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# The effectiveness of a focused rapid response team on reducing the incidence of cardiac arrest in the general ward

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**Abstract**

Rapid response teams have been adopted to prevent unexpected in-ward cardiac arrest. However, there is no convincing evidence of optimal operation with rapid response team. Our aim was to address the impact of focused rapid response team on the safety of patients in wards. Comparison of focused with extended rapid response teams was performed in single center. The extended team operated on adult patients in whole ward (both medical and nonmedical ward) 24 hours per day, 7 days per week during 2012. In 2015, the operational time of the focused team was office hours from Monday to Friday and study population were limited to adult patients in the nonmedical ward. Unexpected in-ward cardiac arrests were compared between the extended team and focused team periods. During the focused team period, there was significant reduction in cardiac arrest per 1000 admissions in whole ward compared to the before the rapid response team period (1.09 vs 1.67, $P < .001$). Compared to that of the extended team period (1.42), there was also a significant reduction in cardiac arrest rate ($P = .04$). The cardiac arrest rate of nonmedical ward patients was also significantly decreased in the focused team period compared to that before the rapid response team period (0.43 vs 0.95, $P < .001$). Compared to the extended team period (0.64), there was a marginally significant reduction in cardiac arrest of nonmedical ward patients ($P = .05$). The focused rapid response team was associated with a reduced incidence of unexpected in-ward cardiac arrest. Further research on the optimal composition and operational time is needed.

**Abbreviations:** CA = cardiac arrest, DNR = do not resuscitation, ICU = intensive care unit, RRT = rapid response team.

**Keywords:** cardiac arrest, hospital rapid response team, wards



## 1. Introduction

In the United States, 48,000 to 98,000 hospitalized patients died annually because of medical errors, including preventable cardiopulmonary arrest.[1] Patients often experience physiological deterioration for several hours before cardiac arrest (CA) and about 50% of the serious adverse event (CA, unplanned admissions to the intensive care unit (ICU), and death) may be preventable.[2,3] A delay between the deterioration of vital signs and early intervention was associated with an increase in patient morbidity and mortality rates.[4,5] In this context, the implementation of rapid response teams (RRT) was recommended for healthcare improvement as part of a "Saving 100,000 Lives" campaign and many hospitals implemented RRT worldwide.[6] Though there remains controversy regarding the efficacy of RRT on the outcomes of hospitalized patients. RRT have been proposed to identify and treat high-risk hospitalized patients in early phases, which might reduce CAs and in-hospital mortality.[7–10] Patients with a delayed activation of RRT were significantly more likely to die in-hospital and had significantly longer hospital length of stay than those with no delayed RRT.[11,12]

The inconsistent results regarding the efficacy of RRT might be due to differences in methodological quality, staff composition, and operational time of RRT despite 1 systematic review and meta-analysis demonstrated the association of RRT with reduction in hospital mortality and cardiopulmonary arrest.[1,13] RRT tend to be multidisciplinary in nature to meet resource and institutional requirements. Therefore, there are differences in the staff composition and operational protocols. In the US, nurses or respiratory therapists may lead RRT, while in the UK the RRT may be led by nurses.[8,14] In Australia, physician-led RRT are common.[15] The optimal composition of staff in RRT and operational time may depend on institution or hospital resources.

In Korea, RRT have been adopted in 7 university-affiliated hospitals since 2008. However, there are several obstacles to the spread of RRT, including difficulties in staff composition,

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**Table 1**

**Rapid response team criteria for "at-risk patients.".**

| |
|---|
| Clinical manifestations |
| Stridor: sign of an upper airway obstruction |
| Chest pain: severe anterior chest or epigastric pain with sweating |
| Altered mentality: altered character and/or depth of mentality (eg, confusion, delirium, drowsiness, stupor, semi-coma, or coma) |
| Vital signs |
| Heart rate: an acute change in the heart rate to <50 or >130 beats/min |
| Respiratory rate: an acute change in the respiratory rate to <8 or >25 breaths/min |
| Shock: an acute change in the systolic blood pressure to <90 mm Hg or a mean pressure <60 mm Hg |
| Laboratory findings |
| A blood gas profile of pH <7.30 or $PaCO_2$ >50 mm Hg or $PaO_2$ <55 mm Hg |
| Lactate >2.0 mmol/L |
| Serum glucose <50 mg/dL with an abnormal mentality |
| Staff member concern for patient (only concerned but not included in other criteria) |

insufficient human resources, lack of hospital costs related to the operation of RRT. In the before period we had an extended (24 hours per day and 7 days per week on adult patients in whole ward) RRT. In the after period we had a more focused RRT (office hours Monday to Friday limited to adult patients in the nonmedical ward). The aim of this study was to examine the impact of focused RRT on the outcome of hospitalized patients by comparing outcome measures before and after implementing focused RRT.

