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Observational Data Acquired on a Neonatal Intensive Care Unit

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Abstract

A unique data-set describing patient (baby) state with associated clinical actions and observations performed by medical and nursing staff were recorded, during the period mid October 2001 to mid February 2003, in a busy Neonatal Intensive Care Unit. This report describes in detail the data collecting protocol and process, the database structures and the software tools that were developed to be used for data acquisition and display.

A data-collection and display system (called *Badger*) acquired time-stamped patient physiological data from monitors and ventilators. In addition a research nurse (observer) was employed to collect the additional data, which were not acquired automatically. These extra data include accurately time-stamped actions taken by the clinical staff and verbal descriptions, from the staff involved, of the baby's visual appearance, and the results of any physical examination. The research nurse used a specially developed data acquisition tool (called *BabyWatch*) to enter these data. The research nurse was able to collect 600 patient-hours of data containing approximately 60,000 data items, which is rich in examples of different situations of interest for the development of clinical decision support.

Post-collection processing was performed on the data-set in order to check and validate the data. This process, which is described in detail in this report, included: validation of time-stamps, validation by medical experts, technical validation of acquisition software's performance, corrections of mistakes in input as indicated by the observer's comments, validation of numerical input and minor corrections. This post processing was done using an in-house developed software tool called the Time Series Workbench (*TSW*).

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1. Introduction

The overall aim of the NEONATE project is to improve decision making in Neonatal Intensive Care by taking advantage of access to real time physiological data.

As part of this project a research nurse was employed for approximately four months to observe the activity at one or more cots and to make as accurate record of this activity as possible. The information recorded was:

- the equipment used to monitor, ventilate, etc.;
- the actions taken by the medical staff;
- regular observations of:
 - bowel movements and urine production;
 - mood;
 - feeding;
 - movement, muscle tone, etc.;
 - size, shape and weight;
 - skin colour and appearance;
 - patterns of sleep and wakefulness;
- the alarm limits in force on the monitors;
- the settings on the various items of equipment;
- the results of blood gas analysis;
- other laboratory results;
- the drugs administered.

Data was entered with a timing accuracy of a few seconds on a laptop computer using a specially written program called 'BabyWatch' running under Windows. All data (with one or two exceptions) were entered by selecting from pre-compiled lists. The lexicon of actions and observations was established prior to the observations by a series of interviews with nurses and doctors.

At the same time as data was being entered manually, the 'Badger' data collection system was automatically acquiring physiological data with a time resolution of one second. The actual parameters sampled depend on the monitoring in place but typically included heart rate, transcutaneous O₂ and CO₂, saturation O₂, core and peripheral temperatures, and blood pressures. Data collection started in mid October 2001 and finished in mid February 2002. We have collected about 550 patient-hours of observations on 41 separate babies consisting of almost 40,000 individual data records.

This report describes:

- the BabyWatch software;
- the lexicon of actions and observations;
- the protocol observed by the research nurse while collecting the data;
- the structure of the output data and the role of the Time Series Workbench (TSW) in visualising these;
- the necessary 'post-observation' processing of the data.

2. BabyWatch Data Collection Software

BabyWatch is a stand-alone Windows program written in Borland Delphi. It was implemented specifically for the NEONATE project, although it could be adapted to allow observational data capture in any ICU. The **BabyWatch - User Manual**¹ should be consulted at this point.

An initial screen allows the observer to prepare for observation by entering basic data on up to eight babies. The observer can then indicate which are actually going to be observed in the

¹ University of Aberdeen, Computing Science technical report number TR0206.

upcoming session. The main screen allows rapid data entry via a number of tabbed pages. Data entry consists of selecting the required action or observation and clicking on an 'Accept' button. The entry is time stamped to one-second accuracy. The observer can move between different pages and between different babies. The state of each page is preserved while it is not active. At any time, the observer can enter a free-text comment that is also time stamped.

The available actions are loaded from a simple text file, as are the possible observations. The output is written to an Access compatible database. All of these inputs and outputs are described in detail in the BabyWatch - User Manual.

3. Development of Lexicons of Actions and Observations

An initial phase of the NEONATE project focussed on developing a concise lexicon of terms used by clinical staff during clinical practice, and was used as the basis for card-sorting experiments designed to elucidate the way clinical staff mentally organise those terms (not reported here). This information was also used to design the interface for BabyWatch.

In order to elicit lexicons for both patient "descriptors" and clinical "actions" we interviewed medical and nursing staff at different levels to delineate their roles in the unit and the vocabularies they use to categorise the actions that they take and data that they obtain about the baby by observation and physical means (which we call 'descriptors'). Thirty-two staff (eight each of junior nurses, senior nurses, junior doctors and senior doctors) were interviewed with a result that 552 descriptors and 191 actions were identified. Senior clinical staff subsequently reviewed these raw lists for consistency, and to remove synonyms and singletons (single words used by only one member of staff). The derived actions lexicon contains 51 terms, while the descriptors lexicon contains 166 terms. A glossary describing the clinical actions, that were derived, is shown in Annex A.

4. Observation and Data Collection Protocol

A qualified nurse trained in neonatal intensive care recorded the observations. Accordingly, there was a heavy reliance on the professional knowledge and judgement of the observer. Subsequent sections set out a protocol that detail the procedure for equipment calibration or checking and the observational procedure, which includes—patient scheduling, observation and ethical considerations.

