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**PhD Title: The Early Diagnosis of
Sepsis in the Acutely Ill Cancer Patient**

Shelley (Michelle) Dolan

**Submitted to the University of Wales in
fulfillment of the requirements for the
Degree of Doctorate of Nursing Science**

Swansea University

2010

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Summary

The sepsis syndrome is the systemic response of the body to infection. It develops from the earliest stage, Systemic Inflammatory Response Syndrome sepsis, to severe sepsis, septic shock and multi-organ dysfunction syndrome. The incidence of sepsis is growing and globally accounts for one in ten admissions to Intensive Care Units. The mortality rate for severe sepsis ranges from 25% to 67%. People with cancer are ten times more likely to develop sepsis and having developed it have a higher mortality rate.

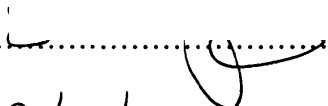
Early recognition and treatment of sepsis has been demonstrated to improve outcomes. This study sought to improve early recognition of sepsis in cancer patients receiving acute treatment. Nurses and patient assessment were the focus of this study. The design was a prospective multi-method observational study with two interventions: a teaching session for 177 nurses; the introduction of a bedside test – Procalcitonin (PCT-Q), an immunological marker of sepsis. PCT has been shown to be a reliable marker of sepsis. The PCT-Q, has been used since the late 1990s but never by ward nurses.

Methods used were: qualitative interviews of ten nurses and a questionnaire survey of 177 nurses pre and post intervention; and a patient database with the PCT-Q test being used 416 times in 320 patients to diagnose sepsis. The study showed that nurses and patients recognise the early changes of deterioration before their observations change. Nurses recognise these changes because they know their patients well. Nurses' knowledge improved in several areas during the study and they used PCT-Q appropriately, diagnosing sepsis at an early stage in 66% of cases. Ordinal multi-regression analysis demonstrated that PCT was more reliable than CRP and, used together with a low WBC and high lactate, accurately predicts sepsis.

Declarations and Statements

DECLARATION

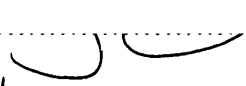
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STATEMENT 1

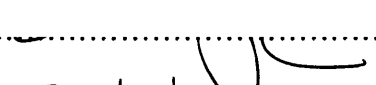
This thesis is the result of my own investigations, except where otherwise stated and other sources are acknowledged by footnotes giving explicit references and a bibliography is appended.

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Chapter 1 Introduction

1.1 Introduction

The study, described in this thesis, which is part of a doctorate in nursing science, was concerned with improving practice in the acute care of people with cancer. The study aimed to improve both the early nursing assessment of a cancer patient deteriorating with sepsis and the associated multi-professional communication and rescue. The researcher was a Nurse Consultant in Cancer: Critical Care working in a major comprehensive cancer centre in the U.K.

People with cancer are more susceptible to sepsis and have a high mortality once it has developed (Groeger 1991, Aisenberg *et al* 2004, Cone *et al* 2004). There is evidence that the early treatment of sepsis reduces mortality and morbidity and improves quality of life (Gattinoni *et al* 1995, Rivers *et al* 2001, Dellinger *et al* 2004, 2008, Rhodes *et al* 2004, Trzeciak *et al* 2007, Ferrer *et al* 2008). To treat patients early necessitates early diagnosis. In the inpatient acute setting it is nurses who are most frequently in contact with patients and are best placed to notice the early signs of deterioration or listen to patients themselves who can identify that a change is taking place (Coyle and Wenhold 2001, Colson *et al* 2004, Green and Hacker 2004).

This study was therefore designed to investigate the nurses' role in the early diagnosis of sepsis and to provide nurses with a new objective tool and dedicated education to improve early diagnosis and rescue.

1.1.2. Theoretical Framework

The theoretical framework underpinning this study, is as follows and is explored in detail in the following chapters:

1. The vulnerability of the cancer patients' immune system and increased susceptibility to sepsis (chapter two);

2. The evidence that early diagnosis and treatment reduces morbidity and mortality in sepsis (chapter three);
3. Nurses' ability to intuit subtle change pre-cognitively which causes discomfort and a stimulus to act (chapter four);
4. Education and its ability to raise awareness of risk (chapter four and five);
5. Packaging of information using an objective test to aid effective multi professional communication and rescue (chapter two and four).

The study was designed to improve practice as it exists in the reality of everyday life on wards. An experimental design was therefore rejected in favour of a pragmatic practice development approach. The study was designed from the outset to have five linked stages as demonstrated in the research framework outlined below in Table 1.1:

Table 1.1: Research Framework with subsidiary research aims and associated research stages 1-5.

No.	Subsidiary Research aims	Research stages
1.	<p>Pre-intervention</p> <ol style="list-style-type: none"> 1. The experience of caring for cancer patients deteriorating with sepsis. 2. The experience of communicating with and mobilising the multi-professional team about a patient deteriorating with sepsis. 3. The introduction to a new bedside blood test that may help in identifying sepsis earlier. <p>Post intervention</p> <ol style="list-style-type: none"> 4. Experience of the patient deteriorating from sepsis. 5. The experience of using the PCT-Q in practice 6. Nurses' accounts of the optimal ways of learning and developing their practice. 7. How nurses think an effective multi-professional response with a deteriorating patient can be 	<p>Pre and post - intervention qualitative interviews with 10 nurses of varying cancer and critical care experience.</p> <p>Post-intervention qualitative interviews with 8 of the 10 nurses previously interviewed.</p>

	<p>improved.</p> <p>8. Nurses' recommendations to improve the early detection and treatment of cancer patients developing sepsis.</p>	
2.	<p>Pre-intervention</p> <ol style="list-style-type: none"> 1. Raising awareness of sepsis. 2. The nurses' knowledge of sepsis: incidence, mortality risk, early diagnostic tests, procalcitonin and its role in the early diagnosis of sepsis. 3. Introduction to the bedside procalcitonin test (PCT-Q). 4. Examples of patients deteriorating with sepsis and nurses finding it difficult to convince the team. <p>Post intervention</p> <ol style="list-style-type: none"> 5. Changes in nurses' awareness and knowledge regarding sepsis: incidence, mortality risk, early diagnostic tests, procalcitonin and its role in the early diagnosis of sepsis. 6. The nurses' experience of using the PCT-Q in practice. 7. The nurses experience of thinking that a patient was deteriorating but finding it difficult to convince other nurses/doctors or other health care professionals. Examples from practice. 	<p>Pre and post intervention questionnaires to 177 nurses across the hospital.</p> <p>Post-intervention questionnaires completed by 85 of the original 177 nurses.</p>
3a.	<ol style="list-style-type: none"> 1. Ward teaching sessions on the cancer patient and sepsis, associated risks and mortality rate, the evidence on early diagnosis and treatment and assessment tools including procalcitonin. 2. Introduction to the use of the PCT-Q bedside test. 	Intervention (1)
3b.	<ol style="list-style-type: none"> 1. Introduction of the bedside test PCT-Q in the hospital for the first time. PCT-Q bedside blood test used on all patients that nurses assess as showing early signs of sepsis. 2. Each patient recruited for the PCT-Q test to have all other infection markers mapped to be able to compare the efficacy of the PCT-Q test to those usually used in the hospital. 	Intervention (2)

	<p>3. All patients entered into the study to have episode and hospital outcomes mapped with the objective of comparing outcomes of those who had PCT-Q measured in the study year to outcomes in the three previous years when the PCT-Q test was not available.</p>	<p>Archival notes review used to compare historical data with study data.</p>
<p>4.</p>	<ol style="list-style-type: none"> 1. Assess if the PCT-Q is used appropriately. 2. Assess if using the PCT-Q in sepsis assessment means that sepsis is diagnosed earlier. 3. The performance of the PCT-Q compared to the sepsis predictive markers already used by the hospital: White Blood Cell count, C-reactive protein, blood lactate, altered physiological parameters particularly mean arterial blood pressure. 4. The effect of introducing the two interventions: education and the PCT-Q on sepsis episodes and outcomes compared to the three previous years. 	<p>PCT-Q patient survey with 320 patients and 416 sepsis episodes in patients receiving acute care across the hospital.</p>
<p>5.</p>	<p style="text-align: center;">Overall Research Aim</p> <ol style="list-style-type: none"> 1. To investigate the nurses' role in the early diagnosis of sepsis and to provide nurses with a new objective tool and dedicated education to improve early diagnosis and rescue. 	<p>Integration of all qualitative data and comparison with quantitative data.</p>

The primary objective was to diagnose patients' sepsis at an earlier stage, recognising that nurses report a difficulty in convincing colleagues, an objective bedside test was to be introduced to improve multi-professional communication and therefore rescue. The secondary objectives were to:

1. Learn more about nurses' experience of the cancer patient deteriorating with sepsis and any barriers to effective communication and rescue;
2. Gain an in-depth understanding of nurses' awareness of sepsis and its assessment and management and how this could be improved, particularly how nurses felt they learnt optimally;
3. Explore whether nurses' judgement about the patient developing sepsis was accurate and whether they could use the PCT-Q appropriately;

4. Gain an in-depth understanding from the nurses how they felt the use of the PCT-Q has impacted upon practice and how easy in practice it was to use;
5. Assess whether in the nurses' hands and with cancer patients the PCT-Q was reliable in identifying sepsis compared to WBC, lactate, CRP and mean arterial pressure falls;
6. Evaluate if the use of the PCT-Q as part of clinical nursing assessment and communication resulted in earlier referrals and improved outcomes;
7. Compare the outcomes of patients during the study year to three previous years;
8. Evaluate whether the dedicated education session improved awareness and knowledge about the cancer patient with sepsis.

The research was undertaken on the acute wards and Critical Care Unit (CCU) of the cancer hospital. The patients had a variety of types of cancer and were all being actively treated as inpatients. The anti-cancer treatments were either single therapy or a combination of chemotherapy, radiotherapy, surgery, blood or marrow transplantation (BMT). The patients were receiving their first treatment or later treatment following relapse. Any patients entering the study needed to be eligible for full active treatment and not be in the terminal phase of their illness.

Experience and the literature show that identification of the early stages of sepsis is often delayed, with patients sustaining multi-organ failure before referral to the CCU team (Cioffi 2000a, DH 2003, Bellomo *et al* 2004). Discussion with nurses revealed that they recognise the signs of deterioration but lack the confidence or tools to persuade themselves or others to take action. This research was undertaken to improve both the early detection of sepsis and the mobilisation of the multi-professional team.

