Original article

Track and trigger in an emergency department: an observational evaluation study

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ABSTRACT

Objective To evaluate the utilisation of paper-based track and trigger (T&T) charts in a UK emergency department (ED).

Methods A single-centre prospective observational cohort study was conducted in the ED of a medium-sized teaching hospital. Charted vital-sign data were collected from adults attending the resuscitation room, majors or observation ward. These data were examined in parallel with clinical notes to identify 'escalation' events. For each set of vital signs, the authors calculated the T&T score retrospectively.

Results Data from 472 patient episodes (2965 sets of vital signs) were examined. 85.8% of patients had at least one full set of observations (CEM standard) and 60.6% had at least one T&T score documented. However, only 34.5% of observation sets had a corresponding T&T score. 20.6% of T&T score totals (1024) were incorrect, potentially preventing a 'trigger' from being recognised. 204 patient episodes had at least one recorded escalation. Physiological escalations were associated with vital-sign scores that met the triggering thresholds (98/104), while patients who had non-physiological escalations or no escalations were more likely to have scores below the triggering thresholds (88/100). Only 26.9% of physiological escalations were associated with a documented T&T score above the triggering threshold. Retrospective completion of the charts increased that figure to 94.2%.

Conclusion T&T in the ED is challenged by poor completion rates and numerical errors made during score calculation. However the potential for recognition of a deteriorating patient should not be ignored. The future work of the authors intends to evaluate an electronic system for automatically calculating T&T scores within the ED environment.

INTRODUCTION

Adverse events in healthcare have been documented, classified and debated for many years. Failing to recognise that a patient's condition has deteriorated is a particular issue[1][2] since a successful intervention can only happen if deterioration is detected early, recognised as important, communicated to appropriate team members and care escalated rapidly.

One method of enabling patient deterioration to be identified and acted upon is the track and trigger (T&T) system.[3] Scores are assigned to observations of patient physiology routinely taken by clinical staff ('tracking'). High scores 'trigger' a call for further clinical action.

In response to national guidance,[4] the Oxford Radcliffe Hospitals NHS Trust reviewed the available scoring systems for identifying patient deterioration, and formally adopted a hospital-wide T&T system. This was introduced into the emergency department (ED) for all adults requiring more than a single set of observations, with two aims: (1) to provide a standardised system of observation and (2) to provide continuity of patient care from the ED through to other wards. The T&T system is implemented using a paper-based form (online appendix A) that comprises a traditional-style observation chart, a table of scores for each physiological variable and a flow diagram explaining what actions should be taken in the event of a trigger. A high score triggers an immediate request for a doctor review of the patient.

T&T charts on the wards typically mandate observations at hourly to daily intervals. In contrast, ED patients with high levels of acuity and short lengths of stay in the department require more frequent observation. In the absence of any evidence-based guidance about frequency of observations in emergency care, a consensus was reached between local experts. Hourly observations are taken when there are no alterations in a patient's vital signs, as determined by the scoring system. The observation frequency should be increased for a patient with abnormal vital signs, with the option of continuous monitoring for the sickest patients.

OBJECTIVES

To evaluate the utilisation of paper-based T&T charts in a UK ED environment.

METHODS

A single-centre prospective observational cohort study was conducted in the ED of a medium-sized teaching hospital from January 2009 until January 2010. The study was approved by the National Research Ethics Service.

All adults (over 18 years) entering one of three clinical areas of the ED (resuscitation room, 'majors', observation ward (see online appendix B)) whose seven-digit hospital number ended in '0', '5' or '7' were eligible for inclusion. Recruitment was restricted to times when there was a member of the research team on duty, typically during daytime hours. Participants were excluded if they were unable to understand English or did not consent. Those unable to consent due to their acute clinical condition were followed up at an appropriate time or had assent provided by next of kin or a nominated consultee.