Clock Synchronisation

The Badger system uses a clock on each cot-side computer to time-stamp physiological and equipment data that was automatically recorded. However, the observer's lap-top computer in has its own clock and it is not feasible to synchronise this with the clock of the baby being observed (as more than one baby may be observed at a time). A method was developed to allow us to reconcile after the data acquisition phase the times of the recording of the automatically collected data and the observed data. This involved the observer undertaking two separate actions. This first was simply to note the time on the cot-side computer as a time stamped comment on the observer's laptop (where the time stamp was derived from the lap-top). This procedure was typically carried out once per shift per cot. In detail, it consisted of:

1. *Prepare a comment referring to an upcoming time on the cotside system - usually this would be an exact minute so the comment would be: "time on Badger cotside is 17:02:00"*
2. *Wait until this time came up on the cotside system and then press 'Accept' to enter the comment. We believe that this allowed synchronisation to within a second.*

As an additional source of information, which would enable us to see a synchronisation signal directly in the recorded data, the observer carried out the following steps (again typically once per shift).

1. *At a quiet time, ask the nurse caring for the baby to unplug and re-plug the data lead for either the Heart-Rate (HR) or the oxygen saturation (SO₂) channel and to do this twice in succession. Typically the probe would be removed for about 30 seconds, with a 30 second gap in between.*
2. *Record "Resite Probes / Time Test" using the actions menu .of BabyWatch.*
3. *Subsequently insert a comment noting that the time check had taken place.*

Basic Instrumentation Checks

To obtain consistent sets of data (and to minimise risk to patient) the instrumentation was checked to confirm that it was working; i.e. check that the instrumentation was plugged in (data and power) was switched-on, configured correctly and operating within normal clinical limits.

The observer checked that a display for appropriate data was appearing on the Badger system for each piece of instrumentation that was (or was supposed to be) connected. Any unusual configuration was noted.

Alarm Limits

The triggering (and resetting) of alarms were recorded, as this is an input to clinical decision making and has impact on the clinical environment.

The observer recorded alarm limits set for instrumentation, via the "Alarms" tab of BabyWatch, at the beginning of the observational period, and when (if) the limits were subsequently changed.

Ventilator Data

The ventilator data was recorded using the "Settings" tab of BabyWatch, which has the appropriate parameters listed.

Patient Scheduling

At the beginning of the shift, after completing the calibration/set-up procedures detailed in the previous sections, babies were categorised and prioritised in terms of their dependency on nursing and medical care. (Clinical staff had indicated that, usually, clinical activity focussed on most babies in the NNU was low, while there may be intense bursts of clinical activity surrounding one or two babies.)

Initially, the focus was on the high-dependency babies. If there was more than one, observations were concentrated on the baby associated with the highest clinical activity at the time. Early in the data collection phase, once the clinical activity, surrounding a baby under observation, had settled down to a routine level, the attention was moved to the next high-dependency baby, if one existed. However, by mid-phase, it was deemed appropriate to focus on the observation of individual babies for longer periods, in order to gain complete 'pictures' of activities.

Apparently, there was only one team of doctors on duty per shift; therefore it was thought appropriate for the researcher to follow the medical team (who see patients in priority of medical need).

When there was a lull in the activity surrounding all the high-dependency babies, or if there were no high-dependency babies at the time, other babies were observed in an orderly fashion. Some activities that staff perform on babies was planned and the case nurses were approached at the beginning of a shift to get a program of planned activities for the babies; e.g. feeds, nappy changes, probe changes, mother's care. This allowed more targeted data

collection of more routine activities. At times where appropriate, two physically adjacent babies were observed simultaneously.

Observation

This section describes how the observations were carried out. It is clear that there was a heavy reliance on the professional knowledge and judgement of the observer.

1. At the beginning of the Observational Session for each Baby

The BabyWatch initial window was used to record the baby ID (anonymous Badger code) and the equipment in use for each baby under observation. Data was entered in the columns as appropriate, note that the baby's name was not recorded but used as a memory aid only.

The start of an observational phase, for one or more babies, was recorded by selecting "yes" in the "Obs" column. While the observer was not observing (e.g. coffee break), or at the end of the session, the "yes" item was toggled off.

Also, at the start of a session, the patient state was also recorded. This was achieved, firstly, by the observer entering descriptions of the baby under consideration (using pre-defined patient descriptors) under the following seven categories:

- I. Skin appearance*
- II. Movement/Muscle tone*
- III. Size/Shape/Weight*
- IV. Crying/facial expressions*
- V. Feeding*
- VI. Sleep*
- VII. Bowel/Urine*

(Note: Some of these states may not be observable at the time of observation - in particular items V to VII. If this was the case, this information was obtained from patient notes if available, at an opportune time.)

The attending clinician was asked to describe the baby's state without prompting (just after their examination if possible). Babies state descriptors were also collected opportunistically while observing ward rounds.

Ventilator parameters were recorded as set out above.

2. During the Session

If there was any clinically significant change in the patient state (as judged by the researcher), this was recorded, as was any comment as to change in patient state from clinical staff. The source of the description was recorded by selecting the appropriate item from the actor pick-list.

The actions being performed by attending medical staff were recorded. According to the schedule discussed above, the observer recorded, as far as possible, all the clinical actions that occurred during the session for each baby observed.

Once an action had begun, the appropriate action word was selected. The exact interpretation of each action is given in the **Glossary of Actions** in Annex A.