1.2 The burden of cancer

Cancer is recognised as a global health problem. In the Western world cancer is, after heart disease, the second most common cause of death (La Vecchia *et al* 2003). Worldwide, it is estimated that there are 10.9 million new cases of cancer a year, 22 million people live with it and 6.9 million people die from it (Parkin 2001, Cancer Research UK 2005, 2006). These estimates represent an increase of approximately

22% since the estimates of Parkin *et al* in 1990 (Parkin *et al* 1999). Cancer in the Western world is a disease that mainly affects older people, with a peak in incidence (59%) in people over the age of 65 (Cancer Research UK 2005). There are some cancers, for example Leukaemia, which peak in incidence at birth up to four years and then range across the age span. In the UK in 2001 there were approximately 225,000 new cases of cancer. The incidence is increasing, with approximately 289,000 new cases in the UK in 2005 and 154,162 people dying from cancer in 2006 (DH 2004, Cancer Research UK 2005, 2006).

All cancer patients are susceptible to sepsis (Table 1.1, Williams *et al* 2002, Williams *et al* 2004b). Some cancer patients are more vulnerable because their disease, sited in the bone marrow, directly affects the body's immune response (Cherif *et al* 2003). The definitive treatment for these cancers is ablation of the bone marrow with chemo/radiotherapy and then replacement with a stem cell or bone marrow transplant from another person (allogeneic) or from themselves (autologous). Some cancer patients with solid tumours, for example teratoma, may receive the same marrow ablative chemotherapy. The mortality rate for patients receiving a transplant who develop severe sepsis is quoted as being between 65% and 85% (Groeger 1991, Chernecky and Berger 1998, Aisenberg *et al* 2004, Cone *et al* 2004). In some patients, such as those with leukaemia, sepsis is the major reason for transplant-associated death in the first six weeks of therapy (Williamson *et al* 1999, Pastores *et al* 2002, Uys *et al* 2007, Merz *et al* 2008, Scales *et al* 2008).

There are times in the patient's cancer journey when they are more at risk from sepsis (see chapter two). In general, this is during periods of active treatment of the disease. For most patients this is the first treatment period after diagnosis, and then at times of active treatment for relapse.

Table 1.2: Risks of infection and sepsis for the person with cancer

Characteristic	Reason for greater risk of sepsis
Repeated hospitalisations.	Increase in nosocomial (hospital acquired) infections.
Repeated invasive therapy using short or long term central venous access devices (CVAD).	Increased exposure to CVAD associated infections.
Bone marrow suppression due to disease	Bone marrow suppression results in

infiltration of the marrow or metastatic disease involving the bone.	pancytopenia with a resultant lowering of the white cell count, the platelet count and the red cell count. The white cells are the body's first and most important response to infection.
Bone marrow suppression as a result of treatment, either chemo or radiotherapy.	The resultant neutropenia (reduction in the absolute neutrophil count (ANC)) renders the body susceptible to infections.
Malnutrition associated with disease or treatment	Poor immunity and resistance to infection.
Predominantly older population more likely to have co-morbid conditions.	Generally frail health, likely to be less resistant to infections.
Increased exposure to transfused blood and its components, either as a result of repeated surgery or the disease and chemo/radiotherapy.	The transfusion of donated blood and its components such as platelets, clotting factors and fibrinogen carry the risk of transmitting donor infections.

For any patient who develops sepsis and multi-organ failure the experience is frightening, uncomfortable and often life threatening. Patients are hospitalised and need immediate invasive therapy and admission to the Critical Care Unit.

1.3 The focus of research in sepsis and cancer care

In cancer and sepsis research, much work has focused on the treatment of infection and the management of sepsis, especially in the following areas:

- improved anti-microbial agents;
- improved agents to reverse the immunological sequelae associated with sepsis and severe sepsis (Pastores *et al* 2002, Vincent and Jacobs 2003); and
- agents to support the host's defence against infection (Wheeler *et al* 1999, Yan *et al* 2001, Dolan *et al* 2005).

1.4 Overall aim of this research study and rationale

This study was designed to tackle sepsis from another angle, that of the early identification of sepsis. The overall aim of the study was to investigate the nurses'

role in the early diagnosis of sepsis and to provide nurses with a new objective tool and dedicated education to improve early diagnosis and rescue.

The sepsis syndrome has been defined as having four stages, with one being the earliest and fourth the latest and worst. Diagnosis and treatment at an earlier stage has been demonstrated to improve morbidity and mortality (Gattinoni *et al* 1995, Rivers *et al* 2001, Dellinger *et al* 2004, Rhodes *et al* 2004, Trzeciak *et al* 2007, Dellinger 2008). Each stage has defining characteristics and is described further in chapter three (Bone *et al* 1992, Dellinger *et al* 2004, 2008).

The four stages of the sepsis syndrome are:

1. Systemic Inflammatory Response Syndrome (SIRS);
2. Sepsis;
3. Severe Sepsis; and
4. Septic Shock and Multi-Organ Dysfunction Syndrome (MODS).

1.5 Rapid deterioration of the person with cancer who develops sepsis

In those patients who have cancer and are immune compromised, the time from the onset of SIRS to the development of sepsis may be short. It is therefore essential to identify patients early to minimise the chance of further deterioration. The rationale for this study, therefore, is the rapidity with which patients deteriorate and the importance of nurses being attuned to the risks and early signs of sepsis.

1.6 The role of the nurse in identifying sepsis

Nurses in the acute hospital setting are the healthcare professionals who spend the most time with a patient. For the nurse working in a cancer centre, one of the key parts of their monitoring role is to work with the patient and teach them to recognise and report key changes in their condition that may indicate sepsis or other cancer emergencies (Shannon-Dorcy 2002). The early changes associated with the first part of the sepsis continuum, SIRS, can be subtle and difficult to quantify. Nurses,

patients and their families can often identify a change, although there may be few visible or measurable changes in the patient's physiological parameters (Eggenberger *et al* 2004). One of the most important aspects of this study is the development of nurses' awareness of the "at risk" patient and their sensitivity to early subtle changes or triggers.

Early signs may be the result of changes in biological parameters, but are manifest by subtle changes in the patient's behaviour or appearance that the nurse notices because she/he has cared for the patient before. It is these early changes in a patient that can be used alongside an increased awareness and knowledge of the sepsis syndrome to aid in early recognition and so improve outcomes for patients (Cioffi 2000a, b, Andrews and Waterman 2005).

1.7 The expert patient and intuition

An important philosophy underpinning this study is the "cancer patient as an expert" who understands their illness experience (Costain Shou 1999). Despite acute illness, patients with cancer are often able to recognise symptoms and changes which provide an early warning of sepsis. These subjective experiences (for example increased malaise, feelings of cold or flu-like symptoms, "not being as well") are an important contribution to the early recognition and diagnosis of sepsis. Intuition experienced by the patient or nurse is an important part of the theoretical framework of this study where recognition of subtle change is so important. For this study it is explicitly Bernadetto Croce's (1872) model of intuition that is being used and this is explored in detail in chapter four.

1.8 Development of the research idea

As the Nurse Consultant for Cancer: Critical Care, the researcher's responsibility was to lead a comprehensive critical care service from CCU. There is recognition across the world that patients are referred late to critical care services. The evidence shows that ward patients are referred late, are sicker than other admissions, stay longer, and have a higher morbidity and mortality rate (McQuillan *et al* 1998,

McGloin *et al* 1999, Goldhill *et al* 1999 Chellel *et al* 2002, Clarke and Aiken 2003, DH 2003, Goldhill 2005, Hillman *et al* 2005, Robson and Daniels 2008). In 2000, the researcher decided to use the 50% clinical practice element of the Nurse Consultant role to develop a critical care outreach service. This initiative was supported by the National Service Framework for Critical Care (DH 2000a). On developing the outreach service two issues were quickly apparent: sepsis was the most common non-elective reason for admission and patients were referred to CCU too late. Listening to the ward nurses it was apparent that they identified a problem but this was not translated into a referral. Reasons provided for delayed referral were lack of confidence by the nurse, self-identified gaps in their knowledge, inability to convince others – usually junior doctors - and difficulty in recognition of acute illness. Patients also described knowing they were getting worse but said they had found it difficult to convince both nursing and medical staff. Finally, there were also examples of deterioration accompanied by organisational delays in mobilising appropriate rescue. Working closely with clinical teams, the researcher knew that to achieve sustained practice improvement the study would need to be designed in a way that recognised real practice as it happens every day on busy wards, where nurses and junior doctors have competing roles and imperatives and may be short staffed.

Further discussion with nurses and junior doctors revealed two key problems: first, a lack of knowledge of the dangers of sepsis and the speed of its development in the cancer patient; and secondly a gap in communication between nurses and junior doctors. Nurses felt that doctors listened more to numbers or objective data. Nurses knew the patient was deteriorating but felt they needed something more objective in order to convince others. This clinical experience led to the formulation of the research idea and the design of the study. The overall aim and subsidiary aims and objectives were developed from the theoretical framework that earlier diagnosis and optimal management of sepsis leads to decreased mortality. In practice that timely assessment would translate into earlier referral to critical care outreach, reduction in late admissions to CCU and therefore a decrease in morbidity and mortality. The emphasis of the study was to improve practice as it happens in reality and to integrate the research with nurses' daily practice in an imperfect environment.

Two interventions were identified: a targeted teaching initiative to be delivered to nurses working on the acute wards; and the introduction of a bedside tool to give nurses an objective measure that they could use to convince themselves and others of the need to act. The dedicated teaching session on the sepsis syndrome, early diagnosis and assessment, and the use of the predictive blood test (see appendix 6 for lesson plan) was provided to 177 ward and critical care nurses. Nurses and junior doctors typically use several blood tests as sepsis indicators: white blood cell (WBC) count, C-reactive protein (CRP) and arterial blood lactate. The bedside tool – the PCT-Q – was a new blood test to measure Procalcitonin (PCT, an early indicator of sepsis described further in chapter three). The PCT-Q had only previously been used worldwide in the CCU setting, but by definition patients in the CCU are already critically ill and the aim here was to identify deterioration at a much earlier stage. This was the first time in the world that the PCT-Q was used by ward nurses.

Junior doctors in the study hospital are composed of Senior House Officers (SHOs) and Specialist Registrars. The former rotate to the hospital for six months, have minimal cancer knowledge and have not established a relationship with the nurses. These junior doctors did not feel they could change practice on anything other than objective data and also identified that they lacked knowledge of the acutely deteriorating cancer patient. Although not the subject of this study, additions were made to their induction and mandatory training programme in collaboration with the clinical tutor.

1.9 Relevance and contribution to nursing practice

Medical cancer research is aimed at improving curative cancer therapies. Nursing cancer research has predominantly concentrated on describing the patient experience, reducing symptomatology, information giving and helping patients to live with long-term effects of cancer and its treatment (Davidson *et al* 2006, Pattison *et al* 2007, Faithfull and White 2008). This study aimed to reduce the risk of a life-threatening event during acute cancer treatment, in an area not previously researched in the cancer literature. There is a growing body of research in the critical care literature on the early diagnosis and interventions for sepsis (Gattinoni *et al* 1995,

Rivers *et al* 2001, Dellinger *et al* 2004, 2008, Rhodes *et al* 2004, Trzeciak *et al* 2007).

