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User compliance with documenting on a track and trigger-based observation and response chart: a two-phase multi-site audit study

Running head: User compliance with an observation and response chart

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Conflict of Interest

No conflict of interest was declared by the authors in relation to the study itself. Note that Robyn Gallagher is a *JAN* editor but, in line with usual practice, this paper was subjected to double blind peer review and was edited by another editor.

ABSTRACT

Aims. To examine user compliance and completeness of documentation with a newly designed Observation and Response Chart and whether a rapid response system call was triggered when clinically indicated.

Background. Timely recognition and responses to patient deterioration in hospital general wards remains a challenge for health care systems globally. Evaluating practice initiatives to improve recognition and response are required.

Design. Two-phase audit.

Methods. Following introduction of the charts in 10 health service sites in Australia, an audit of chart completion was conducted during a short trial for initial usability (Phase 1; 2011). After chart adoption as routine use in practice, retrospective and prospective chart audits were conducted (Phase 2; 2012).

Findings. Overall, 818 and 1058 charts were audited during the two phases, respectively. Compliance was mixed but improved with the new chart (4-14%). Contrary to chart guidelines, numbers rather than dots were written in the graphing section in 60% of cases. Rates of recognition of abnormal vital signs improved slightly with new charts in use, particularly for higher levels of surveillance and clinical review. Based on local calling criteria, an emergency call was initiated in 33% of cases during the retrospective audit and in 41% of cases with the new chart.

Conclusions. User compliance was less than optimal, limiting full function of the chart sections and compliance with local calling criteria. Overcoming apparent

behavioural and work culture barriers may improve chart completion, aiding identification of abnormal vital signs and triggering a rapid response system activation when clinical deterioration is detected.

Key words

audit, clinical deterioration, compliance, deteriorating patient, human factors design, nursing, rapid response system, observation charts, track and trigger

Summary Statement

Why is this research needed?

- Exploring factors that influence early identification and detection of clinical deterioration in patients (the afferent limb of the rapid response system) is relatively under-researched.
- Evaluating specific practice initiatives that seek to improve this recognition and response to clinical deterioration are required.
- These human factors-designed Observation and Response Charts incorporating a track and trigger system had not been previously evaluated in routine clinical practice.

What are the key findings?

- Compliance with vital signs documentation improved with use of the new charts, but not to their optimal level of functioning.
- Continuing documentation practices worked against the human factors principles of the charts, potentially limiting recognition of clinical deterioration.

- Initiation of an emergency response also improved with use of the new chart, although opportunities for improved rates of recognition and response were also evident.

How should the findings be used to influence policy/practice/research/education?

- The identified benefits and challenges for chart users in relation to recognising patient deterioration can inform health care professionals internationally who are using or implementing similar charts with track and trigger characteristics in their rapid response system.
- Continued exploration of workplace and practice issues influencing the recognition and responses to unmet needs of a deteriorating patient in general ward areas is recommended.
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INTRODUCTION

Improving the timeliness and effectiveness of responses to clinical deterioration of patients in general wards of acute care hospitals remains a key imperative for health care organisations (Australian Commission for Safety and Quality in Healthcare 2010). System changes have included evolution from reactive 'cardiac arrest' teams to more proactive 'medical emergency teams' (METs) or 'rapid response teams' (RRTs) (Hillman et al. 2001), reflecting initiatives for the 'efferent' limb of a Rapid Response System [RRS] model (DeVita et al. 2006), with resulting improvements for in-hospital mortality rates (Jones et al. 2011). Of equal importance but less explored in the literature is the 'afferent' limb, reflecting practices that focus on early identification and detection of clinical deterioration in patients by measuring, recording and reporting patients' vital signs.