- *If the associated pick-list did not have "start" or "stop" in the list, then the actor and any other appropriate attributes were selected.*
- *If the associated pick-list did contain "start" and "stop" (interval-timed action), then the actor and "start" only were selected from the pick-list. At the end of the action, the appropriate action word was re-selected, then "stop", and appropriate attributes were selected if any.*

Sometimes an action had started before the shift had begun; e.g. phototherapy. In this case, the appropriate “start” button was pressed, and a comment entered stating that the action was commenced prior to the start of the observation period. If an action was still ongoing at the end of a shift the “stop” button was not pressed.

If there had not been actions performed on the baby for 30 minutes or more, the “no action” item was selected on the actions list. This indicates 30 minutes of verified base-line data. If the caring nurse for a particular baby stated that no actions had been performed on that baby for 30 minutes or more, this was recorded as if by direct observation.

The descriptors lexicon was found to be mostly adequate. However, sometimes a descriptor, found in the larger original list², but not in the final list, was appropriate. In this case it was entered in the comments.

Free-text comments could be entered at any time. A **Glossary of the Abbreviations Used in Comments** is given in Annex B.

3. At the end of the Session

Where possible, observations defining baby state were recorded.

At the end of each baby’s observational session (or during breaks, e.g. coffee break), the “Yes” item, in the “Obs” column in the Data Entry start-up window was toggled off (de-selected) and OK clicked.

The blood gas data and lab results for each baby under observation were recorded using BabyWatch. Complete lists of parameters, with entry boxes, were presented under the appropriate tabs on the software interface for ease of recording.

Ethical Considerations

As the observer was a professionally qualified nurse in the area of neonatal intensive care, the situation could arise where she was observing a clinical situation where, in her opinion, actions or non-actions have lead to the baby’s life being in threat. The (nurse) observer was instructed not to interfere with the actions of, or prompt the attending staff, unless in her professional opinion not to do so would have grave impact on the baby. However, fortunately no ethically controversial situation did occur.

5. Time Series Workbench (TSW)

The format of the output data from BabyWatch was designed so that (1) it could be easily collected in real time and (2) it was as secure against mishap as possible. In particular, this meant that the starts and ends of intervals were written to the database as separate events. The observational data is re-united with the Badger physiological data using a separate software package called the Time Series Workbench. This is not the place to provide a complete description of the TSW. Information is available at:

<http://www.csd.abdn.ac.uk/~jhunter/research/TSW>

Unlike BabyWatch, temporal reasoning within the TSW is based on the interval rather than the point (which are treated as intervals of zero duration).

The TSW was augmented to handle and display the BabyWatch observational data. One of the most important aspects of this was the reconstruction of the action intervals. This meant pairing up corresponding BabyWatch interval starts and stops. For various reasons this was

² The original list of observations elicited from the clinical staff was culled of synonyms and singletons.

not always possible and one might find a start without a corresponding stop and vice versa. The specification of an interval in the TSW was extended to allow for the possibility of such 'unbounded' intervals.

All intervals are stored in the TSW in a common format - the 'intervals' table. The structure of records in the intervals table is given in Annex C: **TSW Interval Record Format**.

As part of this process, the TSW generated two other types of record, with the FullDescriptor field containing the following values:

1. OBSERVATION DAYS: There is one record for each patient who had any observation made on a given day; the interval specified is the 24 hours from midnight to midnight.
2. OBSERVER SHIFT: If one were to present all of the data for a full 24 hour day, there would be a lot of time for which there were no observations – given that the observer typically works an 8 hour shift. Again there is one record for each patient who had any observation made on a given day, but the interval specified runs from the start of the first OBSERVER PRESENT interval on that day to the end of the last OBSERVER PRESENT interval on the same day.

6. Post-Collection Processing of the Data

Most of the post-collection processing was carried out using the TSW

Presence of Observer

We used a special display on the TSW to summarise the observational activity on all babies for a given day. We wanted to establish whether the observer had occasionally forgotten to 'log out' when taking a break. This would be indicated by an absence of observations (and actions) for period where the observer was indicated as being present and where there was no indication of 'no action'. One or two such episodes were discovered. We did not want to leave them in, as to do so would risk the interpretation that the data corresponded to a 'baseline' where no actions were taking place. We preferred to align the observational periods so that they covered the periods where actions were clearly taking place. Thus we preferred the risk of needlessly losing observation time rather than asserting that observation was taking place when it was not.

Time Reconciliation

It was noted in section 4 that the cot-side computer clocks and the observer's lap-top computer clock were not synchronised during data collection. However, a description was given of procedures that were carried out to allow us to reconcile the cot-side and lap-top clocks post-hoc. We now describe this post-hoc procedure.

We adopted three approaches to time reconciliation

- time-stamped time comments (i.e. comments entered as free text by the observer);
- synchronisation signals in time-series data;
- time interpolation and extrapolation.

The "gold standard" for time reconciliation was the use of the "Badger" time *comments*, with the other approaches being used when the time comments were not available. If both the time comments and the synchronisation data signals were present, they were used to cross verify each other. In these cases we found that there was always good correspondence between the Badger time comments and the synchronisation signals. This led us to trust the Badger time comments when only they were available. Some of the data, that were collected in the early part of the collection phase, was not reconcilable. Each record in the database was given an appropriate annotation (in the ContextDependentData field) indicating the time

reconciliation status and the mode of reconciliation. These annotations were fixed in format and were of the form: “*Clocks=reconciliation_state (mode 1,[mode 2]; [comment])*”, where reconciliation state is one of: “Reconciled”, “Unreconciled” or “Approximate”; mode 1 or mode 2 can be: “Badger Clock”, “Time Test OK”, “Badger Clock Interpolated” or “Badger Clock Extrapolated”. The brackets [] indicate this information is not mandatory. Following is an example of an annotation: “Clocks=Reconciled (Badger Clock; Time Test OK; HR & SO only)”, indicates that the record has been time reconciled using both the Badger clock comment and the time synchronisation data signal, and the comment states that only Heart-Rate and oxygen saturation data channels are available.