Standard practice in these clinical areas is for patients to be connected to a bedside monitor with vital-sign data recorded at intervals onto paper charts by clinical staff. T&T is recorded below the vital signs, and the facing page shows the flow diagram of actions to be taken for each T&T score (chart at online appendix A). Vital sign and T&T data including heart rate (HR), systolic and diastolic blood pressure (BP), respiratory rate (RR), peripheral oxygen saturation (SpO_2), temperature and Glasgow Coma Scale (GCS) score were collected from each participant's manually recorded observation chart. Clinical notes were collected after each patient left the ED, so that vital-sign data could be linked to each patient's clinical context.

Observations from the paper T&T charts were transcribed into an electronic database. To minimise transcription errors, the observations were double-entered by two independent teams. The two sets of data entries were compared by an independent observer using computerised assistance and any discrepancies rectified by reference to the original data. In addition, patient demographics were also entered.

An escalation was defined as any prompted increase in the level of care a patient receives. The following types of escalation were identified: move to resuscitation, review prompted, referral to intensive care unit, admission to intensive care unit, cardiac arrest, trauma team, stroke team, death and other. Each escalation was determined from the patient notes. Two clinicians (RW, RP) independently reviewed every set of clinical notes to identify the time at which an escalation had occurred, and whether it had occurred on arrival. The two assessments were reviewed and any disagreements were reconciled by a third clinician (SJW).

Escalations were further classified as either 'physiological' (with abnormal cardiorespiratory or neurological observations) or 'non-physiological' (without abnormal observations). The first escalation for each patient was analysed in greater detail because subsequent escalations may be correlated with the initial escalation.

Outcome measures were:
► completion rates of paper documentation
► number of escalation events
► number of patients who had physiological escalations either on arrival or during their ED stay
► comparison of the T&T charts with the escalations in care that occurred.

RESULTS

Four hundred and seventy-two patient episodes fulfilled the study inclusion criteria (figure 1), providing a dataset of 2965 vital-sign observations. Thirteen patients attended the ED more than once and each episode (total of 33) was included separately. The remaining 439 patients attended once. A minimum of three recorded sets of vital-sign observations was deemed necessary a priori to reduce the influence of spurious or 'one-off' observations.

Five hundred and fifty-seven patients were recruited to the study, and 472 patients fulfilled the study inclusion criteria (figure 1). The ratio of male to female patients was 51:49, and the mean age of the patients was 61 years (range 18–99, SD 21.8). Two hundred and eighty (59.3%) of the patients were later admitted to hospital (Demographics for the 472 Study Patients available online). The 58 patients excluded from analysis for having fewer than three sets of vital-sign observations were similar to the study group, but were less likely to be admitted to hospital (46.7% admitted).
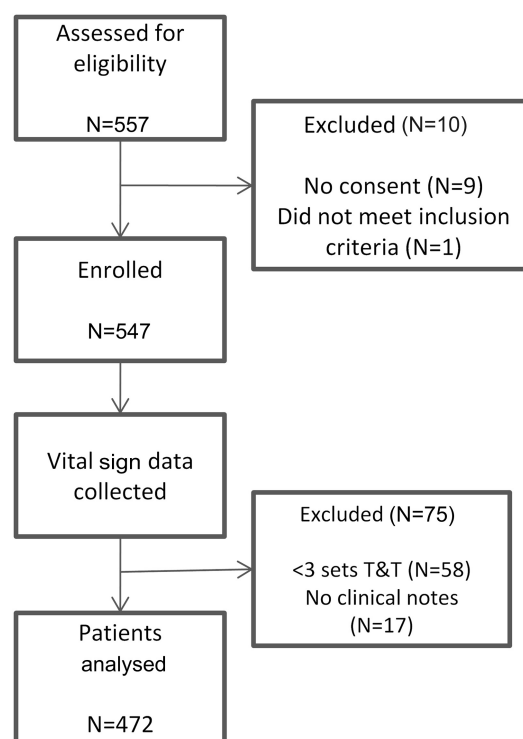
Figure 1 Consort diagram. T&T, track and trigger.