## 2. Material and methods

### 2.1. Study design and population

This study was approved by the Institutional Review Board of Hanyang University Seoul hospital (IRB No.: 2018-07-050). The need for informed consent was waived given the study's observational, and anonymous nature. This prospective observational study was conducted at Hanyang University Hospital, an 813-bed tertiary teaching hospital. Approximately 29,000 patients per year are admitted to this hospital. This hospital has 45 ICU beds (16 medical, 15 surgical, and 14 neonate). Full coverage of organ transplantation services for adults and children, a surgery program, and medical sub-specialties are available. The institutional review board approved the present study and waived informed consent due to its observational design.

RRT implementation was initiated in March 2012. At this time, admitted ward patients at least 18 years of age were included. We modified "at-risk patients" criteria from previous studies and reported the impact of extended RRT in 2014.[5,16–20] The detailed RRT activation criteria are outlined in Table 1. If any of these conditions were met, the nurses or primary physicians were instructed to call a mobile phone that was exclusive to the RRT. In addition to these activation calls from the primary team, we actively screened high-risk patients. Computerized alerts for abnormal laboratory finding also resulted in RRT activation. We also screened patients in the step-down units of each ward and closely observed patients transitioning from the ICU to the general ward. Step-down units are located adjacent to each wards. It is an area for patients who get worse in the general ward or transferred from the ICU. Doctors in each department take care of patients in step-down units. RRT staff performed regular rounding twice daily and assessed patients each day. Patients who were considered high-risk by the anesthesia department in pre-operational consultation were also monitored 1 day before the operation and for at least 2 days after surgery. We excluded patients in the emergency department, operating room, and ICU. These RRT systems were conducted 24 hours per day and 7 days per week. We defined this RRT system as the extended RRT (March 2012 to February 2013), which included as staff members 1 intensivist, 1 interventional cardiologist, 2 internal medicine doctors (1 day and 1 night duty), and 1 ICU nurse.

Since March 2015, the operational time of the RRT was changed to office hours (9:00 to 18:00 Monday to Friday) due to insufficient resources (Table 2). The subject population was changed from all hospitalized adult patients to nonmedical adult patients. Nonmedical patients mean all patients except those admitted to the department of internal medicine. We defined this RRT system as the focused RRT. The other inclusion criteria were same as described above. The staff members included 1 board-certified emergency physician (also intensivist) and 1 ICU nurse.

The focused RRT had regular rounding once a day or more until the patient deterioration was resolved or the patients were transferred to the ICU. Emergency consultation was provided to

**Table 2**

**Differences in the nature of the service before and after the implementation of focused rapid response team.**

| | Before RRT | Extended RRT | Focused RRT |
|---|---|---|---|
| The years | March 2011 to February 2012 | March 2012 to February 2013 | March 2015 to February 2016 |
| Hours of operation | Not applicable | 24 h per day | 9:00 to 18:00 Monday to Friday |
| Team member | Not applicable | Members 1 intensivist, 1 interventional cardiologist, 2 internal medicine doctors and 1 ICU nurse | One board-certified emergency physician (also intensivist) and 1 ICU nurse |
| Patients who were seen | Not applicable | Whole adult patients in wards | Adult patients in nonmedical wards |
| Number of overall adult admissions | 25, 9 + 4 + 20 + 9 002 | 26,021 | 26,482 |
| Number of medical/nonmedical patients | 7242/ 17,760 | 7510/18,511 | 8080/ 18,402 |
| Raw number of the in-ward CA events (medical/nonmedical) | 42 (25/17) | 37 (25/12) | 29 (21/8) |
| Raw number of the in-ICU CA events (medical/nonmedical) | 64 (34/30) | 61 (27/34) | 47 (27/20) |

CA = cardiac arrest, ICU = intensive care unit, RRT = rapid response team.

primary treating team verbally and recorded on the patient's medical record. Emergency procedures (ex, endotracheal intubation, central line insertion, humidified high flow nasal cannula device apply, electrical cardioversion, bedside critical care ultrasound, and other resuscitation) were also provided. End-of-life care regarding "do not resuscitate" (DNR) was also discussed with the primary treating team.

