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ORIGINAL ARTICLE

User acceptance of observation and response charts with a track and trigger system: a multisite staff survey

Doug Elliott, Emily Allen, Sharon McKinley, Lin Perry, Christine Duffield, Margaret Fry, Robyn Gallagher, Rick Iedema and Michael Roche

Aims and objectives. To examine user acceptance with a new format of charts for recording observations and as a prompt for responding to episodes of clinical deterioration in adult medical–surgical patients.

Background. Improving recognition and response to clinical deterioration remains a challenge for acute healthcare institutions globally. Five chart templates were developed in Australia, combining human factors design principles with a track and trigger system for escalation of care. Two chart templates were previously tested in simulations, but none had been evaluated in clinical practice.

Design. Prospective multisite survey of user acceptance of the charts in practice.

Methods. New observation and response charts were trialled in parallel with existing charts for 24 hours across 36 adult acute medical–surgical wards, covering 108 shifts, in five Australian states. Surveys were completed by 477 staff respondents, with open-ended comments and narrative from short informal feedback groups providing elaboration and context of user experiences.

Results. Respondents were broadly supportive of the chart format and content for monitoring patients, and as a prompt for escalating care. Some concerns were noted for chart size and style, use of ranges to graph vital signs and with specific human factors design features. Information and training issues were identified to improve usability and adherence to chart guidelines and to support improved detection and response for patients with clinical deterioration.

Conclusions. This initial evaluation demonstrated that the charts were perceived as appropriate for documenting observations and as a prompt to detect clinical deterioration. Further evaluation after some minor modifications to the chart is recommended.

What does this paper contribute to the wider global clinical community?

- Implementing practice initiatives to improve recognition and response to clinical deterioration (the afferent limb of the rapid response system) remains a global healthcare challenge
- Initial multisite evaluation on the use of this chart format in clinical practice demonstrated utility and broad user acceptance for documenting vital signs and detecting clinical deterioration in adult medical–surgical patients
- Challenges for users related to some chart design characteristics, including chart size and structure, charting values and precision in vital sign ranges, and completion of sections specifically requiring medical input
- Findings uncovered further evidence of the complex decision-making, interprofessional practice and communication issues related to patient deterioration and the afferent limb of the rapid response system.

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Relevance to clinical practice. Explicit training on the principles and rationale of human factors chart design, use of embedded change management strategies and addressing practical issues will improve authentic engagement, staff acceptance and adoption by all clinical users when implementing a similar observation and response chart into practice.

Key words: clinical deterioration, deteriorating patient, experiences, human factors design, nursing, observation charts, perceptions, rapid response system, survey, track and trigger

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Introduction

Across acute care settings worldwide, improving recognition and response to clinical deterioration remains a significant challenge (DeVita *et al.* 2006), with continuing evidence of delays in activation and failure to rescue (Harrison *et al.* 2005, Buist 2008, Adelstein 2011, Shearer *et al.* 2012). Development and evaluation of observation charts to improve detection and response has, therefore, become an increasing focus of recent work (Mitchell *et al.* 2010, Cahill *et al.* 2011). A conceptual model of the rapid response system (RRS) (DeVita *et al.* 2006) has also been proposed to inform practice and research, with clinical observations, identification of deterioration and triggering a response (termed the 'afferent' limb) (Hughes *et al.* 2014) and the response ('efferent' limb) being key components. Other suggested elements include administrative oversight of system functions and data collection and analysis for continuous quality improvement (DeVita *et al.* 2006).

Clearly, delay or absence of identification and documentation of vital signs (Kyriacos *et al.* 2011) and 'afferent limb failure' (DeVita *et al.* 2010) increase the risk of a patient requiring costly interventions or an unplanned ICU admission (Trinkle & Flabouris 2011) and highlight the importance of timely and accurate documentation practices. Paper-based observation charts remain common for documenting vital signs of patients in adult medical–surgical wards in Australian hospitals (Australian Commission on Safety and Quality in Health Care [ACSQHC] 2011), despite little evidence to support their design or performance until recently (Chatterjee *et al.* 2005, Mitchell *et al.* 2010, Preece *et al.* 2013). Improved documentation of vital signs using redesigned charts and related education has been demonstrated (Mitchell *et al.* 2010, Cahill *et al.* 2011).

