

**CLAIRE ROBERTS**

**D.O.B. 10<sup>th</sup> January, 1987**

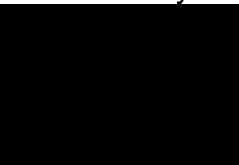
**Nursing care given at the Royal Belfast Hospital for Sick  
Children in October 1996.**

**FINAL REPORT**

**Report prepared by: Sally G. Ramsay**

**Report prepared for: The Inquiry into Hyponatraemia-Related Deaths in  
Northern Ireland.**

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E-mail:



Report of: Sally Ramsay  
Specialist field: Children's Nursing  
Child: Claire Roberts  
On behalf of: The Inquiry into Hyponatraemia-Related Deaths

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## **1.0 INTRODUCTION**

The following report includes the views expressed by me in earlier supplemental reports and addresses queries presented to me in a letter dated 6<sup>th</sup> June, 2012.

### **1.1 The writer**

I am Sally Grace Ramsay. I am registered with the Nursing and Midwifery Council (NMC) as both an adult and a children's nurse. I have managed children's services in both the NHS and independent sectors. My specialist fields are the nursing care of sick children, clinical governance and professional nursing issues. Full details of my qualifications and experience entitling me to give expert opinion are in Appendix 3.0.

### **1.2 Summary of the case**

Claire Roberts was born on 10<sup>th</sup> January, 1987. As a young child she experienced seizures that were treated with anti-epilepsy medicine. On 21<sup>st</sup> October, 1996, Claire became unwell and was admitted to the Royal Belfast Hospital for Sick Children.

By this time she had not had a seizure for several years and was no longer taking any anti-epileptic medicines. On admission to hospital Claire was unresponsive, but all her vital signs appeared normal. It was initially thought her symptoms resulted from a further seizure or encephalitis.

The day after admission it was noticed that the sodium level in her blood had fallen. Claire remained unresponsive and the diagnosis was changed to non-fitting status epilepticus. Early on the morning of 23<sup>rd</sup> October, Claire stopped breathing and her pupils became fixed and dilated. She was admitted to the intensive care unit where a diagnosis of brain stem death was made. Claire died later that day after her treatment was discontinued.

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### **1.3 Summary of my conclusions**

I have concluded that the initial nursing care given to Claire was appropriate for a diagnosis of vomiting due to a viral illness and a possible seizure.

The care plan was not revised when the diagnosis changed and did not fully indicate the care needs of a child with altered consciousness.

Urine output was not measured accurately and the ward-based urine test result was not recorded.

There were omissions in the recording of observations of blood pressure and respirations during the evening of 22<sup>nd</sup> October.

There was a failure to record when a doctor had been specifically informed of changes to Claire's vital signs or any seizures. However, I have concluded that Claire was seen by doctors on at least seven occasions and in my opinion they were aware of changes to her neurological status and vital signs.

I have also concluded that Claire needed 1:1 nursing and that she should have been transferred to a Paediatric Intensive Care Unit earlier in the day.

I believe that Claire's parents were unaware of the severity of her illness.

### **1.4 Parties involved**

Parents of Claire Roberts (deceased)  
Royal Belfast Hospital for Sick Children  
Inquiry into Hyponatraemia-Related Deaths in Northern Ireland

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## 2.0 THE ISSUES ADDRESSED

I have been asked to assist in:

- Analysing the documents including Reports and Statements
- Understanding the medical processes involved in Claire's care and subsequent death
- Identifying areas where other expert views should be sought
- Determining the further matters to be addressed in Witness Statements.

In addition I have been asked to comment on the issues identified by the Inquiry's expert advisors as listed in Appendix 1. My comments are included in Section 4 of the report.

## 3.0 MY INVESTIGATION OF THE FACTS

Claire was born on 10<sup>th</sup> January 1987. She had experienced seizures as a young child for which anti-epilepsy medicine was prescribed. This treatment had ceased eighteen months prior to her admission to hospital in October, 1996. Her last seizure was at the age of four.

Due to learning disabilities, Claire attended a special school. She was able to talk in meaningful sentences, feed herself with supervision and to walk up and down stairs. She was usually very active.

On 21<sup>st</sup> October 1996 Claire was taken to the Accident and Emergency Department of the Royal Belfast Hospital for Sick Children by her mother. The letter from the G.P. (090-011-013) gave the following information:

*"No speech since coming home. Very lethargic at school today. Vomited x3. Speech slurred, speech slurred earlier"*

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*"O/E<sup>1</sup> Pale, pupils reacting – does not like light. No neck stiffness, Temp. Tone ↑↑ R side plantar ↑↑.....L plantar ↓↓"*

Her chest was described as clear and there were no abnormalities of her ears, throat or nose. The G.P queried whether a further seizure had occurred or if there was an underlying infection.

At 19.03, a nursing assessment was undertaken in the Accident and Emergency Department (090-010-012). This was performed by either S/N Blue, the triage nurse or Staff Nurse Jackson the Named Nurse

*"Off form and lethargy.....H/O seizure. Apyrexia...pale and drowsy.....mental handicap"*

Vital signs were documented as *"T (Temperature) – 36.9, RR (Respiratory Rate) - 24, HR (Heart Rate) – 96."*

An examination of Claire's eyes showed the pupils were equal and reacting to light (PEARL). A urine collection bag (uri-bag) was placed and Emla<sup>2</sup> cream applied.

After being seen by the medical registrar, who gave a preliminary diagnosis of *"Encephalitis?"* (09-012-014) Claire was admitted to Allen Ward.

A nursing record sheet giving general information on admission (096-025-347) shows the reason for admission to Allen ward as *"?seizure, vomiting"*.

An entry in the medical record timed at 8pm on admission (090-022-050) states that Claire was *"not responding to parent's voice/intermittently responding"* and *"responding to deep pain"*. A viral illness was diagnosed.

At 9.45pm a form for **"Usual/normal routines"** (096-025-348) was completed. The nursing assessment section includes *"drowsy and lethargic on admission", Nurse beside*

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<sup>1</sup> Abbreviation for On Examination

<sup>2</sup> A local anaesthetic cream used before inserting an intravenous cannula

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*O2 (oxygen) and suction". "Nurse in bed with cotsides."* In the section for eating and drinking it is written *"Observe vomiting and offer clear fluids as tolerated. Ensure safe administration of IV fluids."* The section for breathing and circulation includes *"check P + resps 4 hourly"* (pulse and respirations). It is noted that Claire *"wears a nappy at night time"*.

Vital sign recordings made at 9.45pm (096-025-352, 096-025-348) show:

Temperature *"36.3, pulse – 120, respiratory rate -24 and blood pressure 116/66"*. Weight is shown as 24.1Kg (097-012-082).

The nursing care plan (097-012-110, 096-025-351) prepared on 21<sup>st</sup> October, 1996 by S/N McRandal includes two problems. The first, *Maintaining a Safe Environment*, identifies that *"Claire has the potential problem of further seizures"*. The goal of care is recorded as *"Safety will be maintained during a convulsion and the characteristics of the convulsion will be recorded."* Nursing actions listed include *"inform doctor of length and type of seizure"*. Daily review is indicated by the abbreviation *"R/V"*. The care plan contains pre-printed information to which care, specific to Claire, has been added.

The second problem identified concerns Eating and Drinking. The goal of care is recorded as *"to prevent dehydration and ensure safe administration of IV fluids"*. A lengthy list of interventions includes:

*"Observe and report episodes of vomiting"*.

*"Observe amount, colour and consistency of vomit"*

*"Record accurate fluid balance."*

Other entries relate to care of the intravenous infusion, oral fluids and diet.

The **Nursing Evaluation** (096-025-345) at 10pm shows that on admission to the ward Claire was *"pale and lethargic"*. *Apyrexia*<sup>3</sup> and that she may have had a seizure *"? seizure"*. Specimens of urine are recorded as tested *"direct"* and *"O+S"*. The result of any ward-based tests is not recorded.

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<sup>3</sup> Temperature was not raised

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At 12 midnight Claire was again seen by a doctor who described her as "*slightly more responsive*" (090-022-052). Instructions were to "*observe and reassess am*". At this time the sodium level was noted to be reduced "*Na 132 ↓*" (090-022-052)

The **Fluid Balance and I.V. Prescription** sheet (097-012-103) shows that an infusion of 5/N Saline at a rate of 64mls was started at 22.30. By 0700 on 22<sup>nd</sup> October, 1996, 536mls had been infused. Four "*small vomits*" had occurred and one instance of passing urine (PU), also described as "*small*". Claire passed a "*large*" volume of urine at 11.00 and a specimen was sent to the laboratory. She passed urine again at 1900 and 2100 hrs.

The **Evaluation** timed at 7am on 22<sup>nd</sup> October, 1996 (097-012-107) records that Claire had "*slept well*" and was "*much more alert and brighter*", but she had not taken any fluid orally.

Between 0800 and 1400 she "*slept for periods during the early morning*" but was "*bright when awake*". There was "*no vocalization*". Later in the morning "*Claire became lethargic and vacant*". It is recorded that "*Parents concerned as Claire is usually very active.*"

An untimed record of Dr. Sands' ward round shows "*has not spoken to parents as per normal, wretching. No vomiting. Vagueness/vacant (apparent to parents)*". It is noted that "*no seizure activity observed*". Possible problems are recorded as "*Non fitting status/encephalitis/encephalopathy*" (090-022-052, 090-022-053)

Between 7.45pm on 21<sup>st</sup> October and 12md on 22<sup>nd</sup> October, four recordings of temperature pulse and respiratory rate are shown on the **12 hour Respiration, Pulse and Temperature Chart** (096-125-352). One blood pressure recording is noted.



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Diazepam was given rectally at 12.15pm on 22<sup>nd</sup> October (096-025-028) and central nervous system observations ("CNS obs") started at 1.00pm (096-022-180).

The first entry on the **Central Nervous System Observation Chart** (097-012-105) shows Claire was responding to speech but did not respond verbally, although she obeyed commands. Her pupils reacted to light. The coma score was "9"

Dr. Webb, consultant neurologist, saw Claire in the afternoon, recording his observations in entries timed at 4pm and 5pm (090-022-053, 054, 055). He recorded that she "*appeared to improve after diazepam*" and was "*rouseable*" but "*not obeying commands*" (090-022-053). He felt Claire was showing signs of encephalopathy "*most probably post-ictal in nature*"<sup>4</sup>.

The prescription chart (096-025-280) shows phenytoin was given at 2.45pm. Midazolam (Hypnoval) was given at 3.25pm and Sodium Valproate (Epilim) at 5.15pm with the aim of controlling the seizures, although at the time these were not obvious. Intravenous Cefotaxime and Acyclovir were also prescribed and given.