Completion of observations

In all, 85.8% of patients had at least one set of observations documented to the College of Emergency Medicine (CEM) standard of six parameters[5] at some time during their stay. Figure 2 shows the completion rate for each set of observations. Overall, 25.6% (760/2965) observations were completed to the CEM standard, and 87.6% (2598/2965) contained HR, RR, BP and SpO_2. Observation completion was much higher for the first observation, where 74.6% patients had observations completed to the CEM standard and 94.3% patients had HR, RR, BP and SpO_2 recorded. For subsequent observations, only 16.4% (408/2493) met the CEM standard, largely due to absence of temperature recordings (figure 2).

Completion of T&T scores

Overall, 60.6% of patients had at least one T&T score documented in the ED, whereas only 34.5% of observations contained a T&T score, of which 20.6% (211) were incorrect. In all, 79.1% of the incorrect T&T totals were underscored, potentially preventing a trigger event from being recognised. Overall, 93.4% of the errors can be solely attributed to the incorrect assignment of the score to an individual vital sign. Incorrect addition of individual T&T scores occurred in 2.8% of errors. The remaining errors were due to a combination of incorrect assignment and incorrect addition. Incorrect addition also occurred in 0.5% of GCS totals (figure 3). These errors were compounded by 'follow-through' of a new observer simply copying the previous result without recalculating the total.

Escalations

Two hundred and four patients had at least one escalation, of which 163 occurred on arrival to the ED. These 163 early escalations were associated with patients who were classified in the red and orange triage categories, as shown in figure 4. Thirty-seven of these patients who had an escalation on arrival also had a later escalation in the ED. Of the 41 patients who had

Figure 2 Completion of observations and track and trigger (T&T) by observation number. The thick bars show the number of nth observations, and the number of completed T&T scores. The thinner bars show the number of completed observations for each combination of vital signs as indicated in the legend. BP, blood pressure; GCS, Glasgow Coma Scale; HR, heart rate; RR, respiratory rate; SpO₂, peripheral oxygen saturation.
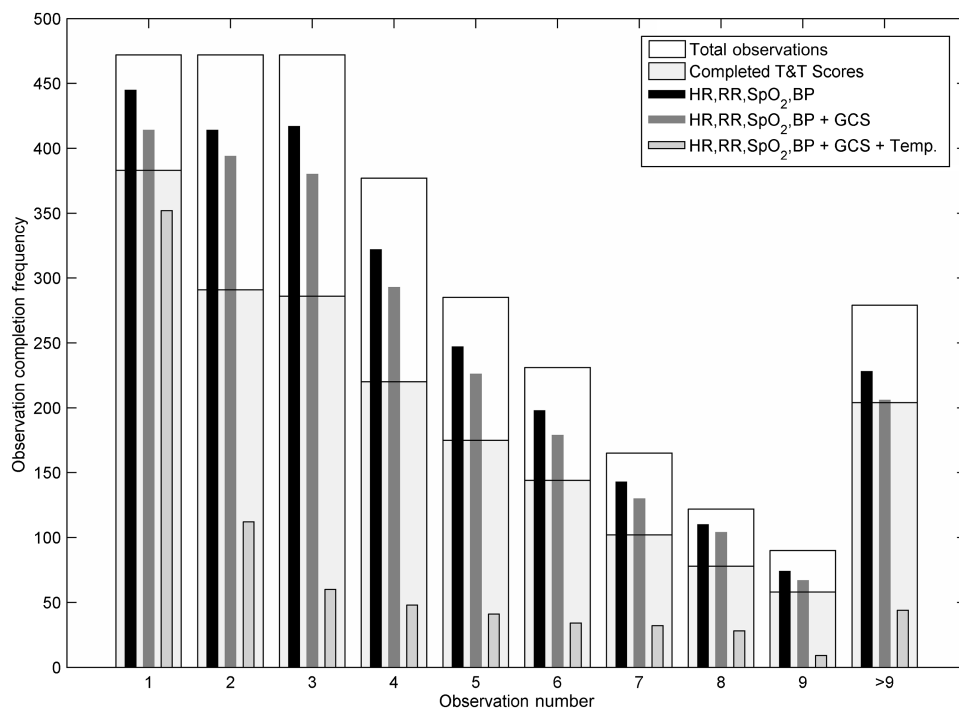
escalations only after arrival, nine proceeded to have secondary escalation events.