To systematically address this issue, a National Consensus Statement by the Australian Commission for Safety and Quality in Health Care (ACSQHC) (2010) identified eight essential elements required to ensure timely recognition and appropriate responses for patients at risk of deterioration. The first element recommended measurement and documentation of six core physiological vital signs: respiratory rate, oxygen saturation, blood pressure, heart rate, temperature and level of consciousness. This article sets out part of the work that developed and tested a suite of charts to address this recommendation.

Background

In 2009, the ACSQHC developed an evidence-based adult general observation chart incorporating human factors design principles that recorded core physiological vital signs, supported accurate and timely recognition of clinical deterioration and specified prompt actions when deterioration was observed (Preece *et al.* 2010). This chart recorded physiological parameters using colour coding for value ranges to define when patients' vital signs had breached acceptable physiological parameters (Australian Commission on Safety and Quality in Health Care 2013). Other factors that might signal clinical deterioration were also noted on the chart, along with varying levels of action or escalation to address increasing clinical needs. The resulting 'Adult Deterioration Detection System' (ADDS) charts were designed using a multiparameter track and trigger system (Preece *et al.* 2013). These charts incorporated an early warning score (EWS), with one version (the ADDS+) including scoring of systolic blood pressure to calculate part of a patient's EWS. The charts were subsequently tested in simulated environments (Christofidis *et al.* 2013, 2015).

Three other observation and response charts (ORCs) were then also developed for the ACSQHC to account for different 'track and trigger' systems across the full range of health services in Australia (Australian Commission on

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Safety and Quality in Health Care 2013). Each of these three additional charts used single parameter alerts for clinical deterioration, but with three different levels of clinical response, depending on RRS resources available in hospitals: one, two or four levels of clinical response (Table 1). These additional charts were not tested in a simulated environment prior to the clinical evaluation reported here.

Charts were formatted as an A3-sized double-sided booklet with a left binding margin and a fold from the right. Further description of the chart structure is reported elsewhere (Elliott *et al.* 2014), and chart examples are provided in Supporting information.

The study

The work reported here formed part of an initial evaluation in a larger two-stage, mixed-methods multisite study [see published study protocol (Elliott *et al.* 2014)].

Aim/s

The primary aims for this study component were to examine the perceptions and experiences of staff using the ORCs in practice, in terms of chart suitability (1) for recording observations and (2) to act as a prompt for responding to episodes of clinical deterioration in adult medical–surgical patients. Secondary aims were to identify chart sections that required modifications and evaluate whether charts could be implemented in practice with minimal training.

Design

A pragmatic prospective evaluation of ORC user acceptanceacce, incorporating staff surveys and short audio-recorded feedback groups, was implemented for this first component of a two-phase multisite study.

Sample/Participants

Participating sites were selected from an expression of interest process involving the ACSQHC, which covered a broad range of healthcare facilities across five Australian states (four in Victoria, two in South Australia, one each in Tasmania, Queensland and New South Wales), public and private hospitals and different levels of service and size ranging from small rural facilities to metropolitan and tertiary-level hospitals. Site-based project officers were seconded to the project and were supported by a training workshop, project manager site visits, teleconferences, telephone and e-mail assistance.

Table 1 Description of chart versions

	Chart version				
	R4	R2	R1	ADDS– BP	ADDS+ BP[a]
Levels of RRS	4	2	1	4	4
Increased clinical surveillance	X	–	–	X	X
Senior nurse review	X	–	–	X[b]	X[b]
Clinical review	X	X	–	X[c]	X[c]
Emergency (MET call)	X	X	X	X	X

ADDS, Adult Deterioration Detection System; BP, (systolic) blood pressure scoring table; MET, medical emergency team; RRS, rapid response system.

[a]An additional section on the chart for scoring systolic blood pressure.

[b]Designated as 'Ward Doctor review'.

[c]Designated as 'Registrar review'.