Background

Paper-based observation charts remain common for documenting patient vital signs in Australian hospitals (Australian Commission on Safety and Quality in Health Care [ACSQHC] 2011), despite minimal evidence supporting their design or effectiveness (Chatterjee et al. 2005, Mitchell et al. 2010). Examples of redesigned charts have demonstrated improved documentation of vital signs (Mitchell et al. 2010) (Cahill et al. 2011), with one key feature being inclusion of a track and trigger system (TTS) to alert users when a patient exhibits signs of clinical deterioration and provide guidance for appropriate actions based on the severity of deterioration (Gao et al. 2007). The alert that triggers the recommended action can be either one pre-defined range for each vital sign (single-parameter TTS); two or more predefined ranges (multiple-parameter TTS); an early warning scoring (EWS) system; or a combination (Kyriacos et al. 2011). While charts with a TTS have improved chances of recognising deterioration (Gao et al. 2007), testing their reliability, validity and sensitivity for stronger evidence remains a challenge due to multiple variations of designs and parameter values (Gao et al. 2007, Subbe et al. 2007). Inconsistent practices of measuring and recording vital signs also continue (Hands et al. 2013), placing patients clinical needs at greater risk of not being recognised in an appropriate and timely manner to prevent further deterioration (Jones 2012). The related concepts of 'afferent limb failure' (ALF) and 'failure to rescue' (FTR) therefore remain a continuing contemporary concern internationally (Johnston et al. 2015, Mok et al. 2015).

The Australian Commission for Safety and Quality in Health Care (ACSQHC) sought to address this issue by exploring practices related to timely care and treatment for adult acute care medical-surgical patients (Australian Commission on Safety and Quality in Health Care 2010). Five evidence-based 'observation and response chart' (ORC) templates were developed (Australian Commission on Safety and Quality in Health Care

2013), each with varying response levels that aligned with different levels of escalation criteria used by RRT in Australian hospitals (Table 1). All chart versions incorporated design characteristics informed by human factors principles to minimise risk of error when recording or interpreting vital signs (Preece et al. 2013).

Charts were A3-sized, folded as a double-sided booklet, with the vital signs charting area on the inside left page when the booklet was open. User instructions were included in the chart (Box 1 for excerpt). Nine parameters were included for charting: respiratory rate, oxygen saturation, oxygen flow rate, blood pressure, heart rate, temperature, consciousness level, urine output and pain score. Colour-coding was used to delineate variations in vital sign abnormalities. Based on human factors principles, users were to place a dot in the centre of the box corresponding to a range of values for that parameter, rather than writing a number on the chart; e.g. oxygen saturation of 90-94% (Preece et al. 2012b). See supplementary material for a 'Frequently asked questions (FAQ) sheet' that provided users with a rationale for the design characteristics of the chart.

THE STUDY

Based on a formal request for contracted research (a 'request for tender') from the ACSQHC, this funded study examined the application and performance of the developed charts in actual clinical practice. The specific project objectives, defined by the ACSQHC, were to determine: 1) whether the charts were suitable for documenting observations of adult medical-surgical patients and prompting a response for episodes of clinical deterioration; and 2) the rate of chart completion, the rate of abnormality in clinical observations and whether a response occurred.

Aims

This paper specifically reports the second project objective, examining user compliance with chart guidelines during chart testing in clinical practice. An earlier version of these findings was provided to the ACSQHC as a requirement of funding.

Design

A two-phase multi-site multi-methods design was developed (Elliott et al. 2014). In Phase 1, an audit of initial user compliance with chart completion was conducted during a 24-hour data collection period after a trial introduction of the new charts. For Phase 2, after a minimum of 2-3 weeks of chart use in routine clinical practice, retrospective and prospective chart audits were conducted to examine compliance and completeness of documentation and whether a RRS response was triggered when clinically indicated.

Site recruitment, chart selection and site preparation

Ten sites from five Australian states with different levels of service and size were selected from over 50 responses following a formal expression of interest process by the ACSQHC (four tertiary / metropolitan; two regional; one rural; three private). One site withdrew from Phase 2, with data from the remaining nine sites therefore reported. Sample wards were all categorised as adult general medical-surgical wards (range 26-40 beds) and selected by site executives. Each site independently selected a chart template that best aligned with their current RRS (Table 1).

A project officer was seconded from each site to facilitate implementation of the chart into clinical practice with ongoing support from the project manager. A full-day training workshop for all project officers was conducted, focusing on data collection processes and including auditing of clinical records using patient scenarios and practice sessions. Each trained project officer then provided site-based user orientation and training on

chart use in the context of human factors principles and collected site-specific study data.

