The Newborn Early Warning (NEW) system: development of an at-risk infant intervention system

The use of early warning systems is widespread but their use in the neonatal age group has been under-investigated. This article describes the development of a Newborn Early Warning 'traffic-light' coded observation chart to enable early identification of adverse changes in physiological parameters. Much work remains to be done but the aim of this initial project is to allow other maternity units to consider how they can improve the safety of at-risk newborn infants on their postnatal wards.

Damian Roland
BMed Sci, BMBS, MRCPCH
Academic Clinical Fellow in Paediatric Emergency Medicine, Leicester University

John Madar
MRCP, FRCPCH, FHEA
Consultant Neonatologist, Neonatal Unit, Derriford Hospital, Plymouth
john.madar@phnt.swest.nhs.uk

Glenys Connolly
Bsc(Hons), RGN, RSCN
Advanced Neonatal Nurse Practitioner, Neonatal Unit, Derriford Hospital, Plymouth

Keywords

neonatal scoring systems; risk stratification; observation chart

Key points

D. Roland, J. Madar, G. Connolly. The Newborn Early Warning (NEW) system: devel-opment of an at-risk infant intervention system. *Infant* 2010; 6(4): 116-20.

1. The NEW observation chart facilitates observation of babies deemed at risk and prompts earlier review in those demonstrating clinical deterioration.
2. There was an increase in retrievable observations from 48% in the retrospective audit to 72% in the prospective audit.
3. The NEW chart threshold criteria prompted management decisions in nine (47.3%) of 19 infants who required intervention.
4. The chart was considered beneficial by a majority of midwives questioned about its use.

It is generally accepted in adult and paediatric practice, that prior to acute deterioration and subsequent transfer to intensive care, patients often show signs of deterioration which are either unrecognised or not acted upon by nursing and medical staff[1,2]. Early warning scores based on physiological observations (heart and respiratory rate etc) which automatically trigger medical review have been validated as useful ways of detecting deterioration and prompting intervention to reduce morbidity in both adult[3] and paediatric[4] populations.

To our knowledge, no such tools have been developed or fully evaluated in the newborn population. A Medline and Embase search found no studies directly related to newborn infants. One reason for this may be the lack of well established normal ranges for biophysical variables. Published studies are sparse and not solely confined to the perinatal period[5-7]. Even the standard textbooks have differences between chapters in the same book, which may result in different clinical approaches (**TABLE 1**). The absence of, or variance in published normal values illustrates a difficulty in establishing response parameters for newborns who require observation. Early warning criteria should not be so brittle as to be over sensitive and thus devalue the tool.

The majority of newborn infants are healthy and not at risk of significant morbidity. A second group are clearly unwell or compromised and declare themselves as justifying enhanced levels of care. Between these are those well babies whose perinatal circumstances identify them as at risk of potentially significant morbidity. These include, for example, those babies at risk of infection through streptococcal carriage, or prolonged rupture of membranes, or those babies born through meconium. In addition are those manifesting behaviour slightly out of the normal range, but not so far as to

Source	Heart rate bpm	Respiratory rate
Examination of the Newborn and Neonatal Health. A multidimensional approach. Ed Lorna Davies, Sharon McDonald[8]	110-160: 80-90 if asleep, 160+ if distressed	40-60 non-distressed
Examination of the Newborn. A Practical Guide. Helen Baston, Heather Durward[9]	90-140 - resting	40-60 breaths/min
Roberton's Textbook of Neonatology. Ed Janet M Rennie[10]	120-160	usually 35-45
Avery's Diseases of the Newborn. Taesch, Ballard, Gleason[11]		40-50 newborn, 35-60 thereafter
Advanced Paediatric Life Support – manual[12]	110-160	30-40

TABLE 1 Normal ranges for newborn infant's heart rate and respiratory rate as published in standard paediatric texts.

