

# Rapid response team calls that overlap in time: incidence, consequences and patient outcomes

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The uptake of rapid response systems (RRSs) has been rapid and uncoordinated,<sup>1</sup> largely based on readiness and acceptance at individual hospitals. The Australian Commission on Safety and Quality in Health Care (ACSQHC) has designated the recognition and response to clinical deterioration as a national safety and quality health service standard (Standard 9) to be adopted by medical facilities in all Australian states and territories.<sup>2</sup>

Almost universally, rapid response teams (RRTs) evolved from pre-existing cardiac arrest teams, often without specific funding to accommodate their expanded role and resource requirements.<sup>3,4</sup> This has strained hospital departments tasked with supporting RRTs, and continues to do so as RRT activity escalates, sometimes dramatically.<sup>5-8</sup> RRT activity, particularly when not distinctly resourced, may disrupt other hospital routines, inconvenience staff and precipitate multiple calls and calls that overlap in time.<sup>9</sup>

Escalating activity, competing clinical demands and overlapping calls all have the potential to inhibit RRT responsiveness and efficiency. Delays in delivery of critical life-saving interventions that are typical of RRT patient care<sup>10</sup> may harm patients.<sup>11,12</sup> The link between overlapping RRT calls, delayed RRT response and the subsequent potential for patient harm has not yet been explored.

Our aims were to ascertain the extent of overlap RRT calls, factors associated with overlap calls and associated patient outcomes.

## Methods

We used retrospective data linkage of prospectively collected data stored within an RRS, an intensive care unit, and hospital administrative databases. The hospital administrative databases provided times of admission and numbers of overnight and same-day patient admissions. The study period was 1st July 2013 to 30 May 2016 (35 months). We obtained ethics approval from the Royal Adelaide Hospital Human Research Ethics Committee (HREC/16/RAH/238), with the study regarded as an audit.

## Setting

We conducted the study at the Royal Adelaide Hospital, an adult tertiary referral centre and university-affiliated public hospital of about 550 beds, including a combined ICU and high dependency unit.

## ABSTRACT

**Objective:** To investigate overlap rapid response team (RRT) calls, factors associated with overlap calls, and their impact on RRT call times and patient outcomes.

**Design and setting:** Review of prospectively collected, linked clinical and administrative datasets, at a public adult tertiary hospital during July 2013 to May 2016.

**Results:** There were 11 669 RRT calls to 7223 patients, of which 10 868 calls (93.1%) were to inpatients. The median number of daily calls was 12 (interquartile range [IQR], 9–15 calls; range, 2–29 calls). The median number of daily calls per 1000 hospital admissions was 56.3 (IQR, 41.3–78.9 calls/1000 admissions; range, 8.3–231.5 calls/1000 admissions), and the median proportion of the day spent at RRT calls was 22.8% (IQR, 16.9%–30.5%). In total, 4575 (39.2%) calls overlapped. Overlap calls, compared with non-overlap calls, had similar patient characteristics, but a longer response time (4 min v 3 min;  $P < 0.001$ ) and scene time (20 min v 34 min;  $P < 0.001$ ). The daily number of calls correlated with the number of overnight-stay hospital admissions ( $r = 0.104$ ;  $P = 0.001$ ), but not with the total number of hospital admissions ( $r = -0.035$ ;  $P = 0.258$ ). The number of overlap calls correlated with the number of RRT calls ( $r = 0.786$ ;  $P < 0.001$ ), and also correlated with the proportion of the day spent at RRT calls ( $r = 0.762$ ;  $P < 0.001$ ). Overlap calls, compared with non-overlap calls, were more likely to result in an ICU admission (484 calls [11.2%] v 571 calls [8.7%];  $P < 0.001$ ). In contrast, efferent limb failure (815 calls [17.8%] v 1195 calls [16.8%];  $P = 0.389$ ) and hospital mortality (496 calls [19.3%] v 781 calls [19.6%];  $P = 0.823$ ) was similar for overlap and non-overlap calls, respectively.

**Conclusions:** Overlap RRT calls are common and influenced by overall RRT and hospital activity. They are more likely to be associated with longer response and scene times and unanticipated ICU admissions.

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## Rapid response system

At the Royal Adelaide Hospital, patient vital signs are recorded on a standardised track-and-trigger patient observation chart, consistent with ACSQHC guidelines.<sup>7,13</sup> The highest tier of the RRS at the hospital is the RRT call

(known locally as the medical emergency response). There are two types of RRT calls: to a medical emergency team (MET), responding to inpatients in a ward; and to a Code Blue team, responding to impending cardiorespiratory arrests, as well as inpatients in a non-ward area and non-inpatients who meet MET criteria. The RRT does not respond to the emergency department (ED), ICU, operating theatres or recovery wards.