Data collection

Phase 1: Audit of chart compliance

Each site selected 2-6 adult medical-surgical wards for initial chart implementation and evaluation, with data collected in June 2011. Each version of the chart was evaluated in at least one site (Table 1). As the trial chart was not an approved medical record during this initial trial period, dual documentation was necessary, with the current hospital observation chart remaining the legal medical record. Following completion of the 24-hour period of data collection for each ward, each project officer audited all charts for completeness of documentation, compared with the hospital's existing chart.

Phase 2: Retrospective and prospective audits

The scope of implementing the chart into routine practice in this phase varied across sites: two executed a health service-wide implementation, four organisation-wide and three implemented in 3-4 wards. Only three of the five available charts were selected by at least one site in this phase (ADDS-, R4, R2 versions) (Table 1). Data were collected by two audits of medical records conducted for February 2011 (retrospective) and February 2012 (prospective) using a specifically designed audit tool. A minimum of 60 admission episodes were audited at each participating site across a 72-hour admission period, with audit days selected as Sunday, Monday and Tuesday to account for activities during both business hours and 'out of hours'. Each site's previous observation charts were examined retrospectively against the local RRS calling criteria.

The prospective chart audit occurred after a minimum of 2-3 weeks of new chart use in routine practice. Variables collected included frequency; number of complete (six core vital signs) and incomplete observation sets; numbers of each vital sign recorded and which of those were abnormal; details of the first three observation sets in the 72-hour period with one or more abnormal vital signs, according to site escalation protocol and if recommended action was taken where documented. Compliance with chart guidelines was also assessed during the prospective audit. Information on MET calls was derived from routinely collected service data from each site.

Project officers and the project manager liaised for any concerns or queries during the audits, providing some level of consistency across sites, but no independent checking of audits for correctness or completeness was possible because of funding and time restraints.

Ethical considerations

For Phase One, each site's Human Research Ethics Committee (HREC) approved the project as negligible/low-risk project, given that clinical staff members were the study participants. Informed consent was obtained from participants prior to data collection. For Phase Two, HREC approval was gained from all ethics committees. Collection of audit data from medical records was considered low-risk. All data were de-identified before submission to the research team and stored according to national guidelines (National Health and Medical Research Council et al. 2007).

Data analysis

All data were collected by the site-base project officers then sent to the research team for centralised management and analyses. Audit data were entered, cleaned, formatted and coded for analysis in SPSS (version 19; IBM, Armonk, NY). Analyses were by chart

type, to explore any potential differences. Medians and interquartile ranges (IQR) were used for continuous data with non-normal distributions; proportions and frequencies were used to present categorical data.

RESULTS

In Phase 1, charts were trialled in 36 wards across 108 shifts with 623 nurses and chart reviews were conducted for 818 patients. Across the two audit periods of Phase 2, 1058 records were audited; 522 retrospectively and 536 prospectively, reflecting 9920 sets of vital signs (4896 and 5024 respectively). The number of charts audited retrospectively and prospectively for each version was: ADDS- (n=60 and 60), R4 (99 and 116) and R2 (363 and 360) charts, respectively. Findings from the two phases have been synthesised below where appropriate.

User compliance with chart instructions: Phase 1 and Phase 2 prospective audits

During the initial 24-hour chart trial (Phase 1), compliance with chart completion guidelines was highest for consciousness (98%); blood pressure (in 79% of cases arrows were correctly placed and 55% had arrows joined by a dashed line); and pain scores (81%) (Table 2). Levels of compliance in Phase 2 improved with the new chart by 4-14% across all parameters.

Overall, compliance with use of arrows for systolic and diastolic blood pressure (100%) and lines connecting arrows (92%) was high. Placing a dot in the centre of the corresponding square of the value ranges, for respiratory rate, O₂ saturation, O₂ flow rate, heart rate, temperature, consciousness and urine output, improved overall from 54% to 70% across the two phases. Frequently however, it was audited that users attempted to reflect the actual value in the parameter range by locating the dot higher or

lower in the box (not in the centre of the box, as per instructions). For existing hospital charts, users often used a different symbol to a dot, or placed a dot on the dividing line between ranges in an attempt to document with more accuracy.