Sites selected one of the five versions of the ORC (Table 2), which best matched their existing RRS for managing deteriorating patients, with parameter values then adjusted to match each site's requirements and align observations and response actions to local RRS protocol and practices. Two sites had different campuses with different calling criteria for care escalation, so 'campus-specific' versions were developed. All relevant clinical staff, mostly nurses, were informed about the components and features of the chart, the aims of the project and related data collection processes. Given the issue of shift work and access to staff, this information was in both written and verbal forms.

As the trial charts were not approved as a medico-legal record, double documentation was required during this initial evaluation. For this process, clinical staff were instructed to document on the hospital's current observa-

Table 2 Study sites, number of trial wards and available beds, and chart version used

Site	Hospital type	Wards (*n*)	Beds (*n*)	Chart Version
A	Tertiary/metropolitan	2	51	R1
B	Regional	3	74	R1
C	Tertiary/metropolitan	2	64	R2
D	Private	3	98	R2
E	Tertiary/metropolitan	6	167	R2
F	Regional	2	80	R2
G	Private	3	90	R4
H	Rural	6	79	R4
I	Tertiary/metropolitan	2	58	R4
J	Private	4	119	ADDS– BP
K	Tertiary/metropolitan	3	84	ADDS+ BP

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tion chart first as per usual practice and then document observations on the trial chart during the same documentation activity, or as soon as possible after observations were taken, to minimise recording variations.

After staff training, charts were introduced into 2–3 wards at each site in June 2011. Any addition to workload of clinical staff was identified as a risk to study compliance and feasibility, and therefore, data collection aimed to minimise 'respondent burden' by scheduling each ward to complete the 'dual-documenting' of observations on the existing hospital chart and the designated chart only within one 24-hour period. A continuous 24-hour cycle of observations in each ward was most appropriate for testing initial usability of the charts and importantly allowed assessment at night, when ambient lighting is lower.

A staged process was developed for each hospital site, so that data collection for each ward was undertaken in sequential 24-hour periods, separated by a data collation day to allow completion of data collection from the previous ward and preparation for the next ward. On the designated data collection day for that ward, the project officer distributed the selected chart for commencement at the start of the 'observation day' (commonly early afternoon).

Data collection

A 28-item survey was developed to examine staff perceptions and experiences with the design and content of the chart for usability in the clinical setting: clarity of text, layout, completeness, ease of documenting and utility in prompting a response for a deteriorating patient (see Supporting information for details). Items used Likert-scale, dichotomous and open-ended responses, and were informed by those already developed and used in online survey and simulation experiments of previous projects during chart design and testing (Preece *et al.* 2012a,b, Christofidis *et al.* 2013, 2014). Demographic characteristics were also collected. Both paper-based and online versions were used.

Users participated in a survey to examine the usability of the chart in practice at the end of their last shift during the 24-hour trial. Each user completed only one survey. At the completion of each shift (particularly after night duty), each site project officer conducted short user feedback groups (10–30 minutes). Some participants trialled the chart for two shifts over the 24-hour data collection period and participated in a feedback group after their second shift. Group feedback sessions were guided by four trigger questions: (1) What were the main issues you encountered when using the ORC? (2) What did you like about using the ORC? (3) What comments do you have about the different components of the form, especially each of the sections on the front and back of the chart? (4) Do you have any other comments? All sessions were audio-taped for transcription of de-identified verbatim comments.

Ethical considerations

Negligible/low-risk approval was granted from the Human Research Ethics Committee for each site and ratified by the University Human Research Ethics Committee (2010-000424) (11 in total). Clinical staff members were the study participants and provided informed consent prior to data collection.

Data analysis

Quantitative data from user surveys were entered into SPSS version 19 (IBM SPSS Statistics, Chicago, IL, USA) and then cleaned and checked for errors prior to data analysis. Data from the user survey were analysed and reported descriptively using frequencies and proportions, for individuals and all participating sites. Qualitative data from open-ended survey items and user feedback groups were analysed using content analysis. Two investigators analysed the data for emerging topics, which were then reviewed during discussions with other members of the research team.