The MET consists of four general medical and surgical doctors and one ICU nurse. The Code Blue team consists of the MET plus an ICU doctor and a second ICU nurse. At the time of the first RRT call, the most senior RRT member will decide how the RRT doctors will split and attend any overlap call. For the RRT nurses, the ICU nurse coordinator will dispatch the next most senior RRT nurse and an RRT trolley. There are four allocated RRT nurses per 8-hour shift, all based in the ICU.

All RRT doctors at the Royal Adelaide Hospital are also scheduled to undertake other hospital duties (eg, admitting patients from the ED, ward calls and inpatient consultations) as are RRT nurses (eg, ICU equipment support, ICU patient care).

RRT trolleys are equipped with a timer that begins recording on RRT activation and is stopped at the end of call, providing total call time. Time from activation until arrival at call location, is also recorded (response time). Scene time was defined as the time between RRT trolley arrival and departure from the call location.

We collected RRT call and ICU admission data prospectively, and missing data were retrospectively completed. There are quality checks for data entry. RRT calls are categorised as inpatient, outpatient, visitor or staff. Patient identifiers (name, date of birth, hospital unique medical record number) and event details (date and time of RRT call and ICU admission) were used as key links to create the study-specific dataset. We performed data management and analysis using SPSS Statistics, version 21 (IBM). We checked linked items manually and with software tools and removed patient identifiers before analysis.

### Outcome measures

Outcome measures for comparing overlap calls with non-overlap calls were:

- RRT call outcome
- efferent limb failure (ELF), defined as a repeat RRT call to the same inpatient, or an unplanned ICU admission, within the 24-hour period following a RRT call whose outcome was that the patient was left in the ward
- hospital mortality
- RRT response, scene and total call times.

### Statistical analysis

An overlap call was defined as a call activated while another RRT call was still active (we defined active as from time of activation until end of call). We show patient and call demographics collectively for all RRT overlap and non-overlap calls. Only inpatients were included for analysis of ELF. We used the  $\chi^2$  test for categorical variables. For continuous variables, we report medians and interquartile ranges (IQRs) and compared them using the Mann–Whitney or Kruskal–Wallis tests. Trends in time-dependent data were analysed using regression curve estimation. Scatter plots and Pearson correlation were used to assess association between daily total and overlap RRT calls with daily hospital and RRT activity. Logistic regression was used to assess predefined predictors of patient characteristics (age, sex and home ward outlier status), RRT call features and activity (time of day category, day of week, night or day RRT called, reason for call and number of daily calls) and hospital activity (daily number of hospital separations) with overlap RRT calls. Statistical significance was set at  $P < 0.05$ .