Compliance with chart instructions for drawing a straight line to connect dots between time points was initially low, making trends in vital signs more difficult to recognise according to human factors principles. In Phase 1 only 9% of charts had all dots connected by a line, while in 60% of charts, dots were not connected at all. Use of lines had improved with further chart use by Phase 2, with 68% compliance, although this was frequently incomplete or inconsistently applied. Lowest documentation compliance related to urine output, with only 45% correctly completed (range 33-82%) in Phase 1 and this low compliance continued in Phase 2 (range 3-69%; Table 3). Note however that this parameter was not recorded on any existing hospital observation charts and was therefore a new practice for users and potentially contributing to this low compliance.

Of note, actual numbers were also recorded along with dots - contrary to human factors principles and chart instructions - in 60% of charts audited in Phase 2; and in 3% only numbers were documented. The highest percentages of written numbers were for temperature (33%) and oxygen saturation (31%), while other parameters had less but still significant instances noted; heart rate (22%), blood pressure (25%) and respiratory rate (10%).

Completion of other chart sections was also low in both Phases. As other patient medical records were not audited during Phase 1 (Table 2), it was unclear whether this low rate of completion was clinically appropriate or not. No 'modifications' were documented for any parameters in 95% of cases (n=775). Where modifications were documented,

systolic blood pressure (58%), oxygen saturation (33%), oxygen flow rate (30%) and heart rate (30%) were most frequently modified.

Use of the 'Additional Observations' section increased for Phase 2 to 53%, (blood glucose level, weight, bowels, urinalysis). 'Modifications' were used once in 6% and twice in 1% of charts. For the 'intervention' section, 25% and 20% respectively had documentation and 2% and 4% had a doctor's 'clinical review' recorded.

Rate of chart completion (comparison between retrospective and prospective audits, Phase 2)

Vital sign frequency was not documented in either care plans or medical records for 27% (n=291) of cases. While 60% of patients were to have their observations measured at least four times per day based on the documented required frequency (Australian Commission for Safety and Quality in Healthcare 2010), the actual median frequency was three times a day across both retrospective and prospective audits.

For documentation of the recommended six core vital signs (Australian Commission for Safety and Quality in Healthcare 2010), 74% (n = 7334) were complete across both Phase 2 audit periods. Improved compliance was noted with the new charts in use; 4-14% across vital signs parameters. Compared with the retrospective period, more complete documentation was noted for respiratory (14%); oxygen saturation, heart rate and temperature (8%); blood pressure (7%); and oxygen flow (4%). Other notable improvements were in level of consciousness (67% increase) and pain (32% increase), although previous charts did not commonly specify these parameters (Table 3 for differences in completion rates across the three chart versions in use).

Rate of recognition of abnormal clinical observations (Phases 1 and 2)

In Phase 1, 46% of audited charts had at least one set of vital signs that met one or more of the local site's RRS response criteria. When these criteria were met, 52% of cases had the action correctly documented on the chart (range across chart versions: 46-53%).

Where details of actions were recorded on the chart, 349 actions taken were documented with a free-text explanation, often as reasons for 'not taking action'. This usually occurred when vital signs were considered in acceptable ranges for the patient, even though no 'modifications' had been documented and the values were abnormal according to the local site's RRS criteria.

The most commonly documented vital sign abnormalities across both audit periods of Phase 2 were for systolic blood pressure, oxygen saturation, heart rate, temperature and respiratory rate. Rates of recognition were slightly higher with the new chart – 8.2% versus 9.3% for blood pressure and 4.6% versus 7.6% for oxygen saturation, respectively. Incidences of abnormalities for respiratory rate were much lower – 1.8% and 2.2% for each audit period, respectively. Patterns of incidence for abnormal parameters varied depending on the chart used; while systolic blood pressure remained most common for abnormal values, abnormalities for heart rate and temperature were more common than oxygen saturation with use of the ADDS[®] chart (note however that this chart was used in only one site, with a small sample size).