Tables 1 and 2 demonstrate the relationship between T&T scores and the first escalation event per patient. Table 1 indicates all instances where patients exceeded the T&T alerting threshold on the paper charts and whether they had an escalation of care. Table 2 shows similar information, using all available observations to determine T&T scores retrospectively. All escalations recorded in the notes and T&T charts were manually checked to ensure that they related to the same event in time.

Table 1 shows that 28 patients had a physiological escalation with an overall T&T score exceeding the alerting threshold. The only patient who had a non-physiological escalation and also exceeded the T&T alerting threshold was escalated on arrival for chest pain, but also had incidental hypertension.

Twenty-two patients exceeded T&T alerting thresholds but had no documented escalation. One of these exceeded the overall T&T threshold because the individual scores were added incorrectly, and this patient was correctly not escalated. The other 21 patients exceeded the alerting thresholds for a variety of reasons (12 hypertension, two hypotension, three tachycardia, one bradypnoea and three for a combination of abnormal vital signs). The clinical notes for these patients indicate that the absence of a documented escalation was appropriate.

Thirty-two patients had physiological escalations without an associated T&T score trigger. Of these, 29 did not have T&T scores completed at the time of the escalation, and three had scores incorrectly allocated.
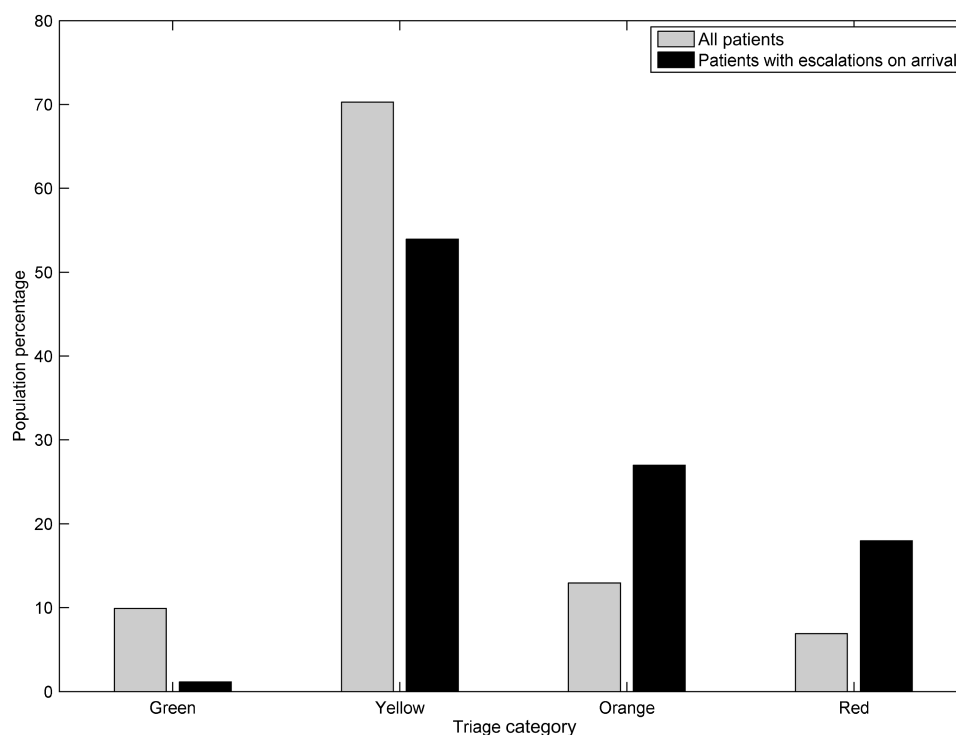
Forty-four patients had physiological escalations but no T&T scores.