## Results

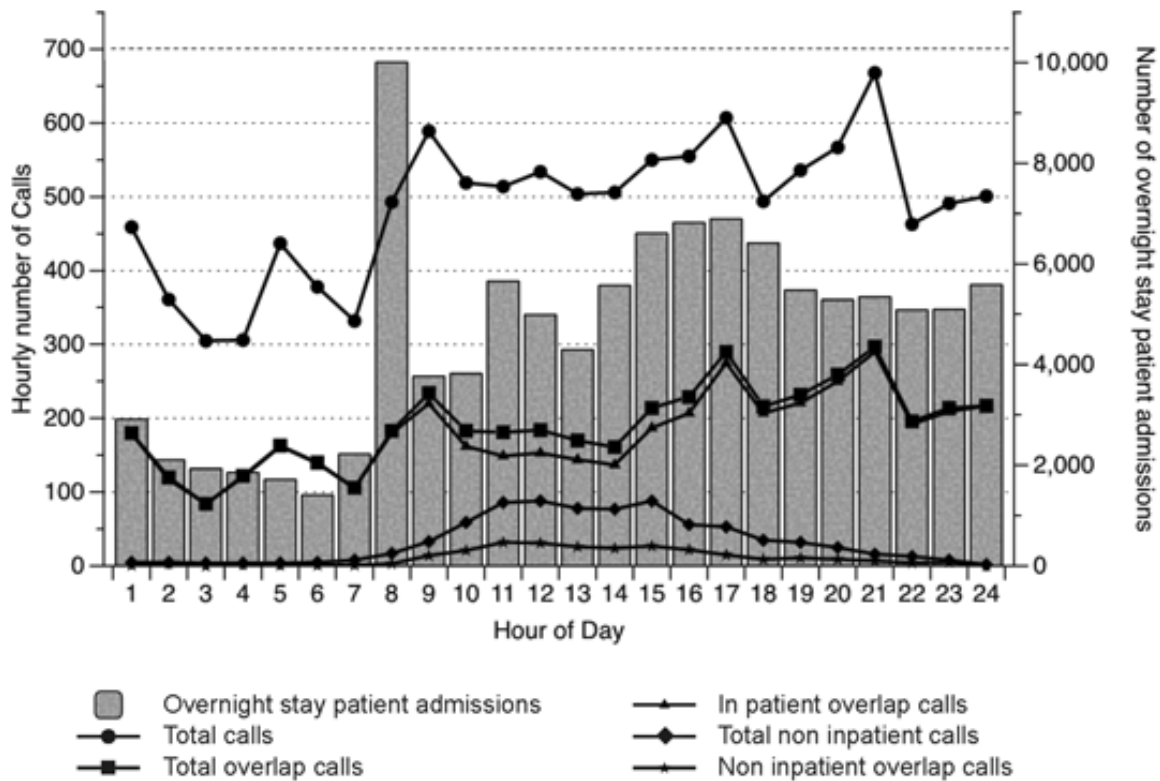
### Total RRT activity

There were 11 669 RRT calls: 10 104 (86.6%) to the MET and 1565 (13.4%) Code Blue calls. Most were to inpatients (10 868 [93.1%]), followed by outpatients (405 [3.5%]), visitors (272 [2.3%]) and staff (124 [1.1%]). Calls occurred to 7223 patients, of whom 6526 (90.4%) were inpatients and 3748 (51.8%) were men. The median age was 71 years (IQR, 56–82). There was no significant change in median age over the study period. Inpatients were older than non-inpatients (median age, 72 years [IQR, 57–83 years] v 57 years [IQR, 37–71 years], respectively;  $P < 0.001$ ).

Most calls (6297 [54.0%]), occurred between 18:00 and 08:00 hours. This differed for inpatient calls (6149 [56.6%]) compared with non-inpatient calls (148 [18.5%]) (Figure 1). Tuesdays (1763 calls [15.1%]) and Thursdays (1741 calls [14.9%]) were the busiest days for calls, followed by Wednesdays (1683 calls [14.4%]), Fridays (1678 calls [14.4%]), Saturdays (1664 calls [14.3%]), Mondays (1616 calls [13.8%]) and Sundays (1524 calls [13.1%]).

The median daily number of calls per 1000 total hospital admissions was 12 (IQR, 9–15 calls/1000 admissions; range 2–29 calls/1000 admissions), equivalent to a daily median of 56.3 calls/1000 admissions (IQR, 41.3–78.9 calls/1000 admissions; range 8.3–231.5 calls/1000 admissions). There was no significant change in the daily number of calls, or calls per 1000 hospital admissions, over the study period. The median proportion of the day spent at RRT calls was equivalent to 5 hours and 28 minutes (22.8% of the 24

**Figure 1. Pattern of rapid response team activity, overlap calls and time of hospital admission for overnight stay separations, by hour of day**



hours [IQR, 16.9%–30.5%]), and the median proportion of each hour was equivalent to 15 minutes (24.3% of each hour of the day [IQR, 21.5%–26.7%]).

### Overlap RRT Calls

Overall, 4575 RRT calls (39.2%) were overlapped by another RRT call. There were two overlapping calls recorded for 4200 calls (36% of total calls; 91.8% of overlap calls), three for 340 calls (2.9% of total; 7.4% of overlap calls), four for 34 calls (0.3% of total; 0.7% of overlap calls) and five for three calls (0.03% of total; 0.1% of overlap calls). The median number of daily overlap calls was four (IQR, 2–6 overlap calls; range 0–18 overlap calls) and the proportion of calls that were overlapped was 37.5% (IQR, 22.2%–50%). There was no significant change in these values over the study period.

Compared with non-overlap calls, overlap calls were for patients with similar characteristics but had longer response, scene and total times, as well as different triggers, and were later in the day (Table 1). This pattern was replicated for the order of overlap calls; that is, fourth and fifth overlap calls had longer response times and were associated with periods of higher RRT activity (Table 2).

### Relationship of total and overlap calls with RRS and hospital activity

There was diurnal variation in total, inpatient, non-inpatient, and overlap calls (Figure 1). The hourly number of RRT calls correlated with the hourly number of overnight ( $r = 0.662$ ;  $P < 0.001$ ), but not same-day ( $r = 0.302$ ;  $P = 0.152$ ), admissions.