Responses to abnormal clinical observations (Phase 2)

Actions varied between chart versions when abnormal vital signs were documented. Clear patterns emerged for 'clinical reviews' on the R2 chart, where abnormal oxygen saturation values resulted in double the frequency of 'reviews' during the prospective audit, compared with the retrospective audit. For the R4 chart, 'increased surveillance' was required twice as frequently for respiratory rate and systolic blood pressure, while

‘increased surveillance’ and ‘senior nurse review’ actions were significantly higher for heart rate. Use of the ADDS chart provided no evidence of an increase in ‘actions required’ during the prospective audit.

According to local RRS calling criteria, during the retrospective audit period a MET call was initiated in only 33% of cases; this increased to 41% of cases with the trial charts. Actual cardiac arrests were 3% of all emergency calls, while 15% of calls resulted in an unplanned ICU admission. Calls were out of hours in 40% and 31% respectively. Similar findings were noted for the second instance of abnormal vital signs in the same patient, with fewer initiated MET calls for the third set (Table 4); numbers however were too small to demonstrate statistical significance. Actual MET call rates were 4.9 and 5.5 per 1,000 bed days for the two audit periods, respectively. If a MET was called every time an abnormal vital sign was documented according to the local RRS criteria, call rates would have been 13.6 and 14.8 per 1,000 bed days, respectively.

DISCUSSION

Key Findings in relation to previous literature

Use of these trial track and trigger-based observation and response charts demonstrated some improvement in documentation of vital signs and related actions and responses to identified abnormalities, when compared with existing hospital charts in use across the study sites. Full use of all section of the charts was not achieved however, limiting their purpose and ability to support identification of clinical deterioration, including when abnormal vital signs were clearly observed and documented. This finding appeared to be related to existing observation documentation practice behaviours and reporting decisions of staff; an important consideration in complex sociotechnical practice environments (Jones et al. 2011, Astroth et al. 2013, Douw et al. 2015).

Overall, compliance for documenting the nine patient vital sign variables did not fully align with chart developer guidelines and related human factors principles. While compliance improved between Phases One and Two, some noted practice issues for users were identified from the audits. Central to this was the continued and common behaviour of writing numbers for vital signs in the charting area, particularly when nurses were concerned about a patient's increased risk of clinical deterioration. This decision was commonly taken because of a perceived lack of precision when documenting a range (e.g. within a 10 mmHg band for Blood Pressure) not a specific number, especially for respiratory rate, O₂ saturation, O₂ flow rate, blood pressure, heart rate and temperature. According to human factors principles however, writing an actual number can actually detract from a clinician's ability to detect abnormal visual patterns in the observation charts (Christofidis et al. 2015b, Brier et al. 2015); creating visual clutter and increasing the risk of not recognising clinical deterioration (Preece et al. 2012b).

Minimising this seemingly entrenched documentation behaviour has been noted by others and requires a proactive, broad and systemic cultural change for all health professionals (Odell 2015). Despite any initiatives to modify practice and documentation behaviours, this discordance may continue while digital values, often provided by automated bedside observation devices (Bellomo et al. 2012), need to be converted manually by nurses into ranges to fit the requirements of a paper-based documentation chart. Adoption of a fully digitised and networked practice environment will of course ultimately render this issue obsolete (Bates and Zimlichman 2015), but until these clinical information systems are widespread, challenges will remain for clinicians, educators and managers.

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Use of symbols for documenting vital signs and assisting in visual pattern recognition - another human factors design principle - was also mixed. Dots were placed in the centre of the square in just over half of the charts and were connected by lines in just over one-third of cases. Arrows were used for blood pressure consistently well, perhaps reflecting historical and routine blood pressure recording practices. Compliance with use of dotted lines to connect systolic and diastolic arrows was lower, in just over half of the audited charts. Use of arrows and connecting lines for recording blood pressure are important aspects of graphing vital signs to promptly recognise clinical deterioration (Christofidis et al. 2015b). Documenting of consciousness and pain score was consistently high, but Urine Output was documented poorly, despite user education during chart implementation. This latter finding may be related to usual practice, where urine output is documented on a fluid balance chart if required for patient care and treatment, but not recorded on vital signs observation chart.