We will now describe the procedure used in time reconciliation using the above-mentioned approaches. Firstly, we will briefly describe the common procedure used to actually perform the time reconciliation using the TSW software (described in section 5). Secondly, we will describe the different methods of determining the discrepancy in time between the cot-side and lap-top clocks.

Each time reconciliation was done using the TSW software in data display mode; i.e. the data is plotted in channels versus time. This view shows a tool-bar near the top of the screen, which contains four time manipulation buttons. These are indicated by the '<', '<<', '>>' and '>' symbols. Depressing any one of these buttons 'slides' the data either forwards or backwards relative to the time scale near the bottom of the screen. A single symbol, such as '<', slides the data in one second increments while the double symbols (e.g. '<<') slide the data in one minute increments. The direction of slide is obvious from the symbol. The time manipulation is also applied to the time-stamps of the comments, which are displayed in a panel at the bottom of the screen. There is another button in the tool-bar containing an icon of a clock. When this button is depressed an annotation in the comment field is produced: “Clocks=” that is then completed by the user.

The procedures for producing the time comments and producing the data synchronisation signals was described in section 4. Following is a description of how these are used to deliver the time reconciliation required.

1. Time Comments

Where available, time-stamped time comments, such as “time on Badger cotside is 15:12:00” are used to reconcile the cot-side and lap-top clocks. Each comment is time-stamped with the lap-top clock at the instance of the comment entry. To reconcile the clocks, the time manipulation buttons are used to adjust the time comment's time-stamp (lap-top clock) to equal the Badger clock time indicated in the comment itself.

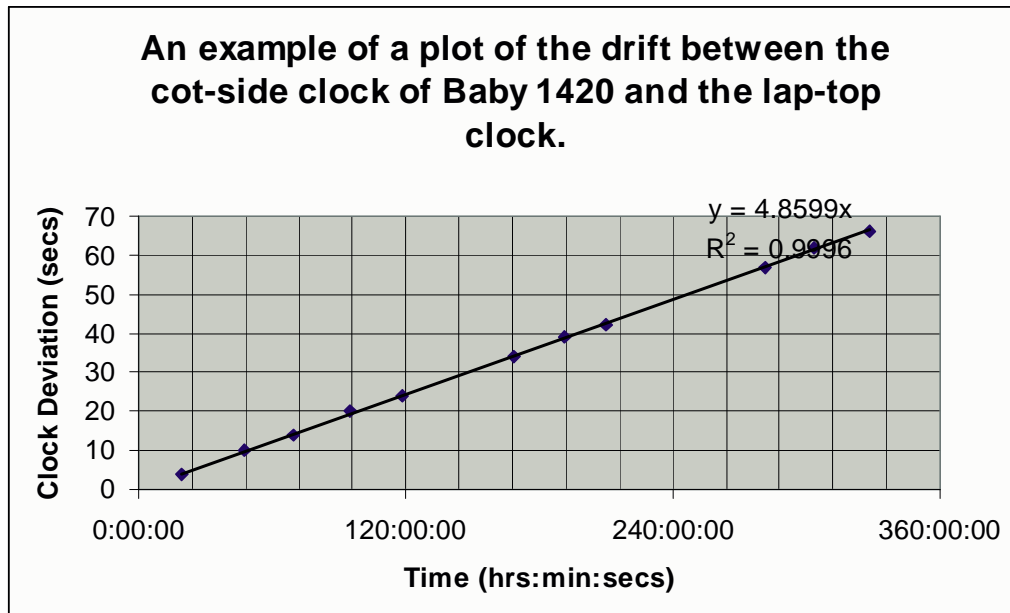
2. Data Synchronisation Signal

Another approach to allow post-hoc time reconciliation was to produce synchronisation signals in actual data channels, as described earlier. Time reconciliation was achieved by using the time manipulation controls to 'line up' the synchronisation signal in a specified data channel (e.g. oxygen saturation) with the matching “Time Test” action interval, which was recorded nearly simultaneously with the production of the synchronisation signal. However, due to noise and artefacts, the synchronisation signal was not always unambiguously apparent. In this case, only the Badger clock (trusted) was used if available, else time interpolation or extrapolation was used if appropriate.

3. Interpolation and Extrapolation

As a part of the timing reconciliation exercise we carried out an investigation on the relative stability of the discrepancy between the lap-top clock and the various cot-side clocks (drift), which we found to be very low. The average drift across all cot-side clocks, compared to the lap-top clock, was found to be 4.5 seconds/day with a standard deviation of 0.8 sec/day. We also found that the drift between the cot-side clocks and the lap-top clock was remarkably linear as shown in the graph below.

Some records in the database did not have a Badger clock comment or discernible synchronisation signals and are therefore impossible³ to reconcile by themselves. However, in light of the stability and linearity in the deviation of the cot-side and lap-top clocks (over time) we decided to reconcile the times in these records by interpolation or extrapolation, when they fell in between or near records with trusted time reconciliation of the same patient. These records are labelled appropriately as: “Clocks=Reconciled (Badger Clock Interpolated)” or “Clocks= Reconciled (Badger Clock Extrapolated)”.



