Human factors research regarding observation charts: Research project overview

Report prepared for the Australian Commission on Safety and Quality in Health Care's program for Recognising and Responding to Clinical Deterioration

Mark S. Horswill, Megan H. W. Preece, Andrew Hill, Melany J. Christofidis, Rozemary Karamatic, David Hewett, and Marcus O. Watson

School of Psychology, The University of Queensland

May 2010

Preface

Chief Investigator:
Dr Mark Horswill
School of Psychology
The University of Queensland

Project Manager:
Ms Megan Preece
School of Psychology
The University of Queensland

Principal Investigator:
Associate Professor Marcus Watson
Queensland Health
Skills Development Centre

Senior Consultant:
Mr Andrew Hill
School of Psychology
The University of Queensland

Senior Consultant:
Dr David Hewett
Queensland Health
Skills Development Centre

Senior Consultant:
Dr Rozemary Karamatic
Queensland Health
Skills Development Centre

Researcher:
Ms Melany Christofidis
School of Psychology
The University of Queensland

Corresponding author:
Dr Mark Horswill
m.horswill@psy.uq.edu.au
(07) 3346 9520
School of Psychology, The University of Queensland, St Lucia, QLD 4072, Australia

Acknowledgments

We would like to thank all of the interested parties who provided us with observation charts from their hospital or area health service for inclusion in this project and also helped us to recruit participants for the studies. We would also like to thank Nicola Dunbar, Lynette Adams, Kirsten Price, Jillann Farmer, John Wakefield, Alexandra Sonsie, Kevin McCaffery, Imogen Mitchell, Heather McKay, Helen Ward, Aaron Armstrong, and David Collard for their valuable input into the project.

Thanks to all the people who have helped this project run so smoothly, namely Kelly Ryan, James Bishop, Lisa McCoy, Kerrilee Gow, Mark Wetton, Paul Jackson, Lachlan Window, Paul Nines, Hayden Goodwin, Matt Seaman, Holly Dennis, Diana Dragisic, Tricia Hill, Robert Oldham, Christina Lee, and Bill Von Hippel.

Finally, thanks to our team of research assistants: John Manly, Georgina Parker, Natasha Innes, Olivia Ng, Lachlan Rowlands, and Nonie Finlayson.

Contents

Executive Summary

This report gives an overview of a project funded by the Australian Commission for Quality and Safety in Health Care and Queensland Health to investigate the design and use of observation charts in recognising and managing patient deterioration, including the design and evaluation of a new adult observation chart that incorporated human factors principles.

The project involved the following five phases:

Phase 1: A heuristic analysis of 25 existing patient observation charts from around Australia and New Zealand, designed to systematically review human factors problems in those charts.

Phase 2: An online survey of health professionals intended to illicit opinions on the design of patient observation charts.

Phase 3: Design of a new observation chart: the Adult Deterioration Detection System (ADDS) chart using the outcomes of Phase 1 and Phase 2.

Phase 4: A behavioural experiment to compare the ADDS chart with four existing charts in terms of participants' ability to detect abnormal observations.

Phase 5: A behavioural experiment to compare the ADDS chart with four existing charts in terms of participants' ability to record patient data.

The outcomes of each of these phases are described in detail in separate reports available from the Australian Commisson for Safety and Quality in Health Care. In this report, we bring together a summary of each of these phases, together with general conclusions and recommendations arising from this research.

Overall, the results of the experiments supported the use of the human factors principles of chart design derived from the heuristic analysis, with the better designed charts yielding fewer errors by participants (aggregating across both experiments). The ADDS chart significantly outperformed all of the existing charts, and so we recommend the use of the ADDS chart as best practice from a human factors perspective.

General Background

Improving the recognition and management of patients who deteriorate whilst in hospital is a priority both at the national and state level. The Australian Commission on Safety and Quality in Health Care (ACSQHC) has launched a national program for 'Recognising and Responding to Clinical Deterioration' (1). In parallel, Queensland Health's Patient Safety Centre has released a strategy options paper discussing gaps in the recognition and management of the deteriorating patient (2).

Changes in physiological observations or 'vital signs' commonly precede serious adverse events such as cardiac or respiratory arrest, unplanned Intensive Care Unit (ICU) admission, or unexpected death (3-8). Several studies report that derangements in vital signs are observable up to 48 hours before the adverse event (3, 5, 6, 9). This suggests that if deterioration is recognised early and appropropriately managed, then complications arising from delays could be reduced (e.g. morbidity, unexpected ICU admissions, extended length of stays in hospital), and some serious adverse events could potentially be avoided altogether (11-12).

Paper-based observation charts are the principal means of recording and monitoring changes to patients' vital signs. However, vital signs are not always correctly recorded or appropriately acted upon (3, 6, 9, 13). The design of the observation charts themselves may contribute to failures in the ability of medical and nursing staff to record vital signs and recognise deterioration.

There is considerable variation in the design of observation charts in current use in Australia. They vary in both the number and selection of vital signs monitored. Observation charts also exhibit diversity in the way in which they display information. For instance, respiration rate may be displayed on one chart as a row containing boxes in which to write the number of breaths taken by a patient per minute at each time-point, while on another chart it may be plotted as a graph over time. Finally, observation charts also vary in the degree to which they incorporate track and trigger systems based on clinical criteria to help users recognise a deteriorating patient and respond appropriately.

There is presently a lack of empirical research on the design and use of observation charts. In Australia, observation charts tend to be designed at the local hospital or individual health service area level, resulting in a nationwide duplication of effort (2). Some observation charts appear to have been trialled in specific wards before full implementation or evaluated by means of a staff survey. Rigorous empirical evaluation is lacking in most cases.

There are indicative findings that efforts to improve the design of observation charts can produce benefits for patients, staff, and the hospital. In the United Kingdom, Chatterjee et al. carried out an empirical evaluation of 5 observation charts in use at a district general hospital (14). They reported that the design of the charts had a significant effect on the ability of staff to recognise patient deterioration (with a detection rate as low as 0% for one vital sign), and that no single existing chart was best for all vital signs. As a result, they designed and implemented a new chart incorporating a track and trigger system. They found that there was a significant improvement in staff's ability to recognise deterioration (all detection rates over 90%), after the re-design and implementation of the

new chart. Their new chart produced improvements in the detection of four forms of deterioration, hypoxia (45% increase in detection), tachypnoea (41% increase in detection), tachycardia (29% increase in detection), and fever (16% increase in detection). A recent Australian project to improve the early detection of patient deterioration, which included improvements to observation chart design (together with other interventions such as training), was found to produce statistically significant gains in the frequency of recording vital signs, as well as decreasing unplanned ICU admissions, decreasing the rate of cardiac arrests, and decreasing the rate of hospital deaths (15).

Phase 1: Heuristic Analysis of 25 Australian and New Zealand Adult General Observation Charts

The aim of the first phase of the project was to evaluate the quality and extent of design problems in a sample of 25 existing observation charts from Australia and New Zealand (16).

