Massey, D., Aitken, L. M. & Chaboyer, W. (2015). The impact of a nurse led rapid response system on adverse, major adverse events and activation of the medical emergency team. Intensive and Critical Care Nursing, 31(2), pp. 83-90. doi: 10.1016/j.iccn.2014.11.005

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TITLE: The impact of a nurse led rapid response system on adverse, major adverse events and activitation of the medical emergency team

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Aim: To identify the relationship between one example of a Rapid Response System (RRS), specifically, an after-hours Clinical Team Co-Ordinator (CTC), and the incidence of Medical Emergency Team (MET) activations and, adverse and major adverse events in medical patients.

Method: A retrospective chart audit of patient's medical records was undertaken. The intervention group consisted of 150 randomly selected medical patients admitted during 3 months after the introduction of the CTC after-hours service. The control group consisted of 150 randomly selected medical patients admitted before the introduction of the after-hours CTC service. Multiple logistic regression was used to determine which of the potential predictors, along with the after-hours CTC service, was associated with adverse and major adverse events.

Results: A total of 130 patients (n=63, 42% control; n= 67, 45% intervention) exhibited physiological abnormalities that should have activated the MET yet it was only activated 5 times. In total there were 69 adverse events (n=32, 21% control; n=36, 25% intervention) and 25 major adverse events (n=7, 5% control; n=18, 12% intervention). There were more adverse and major adverse events identified after the introduction of the CTC after-hours service. Changes in heart rate and reduction in Glasgow Coma Score (GCS) were significant predictors of an adverse event. A low urine output and a drop of 2 or more in the GCS were significant predictors of a major adverse event.

Conclusions: The introduction of an after-hours CTC service in a specific clinical site was associated with an increase in the identification of adverse and major adverse events in medical patients. Further exploration of nurse-led rapid response systems should be undertaken in different clinical settings.

Background

The past decade has seen increased focus on recognising and responding to deteriorating hospitalised patients (Australian Commission on Safety and Quality, 2010, Institute of Healthcare Improvement, 2006, National Institute of Health and Clinical Excellence, 2010). Much of this interest has been prompted by findings that demonstrate patient deterioration is often not recognised or responded to in a timely manner (Hodgetts et al., 2002, Jacques et al., 2005). Failure to recognise and respond to patient deterioration and to escalate care has led to an increased risk of adverse (AEs) and major adverse events (MAEs) in hospitalised patients that may have been avoided had appropriate care been instituted earlier (Buist et al., 2004). In response to this recognised threat to safe, high-quality care, a number of patient safety initiatives have been implemented. Rapid Response Systems (RRS) are an example of such safety initiatives.

RRS can incorporate either "high capability teams" or "ramp up teams" (DeVita et al., 2006). A high capability team is physician-led. The Medical Emergency Team (MET) is an example of a high capability team (DeVita et al., 2006). Ramp-up teams are primarily nurse-led (DeVita et al., 2006). Ramp up teams have been successfully implemented and well evaluated in the United Kingdom (Priestley et al., 2004, Watson et al., 2006). In Australia the after-hours Clinical Team Co-Ordinator (CTC) role is emerging as a ramp-up RRS (Williams et al., 2012). The after-hours CTC has been implemented to improve the care and management of the deteriorating patient in the hospital after-hours. However there is limited uniformity in how this service is operationalised or implemented and very little evaluation of the role. Formal evaluation was therefore required because empirical evidence would help in the understanding of whether this role influences patient outcomes.

Aims of the study

To identify the relationship between one example of a RRS, specifically an after-hours Clinical Team Co-Ordinator (CTC), and the incidence of Medical Emergency Team (MET) activations and adverse and major adverse events in medical patients.

Four research questions were derived from this overarching aim:

1. To what extent was the introduction of the after-hours CTC service associated with a reduction in AEs and MAEs in medical ward patients?
2. To what extent was the introduction of the after-hours CTC service associated with an increase in the activation of the MET?
3. To what extent was the implementation of the after-hours CTC service associated with a reduction in physiological abnormalities associated with life-threatening clinical deterioration?
4. What clinical factors predicted the occurrence of AEs and MAEs in medical patients?