Importantly, the two- and four-level chart versions (R2 and R4) in particular appeared to generate higher levels of surveillance and review when compared with existing hospital charts. In Phase 2, identification of abnormal blood pressure findings increased slightly from eight to nine percent and oxygen saturation from five to eight percent. Of note, the incidence of an abnormal respiratory rate was low; around two percent for both audit periods. While a change in respiratory rate is a strong physiological indicator of deterioration, this study and others (Jacques et al. 2006); (Kause et al. 2004) suggest it is not the most reliable vital sign, especially in isolation. These findings may therefore highlight an important feature of the single-parameter R2 and R4 charts; with early identification of one abnormal vital sign, specific focused surveillance or review actions may precede further deterioration and an impending MET call - a key goal of this type of clinical decision-support tool.

Other sections of the charts – intervention, clinical review, additional observations, modifications in use - were not completed according to developer guidelines, across both phases. In Phase 1, the 'Intervention' section was used in one quarter of cases, with some user confusion regarding use of the 'coding' letters. A 'Clinical Review' was used in a small number of cases, although routine practice is for doctors to write any review in the patient's medical records, with no double-documentation. The 'Additional Observations' section was used mostly for glucose level, bowel activity and weight. Other speciality observation charts were documented as not in use for the majority of the audit cases; fluid balance and neurological / neurovascular charts comprised one-half and one-quarter of other chart types in use, respectively. Systolic blood pressure, oxygen saturation, oxygen flow rate and heart rate were the most common parameters adjusted in the 'modifications in use' section.

It is possible that practice culture and behaviours influence clinician decisions on whether to escalate care. In this audit, decisions to activate a MET call appeared to be based on individual clinical judgement rather than complying with chart instructions and local escalation criteria. Despite explicit identification of abnormal vital signs documented in the observation charts, a response based on each site's RRS protocol was not always triggered; a similar finding noted elsewhere (Gibbs 2007, Storm-Versloot et al. 2014). Importantly, when no appropriate action occurred at the first observation of an abnormal value, abnormalities continued to be present with subsequent observations; again similar to other findings (Harrison et al. 2006, Tirkkonen et al. 2013, Crispin and Daffurn 1998, Trinkle and Flabouris 2011). While use of the new chart appeared to improve MET calling rates when compared with the previous chart, actual calls based were still less than half of the expected calls, when compared with local calling criteria.

Strengths and limitations

The number and range of participating sites across five Australian states offers strength to the external validity of our findings. While a before-after design limited causal inferences related to the chart and use of control wards may have improved interpretation, other extraneous factors may also have influenced findings, such as different ward cultures, case mix and contamination bias. Use of an onsite project officer seconded from the local organization enabled engagement with clinical staff.

In relation to chart design characteristics, modifications to parameter values and response levels enabled alignment with local site needs, policies and practices. While this 'flexible standardisation' enabled some site input, higher levels of engagement with front-line clinicians in setting parameter ranges may have improved acceptance and compliance. While the three non-ADDS charts had no simulation testing prior to this clinical testing, the design characteristics and sections, including the graphing section, were similar across all versions. Different chart versions were not directly compared with each other in sites and limited any ability to identify user preferences for a specific chart version, based on use in clinical practice rather than an a priori decision.

The project brief required a restricted timeframe in which to collect data from all participating sites. While data collection periods were short, these were to minimise participant burden in busy clinical environments. Training for chart implementation in Phase 2 was timed to coincide with the start of a new clinical term for resident medical officers, which meant clinical staff using the charts on a daily basis, primarily nurses, had at least three weeks of routine practice experience with the chart prior to data collection. Funding and human resource limitations across these multiple sites precluded inter-rater reliability checks for extraction of audit data, although group training for all project site-based officers and the use of a standardised audit form were

designed to limit any systematic bias during the audits. While use of routinely collected MET data was designed to minimise collection burden, it was evident that no standard dataset exists for use across all sites in this sample.

CONCLUSION

These human factors-designed, TTS-based charts had not been previously evaluated in routine clinical practice. The multi-site audits of chart use demonstrated some clear improvements in documentation and responses to signs of patient deterioration when compared with existing charts, after a short period of use in practice. These current and related findings (Elliott et al. 2016, Elliott et al. 2015) indicated however that cultural issues and entrenched practices limited full function of chart sections and compliance with local RRS calling criteria. With continued clinical use that is actively supported by targeted auditing and training, optimal chart functionality aligned to developer guidelines, can be achieved.