### 2.2. Data collection

Data were obtained from the records of the cardiopulmonary resuscitation committee and from prospectively collected RRT databases. The primary outcome of this study was the rate of unexpected in-ward CA rate, which was defined as CA without DNR orders per 1000 hospital admissions. The secondary outcome was overall (ward, operating room, and ICU) in-hospital mortality with or without DNR orders per 1000 admissions. Comparison of the outcome rates between the extended and focused RRT was conducted. Comparison with the before-RRT period (before the implementation of extended RRT, March 2011 to February 2012) to both the extended (March 2012 to February 2013) and focused RRT (March 2015 to February 2016) periods was also performed.

### 2.3. Statistical analysis

All statistical analyses were performed using IBM SPSS Statistics for Windows, version 21.0 (IBM Corp., Armonk, NY). Continuous variables were analyzed as the means ± standard deviation or medians with interquartile ranges, while categorical variables were analyzed as absolute or relative frequencies. The incidence rates of unexpected CA and overall in-hospital mortality of focused RRT were compared to those of the extended RRT and before RRT periods by chi-square tests. A 2-sided $P$-value $\leq .05$ was considered statistically significant.

## 3. Results

### 3.1. Details of patients admitted in difference time periods

Between March 2012 and February 2013, 2722 at-risk patients among all hospitalized adult patients were screened by extended RRT. Of these patients, 1996 were treated with interventions including emergency consultations, procedures (eg, intubation, central line insertion, and other resuscitation) and ICU arrangements, and the rest were closely observed without actions. Most of the subjects were patients in step-down unit or were at-risk patients who were automatically identified by an emergent cardiology or respiratory consultation (n = 2302, 84.6%). Other patients were identified following calls from primary physicians (n = 234, 8.6%), abnormal laboratory findings (n = 141, 5.2%). Between March 2015 and February 2016, 1326 at-risk patients among all nonmedical hospitalized adult patients were screened by focused RRT. An average of 14.5 patients was screened by RRT per day. There were 50.1 activations per 1000 admissions. Among these patients, 614 (46%) were screened for high risk in preoperational consultation, 486 (36.7%) were in the step-down unit of each ward whose transition from the ICU was closely monitored, and 164 (12%) with abnormal reported values were monitored (among 17,454 cases of automatic messages). There 47 and 13 calls from doctors and nurses, respectively (Supplementary Figure, http://links.lww.com/MD/D883). Hemodynamic assessment with consultation (ie, bedside critical care ultrasound, fluid resuscitation, laboratory analysis) was performed in 1208 cases (91.1%). Endotracheal intubation was conducted in 13 cases (1.0%) and high-flow nasal cannula oxygen was administered in 39 cases (2.9%). The other interventions are summarized in Table 3.

**Table 3**

**Interventions performed by the focused rapid response team.**

| | |
|---|---|
| Interventions | |
| Vital sign monitor and consultation, n (%) | 1208 (91.1) |
| 118 procedures in 56 cases | |
| POCT ABGA, n (%) | 29 (2.2) |
| $ETCO_2$ monitor, n (%) | 15 (1.1) |
| Endotracheal intubation, n (%) | 13 (1.0) |
| High flow nasal cannula oxygen, n (%) | 39 (2.9) |
| Shock management with central line insertion, n (%) | 22 (1.7) |

ABGA = arterial blood gas analysis, $ETCO_2$ = end tidal $CO_2$, POCT = point of care testing.