At 3.10pm on 22<sup>nd</sup> October Claire had a seizure lasting 5 minutes. Details are recorded on the form **Records of Attacks Observed** (096-025-349). At 4.30 her teeth "*tightened slightly*" and at 7.15pm her teeth "*clenched and groaned*". At 9pm she had an "*episode of screaming and drawing up of arms*". Her pulse rate increased to 165 beats per minute (bpm). Her pupils are recorded as reacting to light. The last episode lasted 30 seconds and the doctor was informed, although there is no corresponding entry in the medical records.

The nursing evaluation recorded between 2pm and 8pm on 22<sup>nd</sup> October states "*very unresponsive – only to pain*". (096-025-346)

There are numerous entries on the **Central Nervous System Observation Chart** (097-012-105). They show that from 4pm on 22<sup>nd</sup> October, Claire did not open her eyes. After several recordings noting she did not respond verbally, from 6pm the "*incomprehensible*

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<sup>4</sup> The altered state of consciousness after a seizure

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*sounds*" box show ticks. In one entry at 8pm she apparently obeyed commands and this coincides with a coma score of 8. Subsequent recordings show the score reduced to 6. Several respiratory rate recordings are missing. The pulse rate entries vary between 84 and 120 and blood pressure is mostly 120/70 with a peak at 7pm of 130/70. Oxygen saturation is recorded as 99 and 98 between 4pm and 10pm and then 97 and 96 from then onwards.

In a medical record timed at 23.30 a sodium level of 121 is noted. Hyponatraemia is recorded as resulting from "*? fluid overload & low Na fluids*" and "*?SIADH<sup>5</sup>*". These findings were discussed with the registrar and the intravenous fluid reduced in volume. Urine testing for osmolality was ordered (090-022-055).

An evaluation sheet entry timed at 11pm, shows that the volume of intravenous infusion was reduced to 41mls hourly. "*observations within normal limits*" (097-012-106) is also noted.

At 2.30am on 23<sup>rd</sup> October, 1996, Claire stopped breathing. The evaluation record (096-025-344) show the doctor was contacted immediately and oxygen and suction given. Claire was transferred to the intensive care unit.

On admission to the intensive care unit a care plan was prepared. This includes an assessment of her condition/needs and goals and a plan of care (090-027-082). Evaluations are recorded for the morning and evening of 23<sup>rd</sup> October on a separate sheet (090-027-084).

On a **Relative Counselling Record** (090-028-088) details of two discussions between Drs Webb and Steen and Claire's parents are recorded. Information includes the explanation that "*Claire had swelling of the brain*" "*probably caused by a virus*". Her parents are described as "*distressed but understood the explanation*"

Brain stem death was diagnosed. Treatment was discontinued and Claire died later that day.

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<sup>5</sup> Inappropriate secretion of anti-diuretic hormone

## 4.0 MY OPINION

In sections 4.1.1 to 4.1.4 I have given my view of nursing activities in 1996. From 4.2 onwards I have given my opinion of the care given to Claire. I believe that I have answered the questions of the Inquiry's expert panel listed at Appendix 1.

### 4.1 Background information

#### 4.1.1 Nursing

Wong (1995) described three dimensions of nursing practice that I consider useful and applicable in 1996. **Dependent activities** were those areas of nursing practice where the nurse was accountable for implementing the prescribed medical regimen. **Interdependent activities** were those areas of practice in which medical and nursing responsibility and accountability overlap and require collaboration with other disciplines. **Independent activities** were those areas of nursing practice that were the direct responsibility of the nurse.

The boundaries between these activities have changed significantly since 1996 roles. In my view, examples applicable at the time were:

**Dependent** – administering prescribed medicines and intravenous therapy

**Interdependent** – assessing and measuring vital signs

**Independent** – positioning the patient in bed, maintaining a clear airway, meeting hygiene needs, involving the family in care.

Although nursing assessments contributed to the information needed to make a medical diagnosis, nurses were not responsible for making that diagnosis.

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#### 4.1.2 Care planning

Standards for record-keeping were issued by the United Kingdom Central Council for Nursing Midwifery and Health Visiting (UKCC)<sup>6</sup> in 1993. The purpose of the records was to provide accurate, current, comprehensive and concise information concerning the condition and care of the patient and record any problems that arise and actions taken.

All children admitted to hospital needed a care plan. These were either individually prepared or, for more common aspects of care, standardised and pre-printed. The care plan followed from an assessment of nursing care needs and reflected the care needs arising from the medical diagnosis. The care plan included goals of care and nursing interventions to achieve those goals. The care plan would normally be prepared within 24 hours of admission to hospital and reviewed and revised on a regular basis in response to changes in care needs, if an aspect of care was no longer needed or additional interventions were required. Examples would be where intravenous therapy has been prescribed as this requires specific nursing observations, interventions and recordings or the need for a coma score.

The UKCC Standards stated that *"The making of entries will be organised so that a measureable, up to date, description of the condition of the patient and the care delivered can easily be communicated to others."*

It was usual to evaluate care regularly, at least at the end of each shift, prior to handing over to another nurse. Depending on local work patterns this was usually after a 7.5 or 12 hour period. Good practice was to record important events or changes in the child's condition as soon as possible.

The care plan often included a separate sheet where communication with the family could be recorded.

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<sup>6</sup> Regulatory body for nursing, midwifery and health visiting in UK prior to Nursing and Midwifery Council

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#### **4.1.3 Assessing, measuring, monitoring and recording vital signs**

The term "observations" is commonly used to describe the assessment, measurement and monitoring of vital signs of temperature, heart rate, breathing (respirations) and blood pressure. In some instances oxygen saturation is included. It also includes broader aspects e.g. the child's behaviour, skin colour and pattern of breathing. Level of consciousness is included where this is an area of concern.

Claire's reduced level of consciousness was initially thought to have followed an epileptic seizure. It is not within my area of expertise to state how long a post-ictal state can be expected to last, although it is my understanding that it varies between children. On the morning of 22<sup>nd</sup> October, Claire's parents became anxious that she was lethargic and vacant.

To my knowledge, in 1996, there were no guidelines stating the frequency with which any observations should be made. Not until 2007 did The Royal College of Nursing issue guidance on minimum requirements for all children admitted to hospital. These did not include specific instructions regarding observation frequency.

In some instances guidelines for the nursing care of specific conditions were written by individual hospitals in the form of nursing practices and procedures manuals. It is likely that a children's hospital had such documents. It is unlikely, in my opinion, that these guidelines stated the precise frequency with which observations should be made. The frequency for some observations may have been included in pre-printed standardised care plans.

The frequency with which observations were made and recorded was determined by the child's condition and possible changes that could occur. In some instances, observations were performed to a pre-determined timing e.g. half hourly for four hours following surgery. In most instances the registered nurse with overall responsibility for the child's care would determine the observations to record, and change them as the child's condition improved or changed. This could be overseen by the ward sister or nurse in charge. A doctor could ask that specific observations were made and recorded

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and agreement with the medical team may have been needed before observations could be changed.

In my experience it was usual practice for nurses to initiate the recording of vital signs as determined by the child's condition and common practice on the ward.

In a recent study, Oliver (2010) found that a lack of consistency in recording vital signs persists. Despite additional education in a children's hospital, the percentage of observations recorded was less than desirable. Some essential observations, such as respiratory rate, were found to often be omitted. Medical consultant preference influenced the frequency of recording observations and which observations were carried out. From the medical notes it was evident that the person making decisions regarding observations varied. In my opinion, a similar situation was likely in 1996.

In 1998 Moules and Ramsay wrote "*Specific Neurological observations are important for almost any child with a neurological impairment.*" They list level of consciousness, pupil size and reaction to light, vital signs, motor function and posture as the elements for assessment. They also stated "*A decreasing level of consciousness is well known as an important sign of serious neurological damage*".

It is my opinion, that both doctors and nurses shared responsibility for ensuring vital signs were assessed and monitored as frequently as the child's condition required. The nurse's responsibility was to take appropriate action in response to any changes and, where necessary, to inform the nurse in charge or the doctor.

#### **4.1.4 Syndrome of Inappropriate Anti-diuretic Hormone Secretion (SIADH)**

Wong's 1995 book described SIADH as frequently accompanying diseases of the central nervous system such as head injury, meningitis, encephalitis and brain tumour. "*Scant quantities of urine are excreted*" and blood tests show there is hyponatraemia and hyposmolality. "*It is important to evaluate all parameters, since the reduced urinary output might be erroneously interpreted as a sign of dehydration.*" In the UK nurses did not request blood tests.

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I believe Wong's book was well-known in 1996. However, it is a large book and all nurses may not have been knowledgeable with regard to the totality of its content. During the early 1990's I was a member of many accreditation panels for P2000 Child Branch education programmes (courses leading to registration as a children's nurse). It is my recollection that many courses lacked clinical focus and there was a recognised disparity between nursing as taught and as practised. (A theory-practice gap) Consequently, it is my opinion that although SIADH may have been included in lectures on fluid and electrolyte balance and in some texts, nurses on a general ward had limited or no knowledge of it as a potential problem.

It was usual for some nursing text books to be available on a ward. In my opinion the following may have been available in 1996.

Wong (1995) Whaley and Wong's Nursing Care of Infants and Children  
Campbell S. & Glasper E.A. (1995) Whaley and Wong's Children's Nursing  
Brunner S. (1991) Lippincott Manual of Paediatric Nursing  
McQuaid L., Huband S. and Parker E. (July, 1996) Children's Nursing.

#### **4.1.5 Giving medicines**

In 1996 all medicines given by nurses required a signed medical prescription. The nurse was expected to give the medicines at the time prescribed and in accordance with the prescription, unless she had concerns. "*The nurse is responsible for ensuring that the correct child receives the correct dose of the correct medicine at the correct time and by the correct route*" (Moules & Ramsay 1998).

The nurse needed to have knowledge of the medicine, its use and side effects before proceeding to give it. She needed to check that it was appropriate for the child's age and condition and that the dose and route were suitable. Several reference points may have been used, such as previous knowledge; ward protocols; a formulary or a

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Paediatric Vade Mecum. The checking was, in most situations, performed by two nurses. However, in some circumstances it could be undertaken by one person.

Some intravenous medicines were only given by doctors. These were usually those that needed to be injected directly into the intravenous cannula and those that could result in sudden collapse if given too quickly. If the nurse had prepared the medicine for the doctor to give by drawing it into a syringe, she needed to ask the doctor to check that it was the right drug in the right dose.

From the prescription (096-025-280) I have concluded the following medicines were given by a doctor as the signature of the prescriber and that of the person giving the medicine are the same;

- 2.45pm Phenytoin
- 3.25pm Midazolam (Hypnoval)
- 5.15pm Sodium Valproate (Epilim)

The nursing records show that the first dose of Acyclovir was given by a doctor at 9.30pm on 22<sup>nd</sup> October (097-012-106).