Severe sepsis is most likely to develop when the person is neutropenic but can occur at any time (Ellerhorst-Ryan 2000, Vidal 2004, Safdar *et al* 2006,). The person with cancer is susceptible to infection and sepsis for many reasons, but particularly due to changes in their immune system (Tervit and Phillips 2006). Having developed sepsis, the person with cancer is also more likely to die from it (Groeger 1991, Aisenberg *et al* 2004, Cone *et al* 2004).

The justification for the study was the imperative to raise nurses' awareness of sepsis and particularly to improve the earlier identification of the patient who is developing sepsis. As discussed in chapter three there is a growing body of evidence that early identification of sepsis followed by appropriate action leads to reduced morbidity and mortality rates (Gattinoni *et al* 1995, Rivers *et al* 2001, Dellinger *et al* 2004, Rhodes *et al* 2004, Trzeciak *et al* 2007, Dellinger 2008).

When severe sepsis is established the organs fail and the patient is critically ill. In the early stages of the syndrome, however, there are often few hard clinical signs, and yet it is at this stage that multi-organ failure may be averted by prompt action, described in the literature as rescue or early goal directed therapy (Gattinoni *et al* 1995, Rivers *et al* 2001, Dellinger *et al* 2004, Goldhill and McNarry 2004, Rhodes *et al* 2004, Ridley 2005, Trzeciak *et al* 2007).

1.10 Failure to rescue

Clinicians working in acute areas often report that the patient, their family and the nurses working with them knew there was something wrong, but for a variety of reasons the appropriate rescue package was delayed (Benner *et al* 1999, Clarke and Aiken 2003, Goldhill 2005). This experience is corroborated by many publications and studies over the last 10 years. Publications reveal several reasons for delay in the appropriate management of patients: lack of communication throughout the team and between teams, lack of education and experience regarding acute care, and a reluctance to refer to more senior colleagues and/or other teams (McQuillan *et al*

1998, McGloin *et al* 1999, Goldhill *et al* 1999, Chellel *et al* 2002, Clarke and Aiken 2003, DH 2003, Goldhill *et al* 2005).

1.11 The context of care

This study was undertaken at a time of growing challenges for the ward nurse, who has to navigate a complex array of professionals, agencies, and patient and family needs. Ward nurses are caring for increasingly ill patients who are likely to deteriorate quickly, against a background of an acute nursing shortage (Finlayson *et al* 2002, Meleis 2005). There are also growing technological changes, particularly in cancer care, and an increase in the public's expectations of care. Finally, people with cancer, in common with other people experiencing chronic illness, are often well educated about their disease, its monitoring and treatment. This patient knowledge is important when encouraging active participation in care but can also be daunting for the nurse or doctor who is new to cancer care (Tattersall 2002, DH 2002, Mechanic 2004).

The role of the nurse working with people who have cancer on a general ward or a haematology unit is diverse, but for this study it was their role as it applies to the assessment and rescue of the patient deteriorating which was of interest. One of the problems highlighted by staff nurses is their inability to convince others of the results of their assessment, observation and monitoring. During this study, one of the areas explored in interviews was whether the nurses found it difficult to convince others of their findings. Liaschenko (1998) suggests that those nursing testimonies that are regarded as legitimate are those that are within the normal boundaries of scientific medicine (Liaschenko 1998, p.11). In practice, examples of those observations that are easily assimilated are a temperature recording or a 12 lead Electrocardiogram (ECG), other observations such as a subtle change in behaviour or appearance may not be credible (Cioffi 2000a).

Nurses often describe the difference in effect when a more senior member of the team provides information to members of another discipline or indeed within nursing. It is part of our behaviour of working with others that we constantly make judgements about oral testimony and its relative value based on our previous

experience of the narrator. If, previously, we have found a nurse to have been accurate in her assessment, this will colour our judgement for further interactions; the opposite is also true. This judgement may be based on seniority, previous interaction or because during the oral testimony we are convinced by the teller. There may also, however, be something else at work here. One of the skills learnt by nurses whose work involves crossing professional boundaries is that of speaking or providing information in a particular form or style. Chase (1995) and Andrews and Waterman (2005) describe this as “packaging information”. This may be almost unconscious, but if made overt can be reflected upon and taught so that communication between disciplines is more effective. An example of this may be the attempt to describe how a patient is “not quite right” or “not the same as they were earlier” although there is little “objective” scientific data to support this perceived change (Smith 1988, Daffurn *et al* 1994, Cioffi 2000a, b). In many of these situations, nurses recount frustration that they cannot communicate this change. It is only when the person starts to deteriorate and there are measurable changes in their blood pressure, for example, that others are convinced (Cioffi 2000a, b, Andrews and Waterman 2005).

Staff nurses do describe finding ways around this problem: asking a more senior nurse to come and make an assessment and then to speak to the team, or approaching a more senior doctor who they know, or calling the Critical Care Outreach team.

1.12 Critical Care Outreach and Medical Emergency

Teams: a method of improving communication and

“rescue”

Following research in the UK and Australia recognising “failure to rescue” on general wards, the Department of Health (DH) in its national service framework for critical care described the need for a critical care service integrated with the whole hospital (DH 2000a). Critical Care Outreach Teams (CCOT) were to provide the link between wards and the critical care service by providing the following roles (DH 2000a):

1. “To avert admissions by identifying patients who are deteriorating and either helping them to prevent admission or ensuring that admission to a critical care bed happens in a timely manner to ensure best outcome.
2. To enable discharge by supporting the continuing recovery of discharged patients on wards and post discharge from hospital, and their relatives and friends.
3. To share critical care skills with staff in wards and the community ensuring enhancement of training opportunities and skills practice and to use information gathered from the ward and community to improve critical care services for patients and relatives” (DH 2000a).

The UK Intensive Care Society (ICS 2002) added two further roles in 2002:

“To promote continuity of care.

To ensure thorough audit and evaluation of outreach services” (ICS 2002).

The DH also recommended, in Comprehensive Critical Care (2000a), that hospitals use a system of physiologically-based Early Warning Score (EWS) or Modified Early Warning Score (MEWS) to identify and monitor patients. These tools, which award points for degrees of physiological abnormality, are used by nurses to communicate with doctors and the multidisciplinary team. Several studies since 2000 have investigated the efficacy of the CCOT and the MEWS in improving communication, care and outcome. The studies investigating the provision of the CCOT have been hampered by methodological difficulties, but several have shown that the CCOT reduce mortality and cardiac arrests on general wards (Buist *et al* 2002, Kern *et al* 2002, Bellomo *et al* 2003, Bellomo *et al* 2004, Priestley *et al* 2004). Ball *et al* (2003) demonstrated some decrease in readmission rates to critical care whereas Leary and Ridley (2003) were unable to demonstrate this. A high MEWS score (3 or more abnormalities equalled 21.3% mortality n=433 ward patients) has been shown to correlate strongly with 30-day hospital mortality (Goldhill and McNarry 2004) and in one study to increase confidence and effective communication between nurses and doctors (Andrews and Waterman 2005). Subbe

et al (2003) found that the introduction of the MEWS did not improve communication or patient outcomes. The MEWS is sensitive in predicting critical illness and can be a useful adjunct to communication (Ryan *et al* 2004). Other factors that have been shown to improve nursing confidence and effectiveness in communicating and managing acute deterioration are:

1. Applied clinical knowledge of pathophysiology and physical assessment skills (McArthur-Rouse 2001, Smith 2001, Coombs and Morse 2002, Adams and Bond 2003b, Andrews and Waterman 2005).
2. The stability of nursing teams (Adams and Bond 2003a).
3. The nurse-to-patient ratio (Silber *et al* 1995, Aiken *et al* 2002, Needleman *et al* 2002, Adams and Bond 2003b, Curtin 2003).
4. Appropriate skill mix for patient dependency (McArthur-Rouse 2001, Adams and Bond 2003b, Clarke and Aiken 2003, Curtin 2003, Lankshear *et al* 2005).

It is important that nurses continue to lobby to improve the four factors cited above. In practice, however, nurses are working in sub-optimal environments and tools such as the MEWS or, as in this study, the PCT-Q may help simplify patient assessment and aid in communication.

1.13 Study design

The study was composed of five stages: the first two were pre and post-intervention and consisted of 10 qualitative interviews with nurses from different specialties and varying levels of experience, and a pre and post intervention questionnaire survey to 177 nurses from all acute wards. The third stage was the introduction of the two interventions: a dedicated teaching session on sepsis and an introduction to the sepsis marker blood test the PCT-Q. The fourth stage was the use of the PCT-Q in 416 sepsis episodes in 320 acutely ill cancer patients alongside other predictive markers already used in the hospital. In order to retain sufficient power for multivariate regression to compare predictors of sepsis, a total of 400 episodes was planned. Finally the fifth stage was the integration of the qualitative data from the interviews

and the open question in the questionnaires and comparison with the quantitative data.

1.14 Overview of chapters two to eleven

Chapters two and three provide the cancer and sepsis literature that forms the background to the study, the rationale for the development in practice, and the choice of sepsis marker. Chapter four focuses in detail on nurses' clinical practice, particularly their sensitivity to patient deterioration and the knowledge they use when assessing the acutely unwell cancer patient. Chapter five provides the explanation for the choice of design and the methodological approach to the study. The findings are presented in chapters six, seven and eight: first, the findings from the interviews with the nurses and the free text from the nurse questionnaire, secondly the data from the pre and post-questionnaire survey of bedside nurses across the trust, and finally the patient data. Chapter nine discusses the findings in relation to the literature and clinical practice. Lastly, chapter ten provides the conclusion to the thesis and implications for future research.

1.15 Conclusion

This study was therefore designed to investigate the nurses' role in the early diagnosis of sepsis and to provide nurses with a new objective tool and dedicated education to improve early diagnosis and rescue. The primary objective was to diagnose patients' sepsis at an earlier stage, recognising that nurses report a difficulty in convincing colleagues, an objective bedside test was to be introduced to improve multi-professional communication and therefore rescue. There were eight secondary objectives designed to achieve the overall and subsidiary aims of the study. The design of the study with its five stages is explained in more detail in chapter five.

The whole of the study was underpinned by a five part theoretical framework: the vulnerability of cancer patients to developing sepsis; early diagnosis and treatment reduce mortality and morbidity; nurses intuit subtle change which can be a stimulus to act; the awareness of risk highlighted by education; and information packaged as an objective test aids effective multi-professional communication and rescue.