Interval Verification

We wanted to establish whether there were any observational errors relating to the duration of action intervals. In particular, any actions that spanned observational sessions were identified. Given that we cannot be sure that the action continued while the observer was not there, such intervals were broken into two unbounded intervals.

In addition, we carried out a statistical analysis of each type of interval and identified those intervals with a duration of twice the standard deviation. If such an interval was clearly an outlier, it was replaced with an interval with an unbounded end point.

Medication entered as free-text

It was possible for the research nurse to enter medications not on the predefined list.

1. Entries to be treated as additional medication.

Name as entered	Name as standardised
0.9 % saline	Normal saline
calcium resonium	Calcium resonium
curosurf	Curosurf
folic acid	Folic acid

³ It may be possible to reconcile these records by using other cues, but would be tedious and error bounds are not known.

Glycerin chip	Glycerine chip
glycerine chip given PR	Glycerine chip
hypermellose eye drops	Hypermellose
konakian	Vitamin K
normal saline	Normal saline
neopain d	Neopain drug
neopain E	Neopain drug
PANCURONIUM	Pancuronium
paracetamol	Paracetamol
phosphate	Phosphate
phosphate solution	Phosphate
sodium bicarb	Sodium bicarbonate
sodium chloride 0.9%	Normal saline
tryclofos	Triclofos
vecuronium	Vecuronium
vit k	Vitamin K

The BabyWatch files have been amended to include the new terms.

2. Dextrose and Hepsal.

These are really fluids. There was only one instance of *dextrose* and it was decided to delete the record. All of the seven instances of *hepsal* coincided with a CHANGE IV/IA LINES action. The use of *hepsal* was normally referred to in a nearby comment. These records were deleted. Note that *Normal saline* is treated as a medication as it was given as a bolus.

3. Amino acids and lipids

There was one instance of this. It really belongs under FEEDING as TPN. We decided to set up an action FEEDING:INTRAVENOUS FEEDING as a point action and to transfer this record to this category. This isn't really right. TPN should be dealt with better in the future. In fact the administration of all fluids is not well handled here - we need a baby-state perspective as well as the action perspective.

4. Blood products

The terms used were *platelets* and *RCC* [also *rc*]. *RCC* stands for *red cell concentrate*. These are given under different circumstances. We decided to augment the BLOOD TRANSFUSION action with the attributes: PLATELETS and RCC. The one 'platelets' record and the three 'RCC' records were deleted but the corresponding blood transfusion records were subdivided. We also went through all the other Blood Transfusion records; where the comments indicated that *RCC* was used, the records were reclassified accordingly.

Minor corrections

In EXAMINE BABY we found six records with the attributes EYES MOUTH occurring together with a space between. The reason for this is unknown and the current version of the data collection program does not reproduce the fault. We assume that EYES and MOUTH were examined together and corrected the records accordingly.

Correcting data based on Comments

In reviewing the free-text comments, it became apparent that the observer had used these to report events which needed to be taken into account when post-processing the data - e.g. an incorrect action or observation had been made. Such corrections were made.

Validation of numerical input

Numerical values were entered for: equipment settings, alarm limits, blood gas results, laboratory results, and medication dose. In entering such numerical values, it was possible for the observer to enter medically unrealistic values by mistake. BabyWatch has no checking built in for this (apart for checking that numerical values constitute legal numbers). The medical experts inspected the sets of values used. Any obvious misplacing of decimal points or confusion about units was corrected.

Overall medical validation

Given the volume of data, it was not possible for the medical experts to examine all of the detail to check for entries that were medically inconsistent. However It is possible to print out the chronological sequence of observations for a given baby and any errors which were obvious here were investigated and corrected. Our medical expert did examine the routes of administration of drugs, and again, any obvious errors were corrected.

Glossary of Actions

Care

change linen – changing any linen but not clothing; click from the time baby is handled or lifted to the point when the baby is placed back into position.

comfort – from the moment when the baby is stroked or talked to (or anything soothing) to the point where the activity stops.

containment – from the point where hands are on the baby to hold the baby in a confined/braced position to the time when hands are removed. Also time when hands are placed on the baby to hold the baby in a position or manner for any intervention i.e. x-ray, IV cannulation until hands are removed.

cuddle/kangaroo care – from the point when the baby is placed in a cuddle or kangaroo position to the point where the baby is lifted off parent to place back into the cot/incubator.

eye care – from the point when the baby's eyes are touched (with saline swabs or specimen swab) to the point no longer being touched – includes instillation of eye drops.

incubator open - moment when the door or one or more portholes are opened to the point when they are shut.

massage – from the point when baby receives repetitive touch movements with or without application of coconut oil to the point the movements are no longer happening.

mouth care – from the point where the baby's mouth is touched for mouth care to the end of the activity. The activity of mouth care includes application of vaseline to lips, maybe cleaning mouth with a solution and possible application of nystatin.

nappy change – from the point where the nappy tabs are released to the point where they are secured back in place. Nappy change involves wiping the nappy area with cotton wool balls soaked in warm water and drying with either dry cotton wool balls or towelling. Baby may be rolled onto his/her side or the legs lifted to remove and after washing to place the clean nappy under the buttocks.

skin care- any care to the skin from the moment baby is touched to the end. May include top & tail wash (warm water with cotton wool balls), nystatin application, oil application. If skin is prepared for an invasive procedure i.e. LP the activity of cleansing the skin is included.

stimulation – from the point of any touching of the baby for the purpose of aiding/encouraging recover from physiological compromise.

turn/change position – from the moment the baby is touched to the point when it is stopped - includes moving between supine, prone and side-lying, lifting onto x-ray plate and changing head position.