### 3.2. Effect of introduction of the RRT and focused RRT on CA rates

The overall ward CA per 1000 admissions during the focused RRT period was 1.09, a decrease of 34% compared to the rate before RRT implementation (1.67, $P < .001$). During the extended RRT period, the overall ward CA per 1000 admissions was 1.42. There was also a significant reduction in overall ward CA in the focused RRT period compared to that of the extended RRT period (Fig. 1, $P = .04$). The CA rate of patients in the medical ward was 6.48 before the RRT period. In the focused RRT period, the CA rate of patients in the medical ward was 2.59, a 60% reduction from the before-RRT period ($P < .001$). Compared to extended RRT period (3.32), the CA rate of medical ward patients was also significantly decreased ($P < .001$). The CA rate of nonmedical ward patients was also significantly decreased in the focused RRT period compared to that in the before-RRT period (0.43 vs 0.95, $P < .001$). Compared to the extended RRT period (0.64), there was a marginally significant reduction in the CA rate of nonmedical ward patients ($P = .05$). During the focused RRT operational time (official time), there were a total of 21 CAs among all adult patients in the focused RRT period. There were 33 and 29 CAs the before-RRT and extended RRT periods, respectively. The numbers of in-ward CAs during the official time in the before, extended, and focused RRT periods were 13, 11, and 11, respectively. During the official time, no CA case was reported in the nonmedical ward in 2015. Four and 1 CA occurred in the nonmedical ward in the before-RRT and extended RRT periods (Table 4). There were 29, 26, and 18 cases of in-ward CA outside of RRT operating time in the before, extended, and focused RRT periods, respectively.

### 3.3. Effect of introduction of the RRT and focused RRT on in-hospital mortality

We analyzed in-hospital mortality during the study period regardless of DNR order. In the focused RRT period, the overall mortality was 15.51/1000 admissions. The mortality was significantly decreased compared to that of the before-RRT period (Fig. 2, 16.71, $P = .03$). There was no difference between the extended and focused RRT periods (14.79, $P = .19$). In medical patients, mortality in the focused RRT period was

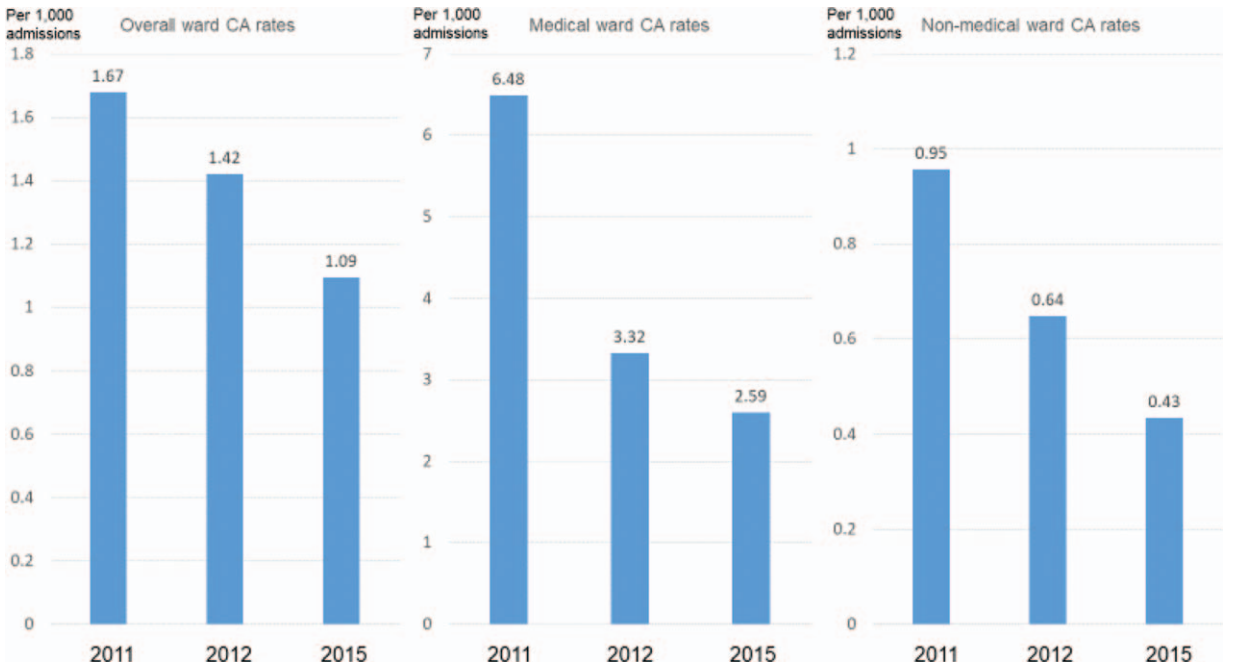


**Figure 1.** General ward cardiac arrest incidence per 1000 admissions for each study period. CA = cardiac arrest.

**Table 4**

**Events of cardiac arrest during rapid response team operational time.**

| RRT operation Time (9 AM–6 PM) | 2011 | 2012 | 2015 |
|---|---|---|---|
| ICU | 20 | 18 | 10 |
| Ward | 13 | 11 | 11 |
| Medical/nonmedical ward | 9/4 | 10/1 | 11/0 |

ICU = intensive care unit, RRT = rapid response team.

significantly decreased compared to that in the before-RRT period (36.63 vs 40.54, $P < .001$). Compared to the extended RRT period, the mortality in medical patients was significantly increased (36.63 vs 32.88, $P < .001$). However, the mortality of nonmedical patients was significantly decreased in the focused RRT period compared to that in both the before-RRT and extended RRT periods (6.24 vs 7.03 vs 7.45, $P = .03$, $P < .001$ for both).