Figure 3 Partial view of observation chart demonstrating addition error in Glasgow Coma Scale total and follow-through of error.

$$3 + 4 + 6 = 12$$

Figure 4 The percentage of patients in each triage category for all patients and those with escalations on arrival. Patients escalated on arrival tended to be triaged in the orange and red categories.

Overall, 73.1% of physiological escalations occurred without a trigger from the T&T chart.

Table 2 is based on retrospective completion of the T&T charts. Eighty patients had an overall T&T score which should have generated an alert but had no documented escalation. Of these, 38 were due to clinically non-significant isolated hypertension.

The remaining 42 alerts were due to: tachycardia (nine), low oxygen saturation (11), tachypnoea (five), bradypnoea (two), hypotension (four), fever (one) and a combination of vital signs (10). A review of the notes for these patients indicates that 38 were unlikely to have had any change in their clinical management. The remaining four patients could have been assessed and treated more promptly; however, the level of documentation made it difficult to draw any further conclusions.

Six patients had physiological escalations without a corresponding trigger. Four would have exceeded the T&T alerting threshold if observations had been recorded on the T&T chart instead of in the notes. Another patient may have had observations that exceeded the T&T alerting thresholds at the time of the escalation; however, the observation chart was difficult to interpret. The remaining patient was not observed at the time of their escalation, and instead nursing staff were called back to the bedside by a relative. The notes state that appropriate clinical action was taken thereafter.

DISCUSSION

In this study, we showed that 74.6% of patients had a full set of observations on arrival at the ED. This compares favourably with the work by Armstrong et al[6] who found that 58% of their ED patients had HR, RR, BP, SpO$_2$ and temperature recorded within 15 min of arrival. However, only 25.6% of the total observations were completed to the CEM standard.[5] If temperature and GCS were normal, they were typically not observed as frequently as the other vital signs. Temperature may be recorded least well because thermometers are not available in each bed space, whereas all other parameters can be recorded at the bedside.

This study is limited by its reliance on contemporaneous documentation. It is likely (due to the busy and immediate nature of some reviews in an ED environment) that some observations, escalations and patient reviews were never documented, and could not be considered in our analysis. The failure to document observations and events does not reflect well on the care standards being delivered: 'if it wasn't documented, it didn't happen'.

The number of patients included in our study is a small subset of the ED population. We believe that the studied patients are representative of the 23 000 adult patients who attend the majors and resuscitation areas of our ED each year. When research staff were on duty, all eligible patients were

Table 1 Completion of paper T&T charts ('Real T&T')

	Physiological escalation	Non-physiological escalation	Never escalated	Total
T&T score exceeding alerting threshold*	28	1	22	51
T&T score not exceeding alerting threshold*	32	62	141	235
T&T scores not calculated†	44	37	105	186
Total	104	100	268	472

*At the time of escalation, when an escalation occurred.
†At any time during ED stay.
ED, emergency department; T&T, track and trigger.

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Table 2 Retrospective T&T completion ('Potential T&T')

	Physiological escalation	Non-physiological escalation	Not escalated	Total
T&T score exceeding alerting threshold*	98	12	80	190
T&T score not exceeding alerting threshold*	6	88	188	282
Total	104	100	268	472

*At the time of escalation, when an escalation occurred.
T&T, track and trigger.

recruited. Those excluded were of similar demography, but less likely to have been admitted. This may reflect the fact that they were not ill enough for multiple sets of observations to have been deemed necessary by clinical staff. Staff were unaware that at least three sets of observations were required for inclusion in analysis, and therefore it is unlikely to have biased our conclusions.