Study Design

In this study it was not possible to manipulate the independent variable because the after-hours CTC had already been introduced, therefore a non-experimental approach was taken. A causal-comparative study was undertaken (Johnson, 2001). Causal-comparative research, also known as ex-post facto research (Polit & Beck, 2006), aims to find a cause or explanation for existing differences between (or among) groups. Two or more existing groups are compared retrospectively. A retrospective medical record review of adult general medical ward inpatients whose hospital length of stay (LOS) was greater than 2 days was undertaken. Patients exposed to the after-hours CTC service (the intervention) were compared to patients not exposed to the intervention (the control)

Previous research demonstrates that inter-rater reliability of chart audits can be more than 80% with adequate training (Thomas, Lipsitz, Studdert, & Brennan, 2002). The reliability and accuracy of retrospective chart reviews has also been demonstrated in previous

research examining the extent, nature, and consequences of adverse events (Chaboyer et al., 2008).

During the design of this research a number of steps were implemented to improve the validity of the data collection method, as suggested by Gearing and Colleagues (2006). Once the research questions and study aims were prospectively defined the study design phase of the research, including the outcomes and predictors were clearly identified. Specific definitions of all study predictors were developed to optimise accurate and consistent data abstraction. The chart review and the data abstraction process was standardised through the use of a validated data abstraction form (Chaboyer et al., 2008; Woloshynowych et al., 2003).

Setting

The study was set at Gold Coast Hospital, Queensland;a 480 bed tertiary teaching hospital. The hospital had over 67,000 emergency presentations and over 70,000 overnight hospital admissions a year. The Gold Coast Hospital operated a two-tiered RRS. The after-hours CTC service was introduced in July 2008 to provide a rapid response to assist clinicians throughout the hospital. The after-hours CTC service was the first tier of the RRS system and was activated by nursing staff in the hospital after-hours; operating between 14:00 to 07:30, 7 days per week. The second tier of the hospital's RRS was the MET. The after-hours CTC activated the MET if a patient continued to deteriorate and required further escalation of care. The after-hours CTC service was provided by six experienced acute care nurses who supported ward nurses and other members of the multi-disciplinary team after hours to recognise and respond to patient deterioration.

Sample

No formal power calculations undertaken in this study because no literature was available on the effect of a similar intervention on AEs and MAEs. For the logistical regression analysis, a sample size of at least 10 times the number of the nine significant

categorical variables to be entered into the model was considered to be the minimum sample (Green, 1991).

Medical ward patients with a hospital length of stay greater than 2 days were included in the study. Patients were excluded from the study if there were < 18 years of age or were in-patients in specialised units for example, maternity.

Predictors and outcomes

We used the generally accepted definition of adverse event: "an unintended injury resulting from health care management, rather than the disease process." (Wilson et al., 1995, p, 461). Consistent with previous researchers (Harrison et al., 2006, Hillman et al., 2002), MAE were defined as; a) unexpected death, b) in-hospital cardiac arrest and c) unplanned admission to the Intensive Care Unit (ICU). Potential predictors of AEs and MAEs measured were: age, gender, diagnostic category, hospital length of stay, and the presence of MET activation criteria.

Data Collection

Following hospital and university ethical approval, the medical records department of the hospital was contacted in order to gain access to the charts required. The medical records department then forwarded the researcher (DM) an Excel™ spreadsheet with the URL numbers of all admissions that met the inclusion criteria, prior to and after the introduction of the after hours CTC. The intervention group consisted of 150 randomly selected medical patients admitted during the 3 months after the introduction of the after-hours CTC service (August 2008-October 2008). Charts from 150 medical patients admitted before the introduction of the after-hours CTC service were randomly selected to make up the control group (January 2008-March 2008). Charted data were collected via a retrospective chart audit tool, using a modified case record form developed in previous studies (Chaboyer et al., 2008,

Woloshynowych et al., 2003). One of the research team (DM) reviewed all of the medical records.