The evaluation was completed using a technique for systematically identifying design problems known as heuristic analysis. In such an analysis, the main output is a list of usability problems identified by evaluators' expert judgment. A total of 1,189 usability problems were identified in the 25 observation charts. Usability problems were identified as affecting the observation charts' page layout, information layout, recording of vital signs, integration of track and trigger systems, language and labelling, cognitive and memory load, use of fonts, use of colour, photocopying legibility, and night-time legibility.

In compiling lists of the various usability problems present in the observation charts reviewed, the report detailing the outcomes of the heuristic analysis can be regarded as a de facto manual for designing better observation charts. We have also produced an advice sheet for chart designers (available from the Australian Commisson for Safety and Quality in Health Care), which brings together the key points. No other such guide presently exists to help those charged with designing observation charts.

Phase 2: An Online Survey of Health Professionals' Opinions Regarding Observation Charts

The aim of the second phase of the project was to gauge the opinions of the population who actually use observation charts (17).

We recruited a large sample of health professionals (N = 333) to answer general questions about the design of observation charts and specific questions about nine observation charts. The participants reported using observation charts daily, but only a minority reported having received any formal training in the use of such charts.

In our previously-reported heuristic analysis of observation charts, we found that the majority of charts included a large number of abbreviations. In this survey, participants were asked to nominate

which term they first thought of when seeing particular abbreviations. Most abbreviations were overwhelmingly assigned the same meaning. However, some abbreviations had groups of participants nominating different terms. Participants were also asked to nominate their preferred terms for 9 vital signs that commonly appear on observation charts. For some vital signs, there was a high level of agreement as to which term was easiest to understand; however, for other vital signs, there was no clearly preferred term.

Participants were also asked about their chart design preferences both in terms of (a) recording observations and (b) detecting deterioration. In both instances, participants preferred the option to "*Plot the value on a graph with graded colouring, where the colours correspond to a scoring system or graded responses for abnormality*". Participants' preference was in line with what a human factors approach would recommend (i.e., charts with a colour-coded track and trigger system).

In the final sections of the survey, participants were first asked to respond to 13 statements regarding the design of their own institution's current observation chart, and then to respond to the same 13 statements for one of nine randomly-assigned observation charts. The nine observation charts included the ADDS chart and eight charts of "good", "average", or "poor" design quality from the heuristic analysis.

Participants' mean aggregated rating across the 13 items for their institution's current observation chart was close to the scale's mid-point, 3 = *neutral.* For the assigned charts, there was a statistically significant effect of chart type on the aggregated rating. The *a priori* "poor" quality charts were each rated as having a significantly poorer design compared to each of the other charts (collectively, the *a priori* "average" and "good" quality charts). There was partial support for our hypothesis that health professionals would rate the "good" charts as having better design, compared to the "average" and "poor" charts.

In conclusion, the online survey served two main purposes. First, it collected quantitative data on health professionals' general preferences regarding aspects of the design of observation charts. This information informed the design of the ADDS chart and could also be used by other chart designers to produce more user-friendly hospital charts. Second, the online survey enabled health professionals to rate the design of the new ADDS chart as well as eight existing charts of varying quality. Overall, health professionals agreed with our human factors-based rating with regards to the "poor" quality charts. However, the health professionals did not differentiate between the "average" and "good" quality charts in their ratings.

Phase 3: The Development of the ADDS Chart

Using the information obtained from the heuristic analysis, a new chart was designed by combining what were considered to be the best design features of existing charts (18). The chart was largely based on: (a) The Prince Charles Hospital chart (Brisbane, Queensland), which in turn was based on the Compass chart developed at The Canberra Hospital, and (b) the Children's Early Warning Tool (CEWT) paedriatric chart developed at Royal Children's Hospital, Brisbane, Queensland. The new

chart was named the Adult Deterioration Detection System (ADDS) chart and incorporated the following features designed to minimize the design problems that might lead to human error in both recording and interpreting patient data (see Appendices A and B to view both versions of the ADDS chart). Note that the key function of the ADDS chart was to detect patient deterioration, rather than to act as a general observation chart.

- The ADDS chart featured both a single parameter and a multiple parameter colour-coded track and trigger system to facilitate the detection of deterioration. The single parameter system (in which a medical emergency response was required when any single patient vital sign exceeded a given range) had the advantage of simplicity of use. The multiple parameter system (in which vital signs were scored using a colour-coded key and scores were summed to give an overall indication of the patient's condition) was potentially more sensitive to deterioration and could lead to earlier detection of deterioration or fewer false alarms.

- Chart colours were chosen such that colour density correlated with the extent to which the patient's vital signs were outside the normal range (apart from being an intuitive progression, this strategy would aid colour-blind users).

- All information required for use (for example, the colour key, the medical emergency criteria, and the actions to be taken when different levels of deterioration were detected) was provided on the same page as the vital signs data. This was in order to reduce cognitive load (for example, to avoid the user having to retain vital sign data in memory while turning the page to access more information).

- Terms and abbreviations used on the chart were selected in part based on the preferences expressed among a large sample of health professionals.

- Only vital signs considered to be the most important for detecting deterioration were included on the chart. If additional information had been included, this less important information would potentially compete with the more important information for the user's attention.

- Each vital sign was presented as a separate graph. Many existing charts either displayed data numerically (making it difficult to see data trends and hence making deterioration harder to detect) or included graphs with multiple vital signs plotted on the same graph area (increasing visual clutter, and potentially making deterioration harder to detect).

- The most critical vital signs were placed towards the top of the page, as this is where users would look first. Most existing charts did not follow this practice.

- Scales were labelled on both the left and right of each graph and bold vertical lines were placed every 3 columns. These features were designed to minimize the chance of users reading from the wrong column or row.

- There was space to record modifications to vital sign thresholds. This information was placed so that it would be in view when a user first picked up the chart.

- There were two versions of the ADDS chart produced (see Appendices A and B). The first version contained a look up table to determine the ADDS score for systolic blood pressure (positioned to the right of the blood pressure graph). This table allowed the cut-offs for the scoring system to be tailored to a patients' usual systolic blood pressure. Chart users have to circle the column in the table corresponding to a patient's usual systolic blood pressure and then must match the patient's current systolic blood pressure to this column to determine the ADDS score. The second verson of the ADDS chart did not include this look up table and instead assumed that patients' usual systolic blood pressure is 120 mmHg. ADDS scores for systolic blood pressure are determined from the colour coding as per the other vital signs. The first version of the chart (with the table) provided a potentially more accurate indicator of deterioration because of the tailored systolic blood pressure cut-offs. However the second version of the chart (without the table) was potentially easier to use. Both versions of the chart were included in subsequent studies.

Phase 4: Detecting Abnormal Vital Signs on Six Observation Charts: An Experimental Comparison

Both the heuristic analysis and the online survey are opinion-based studies. That is, it is possible that the opinions expressed, as to which aspects of chart design are best, are incorrect. Hence it was critical to conduct empirical work to verify the findings.

In Phase 4, we conducted the first of two experiments designed to measure the performance of the charts directly under controlled conditions (19). This study focussed on measuring the errors made by chart users when making a judgement as to whether a set of vital sign observations were normal or abnormal. We compared performance on six charts (two versions of the ADDS chart and four existing charts). Novices (individuals who were unfamiliar with patient charts) and health professionals (doctors and nurses) were recruited as participants. Each chart design was shown to each participant four times displaying physiological data with one abnormal vital sign (e.g. a high systolic blood pressure), and four times displaying normal physiological data. Participants had to classify the physiological data on the charts as "normal" or "abnormal" (they were made to memorize the normal ranges for each vital sign). Error rates (the proportion of trials where participants made an incorrect normal/abnormal judgement) and response time (the time to read the chart and make the judgement) were measured.