Phenytoin could have caused abnormal heart beats. These could be identified by using a heart rate monitor. The first dose of phenytoin was given as an intravenous injection by a doctor at 2.45pm. There is no indication that Claire's heart was monitored at this time. As this was a medical procedure, I cannot comment on whether a heart monitor should have been used for this specific purpose. The second dose of phenytoin was initiated by a doctor at 11pm and given as an infusion over an hour and monitored by a nurse. There is evidence that during the phenytoin infusion a heart monitor was used (097-012-106). Although monitoring for heart abnormalities was only needed during the infusion and for a short time afterward and the oxygen saturation monitor would have given the pulse rate, I consider

Claire's general condition warranted continuous heart monitoring.



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The midazolam infusion was started by a doctor at 3.25pm (096-025-346) and ran continuously thereafter. Midazolam could have caused Claire's breathing to be depressed. She therefore, needed close observation during the midazolam infusion. In my opinion from the start of the midazolam infusion half-hourly respiratory observations should have been made and recorded.

#### **4.1.6 Communication**

Nurses have a key role in communicating with the family and ensuring their concerns are addressed. In practice this means listening to concerns and imparting information. However, it can be influenced by the nurse's knowledge and confidence. She should act to ensure parents are kept informed of a child's condition, treatment and progress by facilitating dialogue with the medical team or, if required, a more senior nurse.

In my view, it was usual to include brief details of communication with the family in the nursing record. However, it is not possible to prepare a verbatim record of all communication.

#### **4.1.7 Raising concerns**

Where a child's condition is causing concern either through personal observation or those of the parents, the nurse has a responsibility to consult with either the nurse in charge or a doctor.

It is my opinion that the name of the consultant only became important to the nurse, if she needed to query any aspect of the child's care. If the nurse was unhappy with the response of the junior doctor then she could call the registrar. Similarly, if she remained concerned, she could call the consultant. However, some hospital policies required this to be sanctioned by the senior nurse manager on duty. To bypass the registrar in this way did, however, require confidence and experience as well as a consultant who welcomed such calls. I doubt if this was a regular occurrence in 1996 when hospital cultures were more hierarchical than they are today and many nurses less assertive.

The consultant to whom the nurse needed to speak could vary according to the day of the week and the time of day. Unless the consultants did a continuous on-call rota, then

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out of normal working hours the nurse would have called the consultant on call who may not have been the named consultant for a given child.

The identity of the child's consultant was usually recorded on the nursing records and I note that Claire's consultant was Dr. Steen. It would not have been usual to make specific reference to this during the nursing handover. However, I believe the nurses could have concluded that Dr. Webb had taken over her care. Claire had neurological problems. Dr. Webb was a consultant neurologist and spent a length of time examining Claire and interviewing her mother, whereas Dr. Steen did not visit Claire.

#### **4.2 Nursing care - Accident and emergency department**

Claire's vital signs of temperature, pulse, respirations and blood pressure were recorded at 19.03, approximately 20 minutes after she arrived in the Accident and Emergency Department. She had been vomiting that day and was known to have epilepsy. She was drowsy, but not unconscious.

At 19.15 she was examined by Dr. Pathuchearry and later by Dr. O'Hare who gave a primary diagnosis of encephalitis (090-012-014). I believe the record of his examination is the entry in the main medical record timed at 8pm (97-012-083).

It is difficult to determine how long Claire remained in the department before being transferred to Allen Ward. The decision to admit is recorded as 20.45 (090-012-014) and the admission to Allen Ward as 9.45pm (096-025-347). Thus there was approximately 2 hour 45 minutes between the initial vital sign recordings and transfer. During this period Claire was examined by two doctors and her mother was in attendance and it appears there was no change in her condition. Although I consider further recordings of vital signs should have been made during that period, this had no effect on subsequent events.

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### 4.3 Nursing Care – Allen Ward

#### 4.3.1 Care plan

When Claire was admitted to Allen Ward at approximately 21.45 hrs on 21<sup>st</sup> October, 1996 the nurse's understanding of the reason for her admission was a possible seizure and vomiting (096-025-347, 096-025-345). The initial nursing documentation makes no reference to the possibility of encephalitis as shown in Dr. O'Hare's entry on the Accident and Emergency sheet. The Nursing Care Plan reflects the potential problem of further seizures (097-012-110) and the corresponding nursing actions. The nurses were aware that Claire had a history of seizures.

The second problem identified relates to vomiting and Claire's need for an intravenous infusion (096-025-351). The nursing actions listed are aimed at preventing dehydration and ensuring the safe administration of intravenous fluids. They include the need to "*record accurate fluid balance chart*".

It is my opinion that the care plans reflect the identified problems associated with a diagnosis of seizures and vomiting. The nursing actions listed are comprehensive and were prepared in a timely manner. However, I believe more frequent observation of some vitals signs should have been made. (see 4.3.2)

The nursing evaluation (096-025-345) shows that Claire was lethargic and vacant and that her parents were concerned as she was usually active. She was examined by Dr. Sands during the morning ward round on 22<sup>nd</sup> October. The note recorded by the SHO (090-022-052) shows a diagnosis of non-fitting status epilepticus/encephalitis/encephalopathy. I believe this warranted a care plan entry related to on-going monitoring of level of consciousness as there was the possibility of deterioration.

The care plan was not changed and consequently I do not think it reflects the potential severity of Clare's condition. Although the non-fitting nature of the convulsions is recorded in the evaluation, this information may have not been obvious over time and consequently an entry in the care plan was, in my view, needed.

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*"Level of consciousness remains the earliest indicator of improvement or deterioration in neurological status. LOC is determined by observation of the child's responses to the environment. Motor activity, reflexes, and vital signs are more variable and do not necessarily directly parallel the depth of the comatose state."* (Wong, 1995)

In my opinion, level of consciousness can be assessed regularly through interaction with the child and communication with the family. It would not have been usual to make recordings at specified intervals unless there was a specific concern. The nursing evaluations show that although this had not been identified as a specific problem in the care plan, from the time of admission nurses were observing and recording Claire's level of consciousness, *"bright when awake, no vocalization."* (096-025-345).

While nurses can assess, identify problems, plan and implement care without documentation (Wong, 1995) I consider the implementation of a Coma Score (Central Nervous System Observation Chart 097-012-105) should have been separately identified. Given that preparing a detailed care plan often needs to be balanced against the child's immediate care needs I believe the information recorded could have been similar to the following

Nursing problem: Altered level of consciousness

Nursing goal: to detect changes in level of consciousness  
to prevent complications

Nursing intervention: assess and record vital signs using a coma scale hourly

Inform doctor of any changes

Maintain airway

Monitor oxygen saturation

Nursing problem: Seizures resulting from non-fitting status epilepticus

Nursing goal: to minimize seizure activity

Nursing intervention: Administer medicines as prescribed

Observe for cardiac arrhythmias during phenytoin infusion

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Monitor respiratory rate and observe for respiratory depression  
Observe and record seizures

**Nursing problem:** Possible respiratory difficulties due to reduced level of consciousness

**Nursing goal:** Ensure optimum ventilation

**Nursing interventions:** Observe and monitor breathing and colour

Nurse in a position to maintain a clear airway and prevent aspiration (of stomach contents)

Record and monitor oxygen saturation

Turn 2 hourly

**Nursing problem:** Possible aspiration due to reduced consciousness

**Nursing goal:** Prevent aspiration

**Nursing intervention:** Pass naso-gastric tube

Aspirate stomach contents hourly

Measure and record volume of aspirate

It is also my opinion that Problem 2 Eating and Drinking should have been changed as nursing actions in relation to oral fluids and light diet were no longer applicable when Claire was unconscious. (096-025-351).

The unconscious child also has nursing needs concerning mouth, skin, eye care and elimination, positioning. Although these should be recorded in a care plan, when a child is acutely ill it may take longer to document these aspects of care. However, it appears that there were no alterations to the care plan prepared on 21<sup>st</sup> October, despite changes in Claire's condition and nursing needs.

By 3pm when the coma score was 7 I believe Claire needed 1:1 nursing in order to facilitate continuous observation and monitoring. There is no record to show this was the situation.

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#### 4.3.2 Monitoring of vital signs and neurological status

I have based my opinion on the following normal ranges for vital signs:

Wong (1995)

Heart rate – resting (awake), 70-110, resting (sleeping) 60-110, exercise (fever) up to 180

Respiratory rate – 19/20

Temperature – 36.7

A normal blood pressure is age, height and gender related and there is a range of acceptable limits for each age and group<sup>7</sup> Blood pressure values varied between authors and textbooks at that time and did not list values for every age throughout childhood. Wong (1995) gave the following values for 9 year old girls in accordance with the percentile measurement. (Percentile charts give a measurement of a child's height and weight compared to other children)

Percentile <sup>8</sup>	5th	10th	50th	90th	95th
Systolic	81	86	100	115	119
Diastolic	44	48	61	74	77

Moules and Ramsay (1998) gave a range of 96-102 for the systolic pressure in girls aged between 6 and 10 years.

Many factors can influence blood pressure in the hospitalised child e.g. stress, medicines, medical diagnosis. Common factors making readings difficult to interpret can be movement artefacts, distress from discomfort and fitting (Kelsey & McEwing, 2008)

I consider nurses needed to know the spectrum of values for children's blood pressure. Mallett and Dougherty (2000) stated that blood pressure was measured for two reasons:

<sup>7</sup> <http://www.gosh.nhs.uk/clinical-information/clinical-guidelines/cpg-guideline-00039>

<sup>8</sup> Growth parameters are plotted on percentile chart

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- To determine the patient's blood pressure on admission as a baseline for comparison with future measurements.
- To monitor fluctuations in blood pressure.

It is likely that in 1996 blood pressure recordings were made using a manual sphygmomanometer rather than an electronic device. User error was a recognised problem associated with manual recordings, particularly through using the wrong size of cuff. It is my recollection that doctors often took their own measurement as part of the initial medical assessment.

It would not have been usual practice for a hospital nurse to determine a child's height and weight percentiles in order to calculate an absolute normal value for blood pressure. Due to the complexity of blood pressure values and their variability at any given time, I am unable to be specific about what blood pressure would have been "normal" for Claire.

On admission the blood pressure of 116/66, in my opinion, was within normal parameters. Overnight on 21/22 October, temperature, pulse and respirations were recorded 4 hourly. Initially these observations were slightly elevated but by 6am they were within normal limits. There is no evidence, in my view, to show that the doctors caring for Claire felt her condition warranted more frequent observation at that time.