The proportions of patients with CA in nonmedical wards with positive alarm signs within 48 hours were decreased in the

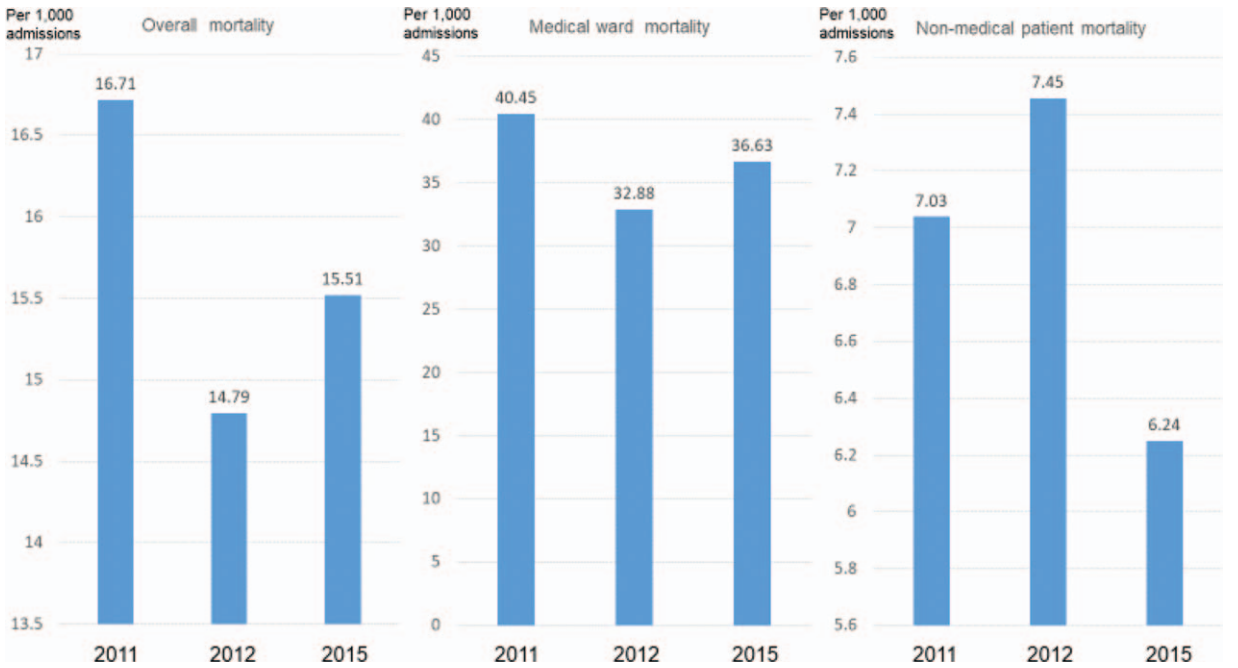


**Figure 2.** General ward mortality rate per 1000 admissions for each study period.

**Table 5**

**Proportion of positive alarm signs within 48 h before cardiac arrest in nonmedical wards in the before, extended, and focused rapid response team periods.**

| Time variables | Positive alarm signs in 2011 | Positive alarm signs in 2012 | Positive alarm signs in 2015 |
|---|---|---|---|
| Operating time | 3/4 (75%) | 1/1 (100%) | 0 |
| Nonoperating time | 5/9 (55.5%) | 6/11 (54.5%) | 3/8 (37.5%) |

The operating time was 9:00 to 18:00 Monday to Friday.

focused RRT period within both operating and nonoperating times compared to that of the before-RRT and extended RRT periods (Table 5). Three patients (37.5%) had positive alarm signals during nonoperating time in the focused RRT period. Positive alarms occurred in 5 (55.5%) and 6 (54.5%) patients in the before-RRT and extensive RRT periods, respectively. Due to the small number of events, we could not test statistical significance.