Overcoming any identified local practice barriers and implementing the ACSQHC (or similar) standards in conjunction with a track and trigger chart that aligns with local escalation protocols provides an opportunity to improve both the identification and response to abnormal vital signs and triggering a MET activation when clinical deterioration is detected.

Implications for practice

This two-phase multi-site audit of user compliance across a range of acute adult medical-surgical ward settings provides a level of generalisability that can inform other organisations considering a similar practice initiative aimed at improving recognition and response of clinical deterioration. While these chart templates were developed and designed for use in Australia, the chart characteristics and features reflect contemporary

international views on TTS and EWS practice initiatives. Other clinicians could therefore apply these findings to their practices in different health systems internationally, noting the following issues for consideration.

Based on reflections from our audit and similar findings by others, any implementation strategy of new charts requires an explicit change management approach from internal organisational and key opinion leaders; to address potential factors that may influence adoption, such as: workplace culture(s); interprofessional collaborative practices; interdisciplinary communication patterns and channels; clinical decision-making; documentation practices; vital sign observation standards and practices; and understanding of and compliance with human factors design principles and related chart characteristics (Christofidis et al. 2015a).

When considering implementation of a new chart facility-wide all relevant clinical disciplines should be fully engaged, as senior management, disciplinary leadership and interprofessional collaboration are essential for these types of charts to be successfully adopted into practice (Hogan et al. 2007). At the core of this collaboration is the local professional and workplace culture(s) across all levels of the organisation.

Continuing professional development and training related to the chart and associated practices for all relevant clinical staff should therefore be tailored to meet local needs and context. Any clinical deterioration training packages should include the principles and rationale human factors design characteristics applied to the chart, how the chart is to be implemented into routine practice and processes for escalation in care according to local RRS criteria. Chart design characteristics based on human factors principles enable clear identification of potential patient deterioration and reduce cognitive load for clinical users (Preece et al. 2012a). The standard layout and features for an

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observation chart developed by the ACSQHC were designed to minimise risk and error. Any local chart modifications by individual health services not involving human factor expertise to guide changes, may potentially increase the risk to patient safety.

Organisations should consider regular audits of chart completion and application to practice to monitor compliance with developer guidelines and practice standards i.e. whether appropriate responses were triggered according to local RRS (and chart) recommendations. Feedback of data will also encourage a collaborative culture, improved staff engagement (Vogelsmeier et al. 2010) within a continuous quality improvement cycle.

Recommendations for further research

The current evidence base, including confirmatory and additional findings from this audit study demonstrate that escalation of care does not always eventuate, despite clear signs of clinical deterioration, sometimes on multiple occasions. While the charts tested here offer an evidence-based tool to complement clinical practice and decision-making, multi-factorial issues regarding clinical acceptance, compliance and escalation of care remain a challenge. Further exploration of workplace and practice culture issues, influencing clinician behaviours of recognising and responding to the unmet needs of a deteriorating patient in general ward areas within local escalation systems, is therefore warranted.

Author Contributions:

All authors have agreed on the final version and meet at least one of the following criteria (recommended by the ICMJE*):

- 1) substantial contributions to conception and design, acquisition of data, or analysis and interpretation of data;

2) drafting the article or revising it critically for important intellectual content.

* <http://www.icmje.org/recommendations/>

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Box 1 Excerpts of user instructions from the ORC

General instructions

- > You must record appropriate observations:
 - On admission
 - At a frequency appropriate for the patient's clinical state.
- > You must record a full set of observations:
 - If the patient is deteriorating or an observation is in a shaded area
 - Whenever you are concerned about the patient.
- > When graphing observations, place a dot (•) in the centre of the box which includes the current observation in its range of values and connect it to the previous dot with a straight line. For blood pressure, use the symbol indicated on the chart (v and ^ arrows).
- > Whenever an observation falls within a shaded are, you must initiate the actions required for that colour, unless a modification has been made.
- > If observations fall within two or more different coloured areas for the same time period, the actions required for the darker colour apply.