The hourly number of overlap calls correlated with the hourly number of overnight ( $r = 0.620$ ;  $P = 0.001$ ) but not same-day ( $r = 0.093$ ;  $P = 0.667$ ), admissions. Similarly, the hourly proportion of RRT calls that were overlapping correlated with the hourly number of overnight ( $r = 0.427$ ;  $P = 0.037$ ), but not same-day ( $r = -0.175$ ;  $P = 0.415$ ), admissions.

The daily number of RRT calls correlated with the daily number of overnight stays ( $r = 0.104$ ;  $P = 0.001$ ), but not with total hospital admissions ( $r = 0.035$ ;  $P = 0.258$ ). The daily number of overlap calls and the proportion of RRT calls that were overlapped correlated with (respectively):

- the number of RRT calls ( $r = 0.786$ ;  $P < 0.001$  and  $r = 0.467$ ;  $P < 0.001$ )
- the proportion of the day spent at an RRT call ( $r = 0.762$ ;  $P < 0.001$  and  $r = 0.545$ ;  $P < 0.001$ ) (Figures 2 and 3)

**Table 1. Comparison of non-overlap and overlap rapid response team (RRT) calls for inpatients**

| Variable   | RRT calls to inpatients only*             |  |          |
|--|---|--|----------|
|  | No overlap calls, <i>n</i> = 6562 (60.4%) | Overlap calls, <i>n</i> = 4306 (39.6%) | <i>P</i> |
| Median age, years (IQR)                                      | 72 (58–83)                                | 71 (57–83)                             | 0.592    |
| Males, <i>n</i> (%)  | 3541 (53.9%)                              | 2297 (53.3%)                           | 0.421    |
| Patients with first call, <i>n</i> (%)                       | 4003 (61.0%)                              | 2539 (59.0%)                           | 0.038    |
| Patients with multiple calls, <i>n</i> (%)                   | 2559 (39.0%)                              | 1767 (41.0%)                           | –        |
| Median call time, hour of day (IQR)                          | 12:50 (07:20–18:35)                       | 14:35 (08:00–19:24)                    | < 0.001  |
| Day RRT calls (09:30–21:30), <i>n</i> (%)                    | 3479 (53.0%)                              | 2382 (55.3%)                           | 0.019    |
| Night RRT calls (21:30–09:30), <i>n</i> (%)                  | 3083 (47.0%)                              | 1924 (44.7%)                           | –        |
| Median response time, minutes (IQR)                          | 3 (2–5)                                   | 4 (2–5)                                | < 0.001  |
| Median scene time, minutes (IQR)                             | 20 (12–33)                                | 34 (20–55)                             | < 0.001  |
| Median total time, minutes (IQR)                             | 25 (15–36)                                | 37 (25–60)                             | < 0.001  |
| Inpatient in non-admitting team ward (outlier), <i>n</i> (%) | 192 (2.9%)                                | 121 (2.8%)                             | 0.768    |
| Trigger for RRT call, <i>n</i> (%)                           |   |  | 0.030    |
| > 3 triggers in lower escalation tier                        | 31 (0.5%)                                 | 18 (0.4%)                              |          |
| Cardiac arrest   | 122 (1.9%)                                | 76 (1.8%)                              |          |
| Deterioration in level of consciousness or sedation          | 905 (13.8%)                               | 547 (12.7%)                            |          |
| O2 saturation < 89%  | 1052 (16.0%)                              | 736 (17.1%)                            |          |
| Pulse rate < 40 beats per minute                             | 110 (1.7%)                                | 73 (1.7%)                              |          |
| Pulse rate > 140 beats per minute                            | 662 (10.1%)                               | 497 (11.5%)                            |          |
| Respiratory arrest   | 23 (0.4%)                                 | 10 (0.2%)                              |          |
| Respiratory rate < 7 breaths per minute                      | 28 (0.4%)                                 | 26 (0.6%)                              |          |
| Respiratory rate > 30 breaths per minute                     | 548 (8.4%)                                | 385 (8.9%)                             |          |
| Systolic blood pressure < 90 mmHg                            | 1682 (25.6%)                              | 1087 (25.2%)                           |          |
| Systolic blood pressure > 200 mmHg                           | 595 (9.1%)                                | 344 (8.0%)                             |          |
| Significant bleeding   | 45 (0.7%)                                 | 46 (1.1%)                              |          |
| Threatened airway  | 80 (1.2%)                                 | 53 (1.2%)                              |          |
| Unattended lower escalation tier                             | 37 (0.6%)                                 | 17 (0.4%)                              |          |
| Unexpected or uncontrolled seizure                           | 183 (2.8%)                                | 106 (2.5%)                             |          |
| Worried  | 459 (7.0%)                                | 285 (6.6%)                             |          |