Results indicated that chart design had a statistically significant effect on both error rates and response time, with the charts identified as having better design tending to yield fewer errors and shorter decision times. Specifically the two versions of the ADDS chart outperformed all the existing charts on both metrics, where the other charts yielded between 2.5 and 3.3 times the number of errors as the ADDS chart. There was no significant difference between novices and health professionals in error rates for any chart, but the health professionals were significantly faster at

making their decisions for the no track and trigger charts. There was no significant difference between doctors and nurses for either of the two performance measures for any of the charts.

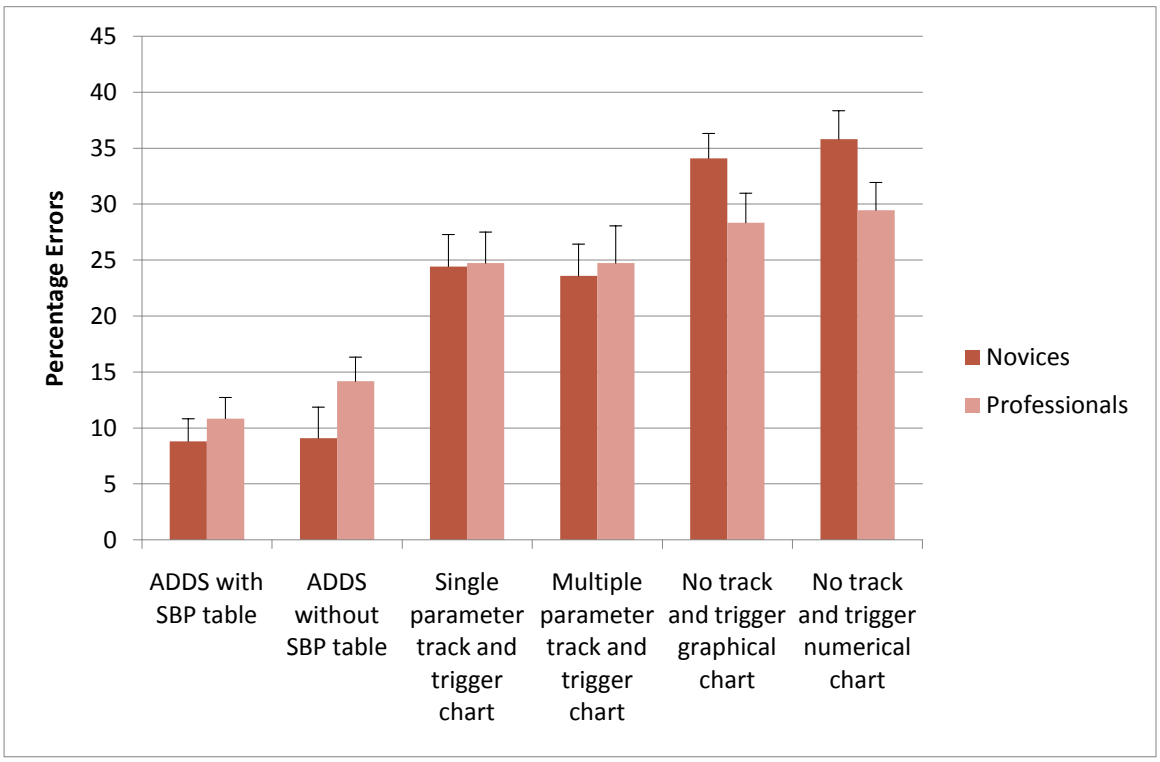


Figure 1: Percentage errors in detecting abnormal vital signs for the six charts. Error bars are standard errors of the mean. Note, SBP = systolic blood pressure.

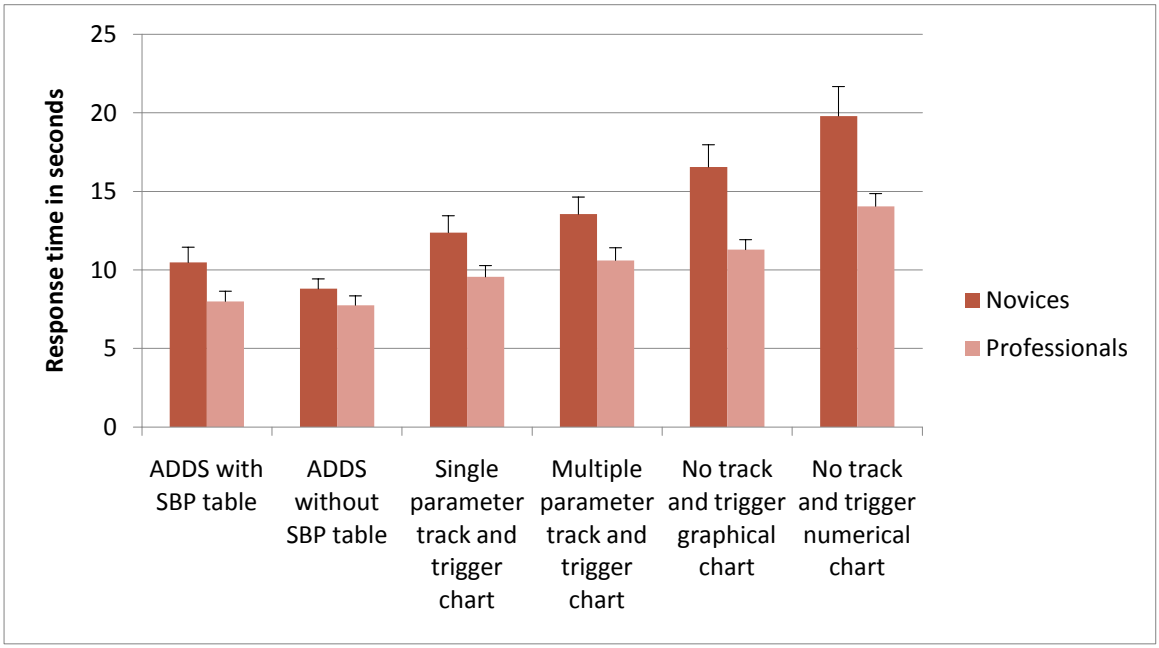


Figure 2: Response times in seconds (to reach decision about whether vital signs were normal or abnormal) for the six charts (error bars are standard errors of the mean). Note, SBP = systolic blood pressure.

These data indicated that differences in the design of observation charts can have a profound impact on chart users' decisions regarding patients' observations as well as the time it takes to make such decisions. It appeared that the ADDS chart was significantly better than other currently available charts in this regard.

Phase 5: Recording Patient Data on Six Observation Charts: An Experimental Comparison

The second experiment focussed on another aspect of chart use where error is also likely to be important: when users are recording data. In this study (20), novice and professional participants recorded real patient data into the six charts over an extended period in a simulated hospital ward, where they were given the task of monitoring six simulated patients (see Figure 3).