Understanding the design of the existing medical records and how clinical data was recorded was an important part of the data collection process. It was critical to ensure that the information required for the research study was available in the medical records available. Thus, prior to the data collection process commencing, three medical charts (Gearing, Mian, Barber, & Ickowicz, 2006) were assessed for the flow of information in order to identify the established charting processes used in the hospital. Additionally, a pilot study applying the retrospective chart audit tool to 2 charts was performed and then reviewed by all members of the research team. Thus the adequacy of the data abstraction tool was assessed and any potential difficulties with data collection were evaluated. Following this pilot study, minor changes were made to format of the data abstraction form to enable data entry to occur in a more reliable and logical way.

Data Analysis

The statistical package for the Social Sciences (SPSS) version 18 was used for data management and analysis. Descriptive statistics were used to identify the characteristics of the sample and the frequency of AEs and MAEs. Differences between the intervention group and the control group in relation to the following three outcomes: (1) meeting MET activation criteria, (2) if a MET was activated and (3) incidence of AEs and MAEs, were assessed using the chi square test and Mann-Whitney U test. A p <0.05 was considered statistically significant. Multiple logistic regression modelling was used to determine which of the potential predictors, along with CTC intervention, were significantly and independently associated with the incidence of AEs and MAEs. Using the enter method; variables that were significant were retained in the model. Adjusted odds ratios and 95% confidence intervals along with the P values are reported.

Reliability and validity

Study intra-rater reliability was assessed by re-checking 17 medical charts over a one-month period and comparing the results with original data abstraction entries. This intra-reliability revealed a 97% accuracy rate across time.

The external validity in this study was enhanced by ensuring the sample selection was representative of the population to which the study may be generalised. A random sample of all medical patients was included in the analysis; thus, the findings of the study can be generalised to a similar sample of medical patients in another hospital.

Ethical considerations

Ethical approval was gained from the Human Research Ethics Committee (HREC) of the Gold Coast Health Service District (HREC/09/QGC /17) and Griffith University (NRS/38/09/HREC).

Results

Characteristics of the sample are detailed in Table 1. Patients were slightly older during the intervention period. Patients in both the intervention and control group had similar lengths of stay in hospital.

During the data collection period, 23% of charted patients experienced an AE. There was no difference in the incidence of AEs (

In the control group 42% of patients met the criteria for MET activation yet only 1% had a MET activated. In the intervention group 45% of patients met criteria for MET activation yet only 2.6% had a MET activated. There were no significant differences between the two groups in relation to meeting MET activation criteria nor activation of a MET.

2) between the two groups. The most common AE in both groups were the onset of complications including:myocardial infarction, deep vein thrombosis, pulmonary embolism, cerebral vascular accident, neurological deficit and/or unplanned return to the operating theatre.

In total, 25 (8.3%) of the sample experienced a MAE (Table 2). Charts from patients in the intervention group recorded significantly more MAEs than those allocated to the control group (P<0.02). Unplanned admission to ICU was the most frequent MAE in both groups. However, because the assumptions of chi-squared test of independence may be compromised due to small numbers of major adverse events, these results need to be interpreted with caution.

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Multiple logistic regression was used to determine which of the factors, along with after-hours CTC service, were significantly and independently associated with adverse events. All significant predictors in the univariate analysis were entered into the model. Patients who experienced a drop of 2 or more in the GCS, were more likely to experience an AE (see Table 3). The introduction of the after-hours CTC service was not significantly associated with the incidence of AEs in medical patients.

Multiple logistic regression was also used to determine which of the factors, along with the after-hours CTC service, were significantly and independently associated with MAEs. All significant predictors in univariate analysis were entered into the model. The factor with the strongest relationship to a MAE was a drop of 2 or more in the GCS. The

introduction of the after-hours CTC service did not have a significant positively or negatively influence the occurrence of MAEs in medical patients (Table 4).

Discussion

In this study the medical records of patients were reviewed to identify any relationship between the after-hours CTC, rates of AEs, MAEs and MET activation in medical ward patients. Based on this random sample of 300 patients there was no significant effect of the after hours CTC on the number of AEs. A total of 23% of patients included experienced an AE, with 8.3% of the sample experienced a MAE. The rates of AEs and MAEs are both higher than previously reported (Brennan et al., 1991, Vincent et al., 2001, Elliott et al., 2008). In this study included patients had an average age of 70 and this may help account for the increased incidence of AEs and MAEs as the risk of AEs and MAEs increases with age. Patients over 65 years of age have been found to have an independent positive association with in-hospital mortality (Neal et al. 2006, Vincent et al., 2001, Wilson et al., 1995).