Claire was described as being "*pale and lethargic*" following a presumed seizure. I consider that hourly recordings of heart rate, respiratory rates and level of consciousness were indicated to ensure she was checked regularly and was not experiencing further seizures. Despite the infrequent vital sign recordings overnight and lack of regular recording of level of consciousness, pupil size and blood pressure, Claire was observed to be "*more alert and brighter*" on the morning of 22<sup>nd</sup> (096-025-345). She was seen and examined several times by doctors, none of whom specifically requested recordings of Coma Scale at that time. However, at 13.00 when the diagnosis changed to non-fitting status epilepticus or encephalitis/encephalopathy, coma scores were initiated.

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Later blood pressure recordings in excess of 120 systolic, were marginally above normal and I believe these could have been interpreted as indicative of the diagnosis of non-fitting status epilepticus.

Observations in accordance with the coma scale were made hourly from 1pm. At 3.10 Claire had a seizure lasting 5 minutes. In my opinion this was a significant change to her condition as she had not previously shown any abnormal movements. A doctor should have been informed, but there is no record to this occurred. However, shortly afterwards she was seen and examined by Dr. Webb who confirmed the coma scores should continue. Whether he was aware of the observed seizure is unknown, but I have concluded the information on the chart was available for him to check.

The medical records indicate that at this time Claire was "*still in status*" (090-022-055) for which diazepam, midazolam, phenytoin and sodium valproate were prescribed and given. All of these cause drowsiness.

The coma scores for 4pm and 5pm were 6. Dr. Webb was again present at this time and it is my view that he was aware of Claire's general condition. Neurological assessment and Glasgow Coma Scores can vary according to the experience of the practitioner. The nurse recorded a score of 6 at 4pm, yet Dr. Webb's entry in the medical record at the same time showed that Claire was "*rousable*" "*eye opening to voice*" "*non-verbal*" and "*withdrawn*". His later entry at 5pm also coincided with a further nursing score of 6. At 5.15pm a doctor gave an injection of sodium valproate (096-025-280) and therefore there was an opportunity for the nurse to inform him of the coma scores, although there is no written confirmation that this information was passed on.

The two respiratory rate recordings of around 30 made at 4pm and 8pm were above the level recorded earlier in the day. Claire was seen at 5.15pm by a doctor who gave sodium valproate and again by Dr. Webb at 6pm. Any problems with her breathing could have been noted by them.

At 7pm on 22<sup>nd</sup> the blood pressure was recorded as 130/70 and a corresponding fall in pulse rate to 100 although this was higher than the rates recorded earlier in the day.



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Fifteen minutes later an episode of groaning and teeth clenching occurred. I believe this information should have been shared with a doctor. *"Change in pulse and blood pressure are important indicators of disturbed autonomic activity which occurs in deep coma and brain stem lesions. The bradycardia (slow pulse rate) and hypertension (raised blood pressure) seen in adults when intracranial pressure is raised is rarely seen in children. When it occurs it is a late sign"* (Moules & Ramsay, 1998)

A temperature of 38° was recorded at 8pm and paracetamol given at 20.30. It is possible that the Paracetamol had been prescribed earlier in order to prevent delays if Claire was experiencing pain or fever. Consequently a doctor may have been unaware of her raised temperature. Since admission Claire's temperature had been normal and therefore an increase was a new feature that needed a medical explanation.

After a peak of 8 at 8pm, the coma scores reduced and remained at 6 from 9pm onwards. The midazolam infusion was in place at the time. However, it is not within my area of expertise to comment on whether this affected the coma score. As Dr. Webb had seen Claire earlier when the score was 6, I think its return to that level did not cause undue concern to the nurse caring for her. The score of 6 at 9pm coincided with an episode of screaming which was reported to a doctor (096-025-349). It would have been usual to also record such an event in the main nursing evaluation and to add any further action needed. My view is that failure to record this significant event was a failure in record-keeping. There is no corresponding entry in the medical record to confirm a doctor had been informed. However, it is not within my area of expertise to comment on the quality of entries in the medical record. I believe Acyclovir was given by a doctor at 9.30pm. Consequently, there was the opportunity for medical review at that time.

No blood pressure recordings are shown for 10, 11 and 12pm. As this was the time that Acyclovir and phenytoin infusions were started, the nurse may have been too busy to record the blood pressure reading. However, these were serious omissions in record-keeping and in my opinion blood pressure readings should have been made.

Respiratory observations are absent from the chart for 5, 6, 7, 8, 10 and 11pm. The omission of respiratory observations is not uncommon. However, this was during a

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period when Midazolam was being given and respiratory depression could have occurred. It is my opinion that these observations should have been recorded at least every 30 minutes during the infusions. The respiratory rate was elevated at times at 30 breaths per minute but Claire was not showing signs of respiratory distress. It is not known whether a doctor was aware of this but it would have been seen during the examination by Dr. Webb.

An oxygen saturation monitor records the amount of oxygen in the circulating blood. McQuaid et al (1995) stated "*The saturation rate should be kept above 92%.*" In the healthy child the percentage saturation of oxygen should be 95-98% (Sims, 1996<sup>9</sup>). Age does not affect the value. Claire's saturation reduced from 99% to 96% by 12mn and coincided with a continuing coma score of 6. Combined with a raised temperature, blood pressure and respiratory rate I believe this needed a medical explanation.

The diagnostic possibilities for Claire's condition were non-fitting status epilepticus, encephalitis and encephalopathy. Whatever the cause of her condition the manifestation was unconsciousness and this was, in my view, the main consideration that should have underpinned her nursing care. Wong (1995) stated "*Encephalitis is an inflammatory process producing altered function of various parts of the brain and spinal cord. Nursing care is the same as for any unconscious child..... This includes conscientious nursing care, control of cerebral manifestations, adequate nutrition and hydration and observation.*"

I believe closer observation was needed to ensure her airway was clear as there was a risk that Claire's breathing could be affected. It is my view that Claire's need for diazepam, midazolam and phenytoin to control the seizures indicated the severity of her illness. At this time, her level of consciousness combined with the sedative effect of the medicines could have resulted in breathing difficulties. Observations and recording of heart rate and breathing every 30 minutes were needed and should have started at or around 2pm. I consider these and increased general observation were best provided by 1:1 nursing care.

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<sup>9</sup> Cited in Trigg E. Huband S. (2000) Practices in Children's Nursing London:Churchill Livingstone

### 4.3.3 Urine testing and measurement

A bag to collect a specimen of urine for routine testing was placed in the Accident and Emergency department. At 10pm on 21<sup>st</sup> October, the nursing evaluation shows urine specimens “direct” and “o/s”. (096-025-345). There are corresponding laboratory reports for these two specimens (090-030-094).

At the time it would have been usual for all children admitted to hospital to have their urine tested on the ward by a nurse. It is a mechanism for identifying abnormalities that require laboratory analysis. In my experience it would have been usual for the nurse to record the results of the test performed on the ward, informing the doctor of any abnormalities. The doctor usually ordered and responded to the laboratory test.

There is no record to show that a specimen or urine was tested by a nurse on the ward.

The method for ward-testing urine was and still is, to dip a urinalysis reagent strip into a urine sample. This requires urine to be collected in either a container or a bag applied to the skin. The reagent strips have absorbable pads that respond and react to the urine to give a degree of positive or negative result for elements in the urine e.g. blood, protein, ketones, glucose (Kelsey & McEwen, 2008). A value is also given for Ph (acidity) and specific gravity. “*Specific gravity measurement gives an indication of the solute content. The normal range is 1.001-1.025*”. (Huband & Trigg, 2000). A high specific gravity can indicate dehydration and the presence of protein or glucose, whereas a low result can result from excessive fluid intake, insufficient anti-diuretic hormone (Wong, 1995). The nursing role was to test the urine and record the results.

It would not have been usual, in my experience, to test every urine specimen. Neither was specific gravity used routinely to assess hydration. It is not within my area of expertise to comment on the relevance of urinary specific gravity in hyponatraemia.

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Failure to note the results of the ward-based test is an omission in nursing care as it was part of the admission assessment. Lawrence (1998) listed ward urine testing as one of the seven essential skills for children's nurses. As a specimen had also been sent to the laboratory for assessment of osmolality "O/S) (a more accurate measure of solutes) I do not think this omission was of major significance at this time.

Claire was vomiting and required intravenous fluids. The care plan (096-025-351) clearly states that an accurate fluid balance chart was required. The fluid balance charts (097-012-102, 096-025-340) appear to show accurate recordings of fluid intake, considering it is not always possible for the nurse to record information at a precise time i.e. on the hour.

The fluid charts show seven entries for small vomits, but their colour is not described. The amount of vomit is difficult to estimate as it may be absorbed into clothing or bed linen. Commonly the terms small, medium and large are used to indicate volume and, therefore, the record is appropriate.

It is good practice to record the colour of vomit as this can aid diagnosis e.g. clear, bile-stained, blood-stained. In view of Claire's reduced level of consciousness and potential risk of inhaling vomit, I consider a naso-gastric tube should have been passed. Regular aspiration of the tube may have prevented vomiting and allowed for more accurate monitoring of the volume and colour of any aspirate. A naso-gastric tube was usually passed with medical agreement. I believe this should have been considered when the coma score was introduced and before the midazolam was given as there was a potential impact on Claire's breathing and, in my view, a greater risk of inhaling stomach contents.

Urine output is only shown as "PU", indicating that it was not measured. In the period between admission and 1800 the following day, "PU" is noted twice with approximately seven hours in between. In my opinion this is not an accurate measurement of output. However, I believe it was custom and practice in many situations to only record the frequency of passing urine and not the volume.

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Wong (1995) regarded "*observations for the signs of altered fluid balance related to abnormal pituitary secretions*" (SIADH) as part of nursing care for the unconscious child. In my opinion, the nurses should have been aware of the possibility of either dehydration or fluid overload in a child with altered consciousness. Urine output could easily have been measured by weighing the nappies before and after use. Although not accurate, this would have been a more useful indicator of fluid balance and reduced urine output may have been more obvious. Wong (1995) regarded an accurate recording of output in children receiving intravenous therapy as a nursing responsibility. Claire was receiving intravenous therapy and, therefore, all urine output should have been measured. Completely accurate measurement can only be achieved by inserting a urinary catheter and this was a medical decision.

#### **4.3.4 General condition**

I have seen nothing in the nursing records to indicate the nurses perceived Claire's condition as unduly serious. I believe they were acting on the understanding that Claire was experiencing seizures and that these needed to be brought under control. However, a diagnosis of status epilepticus should have prompted greater concern. Wong (1996) described status epilepticus as "*a medical emergency requiring immediate intervention to prevent possible brain injury or death.*"

There is nothing to indicate that Claire's level of consciousness was of particular concern to the medical team. It is not within my area of expertise to comment on the level of coma scale that should have given cause for medical concern.

Nurses would, in my experience, become aware of a change of diagnosis through either direct communication with the doctor, or indirectly by checking what had been written in the medical notes. It was usual for a nurse to be present during ward rounds and good practice for the doctor examining a patient to be accompanied by the nurse. However, in reality this was not always possible. When a nurse was not present information could be gained from the parents by asking what the doctor had told them.