Results

Participant characteristics

Charts were trialled for 108 nursing shifts in 36 wards across the 10 sites (Table 2), with user surveys completed by 477 respondents (77% of the 623 rostered nurses on the trial wards); see respondent characteristics in Table 3. Participant numbers in feedback sessions ranged from 2–5. Findings are reported below according to the study aims. When available and appropriate, participant comments from open-ended items of the survey or short feedback sessions are noted in italics in-text to provide context and elaborate on practice issues. Comments are sourced from surveys unless otherwise indicated (site and group number; e.g. I3 is from site I, group 3).

Aim 1: chart suitability for documenting observations

Chart format and layout

Overall, the majority of participants found the general layout for each of the charts to be usable in clinical practice (Table 4). In particular, participants found the language

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easy to understand (96%), the style and size of text easy to read (96 and 95%, respectively) and were confident in using the charts (66%). Narrative comments related to chart structure, format and layout that influenced usability and acceptance in practice included *liked size of boxes, much easier to read than usual chart* and *great for junior nurses*. Interestingly, while 65% of survey respondents agreed that there was enough space to write on the chart (range 60–74%) (Table 4), 12% of participants wrote a separate comment about lack of writing space.

One recurring aspect related to the A3 chart size folded as a booklet, which made it difficult to fit in current bedside (A4 size) folders and to write on when fully open. This commonly caused staff to fold the chart inside out or remove it from the folder, which led to further confusion about which pages were the front and back pages. Comments included: *It is difficult to use in our current folders as unable to unfold it without removing it; need to get different folders to make chart user friendly (I3); both sides of back and front look similar, depending how charts were folded the back and front were different*.

Inclusion of vertical bold lines every three columns, to minimise risk of 'column shift' error, was another structural aspect that generated numerous participant comments. Respondents found the bold lines confusing and distracted them from recording vital signs according to the required frequency. Comments included: *Not sure when to start a new date, does it have to be after a dark dividing line? Bold line after ever 3 boxes is confusing, why is it even there?* (I2). Several participants also commented that patients requiring frequent observations would need multiple charts; for example, *for postoperative patients or blood transfusion observations you go through the form very quickly*. However, for this 24-hour trial, only one ORC form was required in 91% of cases.

Table 3 Participant details

Characteristic	
Discipline	%
Nurses (n = 470)	98
Registered nurses	78
Enrolled nurses[a]	19
Assistants in nursing	2
Nursing students	1
Medical officers (n = 7)	2
Working full-time %	49
Gender (female) %	90
Age (median/IQR) years	36 (26–48)
Years in practice (median/IQR)	8 (3–20)
Clinical specialty, most common (n = 344; 55% response rate)	%
General medical	27
General surgical	26
Rural health	12
Orthopaedics	11
Neuroscience	6
Rehabilitation	6
Cardiac	4
Shift duration	%
8 hours	71
10 hours	24
Shift worked for survey completion[b]	%
Morning	40
Afternoon	40
Night	20

IQR, interquartile range; not all items completed by respondents.
[a]Equivalent to LPNs in the USA.
[b]Similar finding across all sites.

Table 4 User survey results

	Chart version					
Items	All	ADDS+	ADDS−	R4	R2	R1
Total respondents (n)	477	49	46	113	207	62
Proportion strongly agree and agree	%	%	%	%	%	%
Language easily understood	96	94	100	95	96	95
Text style easily read	96	97	95	97	96	100
Text size easily read	95	90	87	99	95	95
Easy to use	85	77	72	86	88	88
Instructions helpful	84	90	81	82	88	72
Colours help identify patient at risk	80	87	74	81	81	72
Chart aids management of deteriorating patient	76	81	63	80	77	70
Chart enables effective handover	74	63	55	75	80	70
Order of vital signs helps recording	67	62	58	69	71	64
Confident to use chart	66	56	46	65	72	61
Enough space to write in	65	73	68	74	60	64

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The two original chart versions, the ADDS charts with an EWS included on the form, were evaluated positively by survey respondents, with strong agreement about ease of use for the ADDS+ (with blood pressure scoring) and ADDS− charts (85 and 65% respectively). Contrary to these findings, several participants commented during debriefing that the blood pressure table was *hard to use and complicated* (A5), with the most challenging issue identifying a patient's usual or target blood pressure. Nursing staff wanted this to be a medical decision, although preoperatively a patient may not see a doctor until the day of surgery.