Prenatal	Perinatal	Postnatal
Pathological cardiotocograph	Thick meconium	Grunting
Scalp pH<7	Venous cord pH <7.1	Abnormal movements
Group B Streptococcus risk	Ventilatory support >3 minutes	Any ongoing concerns
Premature rupture of membranes (PROM)	Five minute APGAR <8	At the request of reviewing medical or neonatal staff

TABLE 2 At-Risk Newborn Infant (ARNI) criteria.

overtly identify them as clearly unwell. Such babies fall into a group where the ability to generate a series of structured observations with evolving trends in physiological parameters permits staff of varying experience to more clearly determine health, stability and the potential need for further intervention. The rapidity with which a baby can become unwell drives a need for clear pointers towards more aggressive intervention. The early identification of an unwell infant may, for example, prompt attention to airway or breathing support, or the early administration of antibiotics and prevent significant morbidity and even mortality.

The aims of this study were:

- To categorise observations on newborn infants in order to formulate prompts for assessment/intervention – the 'early warning score'.
- To develop a recording tool for observations to help generate such a score and prompt appropriate action – the Newborn Early Warning (NEW) chart
- To assess the chart's effectiveness in clinical practice

Materials and methods

Two studies were carried out:

- A retrospective review of observations on babies admitted to the neonatal unit to compare key observations with proposed early warning criteria and determine whether assessment against these criteria would have altered management.
- A prospective study of at-risk babies observed using the NEW chart to determine effectiveness of the chart as a clinical tool.

Derriford hospital is a network neonatal intensive care unit (previously termed a level 3 unit) within the Peninsula Neonatal network with around 4,400 deliveries a year. Babies are looked after on the postnatal wards, but can be admitted to a 15 bedded transitional care ward (TCW) with their mothers (around 900 admissions/year) or to the neonatal intensive care unit (NICU) if more unwell (around 450 admissions/year).

Internal guidelines include those for the identification of so called "At-Risk Newborn Infants" or 'ARNIs'. These are infants who are deemed to be at increased risk of postnatal morbidity by virtue of pre-identified indicators such as adverse maternal health characteristics, markers of perinatal stress (eg poor cord pH values) or the need for significant resuscitation at birth (**TABLE 2**). These indicators are based on well established physiological principles with an incomplete evidence base to back them up[13,14].

Retrospective review

Using the NICU admission records the medical notes of term infants over 2.5kg who presented to the neonatal unit from either the postnatal wards or the transitional care ward over a two year period were identified. These notes were examined for general demographic data, whether the infant had been correctly