T&T's ability to improve patient outcomes by detecting sick or deteriorating patients is currently unclear[3][7] but its effectiveness largely depends on whether observations are completed and scores are calculated. Taking and charting observations does not require high-level training or equipment, and should, in theory, be simple to complete for every patient. Interpreting the observations requires more knowledge and training, and T&T aims to assist in this process. One anomaly with our ED documentation is the lack of space for a T&T score adjacent to the triage observations, and so a T&T score is only recorded for triage observations if it is also charted on the T&T chart. In the instances that the overall T&T scores were calculated, 20.6% were erroneous. This figure is similar to previous work where 27.4% of T&T scores were recorded incorrectly.[8] Our study showed that these mistakes could be attributed to incorrect assignment of T&T scores for individual vital signs and errors in mental arithmetic, which matches the findings of Edwards et al.[9]

Incorrect score assignment was common, and may be due to errors interpreting the scoring chart, and confusion caused by the use of different T&T systems in other locations. Errors in mental arithmetic were uncommon, but may have significant consequences. They are most likely due to time pressures or staff tiredness, particularly during night shifts. In all, 6/8 of the initial incorrect GCS totals occurred overnight which are compounded by the follow-through errors described previously.

The retrospectively calculated T&T scores (table 2) show the potential effect of fully completed T&T charts for each patient. As expected, physiological escalations are associated with vital-sign scores that met the alerting thresholds (98/104), while patients who had non-physiological escalations or no escalation events were much more likely to have scores below the alerting thresholds (88/100). Therefore, an optimal T&T system would have identified most of the clinically important initial physiological escalations where further intervention was taken, and a number of other escalations where it would have been reasonable for a doctor to assess the patient.

The retrospectively calculated T&T scores also identified 80 patients who met the triggering criteria, but had no documented escalation during their stay in the ED. Two interesting examples are described here. One patient had an HR of 150 bpm during only one set of observations. This should have prompted a trigger, but the HR settled within 15 min with no treatment. The tachycardia may have been procedure related, but it is not possible to be certain from the notes. Another patient met the T&T triggering criteria for hypotension during most observations, but had no identifiable trigger event. The care of this patient, as assessed retrospectively from the clinical notes,

appeared to be adequate, but a prompt response to the T&T score may have led to earlier interventions such as catheterisation to optimise fluid balance. Reviewing the clinical notes of all 80 patients does not identify any clinical 'mismanagement', but does highlight the difficulty with retrospective analysis from the sometimes sparse documentation of clinical care and events.

Overall, 38/80 patients met the trigger criteria solely as a result of hypertension, which were all deemed to be clinically irrelevant after retrospective analysis. In light of this, further investigation is required to determine whether the trigger criteria for BP are optimal. Research has started to address this issue by adjusting the scores for individual vital-sign parameters based on clinical data rather than empirical estimates.[10][11]

The low observation completion rate identified in this study may be partly because T&T as used in the ED does not mandate completion of all fields for a trigger to occur. Only 28/104 (26.9%) escalations were associated with a documented T&T score above the triggering threshold. Retrospective completion of the charts increases this figure to 98/104 (94.2%). Triggers based on partial observations are not ideal, but they reflect the reality of working in a busy clinical environment, where the staff are skilled at identifying sick patients. Patients in high acuity areas require more clinical care, reducing the time available for paperwork. Senior clinical staff are likely to have an increased input into patient care in resuscitation, which may reduce the rate of T&T chart completion by junior staff. T&T charts may be used less often throughout the ED, because the senior clinical staff are always nearby.

All departments need to have a means of identifying sick or deteriorating patients in a consistent fashion. This study has identified that a T&T system has utility in the ED to assist with the identification of physiological abnormality, and highlights some of the difficulties we have encountered, particularly relating to documentation. We do not believe that these findings are unique to our ED in terms of either our staff or patient populations.