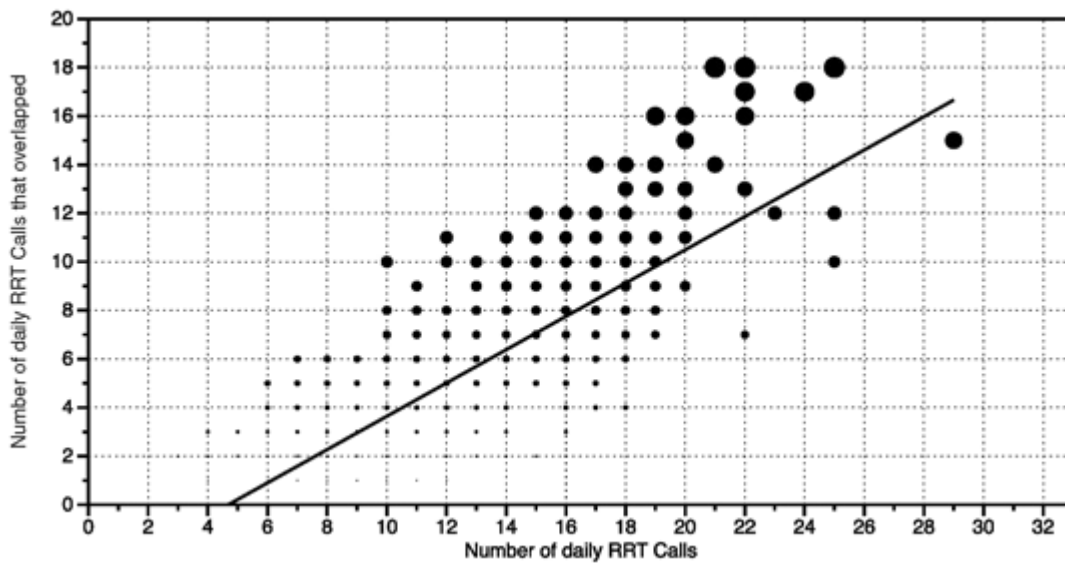
IQR = interquartile range. \* Total inpatient calls = 10 868; total inpatients = 6526.

**Table 2. Comparison of non-overlap calls with first, second, third, and fourth and fifth overlap calls with call times, overall rapid response team activity and patient outcomes**

| Variable   | Calls not overlapped<br><i>n</i> = 7092 (60.8%) | First call overlapped by subsequent call<br><i>n</i> = 1914 (16.4%) | Second overlapping call<br><i>n</i> = 2286 (19.6%) | Third overlapping call<br><i>n</i> = 340 (2.9%) | Fourth and fifth overlapping calls<br><i>n</i> = 37 (0.3%) | <i>P</i> |
|--|---|---|--|---|--|----------|
| Median age, years (IQR)                                | 71 (56–82)                                      | 71 (57–82)  | 71 (57–83)   | 70 (54–82)                                      | 71 (54–82)   | 0.534    |
| Median call time of day (IQR)                          | 12:35 (07:32–18:07)                             | 14:00 (07:55–18:46)   | 14:20 (08:13–19:08)                                | 15:40 (08:39–20:16)                             | 14:49 (08:23–20:17)  | 0.003    |
| Median response time, minutes (IQR)                    | 3 (2–5)   | 3 (2–5)   | 4 (2–5)  | 4 (2–5)   | 4 (3–6)  | < 0.001  |
| Median scene time, minutes (IQR)                       | 20 (11–32)                                      | 33 (20–55)  | 22 (13–36)   | 20 (12–36)                                      | 26 (16–51)   | < 0.001  |
| Median total time, minutes (IQR)                       | 24 (15–35)                                      | 28 (24–59)  | 25 (16–40)   | 25 (16–40)                                      | 30 (19.5–55)   | < 0.001  |
| Median no. calls per day (IQR)                         | 11 (9–14)                                       | 13 (10–16)  | 13 (11–16)   | 14 (12–17)                                      | 16 (14–18)   | < 0.001  |
| Median no. calls/1000 daily hospital admissions, (IQR) | 59.4 (45.3–83.0)                                | 66.4 (50.6–91.3)  | 67.5 (52.0–91.5)                                   | 73.6 (56.4–98.7)                                | 78.4 (66.7–91.9)   | < 0.001  |
| Admitted to ICU <i>n</i> (%)                           | 572 (8.7%)                                      | 254 (14.0%)   | 196 (9.2%)   | 30 (9.3%)                                       | 6 (17.6%)  | < 0.001  |
| Median APACHE II score (IQR)                           | 19 (15–25)                                      | 19 (14–25)  | 18 (14–24)   | 19 (15–25.5)                                    | 21 (14.3–27.5)   | 0.465    |
| Median APACHE II risk of death (IQR)                   | 0.29 (0.15–0.53)                                | 0.29 (0.18–0.46)  | 0.29 (0.16–0.46)                                   | 0.32 (0.21–0.50)                                | 0.40 (0.24–0.40)   | 0.744    |
| Efferent limb failure, <i>n</i> (%)                    | 1195 (16.8%)                                    | 351 (18.3%)   | 391 (17.1%)  | 66 (19.4%)                                      | 7 (18.9%)  | 0.472    |
| Hospital outcome, death, <i>n</i> (%)                  | 781 (19.6%)                                     | 223 (21.4%)   | 237 (18.1%)  | 34 (16.9%)                                      | 3 (15.0%)  | 0.259    |