## 4. Discussion

To our knowledge, this is the first study to assess the impact of focused RRT by comparisons with extended RRT and before RRT implementation. Our study demonstrated that focused RRT implementation was associated with an improved overall ward CA rate. Compared to that of the extended RRT period, the in-ward CA rate during the focused RRT period was also significantly lower. This improvement was consistent in nonmedical ward patients in the focused RRT period. During the operating time of the focused RRT period, no cases of CA case were observed in the nonmedical ward. The overall in-hospital mortality in the focused RRT period decreased compared to that in the before-RRT period; however, no difference from the extended RRT period was observed. In nonmedical ward patients, the in-hospital mortality was significantly reduced in the focused RRT period compared to that in both the before-RRT and extended RRT periods.

The strength of this study was its use of prospectively collected cardiopulmonary resuscitation committee data and the RRT database, which minimized the loss of data regarding outcome events. Although the operating time of the focused RRT period was office hours and the subjects included nonmedical patients, improved outcomes were observed in the overall study population. Subgroup analysis of the nonmedical patients and focused RRT time period showed the same results. We analyzed the CA rates per 1000 medical and nonmedical admissions each rather than overall hospital admissions in order to accurately assess the incidence of the outcome.

Although many hospitals have had interest in the implementation of RRT, initiating and maintaining RRT is challenging because they require additional human resources and operating costs. Furthermore, there is no consensus on the ideal composition of RRT and their operating time.[13,21] Therefore, RRT implementation should be operated according to each hospital's need and environment. In Korea, there is no hospital cost for RRT maintenance or intervention, which may be a barrier to RRT initiation and maintenance. In general, it is recommended that the RRT be operated 24 hours a day, 7 days a week.[21] Numerous studies have reported the effectiveness of full-time RRT.[22–25] In this study, we reported the association of focused RRT with improved in-ward CA rates and in-hospital mortality. Focused RRT might be an alternative to full-time RRT in institutions with limited human resources and resources to maintain RRT.

We reported the effectiveness of extended RRT in 2015.[19] In the focused RRT period, improved outcomes were still observed even though the screened population was limited to nonmedical patients and official time. We do not believe that the result of focused RRT directly affected the outcome. Since 2012 (implementation of the extended RRT), awareness of patient monitoring and the importance of the early detection and intervention of at-risk patients have continued. This cumulative effect of RRT may have persisted in the focused RRT period. Though the RRT did not screen the patients in medical ward, RRT educated the all nurses in hospital about patient monitoring, early recognition, feedback of cardiopulmonary resuscitation, and intervention of at-risk patients in focused RRT period. That might be contribution for decrease of CA rate in medical ward. This assumption is supported by the smaller number of cases of CA in the non-RRT operational time in the focused RRT period. Although we cannot estimate the effectiveness of RRT, in RRT operational time, no nonmedical ward CA cases, which was our main goal, were observed in the focused RRT period. Kim et al reported reduced CA incidence by part-time RRT compared to that of no RRT, although the operational time differed from that in our hospital.[21] However, comparison with full-time was not performed and in-hospital mortality was not changed. The reduction of CA both in general ward and ICU was observed in focused RRT period in our study. The nurse to patient ratio in ICU changed from 3.5 to 3.0 since 2015. That might be another reason why the reduction in CA in the ICU was observed

Our study has several limitations. First, our study was based in a single center, limiting the generalization of these results to other hospitals. Second, the index of patients' severity was not assessed; hence, the improved outcome could have been affected by differences in severity rather than by the effect of focused RRT. Changes in the CA rate in each period might be due to differences in the demographics or case mix of the patient cohort in each period. However, the proportion of positive alarm signal was decreased in the focused RRT period, which suggests the effectiveness of RRT. Third, our results may be biased because the focused RRT operated in official time and upon nonmedical patients. However, the improved outcomes were consistent in the nonmedical and operating times in subgroup analysis.

## 5. Conclusion

Focused RRT was associated with a reduction in the in-ward CA rate and overall in-hospital mortality. Post extended RRT effect such as awareness of patient monitoring and the importance of the early detection and intervention of at-risk patients may have persisted in the focused RRT period. Focused RRT might be an alternative option to full-time RRT for improvement of patient safety in instances of limited institutional environment and resources. Further investigation of the impact of focused RRT is warranted.

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