Figure 3: A patient bed in the simulated hospital ward, with an individual recording vital signs onto one of the six charts under review.

Each patient's vital signs were shown on a computer display by the patient's bedside, and participants were required to record the observations onto one of the six charts (each participant was randomly assigned a different chart to complete for each patient). The simulation was carried out in as realistic an environment as possible, including low lighting and background noise distraction. Results demonstrated that, contrary to the first study, the charts considered to be of poorer design yielded the fewest errors (presumably because recording data on these charts involved simply transcribing numbers from the display rather than converting those numbers into a graph). The more complex charts yielded the highest number of errors, where the two versions of the ADDS charts generated the fourth and fifth highest number of errors. However, the magnitude of the error rates was much smaller than in the first study: the worst-performing chart yielded 2.3%

errors while the best-performing chart yielded 0.2% errors. That is, it appears that the process of recording data is overall far less prone to error than the process of detecting abnormal vital signs (see Figure 4 for results).

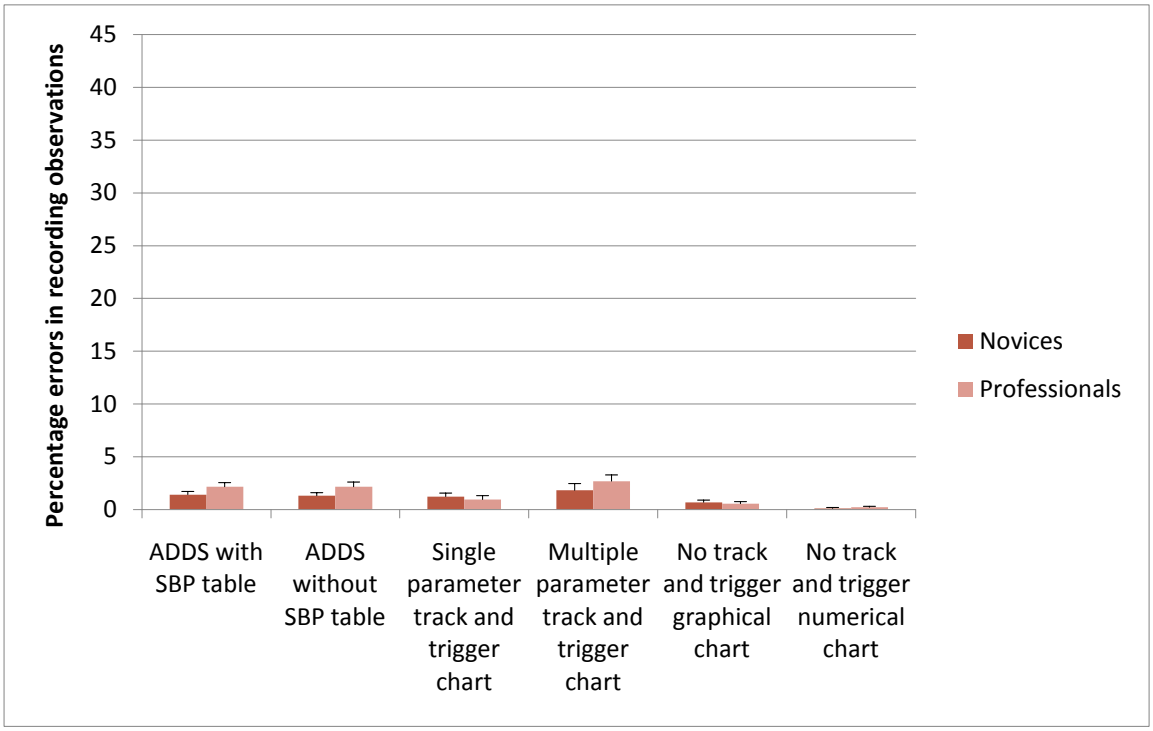


Figure 4: Percentage of recording errors made on the six charts (error bars are standard errors of the mean). Note that the vertical scale (0-45) has been selected to allow direct comparison with Figure 1: a version of this graph with a shorter scale for improved readability can be viewed in the individual report for this study, also available from the Commission). Also note, SBP = systolic blood pressure.

We also investigated the percentage of errors introduced by the scoring systems used by charts with multiple parameter track and trigger systems (these are systems which involve users having to score each vital sign according to a colour-coded key and add up these scores to generate an overall score for each patient, designed to reflect their overall physiological state). The errors associated with scoring these systems were found to be low (see Figure 5), indicating that concerns that such systems may introduce substantial errors into the process appear to be unfounded. Both versions of the ADDS chart were associated with fewer scoring errors than the existing multiple parameter track and trigger system chart.

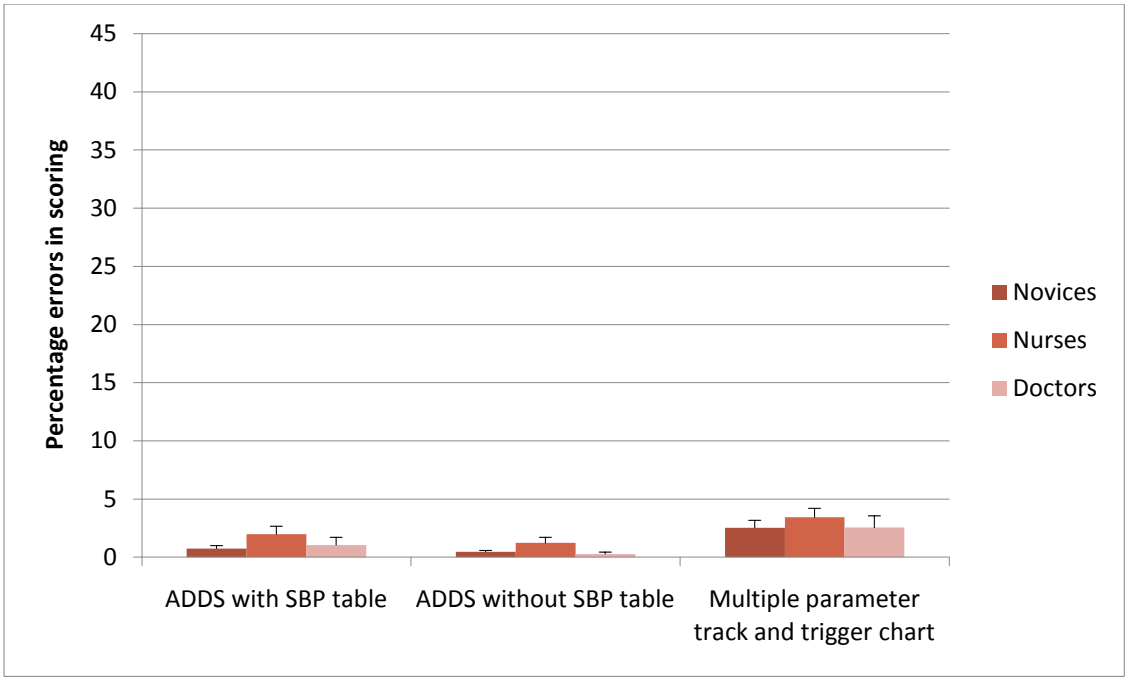


Figure 5: Percentage of errors introduced by using the scoring systems associated with multiple parameter track and trigger systems (error bars are standard errors of the mean). Note that the vertical scale (0-45) has been selected to allow direct comparison with Figure 1: a version of this graph with a shorter scale for improved readability can be viewed in the individual report for this study, also available from the Commission). Also note, SBP = systolic blood pressure.