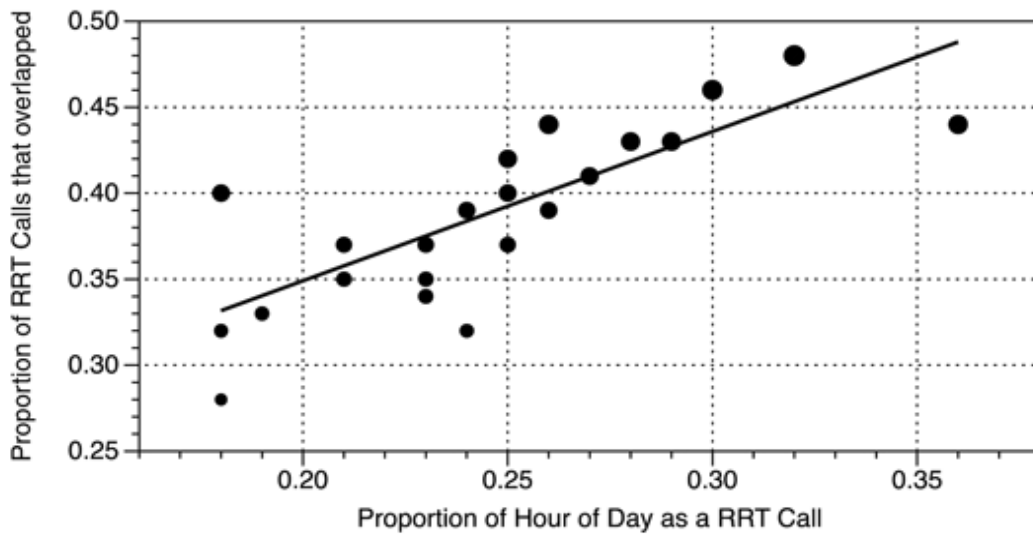
IQR = interquartile range. ICU = intensive care unit. APACHE = Acute Physiology and Chronic Health Evaluation.

**Figure 2. Relationship between daily rapid response team calls that overlap and total rapid response team calls\***



\* The relative size of the circles reflects the proportion of cases distributed to that point.

**Figure 3. Relationship between proportion of RRT calls that are overlap and proportion of the hour of day spent at RRT calls**



RRT = rapid response team.

- the number of overnight-stay admissions ( $r = 0.097$ ;  $P = 0.001$  and  $r = 0.074$ ;  $P = 0.016$ ).

The daily number of overlap calls and the proportion of RRT calls that were overlapped did not correlate with daily hospital admissions ( $r = -0.039$ ;  $P = 0.207$  and  $r = -0.003$ ;  $P = 0.929$ , respectively).

Logistic regression examined age, sex, outlier status, reason for RRT call, hour of day and day of week on the outcome that an RRT call would be an overlap call. The

model was statistically significant ( $P < 0.001$ ) but only accounted for 1.3% of variance (Nagelkerke  $R^2$ ), and had 57.4% sensitivity (95% CI, 55.1%–59.6%) and 64.4% specificity (95% CI, 63.4%–65.3%). Age, sex and outlier status were not predictive for overlap calls. Reasons for the RRT call which were significant factors included, in particular, systolic blood pressure  $> 200$  mmHg ( $P = 0.024$ ; odds ratio [OR], 0.694; 95% CI, 0.505–0.952) and staff concern (“worried”) ( $P = 0.034$ ; OR, 0.781; 95% CI, 0.622–

0.982), and also hour of day ( $P < 0.001$ ; OR, 1.021; 95% CI, 1.015–1.027), and call on Tuesdays ( $P < 0.001$ ; OR, 1.242; 95% CI, 1.016–1.027) and Thursdays ( $P = 0.045$ ; OR, 1.119; 95% CI, 1.002–1.248).