Chapter 2 Cancer and vulnerability to infection and sepsis

2.1 Introduction

The immune system is responsible for protecting the body from infection and disease, and for maintaining a stable environment. It also plays an important role in carcinogenesis. This chapter discusses cancer and its effect on the immune system, and explains why people with cancer are so vulnerable to infection and hence why this study is so important.

2.2 What is cancer?

Cancer is a term that covers over 200 different types of disease resulting from the abnormal proliferation of cells which either mass together and form a tumour or, in the haematological cancers, stay in the blood or lymphatic system. Some cancers are rapidly growing, whilst others are indolent, taking years to become clinically significant. Cancer affects all ages but is more common in the older person. Cancers can be superficially divided into the solid tumours and the haematological cancers. Solid tumours are treated by a single therapy or more commonly by a combination of chemotherapy, surgery, radiotherapy, and hormonal, targeted and genetic therapies. The haematological cancers leukaemia, myeloma and lymphoma change the constitution of the blood, bone marrow and lymphatic system and thus require treatments that replace the diseased marrow, for example blood or marrow transplantation.

2.3 Epidemiology of cancer

There are national and international variations in the incidence and mortality of cancer related to income, lifestyle, genetic influence and access to prevention, screening and treatment. Across the world, incidence and mortality is higher in men than in women (Parkin *et al* 2001). In sub-Saharan Africa reduced life expectancy due to infectious diseases such as HIV and AIDS, tuberculosis and malaria means

that cancer is less prevalent (Murray *et al* 1997). By 2020, however, it is predicted that tobacco-related cancers such as lung cancer will feature in the 15 leading causes of death across the world (Evans *et al* 2006). Across Europe approximately one in four deaths are due to cancer and there are over one million deaths per annum (Cancer Research UK 2005).

Across the UK, the incidence of cancer increases in areas of social deprivation associated with higher tobacco use, poorer diet, delayed diagnosis and delays in treatment, particularly for some cancers such as oesophageal (DH 2004, Quinn *et al* 2005).

Growth in incidence of the rarer cancers is relevant to this study, as it is the haematological and gastrointestinal cancers that are particularly associated with the risk of sepsis and with poorer outcomes once it has developed. The age-standardised incidence rate for the haematological cancers is rising, for example the incidence of non-Hodgkin's lymphomas is increasing by an average of 1.2% a year (Cancer Research UK 2005). Oesophageal cancer incidence is also rising, with the UK rates being some of the highest in Europe (Gilbert *et al* 2002). In the UK the highest rates of oesophageal cancer are seen in Scotland and urban areas of north-west England and Wales (Quinn *et al* 2005). The general rise in the age-standardised incidence of oesophageal cancer, from 11.3 per 100,000 in 1975 to 18 per 100,000 in 2002 (Cancer Research UK 2005), affects admissions to all cancer centres. Due to changes in demographics, treatment regimens, incidence increase and cancer services reconfiguration there is a growing population of patients in cancer centres who are at risk of developing sepsis.

2.4 Immunology and cancer

The primary function of the immune system is to protect against infective micro organisms and against cells that have transformed and become infected, such as cancer cells, cells received from donation or transplant (blood or marrow) and cells which die (Moore 2006). The body's immunity against infection is achieved through a complex networking of innate and acquired immunity.

2.4.1 Innate (non-specific) immunity

This is the system of mechanisms responsible for the killing and removal of foreign macromolecules and pathogens (Moore 2006). Innate immunity relies on the following mechanisms:

1. Barriers;
2. Inflammation;
3. Phagocytosis and complement activity;
4. Complement;
5. Natural Killer (NK) cells;
6. Antimicrobial proteins.

2.4.2 Acquired immunity

Acquired, adaptive or specific immunity is the system of mechanisms that recognises, immobilises, destroys and eliminates foreign micro organisms, abnormal body cells and pathogens (Marieb 2008). Acquired immunity is mediated by two classes of lymphocytes: B and T lymphocytes, known respectively as B cells and T cells. B and T cells derive from the pluripotent stem cells of the bone marrow. B cells kill pathogens indirectly through the production of antibodies that kill the pathogen either directly or indirectly by controlling other immune mechanisms (Thibodeau and Patton 2003, Moore 2006). T cells have a direct action on pathogens, and their mechanism is therefore known as cell mediated immunity (Moore 2006). Acquired immunity depends on an immunological memory developed once the body has been exposed to a foreign antigen. B and T cells express unique surface markers that are different from each other (Thibodeau and Patton 2003). The international classification system for surface markers is the Cluster Designation (CD) system followed by a number. The helper T cell expresses CD4 and the cytotoxic T cell CD8 surface markers (Moore 2006).

Specific acquired immunity defences are:

1. Antigens;
2. Major Histocompatibility Complex (MHC) molecules;
3. B lymphocytes;

4. T Lymphocytes, Helper T lymphocytes, Cytotoxic T lymphocytes; and
5. Antibodies (Cheng *et al* 2000, Janeway *et al* 2001, Marieb 2001, Moore 2006).

The immune response to an antigen is therefore a complex network of mechanisms that may include both innate and acquired responses.

2.5 Inflammatory response to an infection: the beginning of the sepsis syndrome

An infection will result in an inflammatory response, including the activation of polymorphonuclear cells and complement, acute phase proteins, the clotting cascade and kinins, phagocytosis, production of cytokines and activation of macrophages and Natural Killer (NK) cells. If the micro organism is not stopped by the inflammatory response then a specific immune response will be initiated, often with both T and B cell response (Staines *et al* 1993, Moore 2006). The immune system is also closely related to cancer, with some tumours being associated with immunosuppression: Kaposi's sarcoma and lymphoma are linked to HIV (Tulpule *et al* 1999, Cannon *et al* 2000).

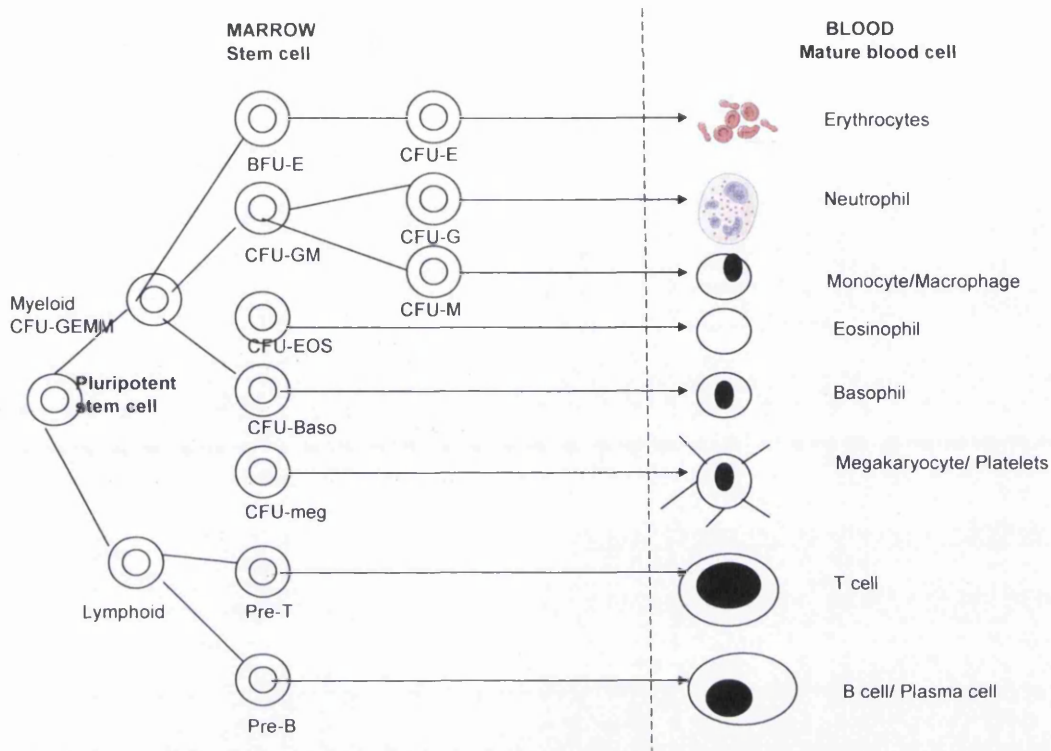
The patients with the highest potential risk of sepsis are those whose bone marrow has become disrupted due to either the disease or the cancer treatment. Major disruption of the bone marrow myelosuppression results in the loss of the polymorphonuclear cells, one of the major defences against infection. A summary of the normal function of the bone marrow as it relates to infection is therefore provided.

2.6 Normal function of the bone marrow related to infection

The bone marrow produces the myeloid cell line generating red blood cells, white blood cells and platelets. These cells are responsible for the carriage of oxygen, protection from infection and the ability of the blood to clot (Traynor 2006). Cancer or the treatment of cancer results in alterations to the function of the bone marrow, and depending on the severity and duration of this malfunction the person will be severely debilitated and may face severe life-threatening complications (Dolan 2006).

Haematopoiesis (blood cell production) is an important function for this study as patients who have a cancer affecting their bone marrow or have received marrow ablative chemotherapy need to wait for cell maturation to achieve immunity to infection. These patients are therefore vulnerable to infection and sepsis for days or weeks. Cell production occurs in the red bone marrow of the axial skeleton and girdles and in the proximal epiphyses of the humerus and femur (Marieb 2008). Haematopoiesis is controlled by a complex network of growth factors, cytokines, and chemokines (Janowska-Wieczorek *et al* 2001). Cells are formed at a different rate depending on the changing needs of the body and the regulation of each cell. All of the cells originate from the same source, the pluripotent stem cell, but then go on to mature along different pathways signalled by membrane surface receptors that respond to particular growth factors or hormones (see figure 2.1). Each cell has a distinct function as it reaches maturity (Traynor 2006, Marieb 2008).

Figure 2.1: Haematopoiesis



Haematopoiesis adapted from Traynor 2006, cells not to scale.

Key:

CFU-GEMM: colony forming unit granulocyte, erythrocyte, monocyte, megakaryocyte

BFU-E: burst forming unit-erythroid

CFU-GM: colony forming unit granulocyte, monocyte

CFU-Eos: colony forming unit –eosinophil

CFU-Baso: colony forming unit –basophil

CFU-Meg: colony forming unit – megakaryocyte

Pre-T: Pre-T cell

Pre-B: pre B cell

CFU-E: colony forming unit –erythroid

CFU-G: colony forming unit –granulocyte

CFU-M: colony forming unit –monocyte.