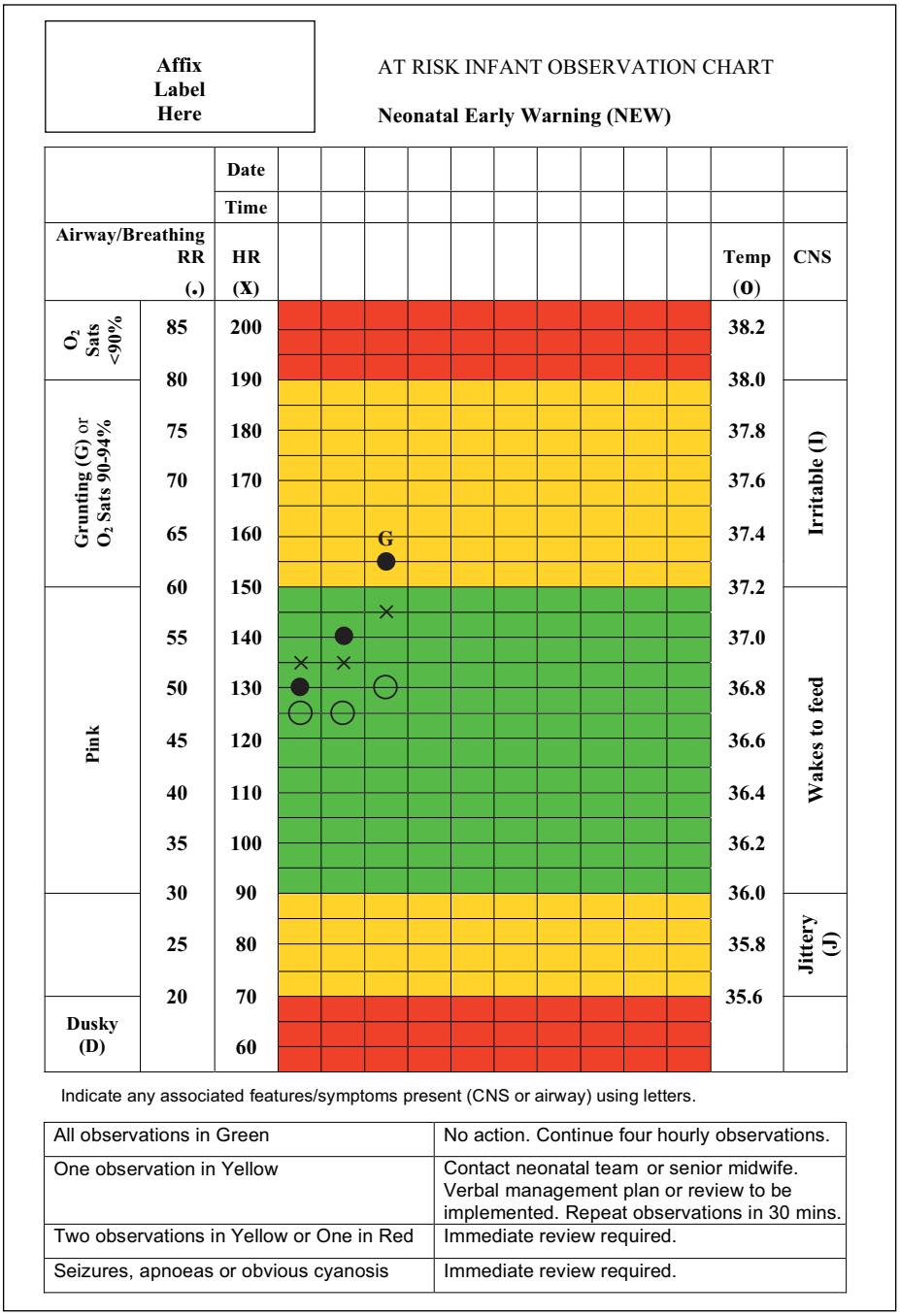

FIGURE 1 Revised Newborn Early Warning Observation Chart containing some sample entries.