Use of colours for abnormal ranges

Different colour coding for abnormal ranges was an important human factors element of the chart design, acting as a trigger for users to recognise and respond to a change in a patient's clinical condition (see Supporting information for range of colours used). Some divergent opinions were noted; some participants noted, *loved the colours* and *easy to use* (A1, A6, A8, C1, G1, G3, H1, H2). A significant proportion (42%) indicated a preference for one or more of the colours used; many also suggested the 'emergency' purple colour be changed to red or blue (42%), as *red is more suited than purple for a rapid response – more alarming* or *blue should indicate possible medical emergency as per Code Blue*. One third (32%) of the respondents also considered that the orange and yellow shades were *too similar in colour*, were *all 'wishy-washy' colours* and *were not distinct enough – too close to each other*.

Charting values in ranges

Overwhelmingly, staff indicated a strong preference to record a numerical value because of concern that existing parameter ranges were too wide to illustrate changes in a patient's condition (see Supporting information for vital sign ranges). Over 80 participant comments reflected how users were accustomed to recording vital signs with more precision and therefore preferred to write a specific number. For example: *Dot points are not specific enough. What happens if the patient ends up being a coroner's case and specific details are being asked regarding the heart rate? I won't be able to answer these questions, all I will have to refer to is a dot.*

Some participants raised specific concerns about the ranges for oxygen saturation and oxygen device flow rate, and with difficulty identifying changes in a patient's condition. For oxygen saturation, one participant noted, *thought it was a big gap from 94–100%; we would intervene at 94%. With this big range you can't graph it improving. In particular, a trend won't be seen with increasing O_2 requirements and that it will be difficult to see weaning.* Conversely, one participant thought that an oxygen saturation of 95% coded as yellow was not warranted – *in fact I recorded in the >95% to avoid having to report*. Concern was also noted about not having a record of the oxygen delivery device in this section, potentially leading to an inappropriate device being used.

Recording urine output on an observation chart was a new practice for users, as this was not recorded on previous observation charts and generated frequent comments, often reflecting frustration. Participants were unclear as to what was required, particularly if a fluid balance chart was already in use or the patient was weighed instead. Some participants wrote a 'guess' urine output for those not on a fluid balance chart. The requirement for double documentation on both observation and fluid balance charts was felt to be an increased burden on workload. More positively, some participants thought that urine output was a good trigger to ask the patient if they were passing urine when carrying out their usual vital sign round, which they currently would not do.

Other chart sections

Very few comments were noted regarding 'general instructions' on the charts. While considered helpful for new or agency staff, this information did not need to be located on the front page of the chart as it would be used infrequently by permanent staff. The 'additional observations' section was used most commonly for blood glucose level (BGL) and bowel activity and less frequently for weight and urinalysis. The majority of participants thought this section was useful and favoured an all-in-one chart that included these other observations rather than using current separate charts.

There was, however, some confusion about how to use this section, mainly relating to frequency of recording observations, especially the BGL, and that it may lead to double documentation again; as commented: *Unsure about blood glucose level – is this one off or is this regular? – need to specify*. Positive comments were noted for the 'other charts in use' section; assisting staff to identify when additional specialty observation charts, such as neurological observations, were in use. Some concerns were raised, however, about keeping this section up to date when other charts were discontinued or new charts commenced.

The 'modifications to calling criteria' section was most frequently commented on during handover debriefings (n = 64). Positive comments noted its intent and participants thought it helpful if used appropriately and

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documented correctly. For example, it *provided immediate access to information without having to trawl through patients' sometimes considerable medical records to find relevant documentation*. One participant also noted: *Hopefully, the modification section will decrease the amount of inappropriate MET calls due to poor documentation by medical team*.