Conclusions and Recommendations

The aim of this project was to investigate the design of adult observation charts using a human factors approach, and to design and evaluate a new chart incorporating human factors principles. To fulfil this brief, we developed a systematic approach to evaluating existing chart design, which involved applying a procedure adopted from the human-computer interface literature, known as heuristic analysis (16). Heuristic analysis involves the identification and documentation of design problems in a range of systems are systematically identified and documented by a panel of trained evaluators, using a pre-defined series of design heuristics. To our knowledge, this is the first time that heuristic analysis has been applied to the design of paper charts. A new chart (the ADDS chart) was developed by combining the features of the best existing charts, as well as avoiding key design problems in existing charts.

It should be noted that the outcomes of the heuristic analysis were based on opinion (albeit the opinion of trained experts), which in principle could be wrong. We considered it critical to empirically test whether the new chart could outperform existing charts (particularly those identified as being of poor design), in terms of reducing user error rates and response times. We carried out two experiments (19, 20) to compare the performance of six observation charts (two versions of the ADDS chart and four existing charts, determined in the heuristic analysis as having designs ranging from good to poor). The outcomes of these experiments also served as a test of our

general approach to evaluating chart design. For example, if the charts identified as poorly designed performed the best then this would raise questions about the effectiveness of our approach.

The results of the first experiment (19), in which participants were asked to judge whether real patient data was abnormal or normal (based on given normal ranges), strongly supported the hypothesis that design quality, as determined in the heuristic analysis, would affect user performance. Charts determined to be better designed outperformed charts determined to be more poorly designed, both in terms of user errors (e.g. indicating a patient's vital signs were within normal ranges when they were not) and in speed of making the judgement. Specifically the two versions of the ADDS charts outperformed the four existing charts by a considerable margin. Another key feature of the data was the substantial magnitude of error rates (see Figure 1). For example, around 1 in 3 judgements were incorrect for the most poorly performing chart, despite the experiment being carried out under good lighting, with no distracters, and with participants being aware that their performance was being monitored.

The second experiment (20) was designed to investigate errors that could occur during the recording of data onto the chart (rather than errors made in interpreting the data). In contrast to the first experiment, the second experiment found that the more poorly designed charts tended to yield fewer errors. This was likely to be because the most poorly designed charts involved a simpler recording process. However, also notable was the comparatively low error rates generated for all the charts (despite this experiment being carried out under realistically sub-optimal conditions, including low light, auditory distracters, and an extended duration). The results suggested that the design quality indicators identified in the heuristic analysis were more focussed on improving the ease of interpreting patient data possibly at the expense of the ease of recording patient data. However, the high error rates observed when detecting abnormal vital signs in the poorly designed charts compared with the low error rates observed when recording data suggest that this trade-off was an appropriate one.

In order to decide which of the charts should be recommended as best practice overall, it was necessary to aggregate the findings from both studies. We have calculated aggregate errors using the following procedure:

(a) We calculated the **proportion of correct judgements** about whether an observation was normal or abnormal, assuming that the recorded data was completely accurate (using data taken from the detecting abnormal vital signs experiment).

(b) We calculated the **proportion of the data that was correctly recorded** into each of the charts (from the results of the recording data experiment).

(c) We worked out the **proportion of the data that was both correctly judged and correctly recorded** by multiplying the outcomes of steps (a) and (b).

(d) We subtracted the outcome of step (c) from 1 to give an **overall error rate** for each chart.

(e) We converted the rate into a percentage by multiplying by 100.

The results of this procedure can be seen in Table 1. Note that it is not possible to conduct statistical tests on these data because participants were not matched between the two studies.

Table 1: Overall errors for the six charts based on aggregating the findings from both the "detecting unstable vital signs" experiment and the "recording data" experiment, without adjusting for scoring errors on the multiple parameter track and trigger charts.

	Percent errors overall
ADDS with SBP table	11.49
ADDS without SBP table	13.24
Single parameter track and trigger chart	25.39
Multiple parameter track and trigger chart	25.91
No track and trigger graphical chart	31.60
No track and trigger numerical chart	32.70

Note. SBP = systolic blood pressure.

In order to attempt to judge the effect of scoring errors introduced via multiple parameter track and trigger systems (in the two ADDS charts and the existing multiple parameter track and trigger chart), we also performed a calculation where we derived the overall accuracy rate by multiplying the proportion of the data that was both correctly judged and correctly recorded ((a) x (b)) by the proportion of correct track and trigger system scores. For charts with no multiple parameter track and trigger system, the correct scoring rate was entered as 1. The outcomes of this calculation can be viewed in Table 2.

Table 2: Overall errors for the six charts based on aggregating the findings from both the "detecting unstable vital signs" experiment and the present study, adjusting for scoring errors on the multiple parameter track and trigger charts.

	Percent errors overall
ADDS with SBP table	12.54
ADDS without SBP table	13.79
Single parameter track and trigger chart	25.39
Multiple parameter track and trigger chart	27.99
No track and trigger graphical chart	31.60
No track and trigger numerical chart	32.70

Note. SBP = systolic blood pressure.

In conclusion, it appears that, overall, the behavioural data still favour the two versions of the ADDS chart, which generated between 2-3 times fewer errors than all four existing charts. It also indicates that despite the simpler charts (without track and trigger systems and using largely numerical data) generating fewer errors during data recording, they nonetheless remain the most problematic overall in terms of users making clinical decisions about the health of their patients.

In addition, the results validate our overall approach to evaluating and designing such charts, in that the overall error rates of each chart map onto the rank order of chart by perceived design quality. We would therefore recommend that our overall process should also be used when developing other charts, especially if the decisions resulting from the data recorded on such charts are considered to be important.