Leukocytes or white blood cells (WBC) account for only 1% of the total blood volume and function extravascularly (Traynor 2006). WBC are essential as a host defence against disease including infections, poisons and tumour cells. There are 4,000–11,000 WBC per cubic millimetre of blood. To mount an inflammatory or immune response the body accelerates their production, so a high WBC count is a useful clinical indicator of infection. There are five types of WBC (see table 2.1) with the neutrophils being the most numerous and the most important group in fighting infections, particularly bacterial and fungal. Neutrophils respond to chemotactic factors released from damaged tissues and bacteria and move to infective sites. The endotoxin of a gram negative bacterial infection causes a neutropenia until the healthy marrow responds causing a neutrophilia (Babor and Golde 2001, Marieb 2001, Traynor 2006).

Table 2.1: Types of white blood cells

Type of cell	Number of cells in the blood (mm ³)	Life span	Function
Neutrophil	3000–7000	6 hours to a few days	Bacterial kill
Eosinophil	100–400	8–12 days	Kill parasitic worms, destroy antigen-antibody complexes, inactivate some of the inflammatory chemicals of allergy
Basophil	20–50	Probably a few hours to a few days	The release of histamine and other mediators of inflammation
Lymphocyte	1500–3000	Hours to years	Immune response by direct cell attack or via antibodies
Monocyte	100–700	Months	Phagocytosis

2.7 Myelosuppression

Myelosuppression is the most common and potentially life-threatening effect of cancer and its treatment (Tervit and Phillips 2006). The three blood cells that are affected by myelosuppression are the erythrocyte (red blood cell) leukocyte (white blood cell) and thrombocyte (platelet) (see figure 2.1). Severe myelosuppression will diminish ability to transport oxygen (erythrocytes) and clot the blood (platelets), both important factors in the development of multi-organ failure, but it is the effect on immunity that is most important for this study. Risk factors for developing myelosuppression can be divided into three areas: patient characteristics, treatment and patient risk history (Lyman *et al* 2003).

2.7.1 Patient characteristics

A patient risk framework has been developed from the evidence of several studies. Lyman *et al* (2003) looked at 577 patients with lymphoma receiving combination chemotherapy (cyclophosphamide, doxorubicin, vincristine, prednisolone). They found that patients aged 65 years and over were twice as likely to experience myelosuppression. In a study of patients with non-Hodgkins lymphoma, Intragumtornchai *et al* (2003) showed that a raised serum lactate dehydrogenase (LDH), lowered serum albumin and tumour involvement of the bone marrow all contributed to a greater risk. Therefore patient risk factors are: age greater than 65 years, female, lowered albumin, raised LDH and decreased performance status and weight (Lyman *et al* 2003).

2.7.2 Treatment cycle-related risk factors

In a study of 175 breast cancer patients, Silber *et al* (1998) found that patients receiving both chemotherapy and radiotherapy were at higher risk, as well as those patients whose absolute neutrophil count (ANC) dropped during the first cycle of chemotherapy. Rivera *et al* (2002) validated the Silber study with another cohort of breast cancer patients.

2.7.3 Treatment-related risk factors

Chemotherapy drugs and regimens have different potentials for myelosuppression (Beveridge *et al* 2003, Dolan *et al* 2005). Patients who undergo a bone marrow transplant (BMT) or peripheral blood stem cell transplant (PBST) receive high doses of chemotherapy, often in combination with radiotherapy, and are therefore at the highest risk of treatment-induced myelosuppression (Outhwaite 2000, Dolan 2005).

The haematological cancers are associated with a greater risk of myelosuppression as the cancer located in the bone marrow disrupts normal cell distribution. At diagnosis the patient with an acute leukaemia, for example acute myeloid leukaemia (AML), may present with bone marrow failure resulting in infection, bleeding, anaemia or all three (Howard and Hamilton 2002). Solid cancers, particularly breast, prostate, lung and adenocarcinoma, can metastasise to the bone marrow with resultant myelosuppression, although usually not to such a degree as the haematological cancers (Howard and Hamilton 2002).

Treatment-induced myelosuppression can be understood in terms of how chemotherapy affects both the malignant and the normal cell cycle. Chemotherapy interferes with the synthesis of deoxyribonucleic acid (DNA), ribonucleic acid (RNA) and proteins and leads to cell death. Some drugs are specific to phases of the cell cycle and some are effective throughout the cycle (Tervit and Phillips 2006). Chemotherapy is directed at rapidly dividing malignant cells, but normal cells that have similar rapid cell doubling times such as bone marrow, hair follicles and epithelial cells of the gastrointestinal tract and gonads are also affected by chemotherapy (Tortorice 2000). Unlike cancer cells, normal cells have the ability to repair, therefore gastrointestinal toxicity, myelotoxicity and alopecia are usually reversible (Wujcik 1992, Tervit and Phillips 2006).

Radiotherapy damages all cells indiscriminately, both directly by the gamma or x-rays breaking the chemical bonds of the cellular DNA and indirectly by biological damage to chromosomes (Bomford and Kunkler 2003, Cule and Butters 2006). Bone marrow is highly sensitive to radiation with damage to the bone marrow dependent on the treatment field. The pelvic area is the most vulnerable to damage, as about 40% of the marrow-producing bone is located in this area (Souhami and Tobias

1998). If the radiotherapy doses are small the unaffected bone marrow sites will compensate, but in the case of patients who are receiving total body irradiation (haemato-oncology) or total pelvic or splenic radiation there is a higher risk of myelosuppression (Quinn and Stephens 2006).

Two further factors are essential in identifying risk for myelosuppression: the impact of multimodality treatment, for example patients receiving chemotherapy whose bone marrow has previously been subjected to radiotherapy (Camp-Sorrell 2000); and the cumulative effect that successive chemotherapy cycles have on bone marrow suppression (Camp-Sorrell 2000, Dolan *et al* 2005, Smith *et al* 2006).

2.8 Effects of myelosuppression on the person with cancer

Some patients develop a generalised bone marrow suppression with all three blood cells affected, others have one or two cell lines affected. All three lines are essential to health, but for this study the most important are those that protect the body from infection – the white blood cells and particularly the neutrophils.

The patient is usually unaware that their WBC count has fallen to a dangerous level. As the neutrophils are the most important in terms of infection, it is usually the neutrophil count that is used to monitor the patient's clinical condition. The severity of the neutropenia is defined according to the National Cancer Institute (NCI) grading system (see figure 2.2):

Figure 2.2: NCI grading of neutropenia (NCI CTEP (1999) Common Toxicity Criteria: Neutropenia)

Grade	1	2	3	4
	Mild	Moderate	Severe	Life-threatening
Absolute Neutrophil Count	<2.0 -1.5 x 10 ⁹ /L	<1.5 - 1 x 10 ⁹ /L	<1.0 - 0.5 x 10 ⁹ /L	<0.5 x 10 ⁹ /L

A lowered neutrophil count exposes the patient to infections that can be life threatening. Infection is the major cause of death in patients who are neutropenic (Ellerhorst-Ryan 2000, Vidal 2004, Dolan *et al* 2005, 2006, Safdar *et al* 2006). The incidence of infection is associated with the severity and duration of neutropenia (Bodey 1966, Meza *et al* 2002, Lyman, 2003, 2005). Patients who have experienced neutropenic infections have a higher chance of developing another event during subsequent neutropenic periods (Leonard *et al* 2003). Severe neutropenia with WBC count of <1.0 exposes the patient to life-threatening opportunistic infections from microorganisms that usually pose no threat (Offidani *et al* 2004). The common sites of infection in patients with a low neutrophil count are the lungs, skin and soft tissue, urinary tract, periodontium, gastrointestinal tract, blood and perineum (Urabe 2004). Neutropenia is the most common reason for chemotherapy dose limitation or a delay which may affect the patient's overall outcome (Bonadonna 1995, Budman *et al* 1998, Link *et al* 2001, Dolan *et al* 2005, Smith *et al* 2006). Assessment of neutropenia risk is made using a full blood count coupled with patient risk modelling: patient characteristics, type of cancer and treatment. Education about risk and minimising infection for the patient, family, and nursing and medical teams is an important aspect of care.

2.9 Management of lowered WBC

The aim is to minimise the risk of neutropenic events such as sepsis. An essential treatment is the use of Granulocyte-Colony Stimulating Factor (G-CSF) to reduce the duration and depth of neutropenia (Ozer *et al* 2000, Dolan *et al* 2005, Smith *et al* 2006).

Naturally occurring G-CSF is produced by endothelium, macrophages and other immune cells. Mouse G-CSF was first identified in 1983 and cloned for clinical use in 1986. G-CSF is a glycoprotein that stimulates the bone marrow to produce granulocytes, while also stimulating the differentiation, proliferation and survival of neutrophils. American Society of Clinical Oncology guidelines recommend using primary (prophylactic) administration of G-CSF if the patient is at high risk due to age above 65, medical history, disease characteristics, and the myelotoxicity of the chemotherapy regimen (Smith *et al* 2006). The European Organisation for the

Research and Treatment of Cancer guidelines also recommend proactive treatment with G-CSF in the person over 65 who is receiving myelotoxic therapy for non-Hodgkins lymphoma, small cell lung cancer or urothelial cancer (Lyman *et al* 2003, Repetto *et al* 2003, Aapro *et al* 2006, Smith *et al* 2006).

2.10 Treatment of cancer

With over 200 different types of cancer and many approaches to cancer treatment it is impossible here to describe a typical cancer treatment regimen. To provide the context, especially the risk of sepsis, two specific treatment examples are provided for two of the dominant cancers represented in the research study: leukaemia and oesophageal cancer.

2.10.1 Leukaemia

The leukaemias are a heterogenous group of malignant blood diseases including acute and chronic forms and further subdivided depending on morphology, cytogenetics, molecular genetics and immunological markers (Jaffe *et al* 2001, Atkinson and Richardson 2006). The four most common types of leukaemia are acute and chronic myeloid leukaemia and acute and chronic lymphoblastic leukaemia (Atkinson and Richardson 2006). Each type of leukaemia is managed differently; the treatment presented here is for a subtype that forms a large percentage of the study sample: acute myeloid leukaemia (AML).

The treatment for AML is chemotherapy +/- radiotherapy +/- a transplant to achieve a complete remission, defined as less than 5% blasts in the bone marrow and eradication of any disease in the central nervous system (Howard and Hamilton 2002, Sheinberg *et al* 2005). The treatment is divided into two phases: induction (to achieve remission) and postremission consolidation treatment (to avoid relapse). The treatment for AML is intensive hospital treatment for several weeks in a designated haematology centre accredited to perform BMT.