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In my experience the severity of a child's illness is usually recognised through discussion between doctors and nurses in addition to the signs and symptoms. Claire's outward signs should have indicated to nurses that she was seriously ill and discussion with the doctors should have told them the possible progress of her illness.

Wards, in my experience, operated with a chain of command. When a nurse was concerned about a child she would share this with the nurse in charge and/or the junior doctor if he/she was present. In most instances it would be for the junior doctor to contact the registrar, possibly prompted by the nurse. The registrar or junior doctor would contact the consultant. However, if the nurses felt their concerns were being inappropriately ignored, then contacting the consultant was an appropriate action.

When professionals work as a team it can be difficult to clarify who has responsibility for passing information to other team members. The nurse had a duty, in my view, to ensure a doctor was aware of any changes in Claire's condition. I think it was reasonable for the nurse to share information with Dr. Webb and to assume that he had a responsibility for her care. In every day practice it was usual for the nurse to ensure the person with most frequent contact with the patient, usually the SHO, had up to date information. I think it was reasonable for the nurse to assume that Dr. Webb, a consultant neurologist, had advised the SHO, registrar or other consultant of his findings.

I think a doctor should have been aware of the following:

- 3.10pm seizure
- 5pm – failure to pass urine for six hours
- 7pm when the blood pressure was 130/70
- 9pm when the coma score was at 6
- 9pm episode of screaming and raised pulse rate

The nursing record shows the doctor was informed of the episode at 9pm, but this is not confirmed by an entry in the medical record. It is not within my area of expertise to comment on whether a doctor should have recorded this information.

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#### 4.3.5 Level of nursing

In my experience it was often difficult to provide 1:1 nursing on a general ward as there were usually insufficient nurses. The administration of midazolam and phenytoin intravenously is not without risk and when these medicines are given an appropriately equipped high dependency or intensive care setting is preferable.

*"A Glasgow Coma Score of 8 or below is generally accepted as a definition of coma"* (Wong, 1995). In describing coma, Hazinski (1992), cited in Wong (1995) states *"no motor or verbal response to noxious (painful) stimuli."* I think a score of 8, combined with the need for complex intravenous therapy should have prompted discussion between nursing and medical staff regarding admission to a Paediatric Intensive Care Unit. Given Claire's level of consciousness, diagnosis, anti-epileptic treatment and level of nursing dependency I believe she should have been admitted to an intensive care unit. My opinion is that this should have been at around 3pm when the coma score was 7 and a midazolam infusion was planned to start shortly afterwards. However, admission to PICU was usually a decision made by senior doctors and, therefore, I am unable to give an opinion on whether there were sufficient medical reasons to require such an admission. It is, however, my opinion, that Claire's nursing care needs at this time were above those that could reasonably be provided on a busy general ward.

I do not know the general criteria applicable to intensive care in Northern Ireland in 1996. However, I have based my opinion on the National Co-ordinating Group definitions derived from Paediatric Intensive Care Society Standards for Paediatric Intensive Care 1992, Revised 1996.

**Paediatric high dependency care - Level 1** - a child who requires closer observation and monitoring than is usually available on a general children's ward. For example the child may need continuous monitoring of the heart rate, or non-invasive blood pressure monitoring. High dependency is sometimes provided as a step down from intensive care.

**Paediatric intensive care - Level 2** - a child who will always require continuous nursing supervision and who may need ventilatory support, or support for two or more

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organ systems. Sometimes the child will have one organ system needing support and another suffering from chronic failure. Usually children receiving level 2 care are intubated to assist breathing.

#### **4.3.4 Communication**

Nurses by their code of conduct are expected to work openly and collaboratively with parents and colleagues. Information shared with the family often depended on the nurse's knowledge, experience and confidence. She would share information, explain what was happening, listen and respond to the parents' concerns and ensure someone was available to answer their questions and give explanations.

Most entries in the nursing evaluations concerning Claire's parents show they were either in attendance or not. One entry shows "*parents concerned as Claire is usually very active.*" (096-025-345). There are no records giving even brief details of information shared with them and any discussions they had with a doctor.

It is my opinion that as a minimum there should have been a record of the information given to Claire's parents, their understanding and concerns. An example of what I would expect to have been noted is "*Parents anxious that Claire is not responding as usual. Seen by Dr. X who has advised them of likely brain problems. Medicines have been explained and parents appear to understand.*"

Nurses should have ensured the parents understood the diagnosis, its implications and treatment needed. They should have explained the medicines, what they were used for and any potential side-effects. The parents should have been told why the observations were being made and given explanations of the on-going process.

In many instances the nursing records included a section to show how parents would be involved in their child's care e.g. bathing, teeth cleaning. There was also a section where information shared with the family, or anxieties expressed by them could be recorded. Other than for PICU no such records have been made available to me. It is, therefore, not possible to judge the quality of information given to the family. I note, however, that



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Claire's parents were not present when she deteriorated. It is likely, in my opinion, that had they been aware of the severity of Claire's condition they would not have left the hospital.

#### **4.4 PICU**

The nursing care plan is of an appropriate standard. There are records giving details of the discussion between the doctors and Claire's parents. I believe these are a satisfactory record.

#### **5.0 CONCLUSION**

I have concluded that the initial nursing care given to Claire was appropriate for a diagnosis of vomiting due to a viral illness and a possible seizure.

Parental anxiety and a diagnosis of non-fitting status epilepticus or encephalitis/encephalopathy for which diazepam, midazolam and phenytoin had been prescribed were indications, in my opinion, that she was seriously ill.

It is my view that urine output was not measured accurately and the ward-based urine test result was not recorded.

There were omissions in the recording of observations of blood pressure and respirations during the evening of 22<sup>nd</sup> October. Failure to record when information concerning changes in observations had been passed to a doctor suggests that information may not have been shared. However, I have concluded that Claire was seen by doctors on at least seven occasions and in my opinion they were aware of her changes to her neurological status and vital signs. Charts would have been readily available for them to check.

I have also concluded that Claire needed 1:1 nursing and that should have been transferred to a Paediatric Intensive Care Unit earlier in the day.

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## 6.0 STATEMENT OF COMPLIANCE

I understand my duty to the Court, and have complied with that duty.

## 7.0 STATEMENT OF TRUTH

I confirm that I have made clear which facts and matters referred to in this report are within my own knowledge and which are not. Those that are within my own knowledge I confirm to be true. The opinions I have expressed represent my true and complete professional opinions on the matters to which they refer.

Signed



Date

17th June, 2012

14 June, 2012

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## APPENDIX 1

### Issues identified by the Inquiry's expert advisors

- (i) The appropriate level of observation of Claire by nursing staff, including the type and frequency of observations, and the observations performed by nursing staff in:
  - Accident and Emergency
  - Allen Ward
  - PICU
- (ii) The person who (a) was and (b) should have been responsible within the nursing staff for determining the type and frequency of observations undertaken on Claire
- (iii) How the observations made by nursing staff were interpreted, particularly in relation to both Claire's history and her age.
- (iv) The level of understanding the nurses had regarding the severity of Claire's condition
- (v) The level of nursing care and monitoring you would have expected Claire to receive, especially after 1700 on 22<sup>nd</sup> October, 1996.
- (vi) The significance of a Consultant not have been called at 2100 on 22<sup>nd</sup> October when Claire's neurological status deteriorated, and whether it would have been usual/unusual for a nurse in those circumstances to have called a consultant if she was worried about a child's condition.
- (vii) The management of Claire's fluids in relation to:
  - Fluid intake
  - Fluid output
  - Monitoring and fluid balance
- (viii) The management and recording of vomiting, both overall and when the GCS fell below 9.
- (ix) The practice and procedure in November 1995 for measuring and recording losses and urinary output, including RBHSC policies for these. In particular, comments on whether nappies were weighed to measure urine loss.

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(x) The management and recording of medication administered to Claire

(xi) The communication by medical staff with colleagues and with Claire's family, including:

- How nurses raised concerns about a child's condition or management at the time and the level of responsibility/proactivity expected at the time.
- The quality of information given to Claire's family by nurses during Claire's hospital stay.
- The response by nurses to information given by the family about Claire's normal behaviour or when the family expressed concern.

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## APPENDIX 2

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Report of: Sally Ramsay  
Specialist field: Children's Nursing  
Child: Claire Roberts  
On behalf of: The Inquiry into Hyponatraemia-Related Deaths

## APPENDIX 3

### DETAILS OF MY QUALIFICATIONS AND EXPERIENCE

#### PROFESSIONAL QUALIFICATIONS

Registered Nurse (Adult)	Nursing and Midwifery Council	1972
Registered Nurse (Child)	Nursing and Midwifery Council	1974

#### CURRENT EMPLOYMENT

##### **Self-employed Children's Nursing Advisor**

**2003-present**

Work has included:

- Member, Review Team, Safe and Sustainable Children's Heart Surgery in England (on-going)
- Member, Review Team, Safe and Sustainable Children's Heart Surgery Services in Northern Ireland
- Member, National Clinical Advisory Team, Review of Neonatal Services, Norfolk, Suffolk and Cambridgeshire.
- Preparing standards, competence based education and training frameworks and other documents for the Royal College of Nursing.
- Preparing expert witness reports
- Reviewing nursing services in independent schools
- Nursing and Midwifery Council – Reviewer for nurse education programmes
- Implementing clinical governance in a children's service of an NHS Trust.
- Interim.
- Director of Governance, Royal Orthopaedic Hospital, Birmingham – 2 periods
- Practitioner panellist, Fitness to Practise Investigating Committee, Nursing & Midwifery Council
- Bank staff nurse, NHS Professionals

#### CAREER HISTORY

##### **Portland Hospital for Women and Children**

**2002-2003**

Independent hospital providing maternity, neonatal and children's services  
**Chief Nursing Officer**

Responsible for:

- Managing nursing and midwifery service.
- Implementing clinical governance strategy
- Clinical risk/complaints management
- Compliance with National Minimum Care Standards
- Nursing/midwifery development, education and training

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14 June, 2012

**Report of:** Sally Ramsay  
**Specialist field:** Children's Nursing  
**Child:** Claire Roberts  
**On behalf of:** The Inquiry into Hyponatraemia-Related Deaths

**Great Ormond Street Hospital for Children NHS Trust** **1994-2002**

Director of Nursing and Family Services  
Director of Nursing, Quality and Clinical Support

Responsible for:

- Standards of nursing practice, education, training and research.
- Managing clinical risk, complaints and litigation.
- Managing Professions Allied to Medicine
- Managing family support services

**Hospitals for Sick Children, Special Health Authority.** **1992-1994**

Director of Nursing

**Guy's and Lewisham NHS Trust** **1990-1992**

Clinical Services Manager – Paediatric and neonatal services.