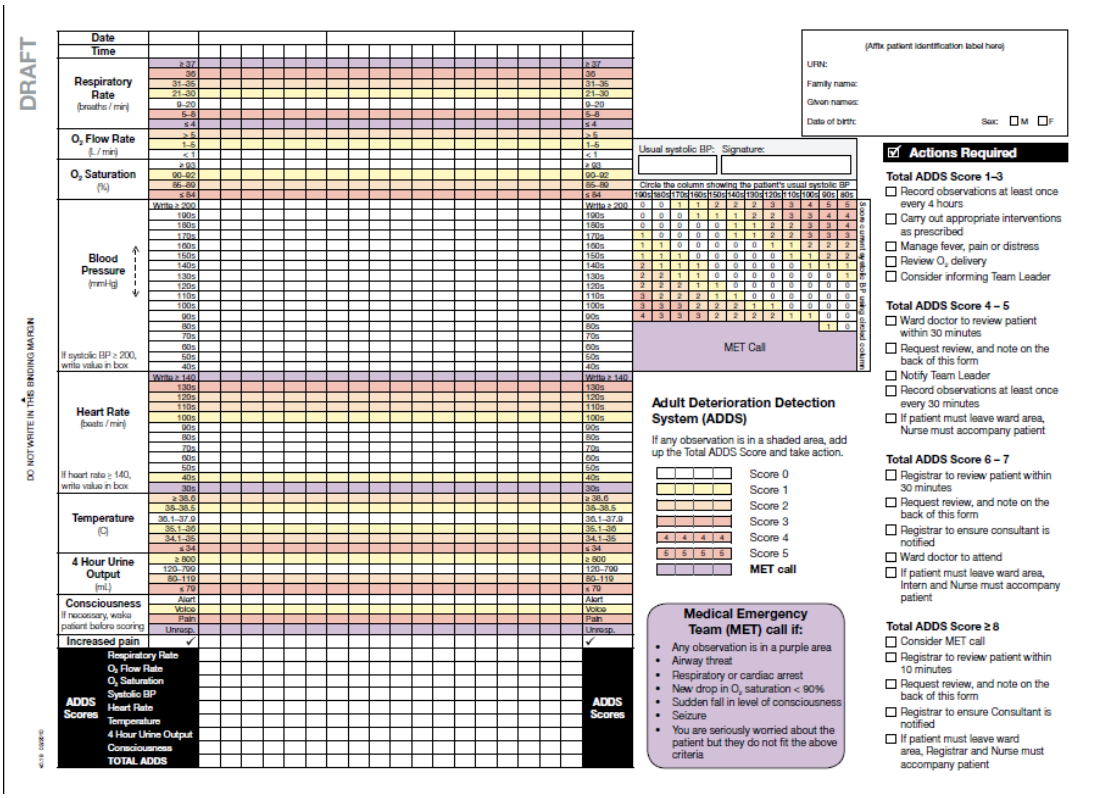
References

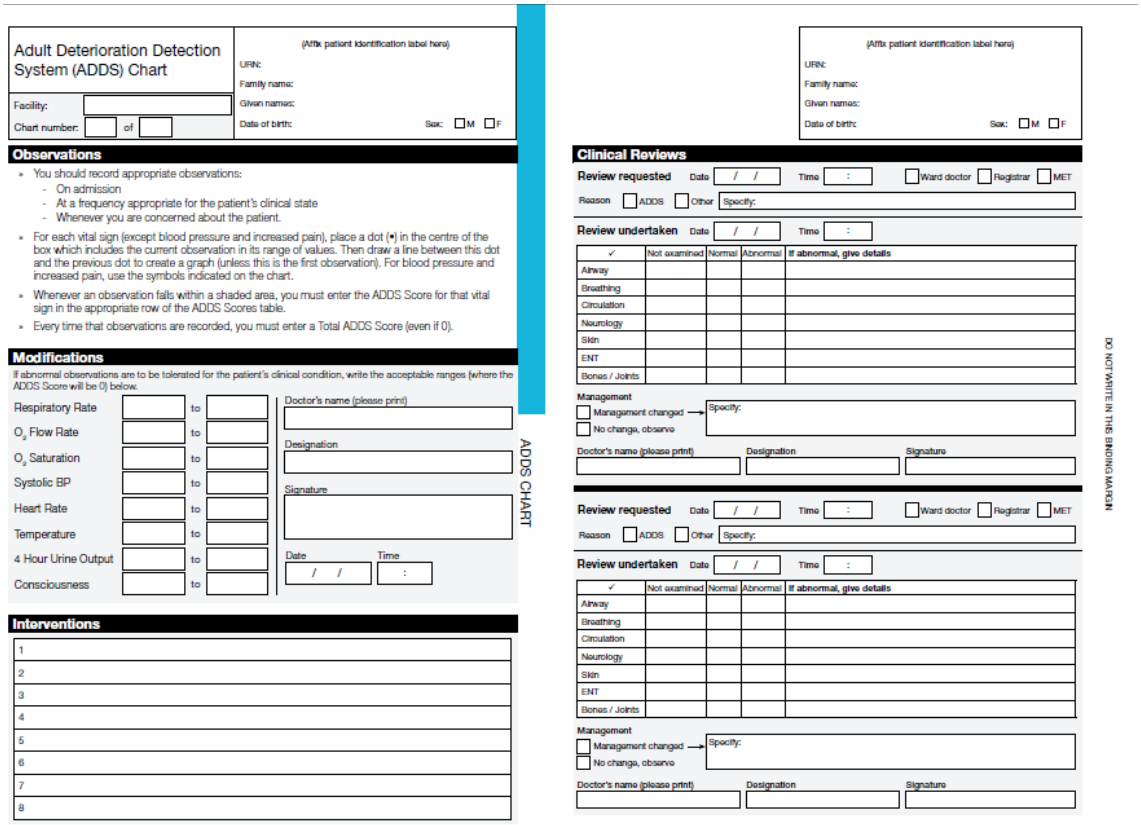
1. Australian Commission on Safety and Quality in Health Care. Recognising and responding to clinical deterioration: Background paper: Australian Commission on Safety and Quality in Health Care, Department of Health and Ageing, Commonwealth of Australia, 2009 Jun.
2. Patient Safety Centre. Recognition and management of the deteriorating patient: Core strategy options paper. Brisbane, Queensland, Australia: Patient Safety Centre, Queensland Health, 2010.
3. Franklin C, Mathew J. Developing strategies to prevent inhospital cardiac arrest: Analyzing responses of physicians and nurses in the hours before the event. Critical care medicine 1994; 22(2):189-91.
4. Buist M, Bernard S, Nguyen TV, Moore G, Anderson J. Association between clinically abnormal observations and subsequent in-hospital mortality: A prospective study. Resuscitation. 2004; 62(2):137-41.
5. Hillman KM, Bristow PJ, Chey T, Daffurn K, Jacques T, Norman SL, et al. Antecedents to hospital deaths. Internal Medicine Journal. 2001; 31(6):343-8.
6. Goldhill DR, White SA, Sumner A. Physiological values and procedures in the 24 h before ICU admission from the ward. Anaesthesia. 1999; 54:529-34.
7. McQuillan P, Pilkington S, Allan A, Taylor B, Short A, Morgan G, et al. Confidential inquiry into quality of care before admission to intensive care. British Medical Journal. 1998; 316:1853-8.
8. Kause J, Smith G, Prytherch D, Parr M, Flabouris A, Hillman K. A comparison of antecedents to cardiac arrests, deaths and emergency intensive care admissions in Australia and New Zealand, and the United Kingdom-the ACADEMIA study. Resuscitation. 2004; 62:275-82.
9. Endacott R, Kidd T, Chaboyer W, Edington J. Recognition and communication of patient deterioration in a regional hospital: A multi-methods study. Australian Critical Care. 2007; 20(3):100-5.
10. Bristow PJ, Hillman KM, Chey T, Daffurn K, Jacques TC, Norman SL, et al. Rates of in-hospital deaths and intensive care admissions: the effect of a medical emergency team. Medical Journal of Australia. 2000; 173:236-40.
11. Bellomo R, Goldsmith D, Uchino S, Buckmaster J, Hart GK, Opdam H, et al. A prospective before-and-after trial of a medical emergency team. Medical Journal of Australia. 2003; 179(6):283-7.
12. Bellomo R, Goldsmith D, Uchino S, Buckmaster J, Hart G, Opdam H, et al. Prospective controlled trial of medical emergency team on postoperative morbidity and mortality rates. Critical Care Medicine. 2004; 32(4):916-21.
13. Van Leuvan CH, Mitchell I. Missed opportunities? An observational study of vital sign measurements. Critical Care & Resuscitation. 2008; 10(2):111-5.
14. Chatterjee MT, Moon JC, Murphy R, McCrea D. The "OBS" chart: An evidence based approach to re-design of the patient observation chart in a district general hospital setting. Postgraduate Medical Journal. 2005; 81:663-6.
15. Mitchell IA, McKay H, Van Leuvan C, Berry R, McCutcheon C, Avard B, et al. A prospective controlled trial of the effect of a multi-faceted intervention on early recognition and intervention in deteriorating hospital patients. Resuscitation. 2010; 81(6):658-66.