There was, however, considerable confusion about how this section actually worked in practice; for example: *How would modifications to yellow be distinguished from modifications to MET (purple) or other colours?* This initial trial chart provided only one modification to each vital sign parameter; if further modifications were required, a new chart would be required. The period for medical review of the modification varied from 48–72 hours across chart templates. For example: *While appropriate for patients with acutely changing clinical conditions, this timeframe would not accommodate chronic patients who fall within calling criteria on a daily basis. In this latter case, frequent reviews would lead to an unnecessary increase in workload*. There was also confusion about who was responsible for completing this section. Some participants suggested: *scope for nurse-initiated modifications such as a respiratory nurse being able to document modified ranges for oxygen saturations*. Finally, there was concern about engaging doctors to complete this section: *The modification section is a good idea but doctors need to be educated so we don't have to chase them to fill it in. Review every 72 hours won't happen!*

For the 'response criteria and action required' section (inside right of chart; see Supporting information), some staff commented that this section was really useful and felt reassured about actions, especially for supporting and providing guidance to new and inexperienced staff. Participants were overwhelmingly positive about the chart 'intervention' section; for example: *it makes it clear what action you took for the observation. Gives you ownership of the vital signs you take* (H2). There was, however, also considerable confusion about how this section was to be used, and what to document; for example: *Hard to know what to write, is it exactly the same as the action required or just what you did different to the action required?;* and *is this recorded in the medical records as well, requiring double documentation?*

For the doctor's 'clinical review' section, respondents frequently noted that doctors would most likely refuse to document in this section, and may or may not document in patient medical records to meet medico-legal requirements (note that medical records were not audited during this phase of the study). For example, *this section is a good idea in theory but don't think it will work as not enough room to write full assessment with history, etc. and doctors probably won't want to double document*. A few participants also highlighted that a lot of patients who need a clinical review will receive more than one in a short period of time, which would require the use of extra charts.

Aim 2: chart suitability as a prompt for responding to episodes of clinical deterioration

Respondents reported that the charts assisted in identifying a patient at risk (80% agreement; consistent across each chart version), aided management of the deteriorating patient (76%) and enabled effective clinical handover of the patient's condition (74%). In particular, the ADDS+ (EWS) system received a high number of positive responses supporting management of a deteriorating patient (87%), including the scoring system (blood pressure table; 83%). The ADDS− chart received slightly less positive responses (63%). The ADDS− and R1 charts had the lowest agreement regarding colour use for identifying a patient at risk (74 and 72%, respectively).

Narrative feedback included: *thought charts looked complicated but once used liked that they helped identify if there was an issue with a patient; it is useful to have the pain score as it prompts you to assess this and consider its relationship to other variables* (H6). Of note, one participant commented on practice surrounding ADDS scoring where a clinical review for a patient was not triggered when required. A doctor phoned to check on postoperative bleeding, but there was no ADD score for this, and a significant loss was not reported (the ADDS chart did not include fluid or volume loss in the scoring system, except for Urine Output). While other chart versions ('R1', 'R2' and 'R4') also do not enable documentation of fluid/blood loss in the charting area, these versions provide for 'increased or unexpected fluid or blood loss' in the 'response criteria and actions required' section (see 'clinical review' in R4 chart example in Supporting information). This fluid loss would also be identified with correct documentation on an accompanying fluid balance chart and appropriately reported.

Secondary aims: potential chart modifications and training requirements

Respondents identified specific sections of the ORCs for potential modification during the survey (see Conclusion and Supporting information). In relation to training and education prior to chart use, most respondents (78%) had

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not previously used a type of ORC in practice (Table 5). Formal education was provided by site-based project officers to 61% of respondents, and overall the training was perceived as helpful and useful for 98% of respondents. After this short trial period of 24 hours per ward, where staff used the chart for only one or two shifts, almost two thirds (63%) noted a preference for using the new chart instead of their current observation chart, and a significant majority (88%) felt confident in using the chart. There was, however, some lack of clarity about what constituted an ORC; one site already had a type of track and trigger observation chart in use, but 50% of their respondents indicated that they had not used one prior to the trial.