Induction chemotherapy and radiotherapy is followed by either an allogeneic or an autologous transplant. In AML, autologous transplant has been shown to be less effective (Soutar and King 1995, Atkinson and Richardson 2006) and research has

therefore focused on allogeneic transplantation (NICE 2004). Allogeneic transplants achieve longer disease-free survival but are associated with greater toxicity from sepsis, acute graft versus host disease (aGvHD), venous occlusive disease (VOD) and pneumonitis (Balsdon and Craig 2003). More recently, non-myeloablative reduced intensity or mini allogeneic transplants have been tried, especially in the frail patient. There is less toxicity but relapse is a significant risk (Richardson and Atkinson 2006).

Many toxicities are associated with the treatment for AML, but important for this study is the severe myelosuppression that begins five to seven days following transplantation and lasts for two to four weeks depending on the patient, disease and treatment regimen (Richardson and Atkinson 2006). Having ablated the patient's diseased marrow with drugs and radiotherapy the patient is pancytopenic until donated marrow cells have reached the bone marrow and normal haematopoiesis has begun. It is during this acute pancytopenic period that patients are at risk of life-threatening bleeds and sepsis.

Severe infections and sepsis are the major cause of death in the transplant period (Williamson *et al* 1999, Pastores *et al* 2002), hence the impetus for the current research study. To minimise the risk, patients are nursed in isolation with or without hepa-filtration and lamina air flow. Studies into isolation techniques for allogeneic transplant are not conclusive and practice varies (Parker 1999, Richardson and Atkinson 2006). Patients are closely monitored for signs of infection and are commenced on empirical broad spectrum antimicrobial therapy (Whedon and Wujcik 1997, Richardson and Atkinson 2006). It is during this period that patients with AML who develop sepsis are referred to the critical care outreach team and, if they deteriorate, to the CCU. Following this acute phase of treatment the patient is supported to recover and then after about six weeks is discharged home. Acute hospitalisation is followed by months of outpatient care monitoring haematological markers, levels of anti-rejection drugs and treatment with prophylactic antimicrobials (Whedon and Wujcik 1997, Richardson and Atkinson 2006).

2.10.2 Oesophageal cancer

Oesophageal cancer now accounts for 2.2% of all cancers and the incidence is increasing (Malthaner *et al* 2006). Many patients present late with widespread metastases and oesophageal cancer is the sixth most frequent reason for cancer death, annually causing over 286,000 deaths worldwide (Pisani *et al* 1999). Where treatment is possible the patient faces complex invasive therapy that requires hospitalisation in a recognised cancer centre (DH 2001). Oesophageal cancer is histologically usually either adenocarcinoma or squamous cell cancer (Thompson and Wells 2006).

For patients who are potentially curable, multidisciplinary assessment is essential to plan a complex combination of surgery, chemotherapy and radiotherapy (Thompson and Wells 2006). For localised disease, surgery is the treatment choice with cure achieved in only 15% to 39% of patients (Law *et al* 1992, Lerut *et al* 1992, Orringer 1993, Lieberman *et al* 1995). To improve survival several studies have investigated preoperative chemotherapy. Reviews conducted by Malthaner *et al* (2003), Kaklamanos *et al* (2003), Chong and Cunningham (2005) and Malthaner *et al* (2006) concluded that there may be a small survival benefit but that further evidence is needed. The survival benefit is balanced against the risk of added toxicity. A meta-analysis of five studies comparing preoperative radiotherapy with no preoperative radiotherapy in 1147 patients demonstrated a small absolute survival advantage of 3% to 4% (95% CI 0.78-1.01) (Arnott *et al* 2005). Finally, for non-resectable oesophageal cancer combined chemotherapy and radiotherapy as opposed to radiotherapy alone in a review of nineteen randomised trials demonstrated a modest absolute survival benefit of 9% (95% CI 5% to 12%) (Wong and Malthaner 2006).

Toxicities of treatment for oesophageal cancer are dependent on the patient, their comorbid disease, the cancer and the treatment regimen. As oesophageal cancer is associated with smoking and is more commonly found in men over the age of 50, patients often have co-existing ischaemic heart disease, chronic pulmonary disease and diabetes (Zambon *et al* 2000, Zeka *et al* 2003). Around 40% of patients undergoing surgery or multimodality treatment develop respiratory and cardiac complications (Gilbert *et al* 2002). Other complications are anastomotic leaks, deep vein thrombosis, and wound infection (Thompson and Wells 2006). Patients who

have undergone chemotherapy and oesophagogastrrectomy are admitted to CCU with a postoperative course that is often interrupted by severe pulmonary or abdominal infection leading to the possibility of sepsis. Patients undergoing multimodality therapy for oesophageal cancer are at increased risk from sepsis. Recovery from acute treatment may take several months while the patient learns to eat again and to restore their weight loss.

2.11 Conclusion

Cancer is a heterogenous disease with over 200 types requiring a large range of treatment modalities. There is an important relationship between the immune system and cancer. Many people with cancer will at some stage require treatment in hospital, during which they may be immunosuppressed as a result of the disease, the treatment or both. From the literature it is apparent that people who are immunosuppressed are more vulnerable to developing infections. People with haematological cancers or upper gastrointestinal cancer are more at risk of developing life-threatening infections. There is therefore a higher incidence of sepsis in cancer patients and a higher resulting mortality rate. Patients have more chance of surviving life-threatening infections if they are diagnosed early and this is the major objective of this study. In the next chapter, the link between sepsis, its epidemiology and cancer will be made.

Chapter 3 Literature review: epidemiology, incidence and pathophysiology of sepsis, Procalcitonin

3.1 Introduction

The previous chapter described the biology of cancer, with particular emphasis on the importance of immunology. This chapter describes the sepsis syndrome, beginning with details of the systematic approach taken in this study to reviewing the published literature on the epidemiology of sepsis, and incidence and early diagnosis of sepsis. The early diagnosis of sepsis is a relatively new field with limited publications and even fewer applied to the person with cancer. Following this review of the literature, there is a summary of the relevant pathophysiology of sepsis, highlighting the altered immune response. Finally, the chapter concludes with a review of the predictive immunological markers of sepsis, with an emphasis on the rationale for choosing Procalcitonin (PCT).

3.2 Collecting the evidence

The modern study of sepsis dates from the seminal meeting in 1992 of the American College of Chest Physicians and the Society of Critical Care Medicine (ACCP/SCCM) (Bone 1992). This therefore provides the start date for the literature review. For the period 1992 to 2008, searches were conducted of the databases of Medline, Embase, Cinahl, The British Nursing Index and the Cochrane library. Manual searches of the following journals for the same period were also undertaken:

- Critical Care Medicine;
- Critical Care;
- Chest;
- Intensive and Critical Care Nursing;
- Journal of Advanced Nursing;
- European Journal of Cancer Care;

- European Journal of Cancer.

A structured review of the literature based on a systematic approach to generating and selecting research-based literature was undertaken (Higgins *et al* 2008). All articles formally reviewed also had searches conducted of their reference lists.

Inclusion and exclusion criteria were identified to define and refine the parameters for the search. Abstracts of all papers conforming to the broad inclusion guidelines were reviewed and some papers immediately included. Where the abstract did not provide enough information the whole paper was reviewed before inclusion. Full papers were obtained of all material conforming to the inclusion criteria, which were then critically analysed before deciding on inclusion. As the search progressed more overlapping areas were found so that, by search four, although 950 papers were identified only 48 were new to the search and included. Duplicate references were removed. The papers were not graded for their level of evidence although they were all appraised.

3.3 Sepsis definition

In 1992, the ACCP and SCCM met in a consensus conference to define the sepsis syndrome for clinicians and researchers (Bone 1992). Following this seminal meeting over 3000 papers were published in English between 1992 and 2008, which focused on the identification and diagnosis, epidemiology, microbiology, definitions and management strategies for sepsis. Of the papers published during this period, 459 focused on the adult with cancer who develops sepsis. For the purposes of this review, publications for review were limited to those that concentrate on the epidemiology, diagnosis, risk factors and predictive markers of sepsis. The initial review was not limited to papers focused on sepsis and cancer, as this would have limited its scope.

3.4 Inclusion and exclusion criteria

3.4.1 Inclusion criteria

1. Research papers focusing on adults

2. International publications available in English
3. Research papers focusing on sepsis, severe sepsis and septic shock
4. Research papers focusing on the epidemiology of sepsis
5. Research papers on the diagnosis of sepsis
6. Research papers on sepsis and cancer
7. Research papers on the early diagnosis of sepsis.

3.4.2 Exclusion criteria

1. Research papers on children
2. Research not published or translated into English
3. Research before 1992
4. Review articles, commentaries, case studies
5. *Papers focusing on the treatment of sepsis, especially pharmaceutical studies
6. Papers focusing on sepsis following trauma
7. Papers focusing on sepsis following tropical disease
8. Papers focusing on sepsis following cardiac surgery
9. Papers focusing on sepsis following burn injuries.

*Papers focusing on the treatment of sepsis in the cancer setting were not included, as treatment is outside the remit of this study.

3.5 The epidemiology of sepsis

There were 30 hits for articles on the epidemiology of sepsis. Of these, 14 had epidemiology as their primary focus. Another five articles were found by using the reference list from one of the most recent overview articles (Linde-Zwirble *et al* 2004). One study was rejected as it concerned the epidemiology of sepsis associated with blunt or penetrating injury and was therefore outside the scope of this study (Osborn *et al* 2004). The 18 articles are listed in appendix 1.

These 18 studies provide a useful overview of the epidemiology and impact of sepsis. Each study has been given a number (1–18) for identification in the following summary. Studies 17 and 18 are the only papers looking at the epidemiology of

sepsis in malignancy and are therefore analysed separately (Williams *et al* 2004b, Danai *et al* 2006). Although a wide variety of countries are represented, there are no studies from the low-resourced countries. Taken together the studies represent a sample of 12,342,424 patients with sepsis, 303,042 with severe sepsis and 12,334 with septic shock, from 33 countries. The time periods surveyed vary from 24 hours to 22 years. The studies have varying endpoints: the progression of sepsis (Rangel-Frausto *et al* 1995), the incidence of infections and their outcome in ITU (Alberti *et al* 2002), and the incidence cost and outcome across a whole country (Angus 2001). The study samples were heterogenous but 13 (76%) of the studies (n=17) used the 1992 ACCP/SCCM consensus conference definitions for SIRS, sepsis, severe sepsis and septic shock (Bone 1992). The United States studies all use the International Classification of Diseases Ninth Revision-Clinical Modification (ICD-9-CM) (Deyo *et al* 1992) with one study (16) using both the ICD-9-CM and the ACCP/SCCM criteria.