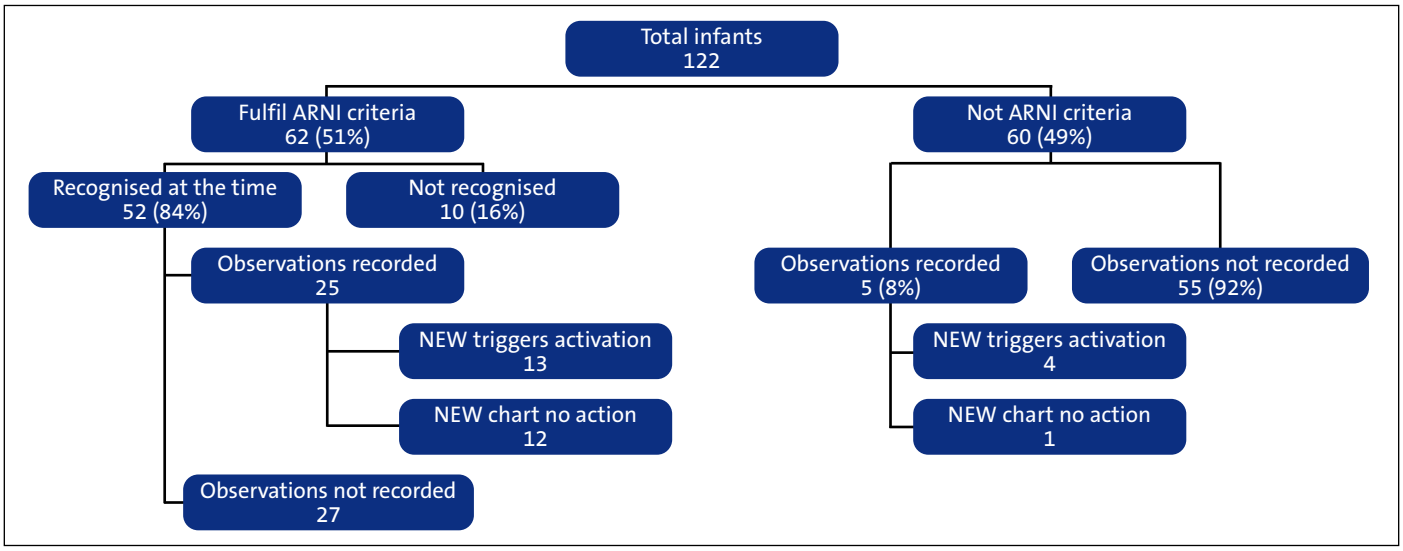

TABLE 3 Details of term babies admitted to the NNU/TCW from postnatal wards.

identified as an ARNI at birth (**TABLE 2**) and whether observations had been recorded.

A pilot NEW observation chart was developed providing prompts to aid in the identification of ARNIs and permit the recording of the observed physiological variables of these infants using symbols, highlighting values of concern. The chart was approved by the Hospital Clinical Records and Knowledge Service committee. As well as physiological observations such as temperature, pulse and respiratory rate, comments about the infant's work of breathing or conscious level were accommodated. Observation values were classified into red (significantly abnormal), amber (abnormal) or green (normal) ranges. The values used were an amalgam of those found in standard neonatal textbooks selected to ensure chart scales were not unwieldy. Values in the chart's amber band were in keeping with the upper range of normal physiological measurements.

Clinical observations from the group of ARNIs were then plotted on the NEW chart to see whether the pre-identified trigger criteria would have prompted earlier medical review.

Based on the results of this retrospective audit a revised chart was generated for the subsequent prospective study with modified trigger values (**FIGURE 1**).

Prospective study

The results of the retrospective review were used to inform an educational programme including presentations and written material. It was aimed at midwifery, nursing and medical staff in the maternity unit and designed to raise awareness of the NEW programme, familiarise staff with the NEW chart and the structure of the proposed study.

NEW charts were made available on the labour suite and postnatal wards. The criteria for using the NEW charts were disseminated among the midwives and posters highlighting the process placed widely around the obstetric and neonatal department. Any child who was on a NEW chart had their observations recorded four hourly or more frequently if deemed necessary.

Babies were excluded from the study if they were admitted directly to the NICU/TCW or fulfilled automatic admission criteria such as being <37 weeks' gestation or <2.5kg.

All NEW charts had an envelope attached so brief details of the infant could be sent to the study administrator as soon as observations were commenced. All infants' notes were collated when the study was completed. Ethical approval was granted by the local relevant ethical committee.

An intervention was defined as an infant receiving an investigation (blood test or CXR), treatment (antibiotics) or transfer to another care environment.

A questionnaire was sent to all midwives to obtain qualitative data on their thoughts on the process.

Results

Retrospective review

The initial audit identified 122 term infants, 51% of these infants fulfilled ARNI criteria. Eighty-four per cent were correctly identified as such (**TABLE 4**). Only 48% (25/52) of those infants recognised as being ARNIs had observations recorded,

Reason	Totals
Prenatal	
CTG	9
Scalp pH<7	0
GBS	6
PROM	29
Postnatal	
Meconium	15
Cord pH <7.1	2
Ventilatory support	1
APGAR <8	1
Postnatal	
Grunting	14
Abnormal movements	0
Concern	15
Request	0
Unclear	9
TCW (child admitted directly to the transitional care ward because of gestational age)	15
Other (infant readmitted at five days of age)	1
Total	**117**

TABLE 4 At-Risk Newborn Infant (ARNI) criteria for enrolled infants: prospective study.

but half would have been reviewed earlier (13/25) by a neonatal doctor or nurse practitioner if their observations had been charted on the NEW chart. Of the babies admitted not classified as ARNIs, few had observations recorded (5/55 – 8%). This audit was of infants admitted to the NICU and does not contain data on those infants who were safely discharged home. Based on this data the decision to conduct a prospective study was made.