Discussion

This study is the first to report staff perceptions and experiences across multiple sites with this suite of observation charts used in clinical practice. Evaluating users' views for new charts in practice is important for the developing knowledge base on elements of the afferent limb of a RRS. While objective data are necessary to develop effective evidence-based observation charts (Preece *et al.* 2012a, Christofidis *et al.* 2015), understanding and preferences of clinical staff (Preece *et al.* 2013) and work culture (Williams *et al.* 2011, Shearer *et al.* 2012, Mackintosh *et al.* 2014, Brier *et al.* 2015, Douglas *et al.* 2016) are also likely to influence successful adoption in practice (Hills 2011, Douglas *et al.* 2016), as reflected in our findings.

Our initial key finding was that users recognised the benefits of many of the chart features in practice, with consistently positive responses for the language, style and size of text used. Most importantly, over two thirds of respondents agreed that the chart enabled effective communication during handover and aided management of clinical deterioration, addressing the original purpose for their development (Preece *et al.* 2012b, Australian Commission on Safety and Quality in Health Care 2013). The majority of respondents used an ORC in practice for the first time in this short trial, with two thirds preferring the trial chart to their usual observation chart, and felt confident in completing the chart.

Some practice and user challenges were also noted as a key finding. Optimal use of some chart features, based on human factors design principles, however, required further explanation, training and experience in practice, a finding similar to others (Mitchell *et al.* 2010, Cahill *et al.* 2011, Kyriacos *et al.* 2015). The A-3 chart size and booklet style not fitting existing bedside folders was a clear practical challenge for users, limiting acceptance and adoption into practice. While the use of bold vertical lines every three columns in the vital signs chart area is optimal for minimising the risk of a 'column shift' (transcription) errors (Preece *et al.* 2013), this design feature and rationale were not fully understood by chart users despite chart orientation and training. Historically with previous observation charts, bold lines were commonly used to denote separation of dates. Staff, therefore, became confused and frustrated with this

Table 5 Education and training prior to chart use

Items	Response options	Chart version											
		All 477		ADDS + 49		ADDS – 46		R4 113		R2 207		R1 62	
Respondents (n)		*n*	%	*n*	%	*n*	%	*n*	%	*n*	%	*n*	%
Previous experience of ORC	Yes	103	22	9	19	5	11	38	35	46	23	5	9
	No	360	78	39	82	41	89	71	65	157	78	52	91
Information provided pretrial (can select more than one option)	None	35	8	0	0	5	11	3	3	21	10	6	10
	Background reading	44	9	16	34	3	7	15	14	4	2	6	10
	Informal	141	30	16	34	17	37	46	42	46	22	16	27
	Formal	286	61	26	55	25	54	57	52	144	70	34	57
	Other: 1 to 1, preshift talk	9	2	0	0	1	2	2	2	3	2	3	5
Prior education helpful	Yes	398	98	45	100	38	100	97	95	175	99	43	93
	No	10	2	0	0	0	0	5	5	2	1	3	7
Chart preference	ORC	249	63	31	76	14	33	64	65	108	67	32	58
	Current	149	37	10	24	28	67	34	35	54	33	23	42
Feel confident to complete	Yes	367	88	31	74	30	77	96	92	163	91	47	87
	No	10	2	3	7	2	5	3	3	1	1	1	2
	Uncertain	41	10	8	19	7	18	5	5	15	8	6	11

Not all items completed by respondents.

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design feature, as they attempted to align observations with their usual frequency of recording vital signs (e.g. four or six hourly), reflecting the ritual nature of this practice (Brier *et al.* 2015).

Some user responses to chart sections, such as graphing ranges, 'modifications' and 'clinical review', also uncovered the disciplinary interplay and tensions between nurses and doctors (Braithwaite *et al.* 2010, Bergstrom *et al.* 2012), a highly charged professional space particularly within the context of a deteriorating patient (Mackintosh *et al.* 2014). Importantly, traditional, ritualistic vital signs monitoring practices (Osborne *et al.* 2015) and workflows (Yeung *et al.* 2012) continue to hinder identification and responses to clinical deterioration (Brier *et al.* 2015).