3.6 Incidence of sepsis

Twelve of the studies measured incidence from ITU admission statistics, with the other six using hospital admission figures. The incidence of sepsis in the ITU admission studies, generally expressed as number of cases per 100 ITU patients (3, 4, 5, 6, 7, 8, 9, 12, 13, 14), ranged from 7.76% to 37%. Six of those studies (4, 5, 7, 8, 9, 13) had more homogenous rates between 7.76% and 14.6%, an average of one in 10 ITU admissions. The Dutch study calculated a one-day incidence at 31.42% with an annual incidence of 11% (van Gestel *et al* 2004, 158). Eight studies (3, 4, 5, 6, 10, 11, 12, 14) generated population incidence rates with a range from 0.5 to 1.5 cases per 1000 people.

The difference in incidence rates can be explained by the different research designs but also by the unequal distribution of ITU beds across the world. The UK and Brazil, for example (8, 12), have fewer ITU beds per population, therefore patients tend to be much sicker before gaining admission (Rowan *et al* 1993, Pappachan *et al* 1999, Padkin *et al* 2003, Silva *et al* 2004). Linde and Zwirble (2004) argue that it would be more accurate to use the term used by oncologists – “treated incidence” – as 12 out of the 18 studies reflect the epidemiology of those admitted to ITUs

(Linde-Zwirble 2004, p. 223). Using “treated incidence” would more accurately reflect two problems with the data: first, the difference in ITU provision, and secondly the decision making about whether patients are admitted for treatment.

Finally, four authors looked at incidence of sepsis over time (3, 7, 10, 11). These studies all describe a rising incidence of sepsis that is confirmed by other studies not described here (McBean *et al* 2001, Hugonnet *et al* 2003). Three describe a significant fall in mortality rates over time, which the authors ascribe to improved treatments and access to ITU (3, 10, 11).

3.7 Characteristics of sample with sepsis or severe sepsis

Eight studies (3, 8, 9, 10, 11, 12, 14, 15) showed that both the incidence and the mortality from sepsis increased with age. Those studies that looked at progression over age showed an increase in incidence, for example from 4.1% in patients below 20 increasing to 10.2% in patients over 80 (Wichmann *et al* 1999) and from <1/1000 at 50 years to 8.7/1000 in those over 80 (Flaatten *et al* 2004). In all samples that measured it, hospital mortality was higher at older ages and greatest in patients over 80. This is important for the present study as the incidence of cancer also increases with age.

3.8 Mortality rates

The ITU mortality rates for sepsis ranged from the low 16% in the early Rangel-Frausto study (1995) to 27% in the recent Vincent *et al* study (2006). As expected, mortality rates were higher for severe sepsis, from 20% (16) to 35.6% (13), and septic shock, 46% (16) to 65.5% (15). Predictors for mortality are shown in table 3.1 which is on the following page.

Table 3.1: Predictors of mortality

No	Author	Date	Predictors of mortality and significance where provided
1	Vincent <i>et al</i>	2006	Number of organ failures; Methicillin Resistant Staphylococcus Aureus (MRSA), Pseudomonas and Candida Albicans infections; female gender (95% CI p=0.013); older age (95%CI p<0.001); comorbid diseases; haematological cancer(95% CI p<0.001); cirrhosis (95% CI p=0.01); medical admissions (95% CI p=0.007); use of pulmonary artery catheters (95% CI p<0.001), mechanical ventilation (95% CI p<0.001), haemodialysis (95% CI p=0.009); positive accumulative fluid balance (95% CI p<0.001)
3	Dombrovskiy <i>et al</i>	2005	Older age; number of organs failing
4	Brun-Buisson <i>et al</i>	2004	Older age (p<0.0001); congestive heart failure (p=0.0002); chronic liver insufficiency (p=0.0002); organ failures – renal, cardiac, neurological (p<0.0001), respiratory, haematological (p<0.001) and hepatic failure (p<0.013)
6	Flaatten <i>et al</i>	2004	Increasing organ dysfunction
7	Laupland <i>et al</i>	2004	APACHE II score (95%CI p<0.0001); chronic organ insufficiency (95%CI p<0.1)
8	Silva <i>et al</i>	2004	Increasing age; comorbidities; number and severity of organ dysfunctions
10	Annane <i>et al</i>	2003	Comorbidity or immune suppression; multiresistant bacteria; organ failure and life-support therapies
11	Martin <i>et al</i>	2003	Organ failure
12	Padkin <i>et al</i>	2003	Increasing age; medical and emergency surgical admissions; renal dysfunction
14	Angus <i>et al</i>	2001	Increasing age; comorbidities; medical conditions;

			organ failure
15	Wichmann <i>et al</i>	1999	Increasing age; increasing organ failure

As can be seen from this table, across the 11 studies (n=18) that looked at mortality predictors the most important predictors in order of significance were:

1. Increasing age;
2. Organ failures;
3. Comorbidities;
4. Multi-resistant organisms;
5. Medical conditions; and
6. Surgical emergencies.

Finally, the studies by Danai *et al* (2006) and Williams *et al* (2004b) describe the epidemiology of sepsis in malignancy. In Danai's study 854 million acute care hospitalisations of 8.9 million cancer patients were reviewed from 1979 to 2001 using a nationally representative sample of non-federal acute care hospitalisations in the United States. The authors used the International Classification Disease-Ninth edition–Clinical Modification (ICD-9-CM) and the National Cancer Institute Epidemiology and End Results (SEER) databases. The SEER programme collects cancer incidence, prevalence and survival data from 14 population-based cancer registries and three supplemental registries representing approximately 26% of the United States population (National Cancer Institute 2005).

Sepsis occurred in 2.3 % of all cancer patients admitted to hospital. The incidence of sepsis in cancer patients increased from 24,150 in 1997 to 87,160 in 2001, an increase of 261% over 23 years. Over the 23 years of the study there were 1,781,445 cases of sepsis giving a mean annual incidence rate of 1465 cases per 100,000 patients. If this is compared to the rates noted previously for non-cancer patients (150 cases per 100,000 non-cancer US population), then cancer patients in this study were shown to be at 9.8 times increased risk of sepsis. The mean age for cancer patients with sepsis was significantly higher than for those without cancer: 62.8

years compared to 58.1 ($p < 0.001$). Incidence rates per 100,000 population in the various cancer subtypes are shown in table 3.2.

Table 3.2: Incidence rates for sepsis in cancer sub types

No.	Cancer sub type	Cases per 100,000 population
1.	Pancreatic cancer	14,468
2.	Multiple Myeloma	10,601
3.	Leukaemia	10,501
4.	Lung cancer	4,604
5.	Lymphoma	3,764
6.	Brain cancer	2,146
7.	Breast cancer	323
8.	Skin cancer	335

Source: Williams (2004b), Danai (2006)

Williams *et al* (2004b) retrospectively analysed over one year (1999) the patient discharge databases from six state hospitals in the United States (Florida, Massachusetts, New Jersey, New York, Virginia and Washington). This data was then merged with US Census data, Centers for Disease Control vital statistics, and National Cancer Institute SEER data. The ICD-9-CM codes for severe sepsis were also used in this study. The incidence of severe sepsis was 4.9% of all cancer admissions, with a higher rate in those admitted for medical (5.5%) rather than surgical (3.8%) reasons. As in the Danai study the cohort of patients with sepsis and cancer was older than the non-cancer patients (68.2 years versus 66.2 years). There were also more males than females with cancer who developed severe sepsis (55.6% versus 49.9%) After adjusting for age and gender, people with cancer are more likely to be hospitalised with severe sepsis (relative risk 3.96 CI 95%, 3.94-3.99). Williams *et al* estimated that nationally there are 126,200 cases of severe sepsis in the cancer population annually. The mortality rate for cancer patients with sepsis was 52% higher than for non-cancer patients (37.8% versus 24.9%).

3.9 Summary of sepsis epidemiology and incidence

The incidence of sepsis cases per annum worldwide is 1.8 million, but with problems in diagnosis and monitoring in many countries this is likely to be an underestimation (Slade *et al* 2003). The authors of Surviving Sepsis Campaign estimate that with an incidence of 3 in 1000 per population a more accurate incidence per annum may reach 18 million, with a mortality rate of between 30% and 70% for sepsis, severe sepsis and septic shock, and higher in people with a chronic disease (Dellinger *et al* 2008). Sepsis therefore, is a leading cause of death worldwide and the commonest cause of death in non-coronary ITUs (Angus *et al* 2001, Hoyert *et al* 2001, Aird 2003, Alberti *et al* 2003, Angus *et al* 2003, Bochud 2003, Padkin *et al* 2003, Decker 2004, Dellinger *et al* 2004, 2008). The elderly are more susceptible to sepsis and have a higher associated mortality, so as their numbers increase it is predicted that the incidence will continue to grow (Slade 2003). Other influences on growth are increases in nosocomial infections and antimicrobial resistance (Wenzel 2000, Annane *et al* 2003, Vincent *et al* 2006). In order to understand the challenges of diagnosis and the lack of progress in reducing mortality rates, it is important to understand the pathophysiology of the sepsis syndrome. The next section therefore explores the current understanding of the syndrome.

3.10 Pathophysiology of the sepsis syndrome

The sepsis syndrome is a complex systemic inflammatory syndrome associated with infection (Almog 2003). It is not the infective pathogen that directly causes multi-organ failure and high mortality, but the host response to that pathogen (Aird 2003). To understand the syndrome it is useful to divide the complicated pathophysiology into four main areas:

1. The individual host response;
2. The role of the endothelium;
3. The disequilibrium of the proinflammatory and antiinflammatory mechanisms; and
4. Activation of the coagulation pathways.

For any nurse who works with people critically ill from sepsis, it is clear that there is a heterogeneity of response to infection. Nurses working with the acutely ill cancer patient will have witnessed two patients with identical microbiology but variant responses to infection: one improves following a course of antimicrobials while the other develops severe sepsis and dies. The large clinical trials conducted in the late 1990s investigating the use of anti-endotoxin antibodies demonstrated that solely targeting the infecting pathogen does not work (McCloskey *et al* 1994, Angus *et al* 2001, Aird 2003, Riedemann *et al* 2003).

3.11 Role of the endothelium

The endothelium is responsible for many vital roles in maintaining health, which include:

- Regulation of cellular and nutrient trafficking;
- Generation of new blood vessels;
- Maintenance of the fluidity of blood;
- Vasomotor tone; and
- A contribution to the local balance of proinflammatory and anti-inflammatory mediators (Rosenberg and Aird 1999, Gross and Aird 2000, Aird 2001, Stevens *et al* 2001, Aird 2003).

It is the interaction of the endothelium with the local environment, for example the invasion of bacteria that is important to this study. Invasion of bacteria causes local endothelial cells to release inflammatory mediators, leucocytes and the activation of the clotting cascade. This endothelial action is a part of the normal healthy response of the body to an invading pathogen. In severe sepsis, however, the endothelial response is dysfunctional with an excessive, sustained and generalised activation of the endothelium (Aird 2003, Bochud 2003). The endothelium of the person with sepsis may be phenotypically altered by several different mechanisms: pathogenic infection of the endothelial cells (Bochud 2003) and/or activation by the host's cell mediators such as cytokines, chemokines, proteases, fibrin, activated platelets and leucocytes, hyperglycemia, changes in oxygenation and blood flow (Volk and Kox 2000, Faure *et al* 2001, Henneke and Golenbock 2002, Zhao *et al* 2001, Aird 2003).