**Ealing Hospital** **1988-1990**

Manager, Children's Service

**Guy's Hospital** **1986-1988**

Nurse Manager – paediatric and neonatal intensive care unit

**Various posts at Nurse Manager, sister and staff nurse level** **1972-1990**

**Renal nursing course, Guy's Hospital** **1974**

**EDUCATION**

M.Sc. Nursing, King's College London **1992**

B.A. (Hons), Social Science, 2:1, Middlesex Polytechnic **1986**

**PROFESSIONAL ACTIVITIES**

Member, National Co-ordinating Group on the Provision of Paediatric Intensive Care 1996-1997  
United Kingdom Central Council for Nursing, Midwifery and Health Visiting Council Member 1995-2002

Member, Chief Nursing Officer's Task Force on the future nursing workforce in paediatric intensive care, 1997.

Member - the Expert Working Group on Alarms on Clinical Monitors in Response to Recommendation 11 of the Clothier Report: The Allitt Enquiry (1996)

Bond Solon expert witness training in 2002.

**Report of:** Sally Ramsay  
**Specialist field:** Children's Nursing  
**Child:** Claire Roberts  
**On behalf of:** The Inquiry into Hyponatraemia-Related Deaths

### **VOLUNTARY ACTIVITIES**

World Child Cancer - Trustee	2010
CLIC Sargent – Children's Cancer Charity – Trustee	2004-2010
Chronic Granulomatous Disease Research Trust – Nursing Advisor	2009 - present

### **PUBLICATIONS**

Ramsay S. Treading the wards again (2004), Paediatric Nursing 16(3)  
Nethercott S. (1999) Child Support. Nursing Standard 13(17)  
Nethercott S. (1994) The assessment and management of post-operative pain in children by RSCN's: an exploratory study. Journal of Clinical Nursing 3, 109-114  
Nethercott S. (1993) A concept for all the family. Family centred care: A concept analysis. Professional Nurse 8(12), 794-797

### **Documents written for the Royal College of Nursing**

- Restrictive physical interventions and therapeutic holding for children and young people. (2010)
- Standards for admission to and discharge from hospital (awaiting publication)
- Mental Health in Children and Young People – A toolkit for general nurses (2009)
- An Education and Training Competence Framework for Intravenous Cannulation in Children and Young People (2005), updated 2009
- An Education and Training Competence Framework for Administering Medicines Intravenously in Children and Young people. (2005), updated 2009
- An Education and Training Competence Framework for Capillary Blood Sampling in Children and Young People. (2005) updated 2009
- Managing fever in infants, children and young people (2008)
- Malnutrition: What nurses working with children need to know and do. (2006)
- Bottle feeding: A guide for nurses (2007)
- Measuring and Recording vital signs in infants, children and young people: an education and training competence framework (2007)
- Standards for assessing, measuring and recording vital signs in infants, children and young people (2007)



# Observations and monitoring: routine practices on the ward

Alison Oliver and colleagues found a lack of consistency in recording vital signs which needs to be addressed if early warning systems are to be implemented

## Abstract

**Aim** To review routine observations on all children admitted to the Children's Hospital for Wales and the feasibility of implementing an early warning score for children developing critical illness.

**Method** Nursing staff, while performing their routine duties, recorded the physiological observations of temperature, heart rate, respiratory rate and blood pressure, as well as identifying airway threat, recording oxygen saturation levels, level of consciousness using the AVPU scale (alert, responds to voice, responds to pain, unresponsive) and identifying if they had concerns about a child on a new paediatric observation chart. The clinical care policy for each ward determined the frequency of recording observations.

**Results** Data were collected for 1,000 patients on whom 9,075 sets of observations were performed. Of those 9,075 sets, temperature was the most frequently recorded observation at 88.4% (95% confidence interval (CI) 87.7-89), followed by heart rate at 86.8% (95% CI 86.1-87.5), respiratory rate at 79.7% (95% CI 78.9-80.5), AVPU at 36.4% (95% CI 35.4-37.4) and blood pressure at 25.1% (95% CI 24.2-26.0). A complete set of observations needed for the Cardiff and Vale Paediatric Early Warning System to trigger effectively were only recorded in 52.7% (95% CI 52.4-53.1) of patients.

**Conclusion** There were variations in the frequency, type and recording of observations. This issue needs to be addressed if scoring systems are to be implemented. The findings of this observational study suggest that the required basic observations of acutely ill children are not being carried out.

### Keywords

Critical illness, early warning scores, routine observations

tool should be used on all patients admitted to hospital, regardless of presentation.

Assessment, measurement and monitoring of vital signs are important basic skills for all practitioners working with infants, children and young people (Royal College of Nursing (RCN) 2007). Failure to recognise or respond appropriately to clinical deterioration can lead to life-threatening events, including cardiopulmonary arrest (Tibballs *et al* 2005, Duncan *et al* 2006, Haines *et al* 2006, McCabe *et al* 2009).

Given that the outcome for children after cardiac arrest is poor (Schindler *et al* 1996), early recognition and management of the deteriorating child is essential (Advanced Life Support Group 2005). The biggest problem for the acutely ill child arises if the healthcare professional performing any task does not recognise the importance of the results obtained, misinterprets the results and takes an inappropriate action in consequence, or does not act on them at all (Department of Health 2003).

The RCN's (2007) Standards for Assessing, Measuring and Monitoring Vital Signs in Infants, Children and Young People state that the following should be assessed, measured and recorded initially on attending hospital and then at varying frequencies:

- Temperature.
- Heart rate.
- Respiratory rate.
- Respiratory effort.
- Blood pressure.

These signs can contribute important information to the clinical condition and potential deterioration of the acutely ill child.

The Nursing and Midwifery Council's (NMC's) (2009) guidelines on record keeping state that good record keeping is 'essential to the provision of safe

THE CONFIDENTIAL ENQUIRY into Maternal and Child Health (2008) report Why Children Die and the National Institute for Health and Clinical Excellence (2007) guidelines on acutely ill patients in hospital recommend the use of early warning systems or scores to aid with the early identification of patients likely to develop critical illness. These bedside tools are simple to use and rely on the recording of 'routine observations'. It is impossible to predict those patients likely to develop critical illness. Therefore, an early warning



and effective care'. Furthermore, the RCN (2007) standards state that good record keeping is essential for effective monitoring and interpretation of vital signs.

This observational study looked at the types and frequency of routine observations carried out on the paediatric wards of the Children's Hospital for Wales. It is a secondary study resulting from a collection of observations that were carried out to test the predictability of a new early warning system – the Cardiff and Vale Paediatric Early Warning System (C&VPEWS) (Edwards *et al* 2009) (see Research digest on page 10). Observations appear to be carried out in an unsystematic manner, depending on the nurse's experience, medical consultant's preference and clinical specialty. This would potentially have consequences for the successful completion and application of any early warning tool.

### Aim

To review the practice of routine observations on all children admitted to the Children's Hospital for Wales and the feasibility of implementing an early warning score for children developing critical illness.

### Method

The Children's Hospital for Wales is based on the University Hospital of Wales's site and is part of the Cardiff and Vale NHS Trust. It is a tertiary centre for paediatric care, with 50 medical, 34 surgical, 16 oncology, seven paediatric intensive care, four paediatric high dependency, four cardiac and four renal beds.

A prospective cohort study began in Cardiff and Vale NHS Trust in 2005 with the aim of designing a tool that would help identify those children at risk of developing critical illness. It is difficult to design a sensitive tool fit for purpose because normal physiological parameters change throughout childhood. A new standardised observation chart was therefore designed to meet the requirements of the proposed tool. Additional observations were added to the chart, such as the neurological assessment scale of AVPU (alert, responds to voice, responds to pain or unresponsive) recording of oxygen saturation levels and space for comments if the nurse or doctor tending the sick child had any worries. Education workshops were provided on day and night shifts to ensure that staff understood the alterations to the observation chart and what was required of them.

The physiological observations of all paediatric emergency admissions to areas excluding the paediatric intensive care unit and the paediatric high

dependency unit were recorded four hourly as was usual practice. During the education sessions the research team requested, for the purposes of the study, two full sets of physiological observations were required in each 24 hours to trigger the newly designed C&VPEWS. The two full sets of observations were required to enable the research team to assess the sensitivity and specificity of the C&VPEWS. A research nurse collected then stored these observations in an Excel database and data were analysed using STATA 10.0.

**Ethical considerations** Ethical approval was granted by the South East Wales Local Research Ethics Committee for the original study and the analysis of the observations. The research was conducted in 2005.

### Results

Data were collected from 1,000 children on whom 9,075 sets of observations were performed. Table 1 shows the total number and percentage of observations carried out in the Children's Hospital for Wales on these 1,000 children. Table 2 shows the percentage of different observations recorded in each ward area.

### Discussion

This observational study came about following the prospective cohort study designed to validate the C&VPEWS which identified the variation in observation recording in the clinical areas in the Children's Hospital for Wales. During the C&VPEWS study period the research nurse consistently requested that staff record at least two full sets of observations. Despite this, only half of the required parameters were recorded.

The study highlighted several interesting points about the selection and frequency of the physiological observations recorded, especially with the current recommendations for the use of early warning tools.

Airway threat was a newly identified observation that was introduced because it was one of the parameters for the C&VPEWS. Nurses were requested to identify any threat to airway through selection of the parameters given to them. This observation was consistently poorly recorded in all clinical areas despite airway threat symptoms being logged in the

*Nurses were requested to identify any threat to airway through selection of the parameters given to them*

medical notes. It was hoped by the research team that, with the frequent use of the pulse oximeter, oxygen saturation would be better recorded. This appeared to be most frequently noted on general medical and cardiac/renal wards. In the authors' clinical experience blood pressure is recorded less frequently in children than in adults. Blood pressure is a poor indicator of shock in children as it is maintained until the child has advanced circulatory collapse (Advanced Life Support Group 2005).

Equipment is needed to measure blood pressure which can cause distress to the already miserable infant so nurses may be reluctant to record it as part of routine observations. Significantly, blood pressure was only recorded in 58 per cent of patients on the surgical ward despite the benefits of monitoring these patients post-operatively. Blood pressure was consistently recorded more frequently in the specialist wards than in the medical wards.

Critical illness in a child can lead to a reduction in consciousness caused by hypoxia. This can be simply recorded using the AVPU scale but, despite being such a simple observation to record, AVPU was only noted in 36 per cent of patients. Temperature was the most frequently recorded of all the observations.

This study also raised the concern that, even with extra education to record the observations specifically to aid the identification of acutely ill children, the percentages of observations recorded were less than desirable. The observations that were carried out varied between ward areas. Some essential observations, such as respiratory rate, were often omitted. Medical consultant preference in some ward areas influenced not only the frequency of recording observations but also

which observations were carried out. It was also evident from medical notes that who makes the decision about frequency of observations varies.