Chest-drain

insert chest drain – from the insertion point of the blade to cut the skin to the point when the procedure is completed. (procedure involves: skin cut, insertion of trochar (removal of trochar) and drain, manipulation of drain into optimal position, application of purse string suture and adhesive tape)

monitor chest drain – any observation of the drain including the site and bottle.

withdraw chest drain – the actual removal of the drain and site care when finished. (removal of tape and suture will be made as a comment prior to the 'withdraw chest drain' being clicked).

Collect data

examine baby - from the point of touching the baby for examination to the point of no touch.

observe baby – any visual observation of the baby or monitor from start to stop.

ophthalmic examination - from the point when the Dr. instils the eye drops until the point when the instruments are removed. (involves: instillation of eye drops, insertion of eye clamps, visualising the eyes with light source, manipulating the eye ball with a probe, removing the clamps).

re-site probes - from the moment when the probe is lifted up and removed to the point when reapplication is complete. (reapplication includes applying fresh electrolyte solution and perhaps recalibration of probe or application of new tc sticker).

weigh - from the moment when the baby is lifted up to be placed onto the scales until to the point when placed back into the cot/incubator.

Therapy

phototherapy – when lights are on - will specify whether they are single or double lights. (comment will be made as to when phototherapy goggles or shield are applied or removed).

physiotherapy - from the time of physical contact to the point when hands are off of baby. Will specify whether its nurse or physio. or whether it's chest or limbs.(common use of physio is chest percussion prior to or during suction).

Investigation

blood (from catheters) - from the moment when the needle or syringe is inserted into the bung to the point when the withdrawing of blood is completed. Will specify the requirement of the blood ie. gases, u & e's

ECG - from the moment the gel and leads are applied to the point when the gel is removed. If there is delay between taking the leads off and removing the gel this will be entered as a comment.

EEG - from the moment the gel and leads are applied to the point when the gel is removed. If there is delay between taking the leads off and removing the gel this will be entered as a comment.

heel prick - from the point of actual prick to the point when the blood is no longer being sampled. (includes the positioning of the heel and gentle squeezing to extract right amount of blood for **the sample**).

lumbar puncture - from the point when the skin is punctured to the point when the plaster is applied. (Includes the holding of baby after proper positioning, catching spinal fluid into 4 specimen containers, application of pressure, collodion and plaster to the site).

SPA - from the point of skin puncture to the point when the needle is withdrawn and site pressure withdrawn. (includes aspiration of needle to obtain specimen).

swabs - from point of contact on the skin/eye to the point when the swab is removed and there is no contact with the site.

USS - from the point of the gel on the baby to the point when the probe is off. If there is delay between taking the leads off and removing the gel this will be entered as a comment.

venepuncture - from the point of the needle insertion to the point when the needle is removed. (includes probing and observation of needle, and flushing to confirm that cannula is in vein properly).

xray - from the point when the xray is being taken to the point just before baby is lifted to remove the plate. The onset of the click is about 10 secs. late as Lindsey cannot be present for the actual xray.

Feeding

aspirate gastric tube - from the point when the NGT lid is opened to the point when the lid is closed or if going to feed, just after the litmus paper is tested.

enteral feeding - from the point when the syringe is connect to the NGT to the point when the feed is completed and the syringe is removed and the NGT lid is closed.

insert gastric tube - from the point when the tube touches the baby's mouth or nose to the point when it's fixed with tape (prior to doing an aspirate).

Lines

blood transfusion - from the point when the line is attached to the peripheral IV to the point when the pump is stopped.

changing IV/IA line – from the point when the IVI is halted to the point when the new infusion is recommenced.

flush lines - from the point when the syringe is connected to flush to the point when the flush is stopped but syringe not necessarily removed.

insert long line - from the point of the needle insertion to the point when the procedure is finished and the site is secured. (includes frequent threading of long line through cannula and flushing to sometimes advance the line properly, may include prolonged pressure and observation before securing takes place as some have tendency to bleed around the site).

remove long line - from the point where the transparent dressing is removed to the point where the finger pressure is removed and there is no bleeding.

insert peripheral arterial line - from the point of the needle insertion to the point when the procedure is finished and the site is secured. (may include probing and flushing of cannula to be certain that line is in proper position and patent).

remove peripheral arterial line - from the point where the tape is removed to the point where the finger pressure is removed and there is no bleeding.

insert peripheral venous line - from the point of the needle insertion to the point when the procedure is finished and the site is secured. (may include probing and flushing of cannula to be certain that line is in proper position and patent).

remove peripheral venous line - from the point where the tape is removed to the point where the finger pressure or cotton wool ball is removed.

insert UAC/UVC - from the point when the cord is held by clamps to the point when the line is stitched and secured. (may include frequent probing, advancing and flushing of line in order to advance catheter and to be certain that line is in proper position).

remove UAC/UVC - from the point when the stitch is cut to the point when the line is removed and/or finger pressure is released.

Respiration

adjust ventilation - from the point where ventilation settings are changed. (includes changes to ventilation settings and o2).