Prospective study

Over a three month period information was collected on 117 infants who had been

Plymouth Hospitals NHS
NHS Trust

NEWBORN EARLY WARNING

OBSERVATION CHART FOR NEWBORN INFANTS

Surname
First Name
Hospital No.
NHS Number
D.O.B.
Affix patient label here

DATE																								
TIME																								
TEMP	39.0																							
	38.0																							
	37.0																							
	36.0																							
	35.0																							
RESPIRATION	85																							
	80																							
	75																							
	70																							
	65																							
	60																							
	55																							
	50																							
	45																							
	40																							
	35																							
	30																							
	25																							
	20																							
GRUNTING																								
HEART RATE	200																							
	190																							
	180																							
	170																							
	160																							
	150																							
	140																							
	130																							
	120																							
	110																							
	100																							
	90																							
	80																							
	70																							
	60																							
COLOUR (SpO_2)	PINK (>94%)																							
	90-94%																							
	DUSKY/BLUE (<90%)																							
NEURO	ACTIVE/WAKES TO FEED																							
	JITTERY/IRRITABLE																							
	FLOPPY/DIFF TO ROUSE																							
	SEIZURES																							
SCORE	RED																							
	AMBER																							

RESPONSE		
	ALL OBSERVATIONS IN WHITE	CONTINUE OBERVATIONS 4 HOURLY OR AS REQUESTED.
	ONE IN AMBER	CONTACT SHO/ANNP/SENIOR MIDWIFE. VERBAL MANAGEMENT PLAN OR REVIEW. REPEAT OBSERVATIONS IN 30 MINUTES.
	TWO IN AMBER OR **ONE** IN RED	**IMMEDIATE REVIEW**

File alongside other observation charts
VERSION 6 – March 2010

FIGURE 2 Final version of the NEW observation chart separating out each variable to improve clarity.

recognised as being ARNIs. Based on an average of 4,600 deliveries per year, approximately 10% (468/4600) of deliveries at Derriford hospital result in an ARNI being born. The breakdown of the specific criteria for this are shown in **TABLE 4**. Of 117 identified, only 84 charts were available for review (71.2%). Nineteen infants received an intervention as per the predefined criteria and in nine this occurred as a result of the NEW chart. One infant was admitted to the NICU directly from the postnatal wards who developed ABO incompatibility on day 2 of life. A chart had been provided for this infant although the reasons for this are unclear. The chart did not affect the infant's management.

A sample of midwives' views on the NEW system were obtained via questionnaire. Notable responses included:

- A majority felt the chart was beneficial.
- Many commented that the chart made them more aware of the normal parameters for a newborn.
- Around half felt the chart was overcomplicated and suggested changes. It was felt a different style of might be easier to interpret.

Conclusion

Our study indicated that many infants achieved 'at risk' criteria, often prompting intervention in terms of investigations, anti-microbial management or transfer to a higher level of care. It is important robust procedures are instituted to avoid unnecessary morbidity and perhaps mortality through inadvertent delay. The benefits of early identification of instability and of necessary intervention are obvious and an early warning chart with clear prompts for action is one tool for facilitating this. Our locally designed and implemented chart appears to have had some success in identifying infants at an earlier stage than would have occurred in their absence. The chart itself may have been the arbiter of the increased detection rate, but the very exercise of introducing the charts, and the educational package surrounding this may also have had an effect in raising awareness.

The true effect of earlier detection on longer term morbidity and mortality is difficult to define with the small numbers of babies involved in this study. However, intuitively, earlier management might be considered a positive outcome, unless prompting unnecessary investigations and interventions on babies who were deemed unstable by virtue of transgressing the predefined criteria. On a pragmatic basis the chart identified nearly 50% of those infants where intervention was deemed clinically appropriate. No direct feedback was given about the chart producing unnecessary intervention apart from the difficulties with the temperature scale. Ultimately however, it is not the chart, or the highlighting of a set of observations that should prompt intervention, but the full clinical evaluation of the baby that subsequently follows. The ability to clearly assess trends in observations may form an important part of that evaluation and is one of the attributes of the observation chart. The NEW chart itself is but one component of a system of care and cannot function effectively without the other elements. Having adequate numbers of staff able to undertake accurate observations is a pre-requisite, with clear arrangements for subsequent communication of concern and an ability to respond effectively to those concerns.