The new observation chart is still in use throughout the Children's Hospital for Wales. This standardisation ensures that nurses and clinicians working in any clinical area are familiar with the format of the chart.

The findings of the prospective cohort study have now been published (Edwards *et al* 2009) and fed back to the nursing management team in the children's hospital and local pre-registration educators. Problems for the children's hospital management group concern which groups of nurses are recording the observations and whether they are interpreting the findings. Ever reducing numbers of qualified nurses in clinical areas results in fewer nurses able to perform the observations or to monitor those observations carried out by healthcare assistants. If children are hospitalised they should have their vital signs recorded otherwise they could be given care at home.

The pressure on bed occupancy has meant that staff are consequently trying to increase throughput by decreasing patients' length of stay. This may have caused staff to carry out observations that they feel are appropriate for the clinical situation rather than the full basic essential observations.

These results suggest that the RCN standards for a minimum set of observations are not being followed. Ideally AVPU and oxygen saturations should be added to the RCN recommendations for the early identification of those children who could go on to develop critical illness.

Aggregate scoring systems, such as that developed by Duncan *et al* (2006), require a full set

Type of observations	Total number of observations	Percentage of observations completed (95% confidence interval (CI))
Airway threat	762	8.1 (7.5-8.7)
Oxygen saturation levels	7,229	76.7 (75.9-77.6)
Respiratory rate	7,511	79.7 (78.9-80.5)
Heart rate	8,181	86.8 (86.1-87.5)
Blood pressure	2,363	25.1 (24.2-26.0)
Alert, voice, pain, unresponsive scale (AVPU)	3,428	36.4 (35.4-37.4)
Nurse/doctor worried	1,950	20.7 (19.9-21.5)
Temperature	8,325	88.4 (87.7-89.0)



**Table 2** Percentage of observations recorded in specific ward areas in the Children's Hospital for Wales

Type of observation	Percentage of observations completed for each ward area (95% confidence interval (CI))					
	Infant medical 0-1 year (n = 4,959)	Medical 1-16 years (n = 2,753)	Adolescent 14-16 years (n = 532)	Surgical 0-16 years (n = 219)	Renal and cardiac 0-16 years (n = 555)	Oncology 0-16 years (n = 388)
Airway threat	10.1 (9.3-11.0)	8.2 (7.2-9.3)	1.9 (0.9-3.4)	10.5 (6.7-15.3)	0.2 (0.0-1.0)	0.0 (0.0-1.0)
Saturations	84.2 (83.2-85.2)	81.3 (79.8-82.7)	26.5 (22.8-30.5)	38.4 (31.9-45.1)	84.2 (77.2-83.9)	33.0 (28.3-37.9)
Respiratory rate	83.4 (82.4-84.5)	77.4 (75.8-79.0)	79.3 (75.6-82.7)	78.1 (72.0-83.4)	81.6 (74.5-81.6)	49 (43.9-54.1)
Heart rate	87.2 (82.1-84.2)	86.2 (84.8-87.4)	91.4 (88.7-93.6)	90.0 (85.2-93.6)	85.7 (78.7-85.3)	85.1(81.1-88.4)
Blood pressure	8.3 (7.6-9.1)	23.0 (21.4-24.6)	85.5 (82.2-88.4)	58.0 (51.1-64.6)	77.8 (70.8-78.2)	80.4 (76.1-84.2)
Alert, voice, pain, unresponsive scale (AVPU)	39.5 (38.1-40.8)	36.3 (34.5-38.1)	15.0 (12.1-18.4)	37.0 (30.6-43.8)	52.4 (46.0-54.5)	8.2 (5.7-11.4)
Nurse/doctor worried	20.2 (19.1-21.4)	17.6 (16.2-19.1)	13.0 (10.2-16.1)	31.5 (25.4-38.1)	58.8 (52.2-60.6)	3.1(1.6-5.3)
Temperature	91.9 (91.9-92.7)	92 (91.0-93.0)	76.0 (73.1-80.4)	77.6 (71.5-83.0)	52.1 (45.7-54.2)	96.6 (94.3-98.2)

of observations to be carried out. Education pre- and post-registration is paramount so that nursing staff have a better understanding of the importance and rationale behind the RCN monitoring standards. Failure to do this will lead to early signs of critical illness remaining unnoticed. Ward managers and practice educators need to ensure in general paediatric areas that staff know which observations to carry out and understand what they mean.

The RCN standards (2007) recommend that nurses, students and healthcare assistants who assess, measure and monitor vital signs in infants, children and young people are competent in observing their physiological status. Additionally, healthcare staff should take appropriate action in response to changes in vital sign assessment and measurement. However, abnormal parameters are difficult to assess. Wallis *et al* (2005) stated that there is a wide range in variation of normal

parameters and therefore uncertainty about where the baseline is. Therefore a change in physiological parameters should trigger an increase in frequency of observation.

The RCN (2007) guidance on frequency of observation is vague as it states that vital signs should be recorded on admission and further observations should then be recorded at varying frequencies. Variations in the Children's Hospital for Wales concerning who makes the decision about the frequency of recording vital signs are evident from examining the medical notes. The instruction 'routine observations' is frequently used but, without a policy identifying what this actually means, it is unclear which observations should be carried out or how frequently.

Pre-registration educators need to consider the findings when preparing nurses for the future. It is essential that nurses understand the necessity

## Research

of recording observations and the significance of those observations when assessing sick children. It is important to get the basics right. If observations are not being carried out then even the most perfect early warning system will fail to identify vulnerable children.

### Limitations

This study is secondary to the original research proposal and was carried out during implementation of a documentation change in the Children's Hospital for Wales. This may have influenced which observations were recorded. Not all staff will have attended educational workshops that were held and may not have used the observation charts as required for the study.

### Conclusion

Physiological observations identify children whose condition may be deteriorating and may go on to develop critical illness. However, in this study children hospitalised for observation did not get the recommended observations of vital signs recorded. There is also variation in observations

recorded in different clinical specialities in this hospital. Current early warning scores developed for paediatric practice require a full set of observations to be recorded. Therefore the successful implementation of such scores will require an improvement in compliance of observation recording.

### Implications for practice

- Pre-registration education should include the relevance and importance of observations of vital signs.
- Education for health care support workers and pre-registered nurses recording vital sign observations in normal parameters.
- There should be observation policies in clinical areas to which all staff adhere.
- Multidisciplinary refreshers in recognition of acutely ill children and the signs and symptoms of deterioration should be held regularly.

This article has been subject to open peer review and has been checked using anti-plagiarism software

Alison Oliver is regional training and development nurse for paediatric intensive care (PIC) services in Wales; Colin Powell is consultant paediatrician, PIC unit, University Hospital for Wales, Cardiff; Dawn Edwards is consultant paediatrician, department of paediatrics, Singleton Hospital, Swansea; Brendan Mason is consultant epidemiologist, department of epidemiology, statistics and public health, Cardiff University, Cardiff

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NEIL O'CONNOR

# Competent on qualifying?

One year on,  
Sophie Pratt  
compares the  
reality of  
practising as a  
staff nurse with  
her expectations  
as a student

Sophie Pratt RN(Child), DipHE,  
Staff Nurse, Milton Keynes  
General Hospital NHS Trust

## KEY WORDS

Nursing: Education  
Paediatric Nursing

**Three years** ago, as I sat in the lecture theatre ready to be welcomed into my nurse training, I felt secure in the knowledge that by the end of the course I would be prepared, as a competent children's nurse, to care for sick children and their families. How does this compare to the reality of qualifying and being the staff nurse three years later? Initially, I had an acute awareness of what I did not know and could not do – a reality which, I believe, is shared by my colleagues. Indeed, my very first shift as a staff nurse, and the donning of a 'staff nurse' badge, will remain etched in my memory forever as reality kicked in.

### Competence on qualifying

Although pre-registration nurse education is required to produce competent practitioners, much has been written about the deficiencies of newly qualified nurses (Fraser *et al* 1997, Luker *et al* 1996). But what skills constitute the competent newly qualified children's nurse? The UKCC uses the term 'competence' to describe the skills and ability to practise safely and effectively without the need for direct supervision (UKCC 1999). Locating actual competencies for newly qualified children's nurses has been extremely difficult. As Fraser *et al* (UKCC 1999) identify, what constitutes competence in midwifery and nursing is so poorly defined that it eludes measurement.

Lawrence (1998) identifies 74 essential, or desirable, skills for paediatric nurses. From her study, only seven skills were deemed to be essential by all of the respondents (see Box 1). Strangely, the ability to

communicate is not mentioned as a skill, neither are negotiation or delegation skills.

My own list for assessment of competence, summarised in Box 2, was based on Rule 18A of the Nurses, Midwives and Health Visitors Act 1989. Without fulfilling these competencies, I would have been unable to qualify. But I had only passed a naso-gastric tube a couple of times and my experience of setting up intravenous fluids was minimal. In fact, the list of things I could *not* do was very long. During my training I visited many different areas in which children and their families are cared for but the time spent in acute settings seemed minimal now that I am working in a district general hospital on a children's ward.

### Being a staff nurse

The first patient allocated to me was a baby with bronchiolitis, who was being cared for in a head box with humidified oxygen and being fed via a naso-gastric tube

### Box 1. Seven essential skills for paediatric nurses (Lawrence 1998)

- Handwashing
- Calculating drugs
- Measuring height
- Measuring weight
- Observing and recording pulse, respiratory rate and apex beat
- Ward testing of urine
- Measuring of oral temperature

### Box 2. Competencies of the qualified nurse: a summary of Rule 18A

- Professional/ethical practice
- Interpersonal skills
- Assessment, planning and implementation skills
- Health promotion
- Accountability/decision making
- Evidence based practice
- Working within a multi-professional environment
- Leadership

– in fact, all my fears wrapped up in one patient. I required a lot of support and identified this with my mentor on this shift. I learned how to provide the care this baby needed through close working with my mentor. Was I incompetent at this time? I don't think so. I was able to identify my need for supervision and acknowledged my limitations while recognising my abilities. I did have the knowledge and some practical skills required, however I referred to others who were more experienced when necessary.

I soon realised that I did possess skills that are intrinsic to the care I deliver; foremost the ability to recognise one's own limitations. Being able to communicate with others (children, their families and other professionals), being aware of possible problems within families and an ability to work in partnership with others (both families and other professionals), as well as possessing a questioning attitude, are what my training provided me with.

One of the best feelings on qualifying was the ability to work unsupervised and to make decisions. To be able to form relationships with my own patients was also a very rewarding aspect of being qualified.

