2006; 36: 231-6.
9 Jones D, Mitra B, Barbetti J, et al. Increasing the use of an existing medical emergency team in a teaching hospital. *Anaesth Intensive Care* 2006; 34: 731-5.
10 DeVita MA, Braithwaite RS, Mahidhara R, et al. Use of medical emergency team responses to reduce hospital cardiopulmonary arrests. *Qual Saf Health Care* 2004; 13: 251-4.
11 Calzavacca P, Licari E, Tee A, et al. Features and outcome of patients receiving multiple Medical Emergency Team reviews. *Resuscitation* 2010; 81: 1509-15.
12 Casamento AJ, Dunlop C, Jones DA, Duke G. Improving the documentation of medical emergency team reviews. *Crit Care Resusc* 2008; 10: 29.
13 Buist MD, Moore GE, Bernard SA, et al. 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.
14 Drennan K, Hicks P, Hart GK. Intensive Care Resources & Activity: Australia & New Zealand 2007/2008. ANZICS, Melbourne. http://www.anzics.com.au/core/reports (accessed Aug 2011).
15 The ANZICS-CORE MET dose Investigators; Jones D, Drennan K, Hart GK, et al. Rapid Response Team composition, resourcing and calling criteria in Australia. *Resuscitation* 2012; 83: 563-7.
16 Jacques T, Harrison GA, McLaws ML. Attitudes towards and evaluation of medical emergency teams: a survey of trainees in intensive care medicine *Anaesth Intensive Care* 2008; 36: 90-5.

17 McGrath RB. In-house cardiopulmonary resuscitation–after a quarter of a century. *Ann Emerg Med* 1987; 16: 1365-8.
18 Peberdy MA, Ornato JP, Larkin GL, et al. Survival from in-hospital cardiac arrest during nights and weekends. *JAMA* 2008; 299: 785-92.
19 Jones DA, Bagshaw SM, Barrett J, et al. The role of the medical emergency team in end-of-life care: a multicenter, prospective, observational study. *Crit Care Med* 2012; 40: 98-103.
20 Flabouris A, Hart G, George C. Observational study of patients admitted to intensive care units in Australia and New Zealand after interhospital transfer. *Crit Care Resusc* 2008; 10: 90-6.
21 Stow PJ, Hart GK, Higlett T, et al; ANZICS Database Management Committee. Development and implementation of a high-quality clinical database: the Australian and New Zealand Intensive Care Society Adult Patient Database. *J Crit Care* 2006; 21: 133-41. ❑

Appendix. ANZICS-CORE MET dose investigators

Writing and management committee

Daryl A Jones (Chair), Kelly Drennan, Michael Bailey, Graeme K Hart, Rinaldo Bellomo, Steven A R Webb

Site investigators (hospitals are in Victoria unless specified)

The Alfred: Sandy Zalstein, Kathleen Collins
Alice Springs (NT): Penny Stewart, Wendy Corkill
Austin: Antoine Schneider, Paolo Calzavacca
Ballarat Health Services: Andrew Thomas, Dianne Hill, Sofia Jasiowski
Barwon Health: David Green, Peter Stow
Bendigo: Jason Fletcher, Julie Smith
Cairns Base (Qld): Drew Wenck, Catherine Pearce
Calvary Mater Newcastle (NSW): Melissa Lintott, Katrina Ellem
Calvary Wakefield (SA): Amanda Rischbieth, Katherine Davidson
Canberra (ACT): Imogen Mitchell, Nicole Slater, David Elliott
Central Gippsland: Jenny Dennett, Tim Coles
Children's at Westmead (NSW): Bradley Ceely, Stephen Jacobs
Dandenong: Yvonne Kearley, Kate Shepherd, Bridget O'Bree
Epworth Freemasons: Nerina Harley, Megan Robertson, Lenise Banner, Kristy Green
Flinders (SA): Andrew Bersten, Elisha Matheson
Flinders Private (SA): Merle Carter, Andrew Holt
Fremantle (WA): Frank Breheny
Gosford (NSW): John Albury, Robert Cameron
Goulburn Valley: Lynn Morcom, Julie Mathewson, Mathew Piercy
Hornsby (NSW): Jay Halkhoree, James Fratzia
Joonalup (WA): Bev Ewens, Brad Power
Lismore (NSW): Di Goldie, Craig McCalman
Liverpool (NSW): Sharon Micallef, Nicholas Mifflin, Michael Parr
Lyell McEwin (SA): Josette Wood, Peter Thomas, Sam Clausen
Nepean (NSW): Stuart Lane, Janet Scott
North West Regional (Tas): Trudy Segger, Alan Rouse
Redcliffe (Qld): Leeona Smith, Hamish Pollock
Repatriation General (SA): Jayne Williams, Andrew Bersten
Royal Children's: Warwick Butt, Carmel Delzoppo, Sophie Sydall
Royal Melbourne: Nerina Harley, Peter Morley, Jennifer Bell
Sir Charles Gairdner (WA): Mary Pinder, Anne Brinkworth, Brigit Roberts
St John of God Ballarat: Barry Flynn
St John of God (Subiaco, WA): Kim Lawrence, David Morgan
St Vincent's: John Santamaria
Townsville Health Service District (Qld): Geoff Gordon, Katharine Hutchinson
Wangaratta: Brett Johnson
Warrnambool: Marcia Beard
Warringal Private: Jenny Broadbent
Women's and Children's (SA): Katrina Welbing, Michael Yung, Neil Matthews