CPAP initiate - from the point when the CPAP facial apparatus touches the baby to the point where it is secured. (includes fixing cpap tubing to baby, ties and hat, also adjusting settings and making sure that there is a proper cpap seal).

CPAP terminate - from the point when the apparatus is removed from the baby's face.

extubate - from the point when the tube is started to be pulled to the point when it is fully out of the mouth (loosening ties and hat will be entered as a comment before hand).

give incubator oxygen - from the point when the incubator is programmed to deliver oxygen to the point when the task is completed (calibration of equipment will be noted as a comment).

nitric oxide initiate - from the point when the machine is switched on to deliver therapy.

nitric oxide terminate - from the point when the therapy is halted.

hand-bag baby - from the point when the handbag is connected to the ETT or placed onto the face to the point when it is removed. (includes rhythmic hand bagging at pace needed to maintain sao₂, comment will be provided if baby is receiving blow by o₂ via bag and mask).

intubate - from the point when the laryngoscope touches the baby's mouth to the point just before the ETT is being stitched. (comment for ETT being secured and stitched and connected to the ventilator).

nasal cannula initiate - from the point when the prongs are placed in the nose and are secured. (will be secured to stickers applied to face, usually either cheek, and by tightening tubing behind baby head).

nasal cannula terminate - from the point when the oxygen is discontinued or from when the prongs are removed. (will include removing tubing from stickers on baby face and loosening from behind baby's head).

resuscitate - from the time of initiating hand ventilation or cardiac massage until supporting treatment is commenced. (includes administration of emergency drugs).

suction - from the point when the catheter touches the baby or if ventilated, when the ETT is disconnected from the ventilator to the point when the catheter no longer touches the baby or the ventilator is reconnected. (may include the installation of saline into ett seconds prior to suction to loosen secretions).

Safety

safety checks - from the point of checking any alarm limits, suction or oxygen apparatus to the point of completing the process.

mute alarm - from pressing the mute alarm on any apparatus. (comment will be made when it is the apnoea alarm).

Communication

routine communication - from the start to the end of any day to day non urgent communication/issues.

urgent communication - from the point when the nurse begins the process to communicate an urgent issue to the point when the communication stops.

No action

no action – a period of time when the baby has had no handling for at least 30 minutes

Glossary of Terms Used in Comments

ABBREVIATION	MEANING
ABD	Abdomen (of baby)
ADJ	Adjusted
ADV	Advantage—brand name
AL	Arterial line
AMT	Amount
ANNP	Advanced Neonatal Nurse Practitioner
ART	Arterial
B&MASK	Bag and Mask
BICARB	(blood) Bicarbonate
BILAT	Bilateral
BLD	Blood
BM	Blood sugar
BNO	Bowels not open
BP	Blood Pressure
BRADYS	Bradycardias (slow heart-rate)
C+S	Culture and Sensitivity
CA	Calcium
CBG	Capillary Blood Gas
CIRC	Circumference
CL	Chloride
CMV	Continuous Mandatory Ventilation (ventilator mode)
COAG	Coagulation
CPAP	Constant Positive Airway Pressure (ventilator mode)
D/C	Discontinued
DP	Delta Pressure
DRSG	dressing
ECG	Electro-Cardiogram
ECM	Expressed Breast Milk
EEG	Electro-Encephalogram
ETT	EndoTracheal Tube
FFP	Fresh Frozen Plasma
GENT	Gentamicin
GM NEG	Gram Negative (bacteria property)
GM POS	Gram Positive (bacteria property)
H2O	Water

HB	Haemoglobin
HFOV	High Frequency Oscillator Ventilation (specialised ventilator mode)
HP	Hewlett Packard (brand-name)
HR	Heart-Rate
INC	Incubator
IT	Inspiration Time
IV	IntraVenous
LG	Large
LL	Longline
LM	Labour Ward
LP	Lumbar Puncture
MEC	Meconium (first stools of newborn)
MET HP	Meta-Haemoglobin
MG	Magnesium
MLS	Millilitres (volume)
MRSA	Multiply Resistant Staphylococcus (a bacterium)
MS	Morphine Sulphate
NA	Sodium
NC	Nasal Cannula
NCO2	Nasal Cannula oxygen
NEC	Necrotising EnteroColitus
NELLCOR	Equipment brand-name
NEOPAIN	Code for neopain study drug
NGT	NasoGastric Tube
NNU	NeoNatal Unit
NO	Nitric Oxide
NS	Normal Saline
OGT	OraloGastric Tube
OHMEDA	Equipment brand-name
PAL	Peripheral Arterial Line
PDA	Patent (open) Ductus Arteriosis
PERI ART	Peripheral Arterial
PIV	Peripheral Intravenous
PR	Per Rectum
PREP	Preparation
PTV	Patient Trigger Ventilation
RCC	Red Cell Concentration
REG	Registrar (medical specialist-in-training)
RESP	Respirations

SAO2	Saturation of oxygen
SHO	Senior House Officer (junior doctor)
SIMV	Synchronised Intermittent Mandatory Ventilation (ventilator mode)
SL	Slightly
SLE	Ventilator brand name
SM	Small meconium
SPA	Supra Pubic Aspiration (for urine specimen)
SPEC	Specimen
STIM	Stimulation
T1	Temperature probe 1
TCM, TC	Transcutaneous monitor (probe)
TECH	Technician (usually X-ray)
TEMP	Temperature
TL	(nurse)Team Leader
TPIECE	T-shaped tube connector
TPNS	Total Parental Nutrition
U&E	Urea and Electrolytes
UAC	Umbilical Arterial Catheter
USS	UltraSound Scan
UVC	Umbilical Venous Catheter
VENT	Ventilator
VITS	Vitamins
WKS	Weeks (gestation period)

TSW Interval Record Format

We set out the format of records in the TSW 'intervals' table, paying special attention to how various fields are used to encode BabyWatch data.