Also of note is the fact that direct entry midwifery students may have had very limited exposure to or training in the care of the newborn baby and little on the recognition of the unwell infant. Hard pressed staff on labour ward and postnatal wards need effective tools to help them in the identification and observation of these vulnerable babies.

It is vital to address any staff reservations about the format of the chart. In the original version, the temperature scale was felt to be over sensitive, prompting review and potential intervention when unnecessary. The format of the chart with different symbols for each variable was also felt to confuse and produce an overcrowded display which was difficult to read. These problems were exacerbated by staff using poor quality photocopies of the original chart, rather than high quality reproductions. Budgetary constraints also compromised the original charts by the use of grey scale rather than colour banding.

Further work and greater numbers are needed in order to evolve a working model which is acceptable to all staff and validation of the results in a different clinical setting should take place. As a result of feedback a further version of the chart has been designed which in pilot testing has proved more popular with midwifery staff (**FIGURE 2**). This chart is based on an obstetric early warning system from Liverpool developed as a result of the Confidential Enquiry of Maternal and Childhood Health review. A similar chart is being used at the Royal Free in Hampstead, UK (personal communication Vivienne van Someren, 2009). This chart separates out the clinical variables, arguably making it easier to determine individual trends. No single chart is likely to cover the needs of all units, but establishing the principle and providing an effective template may help others develop similar tools.

The NEW observation chart is but one component of the systems that need to be in place to ensure optimal care for these babies. This work has demonstrated that such charts can help those looking after such babies target at risk newborn infants more effectively.

References

1. **Franklin C., Mathew J.** Developing strategies to prevent inhospital cardiac arrest: analyzing responses of physicians and nurses in the hours before the event. *Crit Care Med* 1994; **22**: 244-47.
2. **Schein R.M., Hazday N., Pena M. et al.** Clinical antecedents to in-hospital cardiopulmonary arrest. *Chest* 1990; **98**: 1388-92.
3. **Stubbe C.P., Kruger M., Rutherford P., Gemmell L.** Validation of a modified Early Warning Score in medical admissions. *Q J Med* 2001; **94**: 521-26.
4. **Duncan H., Hutchison J., Parshuram C.** The pediatric early warning system score: A severity of illness score to predict urgent medical need in hospitalized children. *J Crit Care* 2006; **21**(3): 271-78.
5. **Montague T., Taylor P., Stockton R., Roy D., Smith E.** The spectrum of cardiac rate and rhythm in normal newborns. *Pediatr Cardiol* 1982; **2**: 33-38.
6. **Rusconi F., Castagneto M., Gagliardi L., Leo G. et al.** Reference values for respiratory rate in the first 3 years of life. *Pediatrics* 1994; **94**: 350-55.
7. **Hooker E., Danzl D., Brueggmeyer M., Harper E.** Respiratory rates in pediatric emergency patients. *J Emerg Med* 1992; **10**: 407-10.
8. **Davies L., McDonald S., eds.** Examination of the Newborn and Neonatal Health. A multidimensional approach. Churchill Livingstone/Elsevier. 2008.
9. **Baston H., Durward H.** Examination of the Newborn. A Practical Guide. Routledge. 2001.
10. **Rennie J.M., ed.** Roberton's Textbook of Neonatology. Fourth Edition 2005. Churchill Livingstone/Elsevier. 2005.
11. **Taesch H.W., Ballard R., Gleason C.A.** Avery's Diseases of the Newborn 8th edition. Elsevier Saunders. 2004.
12. **Mackway-Jones, Molyneux E., Phillips B., Wieteska S., eds.** Advanced Paediatric Life Support: The Practical Approach 4th Edition. Blackwell Publishing. 2005. 7-14.
13. **Madar J.** Clinical risk management in the newborn and neonatal resuscitation. *Semin Fetal Neonatal Med* 2005; **10**: 45-61.
14. **Victory R., Penava D., Da Silva O., Natale R., Richardson B.** Umbilical cord pH and base excess values in relation to advers outcome events for infants delivering at term. *Am J Obstet Gynaecol* 2004; **191**: 2021-28.