CONCLUSION

The introduction of T&T charts into the ED is a step towards earlier and more reliable identification of unwell or deteriorating patients. The recording of basic patient observation data in an ED environment has significant weaknesses. Only 75% of initial observations meet the CEM standard, with the single biggest missing parameter being temperature. The absence or incorrect recording of data limits the value of T&T, but retrospective calculations demonstrate that T&T would have recognised the majority of physiological escalations, and therefore has applicability within an ED environment.

While T&T is simple in principle, we have identified two main challenges with T&T in the ED: the poor completion of T&T charts, and numerical errors in assigning and/or adding individual scores. Similar findings have been documented in other hospital settings,[8] but so far have not been recognised in the ED.

One way to overcome these challenges may be to use an electronic version of the T&T chart, whereby observations are entered into a hand-held device which calculates and sums the individual scores, generating an alert when trigger thresholds are exceeded.[12] The use of an electronic system would remove problems caused by human error and reduce the paperwork load, although it must not discourage hands-on assessments of patients by expert clinical staff. An electronic system should also facilitate regular and prompt observations, and help ensure that alerts are acted upon. Our future work intends to address this by evaluating an electronic T&T system optimised for use within the ED environment.

Competing interests None.

Ethics approval This study was conducted with the approval of the UK National Research Ethics Service (NRES), reference number 08/H1307/56.

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REFERENCES

1. **McQuillan P,** Pilkington S, Allan A, et al. Confidential enquiry into quality of care before admission to intensive care. BMJ 1998;**316**:1853—8.
2. **Cullinane M,** Findlay G, Hargraves C, et al. An Acute Problem? A report of the National Confidential Enquiry into Patient Outcome and Death. London, 2005. http://www.ncepod.org.uk/2005aap.htm (accessed 26 Oct 2010).
3. **Gao H,** McDonnell A, Harrison DA, et al. Systematic review and evaluation of physiological track and trigger warning systems for identifying at-risk patients on the ward. Intensive Care Med 2007;**33**:667—79.
4. **National Institute for Clinical Excellence.** Acutely Ill Patients in Hospital. Recognition of and Response to Acute Illness in Adults in Hospital. 2007. http://www.nice.org.uk/CG50 (accessed 26 Oct 2010).
5. **College of Emergency Medicine Clinical Effectiveness Committee.** Standards for the Recording of Adult Vital Signs in the Majors and Resuscitation Areas of the Emergency Department. 2010. http://www.collemergencymed.ac.uk/Shop%2DFloor/Clinical Standards/Vital Signs/ (accessed 26 Oct 2010).
6. **Armstrong B,** Walthall H, Clancy M, et al. Recording of vital signs in a district general hospital emergency department. Emerg Med J 2008;**25**:799—802.
7. **Goldhill DR.** The critically ill: following your MEWS. QJM 2001;**94**:507.
8. **Prytherch DR,** Smith GB, Schmidt P, et al. Calculating early warning scores—a classroom comparison of pen and paper and hand-held computer methods. Resuscitation 2006;**70**:173—8.
9. **Edwards M,** McKay H, Van Leuvan C, et al. Modified early warning scores: inaccurate summation or inaccurate assignment of score? Crit Care 2010;**14**(Suppl 1):P257.
10. **Tarassenko L,** Hann A, Young D. Integrated monitoring and analysis for early warning of patient deterioration. Br J Anaesth 2006;**97**:64—8.
11. **Prytherch DR,** Smith GB, Schmidt PE, et al. ViEWS—Towards a national early warning score for detecting adult inpatient deterioration. Resuscitation 2010;**81**:932—7.
12. **Mohammed MA,** Hayton R, Clements G, et al. Improving accuracy and efficiency of early warning scores in acute care. Br J Nurs 2009;**18**:18—24.

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