### Overlap calls and inpatient outcomes

ICU admissions were, collectively, ICU admissions associated with an RRT call (793 [76.2%], or an ICU admission within 24 hours of a previous RRT call. Overlap calls, compared with non-overlap calls, were most likely to involve an ICU admission (484 calls [11.2%] and 571 calls [8.7%], respectively;  $P < 0.001$ ). Acute Physiology and Chronic Health Evaluation (APACHE) II scores and predicted risks of death were similar (Table 3). Fourth and fifth overlap calls were more likely to result in an ICU admission than second or third overlap calls (Table 2).

ELF occurred in 2010 RRT calls (17.2%), of which 1762 calls (87.7%) were a repeat RRT call and 248 calls (12.3%) were for patients who were subsequently admitted to the ICU. The ELF rate was similar for both overlap and non-overlap calls.

There were 160 deaths (1.4%) at the time of an inpatient RRT call. This rate was similar for overlap and non-overlap calls (63 deaths [1.4%] v 97 deaths [1.4%];  $P = 0.936$ ). Hospital mortality for inpatient RRT calls was 19.5%, and was similar for patients with overlap and non-overlap calls (781 deaths [19.6%] v 497 deaths [19.3%];  $P = 0.823$ ) (Table 2).

## Discussion

### Principal findings

Using large, linked, clinical and administrative datasets from a single centre, with a median RRT activity of 12 calls per day or 60 calls per 1000 hospital separations, 40% of RRT calls were identified as overlap calls. Overlap calls correlated with increased RRT and hospital activity, had longer response and scene times, showed diurnal variation, and more often resulted in an ICU admission.

### Prior knowledge and new study findings

#### *Overlap calls, RRT activity and hospital admissions*

Overlap calls were not influenced by patient or admitting unit factors, but instead were strongly influenced by RRT activity and hospital admissions, in particular overnight stay admissions. As hospital activity increased, so did RRT activity and in turn, the number of overlap calls. This relationship was linear when the daily number of RRT calls exceeded five. When RRT activity reached 20 calls per day, or one-third of the day was spent at RRT calls, then every second RRT call was an overlap call.

The median RRT “dose” was 57 calls per 1000 hospital admissions. This level of activity is above the median for Australian and New Zealand hospitals,<sup>5</sup> and relatively high in comparison to other reported levels,<sup>14,15</sup> but may be necessary for achieving<sup>16</sup> and sustaining preventable patient adverse events.<sup>7</sup>

**Table 3. Non-overlap and overlap calls to inpatients only, and associated call and patient outcomes**

| Outcome  | Non-overlap calls, $n = 6562$ (60.4%) | Overlap calls, $n = 4306$ (39.6%) | $P$     |
|--|---------------------------------------|-----------------------------------|---------|
| Call outcome, $n$ (%)                                  |                                       |                                   | < 0.001 |
| Left on ward   | 5853 (89.2%)                          | 3732 (86.7%)                      |         |
| Transfer to ICU  | 430 (6.6%)                            | 363 (8.4%)                        |         |
| Transfer to operating theatre                          | 14 (0.2%)                             | 16 (0.4%)                         |         |
| Transfer to ED   | 36 (0.5%)                             | 17 (0.4%)                         |         |
| Transfer to other ward                                 | 138 (2.1%)                            | 119 (2.8%)                        |         |
| Died   | 91 (1.4%)                             | 59 (1.4%)                         |         |
| Hospital outcome, death, $n$ (%)                       | 781 (19.6%)                           | 496 (19.3%)                       | 0.823   |
| Admitted to ICU, $n$ (%)                               | 571 (8.7%)                            | 484 (11.2%)                       | < 0.001 |
| Median APACHE II score, (IQR)                          | 19 (15–25)                            | 19 (14–24)                        | 0.802   |
| Median risk of death, (IQR)                            | 0.29 (0.15–0.53)                      | 0.29 (0.17–0.46)                  | 0.493   |
| Median ICU stay, days (IQR)                            | 3 (1–5)                               | 3 (1–5)                           | 0.992   |
| ICU, died, $n$ (%)                                     | 99 (17.3%)                            | 81 (16.3%)                        | 0.862   |
| ELF, $n$ (%)   | 1195 (16.8%)                          | 815 (17.8%)                       | 0.389   |
| ELF, left on ward and repeat RRT call, $n$ (%)         | 1058/1195 (88.5%)                     | 704/815 (86.4%)                   | 0.167   |
| ELF, left on ward and unplanned ICU admission, $n$ (%) | 137/1195 (11.5%)                      | 111/815 (13.6%)                   | 0.149   |

ICU = intensive care unit. ED = emergency department. APACHE = Acute Physiology and Chronic Health Evaluation. IQR = interquartile range. ELF = efferent limb failure. RRT = rapid response team.