The most commonly occurring MAE in both groups was unplanned admission to ICU which is also the most frequently occurring MAE reported by others (Chaboyer et al., Bristow et al., 2000, Endacott et al., 2010). The introduction of after-hours CTC service may have been associated with an increase in surveillance and an increase in the recognition of, and response to, clinical deterioration. This would lead to more patients being transferred to ICU and may explain the higher incidence of MAEs identified in the current study. An increase in unplanned admission to ICU following implementation of an RRS has also been previously reported (Simmes et al., 2012, Doric et al., 2008).

Underutilisation of RRS is commonly reported and this may minimise improvements in patient outcomes that may have been gained from an otherwise effective RRS (Chen et al., 2009, Trinkle & Flabouris, 2011, Hillman et al., 2005). In this study the MET was clearly

underutilised. In the intervention group 45% of patients met criteria for MET activation and 2.6% had a MET activated. Based on the results of this study it is possible that the after-hours CTC service reduced the need for a MET because patients were assessed and managed by experienced nurses. However, is it also possible that patients may have experienced a delay in RRS activation in this study. A delay in activating RRS worsens patient outcomes, (Tee et al., 2008, Trinkle & Flabouris, 2011) and a number of factors are associated with nurses not activating RRS (Massey et al., 2013). Therefore, research is required to better understand how ward nurses accept, implement and integrate new patient safety initiatives into everyday clinical practice (Francis et al., 2011).

Hypotension, low oxygen saturations, and a drop of 2 or more in the GCS were significant predictors of AEs. An abnormal heart rate and a drop of 2 or more in the GCS were significant predictors of MAEs. Chaboyer and colleagues (2008) demonstrated that an abnormal heart rate was a significant predictor of an MAE. Other researchers also found that a drop of 2 or more in the GCS, abnormal blood pressure, and low oxygen saturations significantly predicted serious AEs (Cuthbertson et al., 2007, Harrison et al., 2006, Jacques et al., 2005). The findings from this study and other published research (Chaboyer et al., 2008, Harrison et al., 2006, Jacques et al., 2005) highlight the importance of vital signs in predicting patient deterioration and preventing serious AEs. Nurses are primarily responsible for taking and recording vital signs and, therefore, play a pivotal role in recognising and responding to deteriorating patients and promoting positive outcomes. However, recording and documentation of vital signs remains infrequent and incomplete (Hillman et al., 2005, Massey et al., 2009). Infrequent or incorrect monitoring or documentation of vital signs may prevent timely activation of an RRS and appropriate escalation of care, and predispose patients to suboptimal care (Doric et al., 2008).

The finding that GCS and urine output were frequently not recorded also indicated that some nurses may lack knowledge and understanding about the importance of these two physiological parameters in alerting nurses and other health-care workers to patient deterioration. Health-care providers, educational providers, and policy makers clearly need to re-examine the content, the learning outcomes, and the assessment strategies of undergraduate and postgraduate programs and ensure they incorporate the recognition of, response to, and management of the deteriorating ward patient.

The after- hours CTC service in this study was introduced to improve the care and management of the acutely ill patient in the hospital after hours. Acutely ill ward patients appear to be more vulnerable to AEs and MAEs in the hospital after hours (i.e. after 5 pm), when many of the more senior experienced staff have left the hospital and minimal staff remain to manage the hospital and its activities. Patients discharged from ICU out of hours and on the weekend, are more likely to deteriorate and suffer AEs and MAEs than patients discharged during normal "business hours" (Alspach, 2010, Duke et al., 2004 Hamilton et al., 2010). Currently, hospitals operate a two-tier level of health care with a much lower level of staffing and diagnostic services available to patients and staff after-hours (Hamilton et al., 2010) which impacts on patient safety (Beckett et al., 2009). The true extent of the incidence of AEs and MAEs in the hospital after-hours are not yet known. Based on the findings from this study, it is recommended that future research examine adverse and MAEs in the hospital after-hours and also examine their impact on patient outcomes.