16. Preece MHW, Horswill MS, Hill A, Karamatic R, Hewett D, Watson MO. Heuristic Analysis of 25 Australian and New Zealand Adult General Observation Charts. Sydney, New South Wales, Australia: Australian Commission on Safety and Quality in Health Care, 2009.
17. Preece MHW, Horswill MS, Hill A, Karamatic R, Watson MO. An Online Survey of Health Professionals' Opinions Regarding Observation Charts. Sydney, New South Wales, Australia: Australian Commission on Safety and Quality in Health Care, 2010.
18. Preece MHW, Horswill MS, Hill A, Watson MO. The Development of the Adult Deterioration Detection System (ADDS) Chart. Sydney, New South Wales, Australia: Australian Commission on Safety and Quality in Health Care, 2010.
19. Horswill MS, Preece MHW, Hill A, Watson MO. Detecting abnormal vital signs on six observation charts: An experimental comparison. Sydney, New South Wales, Australia: Australian Commission on Safety and Quality in Health Care, 2010.
20. Horswill MS, Preece MHW, Hill A, Christofidis, MJ, Watson MO. Recording patient data on six observation charts: An experimental comparison. Sydney, New South Wales, Australia: Australian Commission on Safety and Quality in Health Care, 2010.

Appendix A: The ADDS chart with SBP table

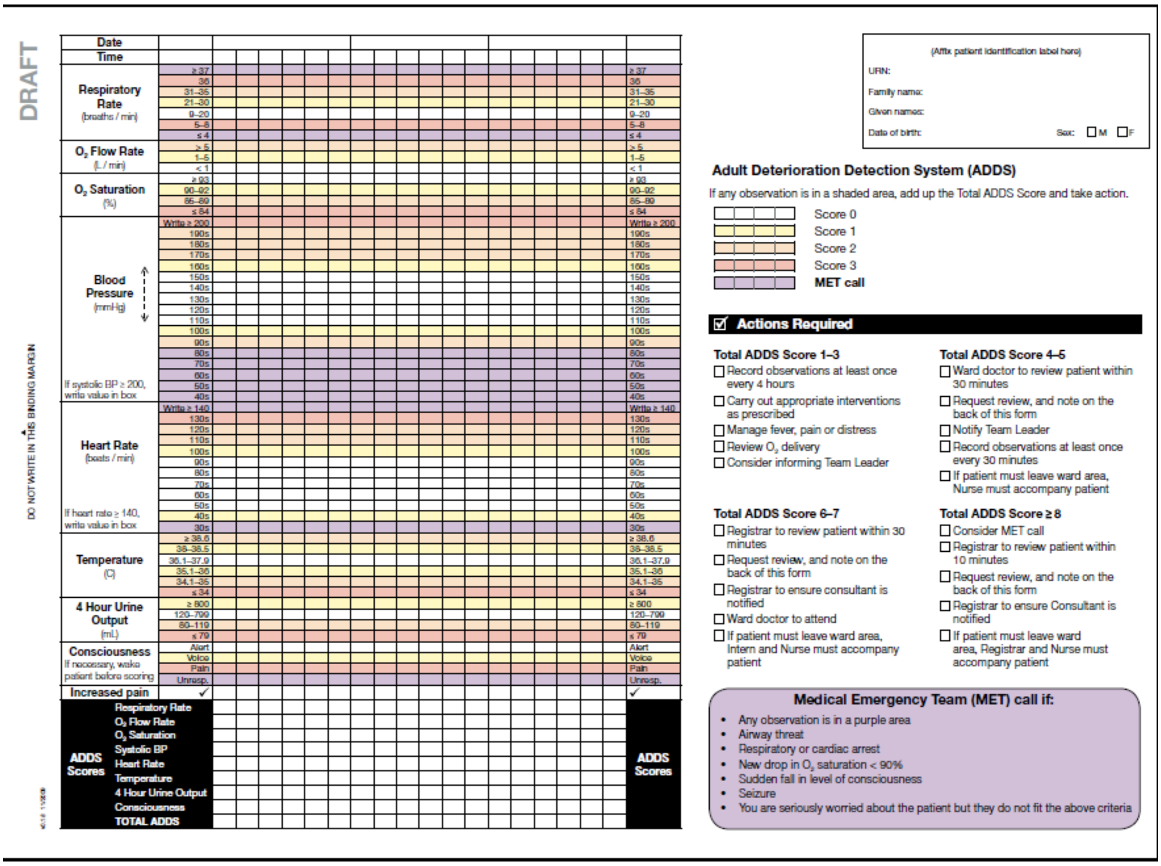
Note: Chart is printed at A3 size double-sided. The chart is updated from the version used in the "detecting abnormal vital signs" study, with horizontal bold lines added to the blood pressure graph to minimize row shift errors.





Appendix B: The ADDS chart without SBP table

Note: Chart is printed at A3 size double-sided


DRAFT

Date	
Time	
Respiratory Rate (breaths / min)	≥ 37; 36; 31–35; 21–30; 9–20; 5–8; ≤ 4
O_2 Flow Rate (L / min)	> 5; 1–5; < 1
O_2 Saturation (%)	≥ 93; 90–92; 85–89; ≤ 84
Blood Pressure (mmHg) — If systolic BP ≥ 200, write value in box	Write ≥ 200; 190s; 180s; 170s; 160s; 150s; 140s; 130s; 120s; 110s; 100s; 90s; 80s; 70s; 60s; 50s; 40s
Heart Rate (beats / min) — If heart rate ≥ 140, write value in box	Write ≥ 140; 130s; 120s; 110s; 100s; 90s; 80s; 70s; 60s; 50s; 40s; 30s
Temperature (C)	≥ 38.6; 38–38.5; 36.1–37.9; 35.1–36; 34.1–35; ≤ 34
4 Hour Urine Output (mL)	≥ 800; 120–799; 80–119; ≤ 79
Consciousness — If necessary, wake patient before scoring	Alert; Voice; Pain; Unresp.
Increased pain	✓
ADDS Scores	Respiratory Rate; O_2 Flow Rate; O_2 Saturation; Systolic BP; Heart Rate; Temperature; 4 Hour Urine Output; Consciousness; TOTAL ADDS

DO NOT WRITE IN THIS BINDING MARGIN

(Affix patient identification label here)
URN:
Family name:
Given names:
Date of birth: Sex: ☐M ☐F

Adult Deterioration Detection System (ADDS)

If any observation is in a shaded area, add up the Total ADDS Score and take action.