#### Preceptorship

Preceptorship offers a period of support and attempts to ease transition into professional practice (Bain 1996). The UKCC (1990) recommended that there should be a period of support for all newly registered

practitioners, and that this support should be provided by an experienced nurse, midwife or health visitor. The UKCC identifies the role of preceptors as role modelling in day-to-day practice.

During my initial transitional period, preceptorship offered me support and guidance. It was expected from the outset of the preceptorship programme that I would be responsible for identifying my needs and



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providing ownership of my own development. This would seem obvious but, as students, many of our learning needs had been identified for us within the inevitable structure of the educational setting.

#### The experience of preceptorship

The experience of preceptorship is individual: three other students qualified with me and our experiences of preceptorship differed greatly. It would be interesting to examine the reasons for this. Our preceptorship package was new to our area and we were the 'guinea pigs' in some respects. However, for me, the experience was positive. I had regular meetings with my preceptor to discuss action plans and set goals, and I had the opportunity to discuss issues that concerned me.

Looking back at my action plans really demonstrates how far I have come in one year. My allocated preceptor was not the only participant in easing my transition to staff nurse, other colleagues provided a supportive framework in which I was able to ask for advice and support when needed.

#### Evaluation: one year on

I have survived my first winter on a general paediatric ward. Looking back to my first patient it was a luxury to have just the one. This winter I frequently nursed five or six infants per shift, with bronchiolitis requiring varying degrees of nursing intervention. Through preceptorship and support from others, I have become more confident in my abilities as a staff nurse and team member.

A year has passed very quickly; I have completed my preceptorship programme and have taken advantage of a couple of clinical supervision sessions. I am about to complete my intravenous administration training and I have taken on the role of preceptor myself. I work with students and am planning to become a student assessor soon. I am, with another staff nurse, looking to change current practice

in how we check the positioning of naso-gastric tubes – and will therefore be writing a new ward protocol using evidence to base our practice on.

My first year has been fun, scary and informative, and yes, my training had prepared me as a competent children's nurse. My confidence has grown through preceptorship and with the support of the people I work with. I look forward to the future knowing that the acquisition of knowledge is neverending **PN**

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# Making sense of pulse oximetry and oxygen dissociation curve

## KEY WORDS

Pulse oximetry, oxygen therapy, hypoxia, physiology

## ABSTRACT

It is important to maintain oxygen supply to the tissues. The article reviews the physiology of oxygen transport and highlights the use of pulse oximetry as a versatile tool for monitoring the adequacy of patient oxygenation in various nursing situations. The practicalities of using a pulse oximeter are discussed

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THE BODY'S TISSUES need a constant supply of oxygen to survive, so it is important to monitor the oxygen content of a patient's blood. Pulse oximetry is one way to do this.

### What is pulse oximetry?

Pulse oximetry is a non-invasive means of detecting how oxygenated a patient's blood is. It is used in many clinical settings, from theatres to neonatal units. Its main function is to detect hypoxaemia.

### What is hypoxaemia?

Hypoxaemia is the low oxygenation of blood. This can lead to hypoxia, a diminished amount of oxygen in the tissues. Oxygen is transported to the tissues bound to haemoglobin in red blood cells (erythrocytes). Normally the blood is well saturated with oxygen (normal arterial values are 95–98%). If saturation falls below 90%, there are severe implications for tissue viability. Organs vary in their sensitivity to oxygen lack, with the brain being most sensitive. Signs of hypoxaemia include systemic oedema; cyanosis; raised respiratory rate; and tiredness.

### How does oxygen transport operate?

Most oxygen (97%) is transported in the form of oxyhaemoglobin. Oxygen binds to haem groups within the haemoglobin (Hb) molecule. A haem group is an organic compound containing an iron atom. It is the haem that gives red blood cells their colour. Four haem groups are embedded in the Hb structure. Oxygen accounts for a minute portion of the whole structure.

### Why are four binding sites per molecule needed?

When all four sites are unoccupied, Hb is unresponsive to oxygen. However, when one site is filled, the structure loosens a little, making it easier for the next oxygen molecule to bind.<sup>1</sup> Because oxygen binds so well, it will not be readily released.

This could mean oxygen easily binds in the lungs but is not released in the tissues. By having four units, this dilemma is somewhat overcome. As one oxygen molecule is released, the structure alters and it is easier for the other molecules to be unloaded.

### What aids oxygen binding?

Although the oxygen binds to Hb, it can be shaken loose, so there needs to be a balance between loss and gain. Binding is assisted

by a high oxygen tension ( $pO_2$ ): the more oxygen molecules there are, the more often one will hit and bind. When all four sites are filled, Hb is said to be fully saturated. The oxygen dissociation curve (Fig 1) illustrates the relationship between saturation and oxygen tension.

The flat part of the curve is a safety feature. Even if the  $pO_2$  drops owing to lung disease or high altitude, Hb in blood will still be largely saturated. The steep part of the curve shows that there is an inbuilt reserve to enable adequate  $O_2$  release, for example in strenuous exercise.

### How is oxygen released?

Most oxygen is unloaded when ambient levels are within a narrow range of  $pO_2$ , between 2.7 and 5.3 kPa (one kPa = 7.5mmHg). This helps in the offloading of oxygen in the tissues where oxygen is needed. The  $pO_2$  is not the only influence on oxygen binding. A raised concentration of  $CO_2$  shifts the curve to the right. This means that, at a given  $pO_2$ , Hb would have a lower affinity for oxygen.

### What else helps oxygen release?

Three other factors also shift the curve to the right:

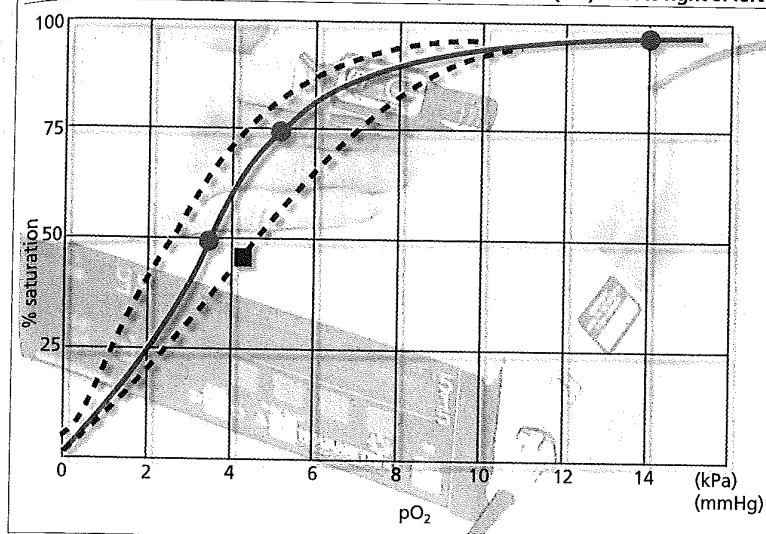
- An increase in hydrogen ions (low pH)
- A phosphorus-containing molecule, 2,3, diphosphoglycerate (2,3,DPG) which is produced by erythrocytes
- Raised temperature.

Active tissues not only demand oxygen, they release  $CO_2$ , hydrogen ions and heat, creating ideal conditions for gas exchange in the capillaries. The first two substances bind to the Hb molecule, altering its structure so that oxygen affinity is reduced. Levels of 2,3,DPG are obviously important in regulating oxygen transport. The level rises when oxygen uptake in the lungs is compromised because of obstructive lung diseases or high altitude. This helps the Hb unload a greater proportion of oxygen at the tissues than usual.

The curve can be shifted to the left, so that Hb has greater affinity for oxygen. This occurs whenever 2,3,DPG levels fall. Also, fetal Hb is less able to bind 2,3,DPG, so it has a greater affinity for oxygen. Consequently, when fetal Hb comes in proximity to maternal Hb in the placenta, it will draw oxygen from the maternal blood. Finally, a low temperature and a raised pH will also shift the curve to the left, making it less



Fig 1. Oxyhaemoglobin dissociation curve: (blue) normal and (red) shift to right or left



easy to offload oxygen for use by tissues. While raised carbon dioxide and acidity levels assist the offloading of oxygen from Hb, the converse also holds. Raised oxygen levels promote the release of carbon dioxide and hydrogen ions from Hb.

#### How does a pulse oximeter work?

Pulse oximeters detect light emissions from tissues. Arterial, oxygenated blood is red because of the quantity of oxyhaemoglobin it contains, while venous blood is bluer since it carries less oxygen. Because of the colour difference, they absorb light at different wavelengths.

The oximeter probe contains two diodes that emit light in the appropriate wavebands (red and infrared). A detector determines the ratio of red to infrared light emitted and thence calculates the degree to which blood is oxygenated at a peripheral point, usually a finger or ear. The machine corrects for emissions from surrounding tissue.<sup>2,3</sup>

#### How sensitive is a pulse oximeter?

Modern machines are generally very sensitive in the range 70–99%. This is because they have been tested and calibrated in normal, healthy individuals. They are less sensitive below 70%, but any reading lower than this would automatically be seen as severe and requiring treatment. Most machines are self-calibrating and should give accurate readings if used properly.<sup>4,5</sup>

#### What practical points should a nurse note in using a pulse oximeter?

Circulation should be promoted to the area to which the detector is attached, for instance by applying warmth. Where poor peripheral circulation may result in inaccurate readings a forehead sensor can be used.<sup>6</sup>

Restrictions to blood flow such as tight

clothing should be avoided. Experiments have shown that measurement error results from excessive pressure, such as when the nurse fastens the sensor too tightly.<sup>7</sup>

The area where the probe is attached needs to remain still. Taping the sensor to the finger helps and can also act to block out excessive ambient light, which interferes with readings.<sup>5,6</sup>

Abnormal haemoglobins, vital intravenous dyes and nail varnish can interfere with the reading.<sup>3,6</sup> The oximeter detects light and does not distinguish between different chemical substances. For example, Hb carrying non-oxygenating substances, such as carboxyhaemoglobin, would emit similar light to oxyhaemoglobin. Smokers can have raised carboxyhaemoglobin levels for up to four hours after smoking, causing false readings.<sup>7</sup>

Unexpected readings must be checked against signal quality and conditions at the probe, such as interference to the signal caused by one of the above or a damaged or dirty sensor.

The nurse should monitor the probe site for possible skin burns (caused by damaged sensors) where the light source is in direct contact with the skin.<sup>5</sup>

#### Why might pulse oximetry be preferable to taking blood gases?

Pulse oximetry is non-invasive and there is less chance of user error. Many machines can take continuous readings on a 0.5–1 second cycle basis, which can help in monitoring procedures both before and after therapy. Research has shown the potential for oximetry to rationalise blood gas analyses in ICU and to detect drops in oxygen saturation.<sup>9</sup> It is more practicable as an aid to weaning patients off mechanical ventilators, although it may be less precise than blood gas analysis.<sup>10</sup> **NT**

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