Previous research on RRSs has used MAEs as the outcome measure (Hillman et al., 2005, Kenward., 2004) to evaluate the effectiveness of RRSs. Findings from this study and others (Hillman et al., 2005, Jones et al., 2009) indicate that the use of MAEs as the outcome measure may be insensitive to the true effect of the RRS. For example unplanned admission to ICU may in fact reflect appropriate care. It is recommended that future research explore

using other outcomes as a means of evaluating RRSs, and incorporate related factors such as the influence of teamwork, collaboration, and culture, and the 'do not resuscitate' status of the patient.

Limitations

Whilst this study has contributed to the existing knowledge and understanding of ramp-up RRS this research has several limitations. First AEs and MAEs in this study were identified through retrospective data using the patients' medical records. It is possible that some MAEs may not have been charted and, therefore, were not identified, which would have an impact on the overall results. However, it is unlikely that cardiac arrest, death, or unplanned admission to ICU would go uncharted, so it is unlikely that this would have had an impact on the main outcomes recorded in this study. It was not possible to control all potential confounders in the study, for example, patient acuity, staffing or skill mix and these may have influenced the outcome measures. The 'dose' (or frequency of use) of the RRS is thought to be important for effect (Bucknall et al., 2013, Santamaria et al., 2010) with an inverse relationship between the length of time an RRS has been in place and the number of cardiac arrests. As the 'dose' of the RRS increases over time, (Santamaria et al., 2010) there is often a delay between the implementation of the RRS and a reduction in AEs and MAEs. Thus, it is possible that a longer time frame was required to see the true effect of the CTC. Additionally, the implementation of the after-hours CTC appears to have added another layer of bureaucracy which created a hierarchical system that delayed timely response to patient deterioration in this study. Nurses first called the after-hours CTC to review the deteriorating patient rather than initially activate the MET. Hospitals using or considering implementing an RRS should ensure that they have systems in place to ensure that the resources required to successfully escalate care for the deteriorating patient are identified, operational, and

available for example, support in terms of administrative staff and access to appropriate information technologies are important.

Behavioural change is perhaps one of the most challenging aspects of introducing a new intervention into a health-care system (Francis et al., 2012). The acceptance of any new system depends on how the system is perceived by its users. The results of this study indicate that the RRS at the Gold Coast Hospital may not have been fully integrated into ward nurses' clinical practice and this led to under-utilisation. Given that a delay in activating an RRT worsens patient outcomes (Bucknall et al., 2012; Tee, 2008; Downey, 2008; Quach, 2008), it is important that strategies are developed and refined to ensure that RRS are maximised and utilised in clinical practice.

Conclusion

The after-hours CTC service provides a ramp up RRS to the hospital after-hours. To date there has been minimal evaluation of ramp-up RRS. Our results add to the developing knowledge in this area. Although we did not identify positive benefits of after-hours CTC service in reducing AEs and MAEs in the hospital after-hours the retrospective nature of data and the conduct of the study soon after implementation of the CTC may have influenced the results. We recommend further evaluation of this role in other hospital settings using more robust methodologies

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Table 1: Sample characteristics (n=300)

Demographic information	Control (pre-CTC) Median (IQR) *n*=150	Intervention (post-CTC) Median (IQR) *n*=150	U	p
Age (in years)	70 (47–80)	74 (59–82)	9587	0.04
LOS (in days)	7 (4–12)	7 (4–14)	10695	0.06
Gender	**Frequency (%)**	**Frequency (%)**	**$\chi 2$**	**p**
Male	74 (48.6%)	76 (51.4%)	0.213	0.64

LOS= Length of stay, CTC= Clinical Team Co-Ordinator, IQR= Interquartile range.