Score 0
Score 1
Score 2
Score 3
MET call

☑ Actions Required

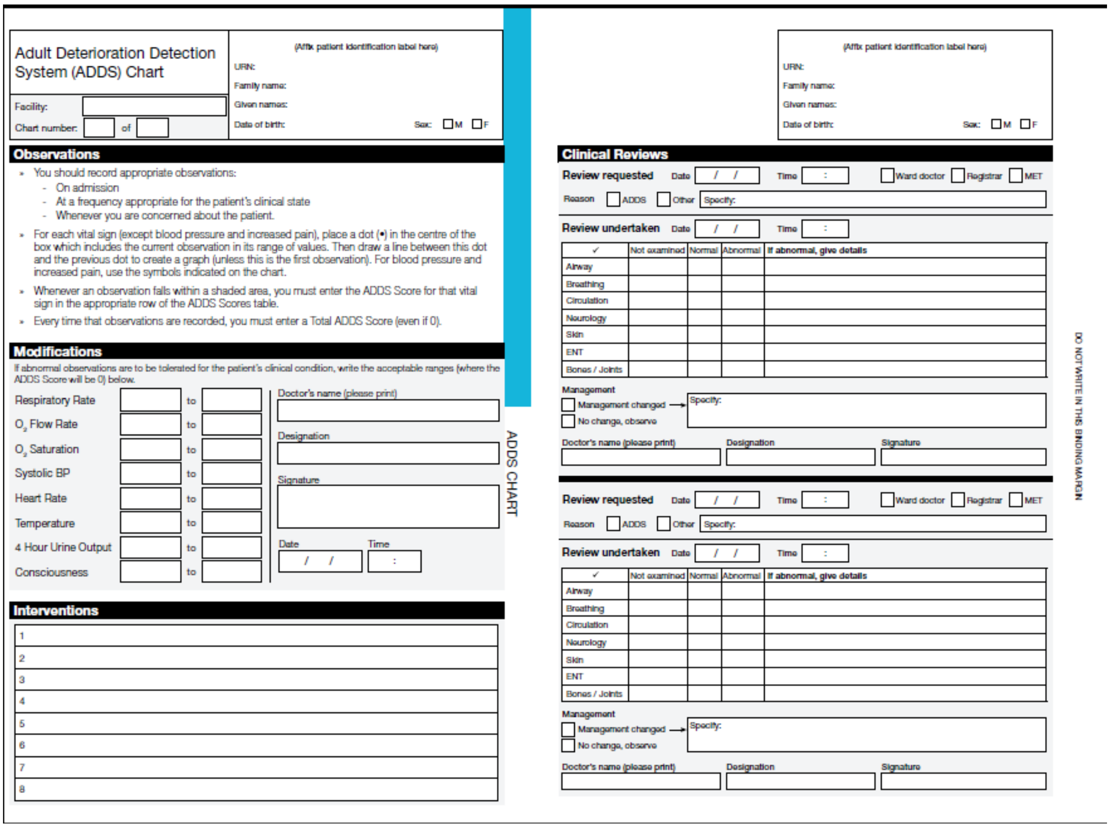
Total ADDS Score 1–3
- ☐ Record observations at least once every 4 hours
- ☐ Carry out appropriate interventions as prescribed
- ☐ Manage fever, pain or distress
- ☐ Review O_2 delivery
- ☐ Consider informing Team Leader

Total ADDS Score 4–5
- ☐ Ward doctor to review patient within 30 minutes
- ☐ Request review, and note on the back of this form
- ☐ Notify Team Leader
- ☐ Record observations at least once every 30 minutes
- ☐ If patient must leave ward area, Nurse must accompany patient

Total ADDS Score 6–7
- ☐ Registrar to review patient within 30 minutes
- ☐ Request review, and note on the back of this form
- ☐ Registrar to ensure consultant is notified
- ☐ Ward doctor to attend
- ☐ If patient must leave ward area, Intern and Nurse must accompany patient

Total ADDS Score ≥ 8
- ☐ Consider MET call
- ☐ Registrar to review patient within 10 minutes
- ☐ Request review, and note on the back of this form
- ☐ Registrar to ensure Consultant is notified
- ☐ If patient must leave ward area, Registrar and Nurse must accompany patient

Medical Emergency Team (MET) call if:
- Any observation is in a purple area
- Airway threat
- Respiratory or cardiac arrest
- New drop in O_2 saturation < 90%
- Sudden fall in level of consciousness
- Seizure
- You are seriously worried about the patient but they do not fit the above criteria


Adult Deterioration Detection System (ADDS) Chart

Facility:
Chart number: of

(Affix patient identification label here)
URN:
Family name:
Given names:
Date of birth: Sex: ☐M ☐F

Observations
- You should record appropriate observations:
  - On admission
  - At a frequency appropriate for the patient's clinical state
  - Whenever you are concerned about the patient.
- For each vital sign (except blood pressure and increased pain), place a dot (•) in the centre of the box which includes the current observation in its range of values. Then draw a line between this dot and the previous dot to create a graph (unless this is the first observation). For blood pressure and increased pain, use the symbols indicated on the chart.
- Whenever an observation falls within a shaded area, you must enter the ADDS Score for that vital sign in the appropriate row of the ADDS Scores table.
- Every time that observations are recorded, you must enter a Total ADDS Score (even if 0).

Modifications

If abnormal observations are to be tolerated for the patient's clinical condition, write the acceptable ranges (where the ADDS Score will be 0) below.

Respiratory Rate		to	
O_2 Flow Rate		to	
O_2 Saturation		to	
Systolic BP		to	
Heart Rate		to	
Temperature		to	
4 Hour Urine Output		to	
Consciousness		to	

Doctor's name (please print)
Designation
Signature
Date / / Time :

ADDS CHART

Interventions

1
2
3
4
5
6
7
8

(Affix patient identification label here)
URN:
Family name:
Given names:
Date of birth: Sex: ☐M ☐F

Clinical Reviews

Review requested Date / / Time : ☐Ward doctor ☐Registrar ☐MET
Reason ☐ADDS ☐Other Specify:

Review undertaken Date / / Time :

✓	Not examined	Normal	Abnormal	If abnormal, give details
Airway				
Breathing				
Circulation				
Neurology				
Skin				
ENT				
Bones / Joints				

Management
☐ Management changed → Specify:
☐ No change, observe
Doctor's name (please print) Designation Signature

Review requested Date / / Time : ☐Ward doctor ☐Registrar ☐MET
Reason ☐ADDS ☐Other Specify:

Review undertaken Date / / Time :

✓	Not examined	Normal	Abnormal	If abnormal, give details
Airway				
Breathing				
Circulation				
Neurology				
Skin				
ENT				
Bones / Joints				

Management
☐ Management changed → Specify:
☐ No change, observe
Doctor's name (please print) Designation Signature

DO NOT WRITE IN THIS BINDING MARGIN