ID: [AutoNumber - Long Integer - Unique primary key]

Unique key identifying the record.

ContextName: [Text - Field Size 50]

Name of the context (for a definition of 'context' see TSW documentation) - for Neonate observational data this will always be 'Badger'.

SourceName: [Text - Field Size 50]

The string which identifies the baby to the Badger data collection system - this is the same as 'PatientID' in BabyWatch.

ChannelName: [Text - Field Size 50]

Name of the channel that this interval refers to; for BabyWatch data this will be one of the following:

None (the interval does not refer to any channel in particular)

OBSERVER PRESENT

ACTION

OBSERVATION

EQUIPMENT

SETTING

XX ALARM LIMIT (where XX is an abbreviation for an analogue channel such as HR, SO, etc)

BLOOD GAS

LAB RESULT

MEDICATION

COMMENT

FullDescriptor: [Text - Field Size 250]

This will contain the complete description of the action, observation, etc. defined by the interval. It will normally consist of data extracted from the relevant BabyWatch fields, separated by semi-colons. We will indicate how this field is composed with reference to the Observation type:

OBSERVER PRESENT

ACTION; <Action class>; <Observation>;<Attribute>

<Action class> means the category of action e.g. CARE, INVESTIGATION, etc.

<Attribute> if any.

Example: ACTION;SAFETY;MUTE ALARM;MONITOR

OBSERVATION; <Observation type>; <Observation>

< Observation type > one of: Bowels, Crying, Feeding, Movement, Skin, Sleep, Size.

Example: OBSERVATION;MOVEMENT;RESPONSIVE

EQUIPMENT; <Observation>; <Attribute>

Example: EQUIPMENT;VENTILATOR;SLE/Florian

SETTING; <Attribute*>; <Observation*>

<Attribute*> this means the equipment (e.g. VENTILATOR) less the type

<Observation*> this means the <Observation> unless the setting refers to the Mode in which case it is the word 'Mode'

Examples: SETTING;VENTILATOR;Mode SETTING;VENTILATOR;FiO2

ALARM LIMIT;MAX ALARM LIMIT;MIN

The name of the channel concerned is in the ChannelName field.

BLOOD GAS; <Observation>

Example: BLOOD GAS;pCO2

LAB RESULT; <Observation>

Example: LAB RESULT;Phosphates

MEDICATION; <Observation>

Example: MEDICATION;Erythromycin

COMMENT

The actual comment is in the VValue field

VValue: [Text - Field Size 250]

This will generally contain the value 'null' except for the following Observation types:

SETTING, ALARM LIMIT, BLOOD GAS, LAB RESULT

The actual numerical value (as a string)

MEDICATION

The actual numerical dose (as a string)

COMMENT

The text of the comment

StartDateTimeDays: [Number - Long Integer]

The TSW uses its own system for measuring time. Days gives the "number of days that have passed since 12/30/1899" - i.e. the standard Windows measure. This gives the start of the interval. This field and the following field are taken from BabyWatch TTime when the TimeType is 0 or 1.

If the start time is not known this will be set to -365,000 (i.e. 1000 years ago - the 'infinite past').

StartDateTimeTicks: [Number - Long Integer]

'Ticks' gives the fraction of the day expressed in units of 1/10,000 second. If the start time is not known this will be set to 0.

EndDateTimeDays : [Number - Long Integer]

The end of the interval - this field and the following field are taken from BabyWatch TTime when the TimeType is 2.. If the interval is a 'point' then the end values will be equal to the start value.

If the end time is not known this will be set to 365,000 (i.e. in 1000 years time - the 'infinite future').

EndDateTimeTicks : [Number - Long Integer]

If the end time is not known this will be set to 0.

CreatedDateTimeDays: [Number - Long Integer]

This field and the following field give the date and time that the record was written to the intervals table; it has nothing to do with the date/time of the observation.

CreatedDateTimeTicks: [Number - Long Integer]

OriginatorType: [Text - Field Size 50]

This gives the type of person or program that originated the record. For BabyWatch data it is always 'Observer'.

OriginatorName: [Text - Field Size 50]

This gives the name of the person or program that originated the record. For BabyWatch data it is always 'LF'.

ContextDependentData: [Text - Field Size 250]

This is used for a variety of purposes depending on the channel type; if it is not used, it is empty. Specific uses are:

ACTION

Derived from the Agent field; it has the form **Agent=Nurse**; or **Agent=Doctor**; or **Agent=Parent**;

OBSERVATION

Derived from the Agent field; it has the form **Agent=Nurse**; or **Agent=Doctor**; or **Agent=Observer**;

BLOOD GAS

Derived from the BabyWatch Attribute field (which gives the site that the sample was taken from); it has the form **Site=<Attribute>**;

MEDICATION

Initially derived from the BabyWatch Attribute field (which gives the route of administration) but with other information derived by hand from post hoc analysis where available and significant; it has the form **Route=<Attribute>**;
Unit=<Units>; **DoseType=Maintenance|Loading**

COMMENT

Confirms that the comment has come from the Observer: **Agent=Observer**;