There was diurnal variation in RRT calls, and this is a common finding.<sup>17-19</sup> There was also diurnal variation in overlap calls. Diurnal variation is often attributed to variation in hospital resources,<sup>20,21</sup> but we noted that diurnal variation in total RRT and overlap calls correlated strongly with the diurnal variation in hospital admissions. This relationship was not replicated for same-day admissions, suggesting that patient acuity may influence RRT activity and, consequently, overlap calls.

Other factors may also explain the diurnal variation. RRT calls to non-inpatients were mostly during daytime hours, with most being to outpatients and visitors; this was in keeping with previously reported studies.<sup>22,23</sup> RRT calls to patients recently discharged from the operating theatre, ED and ICU are not uncommon.<sup>24-28</sup> The time of admission to the ward for post-operative and ED patients is generally later in the day<sup>24,25</sup> and a substantial number of ICU patients are sent to the ward after hours.<sup>29,30</sup>

#### *Overlap calls and call response and scene times*

Overlap calls, in particular third, fourth and fifth overlap calls compared with non-overlap calls, had longer response times. The median response time for non-overlap calls was consistent with current guidelines.<sup>31</sup> In contrast, the median response time for overlap calls exceeded the recommended 3 minutes.<sup>32</sup> The time spent at overlap calls was also longer. The consequence was that the proportion of the day spent at RRT calls would increase, and in turn compound the risk of a subsequent RRT call being an overlap.

The composition and size of our RRT is typical of other Australian hospital RRTs.<sup>3</sup> Similarly to other hospitals,<sup>9</sup> our RRT members have other clinical responsibilities in addition to attending RRT calls. For non-overlap calls, a full team of medical and nursing staff (four doctors and one nurse) attend the patient. For overlap calls, the team would split, often to just one doctor and one nurse, thus becoming less effective, and spending longer at a call. This disruption in team structure, function and resourcing may account for longer overlap call response and scene times.

#### *Overlapping calls and patient outcomes*

Hospital and RRT call mortality and occurrence of ELF were similar for overlap and non-overlap calls. In contrast, patients involved in an overlap call were more likely to be admitted to the ICU as an outcome of that call. It is possible that the longer response and scene times of overlap calls, together with the fragmented, less efficient teams, adversely impact on the timely delivery of critical care interventions and the team's capacity to manage clinical deterioration. However, the severity of illness at the time of admission to the ICU (APACHE II score and risk of death), ICU stay and outcome were similar for the groups. Alternatively, the threshold for ICU admission may have been lower at

overlap calls, due to the reduced capacity of the smaller RRT. Further investigations are required to replicate and better understand our findings.

#### **Strengths and weaknesses**

This was a large, novel study of the nature, attributes, associations and outcomes of overlap RRT calls using large, linked datasets of predominantly prospectively collected data over a stable period of time. Although RRT activity, staffing and RRT-associated mortality at the study site was not dissimilar to that of similar Australia and New Zealand hospitals,<sup>3-5</sup> it was a single-centre study and, therefore, our findings may not be generalisable to hospitals with different RRS and hospital activity.

#### **Study implications**

Our findings have important implications for hospital administrators, clinicians responsible for RRS governance and reporting of RRT dose. Attempts to increase RRT activity and hospital throughput, as well as concentrate acute patient activity within large acute public hospitals will, as we found, affect RRT activity. Overlap calls may limit measures of RRS performance by increasing unanticipated ICU admissions, RRT responsiveness, and may strain RRT resources by increasing the proportion of the day spent at RRT calls, and thus further divert RRT staff away from their other scheduled hospital tasks. In addition, decisions for staffing and resourcing of RRS will be further challenged, as few RRSs are funded,<sup>3</sup> and optimal RRT staffing has not yet been identified or matched to patient outcomes.<sup>32</sup>

We also found that RRT activity is influenced predominantly by overnight-stay admissions. As same-day admissions do not substantially contribute to RRT calls,<sup>33</sup> RRT dose should be reported as a rate of both overnight-stay and total hospital admissions.

#### **Conclusions**

Overlap RRT calls are common and associated with RRT and hospital activity. Overlap calls show diurnal variation, and have longer response and scene times and increased rates of unanticipated ICU admissions. Overlap calls will challenge existing models of RRS staffing, resourcing and performance as we strive to achieve optimal activity and patient outcomes. Future investigations in RRS staffing and resourcing should factor in RRT activity and occurrence of overlap calls.

#### **Competing interests**

None declared.

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