Table 2: Adverse events and major adverse events (*n*=300)

Outcome	Control (pre-CTC) *n*=150 Frequency (%)	Intervention (post-CTC) *n*=150 Frequency (%)	Total Frequency (%)	χ^2	*p*
Adverse event	32 (21.3%)	36 (24.7%)	69 (23.0%)	0.30	0.58
Type of adverse events					
Complications including: MI, DVT, PE, CVA, neurological deficit, unplanned returned to OT	6 (4.0%)	12 (8.0%)	18 (6.0%)	4.11	0.53
Adverse drug reaction	8 (5.3%)	7 (4.7%)	15 (5.0%)		
Hospital accident/injury	7 (4.7%)	3 (2.0%)	11 (3.6%)		
Hospital acquired infection/sepsis	5 (3.3%)	6 (4.0%)	11 (3.6%)		
Other adverse event	6 (4.0%)	8 (5.3%)	14 (4.6%)		
Major adverse event	7 (4.7%)	18 (12.0%)	25 (8.3%)	5.28	0.02
Type of major adverse event					
Unplanned admission to ICU/CCU	7 (4.6%)	8 (5.3%)	15 (5.5%)	8.92	0.01 §
Death	0 (0%)	6 (4.0%)	6 (2.0%)		
Cardiac arrest	0 (0%)	4 (2.6%)	4 (1.3%)		

5 cells (83.3%) have expected count less than 5. The minimum expected count is 1.12. ICU=Intensive care unit. CCU= Coronary care unit. §Likelihood ratio. MI = Myocardial infarction; DVT = Deep vein thrombosis; PE = Pulmonary embolism; CVA = Cerebral vascular accident; OT = Operating theatre.

Table 3: Factors associated with occurrence of adverse events— Multivariable logistic regression model (*n=300*)

Factors	*b*	*p*	OR	95% CI
Drop in GCS of >2	1.27	0.01	3.50	1.31 – 9.74
O_2 Sat <90%	1.20	0.01	3.32	1.29 – 8.53
SBP <90mmHg	1.21	0.07	3.08	1.36 – 7.00
Length of stay	0.45	0.05	1.04	1.01 – 1.07
Temp > 38.0°C or < 35.0°C	–7.0	0.06	0.49	0.23 – 1.03
U0<0.5ml/kg/hr	1.00	0.42	2.73	0.23 – 31.59
RR >25 or <10	–0.28	0.57	0.75	0.27 – 2.02
HR >110 or <50 BMP	0.24	0.59	1.28	0.58 – 3.21
CTC	0.12	0.69	1.13	0.59 – 2.18
Constant	–1.20	0.10	0.29	

GSC = Glasgow Coma Score, O_2 Sat = Oxygen Saturations, SBP = Systolic Blood pressure, RR = Temp = Temperature, UO = Urine Output, Respiratory Rate, HR = Heart Rate, BMP = Beats per minute, CTC= Clinical Team Co-Ordinator, OR= Odds Ratio, CI= Confidence Interval.

Table 4: Factors associated with occurrence of major adverse events—Multivariable logistic regression model (*n=300*)

Factors	*b*	*p*	Odds ratio	95% CI
HR >110 or <50 BMP	1.61	0.01	5.04	1.42 – 17.73
Drop in GCS of >2	1.64	0.02	5.19	1.19 – 22.59
U0 <0.5ml/kg/hr	2.60	0.06	14.60	0.82 – 259.73
O_2 Sat <90%	1.24	0.07	3.48	0.88 – 13.76
Temp >38.0°C or <35.0°C	–0.89	0.12	0.41	0.13 – 1.29
Length of stay	0.04	0.15	0.95	0.89 – 1.01
SBP <90mmHg	0.72	0.23	2.06	0.62 – 6.84
RR >25 or <10 min	0.65	0.35	1.92	0.48 – 7.72
CTC	–0.33	0.57	0.71	0.22 – 2.26
Constant	–2.10	0.82	0.12	

HR = Heart Rate, BMP = Beats per minute, GSC = Glasgow Coma Score, , UO = Urine Output,,O2 Sat = Oxygen Saturations, , Temp = Temperature, S/B/P = Systolic Blood pressure, RR = Respiratory Rate, CTC= Clinical Team Co-Ordinator, OR= Odds Ratio, CI= Confidence Interval.