From a practice and patient safety perspective, participants raised concerns about the use of ranges for recording vital signs. From a human factors perspective, the charting area was specifically designed to improve identification of deterioration (Christofidis *et al.* 2015) by 'tracking' changes or patterns of individual vital signs over time (Christofidis *et al.* 2014) rather than listing a series of numbers (Christofidis *et al.* 2013, 2015). A discord between actual measurements obtained, often as digital values from automated observation devices (Bellomo *et al.* 2012), and recording vital signs in ranges was, however, apparent with our study participants in actual practice; one that may not be fully resolved until complete adoption of a digitised and networked practice environment is realised (Bates & Zimlichman 2015).

Study strengths and limitations

A number of methodological strengths and limitations are noted with the design in this first phase of the project. A multisite design enabled inclusion of a range of health services and contributes to external validity of these findings. A pragmatic data collection period of 24 hours per ward was selected to minimise participant burden (primarily the need for dual documentation by nursing staff), during initial chart evaluation. The 24-hour cycle of data collection enabled involvement and feedback from night-duty staff. With one fifth of participants on night shift during data collection, the charts and specifically the colours for coding responses appeared appropriate for use in low-light contexts, reflecting a strength of the study. A longer data collection period may have provided a different scope and pattern of responses, as participants became more familiar and confident with using the chart (addressed in phase two of the project). Survey findings were strengthened by narrative from user feedback groups.

Recommendations for further research

Exploration of the optimal ranges for vital sign parameters (Kyriacos *et al.* 2011), interprofessional communication and collaboration within the context of clinical deterioration (Jones *et al.* 2013, Elliott *et al.* 2015), and what other factors influence nurses' decisions in complex sociotechnical workplaces (Jones *et al.* 2011, Astroth *et al.* 2013, Douw *et al.* 2015, Elliott *et al.* 2015) during an identified episode of clinical deterioration, require further evaluation.

Conclusion

Based on these initial findings from this first multichart evaluation in practice across multiple sites, the charts demonstrated utility and broad user acceptance for documenting vital signs and detecting clinical deterioration in adult medical–surgical patients, conferring some added value over existing charts. Challenges were, however, noted for users related to chart design characteristics, including chart size and structure, charting values and precision in vital sign ranges, and completion of sections specifically requiring medical input. Chart template modifications were, therefore, recommended to improve usability and support clinician practices related to detection and response to patient deterioration. Based on a review of these findings in consultation with representatives of the ACSQHC and chart developers, a set of chart modifications was approved for use in the second phase of the project (see Supporting information, Box S1) and in routine practice (Australian Commission on Safety and Quality in Health Care 2013).

Relevance to clinical practice

These findings add to the developing literature base on the 'afferent limb' of the RRS (Hughes *et al.* 2014, Mackintosh *et al.* 2014, Storm-Versloot *et al.* 2014, Flabouris *et al.* 2015), providing further understanding of the complex decision-making (Odell *et al.* 2009, Kelly & Vincent 2011, Guinane *et al.* 2013, Mok *et al.* 2015) and communication issues (Andrews & Waterman 2005, Johnston *et al.* 2015) evident within the dynamic context of an unstable at-risk patient (Odell 2015). Other practice implications include the need for adequate training (Cahill *et al.* 2011) and reinforcement on the principles underpinning the human design characteristics of the chart (see Supporting information, Box 2), use of change management strategies to ensure authentic engagement by all clinical staff and, more prag-

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matically, availability of appropriately sized bedside folders to house the charts.

Findings from this evaluation across 10 acute healthcare settings of different complexities and size provide potential applicability and generalisability to other organisations internationally who use track and trigger-based charts within a RRS.

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Contributions

DE conceived of the study, participated in its design and coordination, and drafted the manuscript. EA participated in study coordination and helped to draft the manuscript. SM, LP, CD, MF, RG, RI, and MR all participated in the study design and coordination. All authors read and approved the final manuscript.

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Supporting information

Additional Supporting information may be found in the online version of this article:

Appendix S1.

Box S1. Chart modifications implemented after review of findings.

Box S2. Information and training issues identified after review of findings.

Appendix S2. Examples of chart versions used in the study.

Appendix S3. Participant user survey.

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