Table 1 Chart descriptions and site selections for each phase

Chart versions	R1 ^a	R2 ^b	R4 ^c	ADDS ^{-d}	ADDS ^{+d,e}
TTS type	Single-parameter			Multi-parameter	
RRT response levels	1	2	4	4	4
Testing prior to this study	No	No	No	Non-clinical / simulation environments e.g.(Preece et al. 2012b, Preece et al. 2012a)	
Number and type of sites selecting each chart					
Phase 1	2	4	3	1	1
• Tertiary / metropolitan	1	2 ^f	1 ^f	1	-
	1	1	-	-	-
• Regional	-	-	1	-	-
• Rural	-	1	1	-	1
• Private					
Phase 2	-	6	2	1	-
• Tertiary / metropolitan	-	4	1	-	-
	-	-	-	-	-
• Regional	-	1	-	-	-
• Rural	-	1	1	1	-
• Private					

Notes:

- ^a one response level: emergency (MET) call
- ^b two response levels: clinical (medical) review and emergency call
- ^c four response levels: increased clinical surveillance, senior nurse review, clinical review and emergency call
- ^d Adult Deteriorating Detection System (ADDS); four response levels: increased clinical surveillance, ward doctor review, Registrar review and emergency call
- ^e This version of ADDS had an additional chart scoring systolic blood pressure
- ^f one site trialled two chart versions in different sets of wards

Table 2 Phase 1 user compliance

	Chart version					
	All	ADDS+	ADDS-	R4	R2	R1
Total ORCs (n)	818	87	87	181	348	115
	%	%	%	%	%	%
Completion of observations according to chart instructions						
Dots placed centre of square	54	63	63	46	58	43
Dots connected by line:						
Yes, all	9	16	8	11	8	8
No, all	60	49	74	55	64	57
Mixed	24	36	17	22	26	19
No dots used	6	0	1	12	3	17
Arrows used for BP	79	89	77	85	72	87
Arrows connected by dashed line:						
Yes, all	55	58	58	65	47	58
No, all	13	1	9	11	14	25
Mixed	31	39	32	23	38	14
No arrows used	2	2	1	2	1	3
Consciousness recorded	98	100	95	98	98	97
Urine output recorded	45	82	63	44	33	40
Pain score recorded	81	97	58	80	79	92
Use of intervention, clinical review and additional observations sections						
Intervention section used	25	46	21	27	21	23
Intervention code (letter) linked to observations	79	53	77	90	88	83
Clinical review section used	2	0	1	2	2	2
> 1 review required	14	3	18	14	15	14
Additional observations section used ... If yes ^a :	19	8	15	20	16	39
BGL ^b	52	86	79	40	46	57
Weight	25	0	29	26	16	36
Bowels	49	14	21	73	46	46
Urinalysis	17	0	7	16	20	18

Notes:^a more than 1 section may have been used^b Blood Glucose Level

Table 3 Completion rates of vital signs documentation by parameter and chart across Phase 2 audit periods

Chart audit period	ADDS-		R4		R2	
	Retrospective	Prospective	Retrospective	Prospective	Retrospective	Prospective
Total observation sets (n)	545	433	962	991	3389	3600
Parameter % completed						
Respiratory rate	90	97	72	96	88	94
Oxygen saturation	95	97	94	96	90	94
Oxygen flow	86	90	74	70	88	89
Systolic blood pressure	96	100	97	100	93	95
Heart rate	96	99	94	97	91	94
Temperature	92	97	86	95	86	89
Consciousness	0	87	19	94	29	82
Urine output	1	69	0	15	0	3
Pain score	7	27	41	69	38	58

Table 4 MET calls actioned according to chart criteria for each Phase 2 audit period

Abnormal observations n (%)	1st instance		2nd instance		3rd instance	
Audit period	Retrospective	Prospective	Retrospective	Prospective	Retrospective	Prospective
MET required according to site protocol:	24	22	10	19	6	15
Called	8 (33)	9 (41)	3 (30)	8 (42)	3 (50)	4 (27)
Not called	11 (46)	8 (36)	6 (60)	7 (37)	2 (33)	7 (47)
Missing data ¹	5	5	1	4	1	4

Note: ¹ missing data on the observation chart precluded auditor decision on whether a MET call was required