There is also a heterogeneity of response depending on individual patient factors such as age, genetics, comorbidities, gender, the type of pathogen and the area of the body most affected (Westendorp *et al* 1997, Hermans *et al* 1999, Kumar *et al* 1999, Mira *et al* 1999, Arbour *et al* 2000, Mavrommatis *et al* 2001, Arnalich *et al* 2002, Cariou *et al* 2002, Nadel 2002, Yamamoto *et al* 2002, Aird 2003, Knobl 2005). The function of the endothelium is also affected by: changes in the hemostatic balance resulting in a procoagulant state (Yamamoto and Loskutoff 1996, Weiler *et al* 2001, Yanada *et al* 2002); cell adhesion and leucocyte trafficking (Aird 2003); vasomotor tone with a resultant decrease in mean arterial pressure (McCuskey *et al* 1996); barrier function with increased vascular permeability (Ferro *et al* 2000); and an increased rate of apoptosis (Fujita *et al* 1998, Bombeli *et al* 1999, Kawasaki *et al* 2000, Aird 2003).

3.12 Summary of altered inflammatory response in sepsis

In health the host endothelium responds to insults locally, but in sepsis there is a generalised host response that can no longer be regulated by local negative feedback mechanisms (Munford and Pugin 2001, Bochkov *et al* 2002). This generalised response results in a severe disequilibrium of inflammatory response, which causes generalised tissue injury, vascular permeability, shock and multi-organ failure (Decker 2004, Dolan 2006, Dellinger *et al* 2008). The patient thus develops multi-organ failure necessitating admission to intensive care.

3.13 The early diagnosis of sepsis

There is robust evidence that earlier diagnosis with appropriate monitoring and treatment correlates with improved outcomes. There are, however, challenges to diagnosing sepsis early and thus the experience of many critical care clinicians is that referrals are often received too late. The early diagnosis of sepsis has been shown to reduce mortality rates as it allows prompt treatment: either antimicrobial therapy, or, where possible, removal of the sepsis source such as the gangrenous gut, or the removal of an infected skin tunnelled catheter (Bota *et al* 2003). Several studies have also illustrated the increased mortality associated with a delay in diagnosis (Aube *et al* 1992, Leibovici *et al* 1997, Weinstein *et al* 1997). Work over

the last 10 years has concentrated on early recognition and therapy for sepsis in an attempt to prevent the systemic sequelae of generalised inflammatory change, tissue damage, increased cell permeability, shock and organ damage described previously (Rady *et al* 1996, Rivers *et al* 2001, Vincent *et al* 2002, Dellinger *et al* 2004, 2008).

The challenge for nurses and healthcare teams is that the early clinical signs are often subtle and difficult to recognise. Some of the clinical, biochemical and haematological signs of sepsis are also indicators of non-sepsis conditions such as pancreatitis, cerebral haemorrhage or other major shock conditions (Circiumaru *et al* 1999, Bota *et al* 2003). To reduce mortality rates, evidence and experience indicate that the earlier the person is identified and then monitored the more chance there is of preventing a critical illness (Rivers *et al* 2001, Dellinger *et al* 2004, 2008). As nurses work so intimately with people who are at the highest risk of developing sepsis, they are key members of the multidisciplinary team, and this study is designed to help them to identify at-risk patients and those who are deteriorating at an earlier stage (Ruffell 2004). There are over 42 early predictors of sepsis described in the literature since 1992. Seven of these indicators are clinical signs such as a raised or lowered temperature, a raised respiratory rate and changes in the Glasgow coma scale (GCS). There are two severity of illness scores: SOFA and APACHE II. The remaining 33 indicators are different blood indicators. A table of these early indicators of sepsis can be found in appendix 2.

3.14 Procalcitonin (PCT)

The predictive marker most commonly studied between 1992 and 2007 for its utility in sepsis diagnosis, prediction of the course of illness and mortality is procalcitonin (PCT). PCT is the prohormone of calcitonin (CT), a hormone that was discovered in 1961 to be involved in lowering serum calcium (Copp *et al* 1961). CT was isolated in the thyroid gland (Hirsch *et al* 1963) within the parafollicular cells (Foster *et al* 1964, Meyer *et al* 1968). These parafollicular cells came to be known as C cells and are neuroendocrine cells (LeDouarin 1970). It was the demonstration in the late 1960s and 1970s that these C cells were involved in medullary thyroid cancer (MTC) that led to the isolation of human CT (Byfield *et al* 1969). CT continues in 2008 to be the classical clinical marker of MTC (Becker *et al* 2004). CT is

biosynthesised from the polypeptide precursor prohormone, procalcitonin (Singer *et al* 1974, Roos *et al* 1974, Mouktar *et al* 1975, Moya *et al* 1975, Goodman *et al* 1979, Becker *et al* 2004). CT is therefore characterised as a mature hormone that has been derived from a larger precursor prohormone (Becker *et al* 2004). Procalcitonin (PCT) is a 116-amino acid comprised of three constituent peptides (LeMoullec 1984).

PCT continues to be studied for its sensitivity as a marker for MTC, although as yet it has not been determined whether it is as sensitive as CT (Becker 2004). There are also non-cancer conditions that are associated with higher levels of PCT; these are all conditions characterised by involvement of the pulmonary neuroendocrine cells: chronic obstructive pulmonary disease, tuberculosis, inhalational burns or chemical irritant (Becker *et al* 1984, Becker *et al* 2004). It is the increase of PCT that occurs with sepsis that is key to this study. PCT in sepsis has been shown to be harmful and immunoneutralisation may be a potential effective therapy (Nylen *et al* 1998, Becker *et al* 2004).

3.15 History and discovery of PCT's role in sepsis

In 1983 two articles linked CT with sepsis. One was a letter to the Lancet (Mallet *et al* 1983) concerning a meningitis outbreak in children; the other was concerned with adults with the staphylococcal toxic-shock syndrome (Chesney *et al* 1983). In both cases CT was found to be markedly elevated, and later work revealed that the immunoreactive CT was of a large molecular weight corresponding to PCT and the carboxyterminus peptide 1 (CT CCP-1) (Becker *et al* 2004). This work led to interest in an assay that could predict the severity and even outcome of sepsis and severe sepsis. Several proinflammatory cytokines associated with the severe inflammation of sepsis are raised in the blood, for example Interleukin 6 (IL-6), Interleukin -10 (IL-10), Tumour Necrosis Factor alpha (TNFa) but only intermittently, PCT however increases and remains high.

By 2008, after many subsequent studies, PCT physiology was better understood. PCT is synthesised by thyroid C cells, but in sepsis originates from many areas throughout the body outside the thyroid, even in patients who have had a previous

thyroidectomy (Nishikura 1999). Using gel filtration chromatography, substantially increased levels of PCT were found in the major organs (liver, lung, kidney, pancreas, brain, heart and small intestine) of septic hamsters (Muller *et al* 2001, Becker 2004). In experimental studies following intravenous injection of endotoxin to healthy volunteers, serum PCT is detectable at four hours and maintains a plateau through eight to 24 hours following an increase of proinflammatory cytokines such as TNF α and IL-6 (Dandona *et al* 1994). Four assays have been created to measure PCT in the blood. In Europe the assays are available from BRAHMS Diagnostica and include several assays including a sensitive tracer technology Kryptor assay which may be useful in detecting infection earlier (Nylen *et al* 2003).

3.16 The PCT bedside kit: the PCT-Q

In 1999 a bedside kit was developed: a semi-quantitative immunochromatographic dipstick test which can be used at the bedside as opposed to the laboratory and provides a result in 30 minutes. The PCT is detected by binding to a mouse monoclonal antibody complexed to colloidal gold. By capillary flow the bound complex travels through the strip and turns it red. The concentration of the colour correlates with three different PCT concentrations (Meisner *et al* 2000c). This is the first time a sepsis marker has been available in a bedside form, and its use is described in more detail in chapter five.

3.17 Procalcitonin as a predictive marker of sepsis and severe sepsis

Ten years after the letter to the Lancet about CT (Mallet *et al* 1983), a group of French scientists working with children from newborn to 12 years of age prospectively examined the blood of 79 children admitted to hospital with suspected infections (Assicot *et al* 1993). This early study found that the 19 patients with severe bacterial infection on admission had high serum concentrations of PCT (6–53 ng/ml), whereas children who were found to have no signs of infection had serum PCT levels less than 0.1 ng/ml. The authors of this paper concluded that the serum concentrations of PCT seemed to correlate with the severity of microbial invasion

(Assicot *et al* 1993). Three years later a group of researchers working in Germany, having read Assicot's work designed a prospective study to investigate 337 adult patients who were hospitalised and fulfilled the SIRS criteria (Al-Nawas *et al* 1996). Al-Nawas, Krammer and Shah measured the serum PCT levels on admission and then for nine days. They demonstrated that patients with microbiologically documented infection showed peak PCT values of 30 ng/ml at day three while those adults without sepsis had baseline PCT values of 0.1 ng/ml or lower.

There are over 1034 publications on PCT, but many of these are in populations or for indications that are outside the scope of the present study. A systematic review of the literature was undertaken with the same methodology described earlier. The review was limited to studies concerned with adults, associated with sepsis and written in English. These inclusion criteria reduced the field to 104 studies, 10 of which were meta-analysis.

3.18 Summary of PCT review

PCT has been shown to have an important place in the early diagnosis of infection, sepsis, the monitoring of sepsis and the prediction of mortality. There is no evidence that PCT or any other marker of sepsis is reliable in 100% of patients with sepsis. There is evidence, however, to show that PCT is superior to C-reactive Protein (CRP) in identifying sepsis (Whicher *et al* 2001, Simon *et al* 2004, Mitaka *et al* 2005, Uzzan *et al* 2006). Several studies support the use of PCT-Q in practice as an adjunct to effective clinical care including risk awareness, medical history and physical examination (Levy *et al* 2003, Uzzan *et al* 2006). There is also evidence to support the combined use of markers of sepsis as part of the clinical assessment. Finally, the cut off value for PCT should be applied with careful regard to the clinical context of the patient (Whicher *et al* 2001, Rau *et al* 2004). In other words, increased PCT indicates a SIRS response to infection and is not a "gold standard" for infection, but may make the diagnosis easier when combined with other clinical assessments (Whicher *et al* 2001, Rau *et al* 2004, Meisner *et al* 2005).

3.19 Conclusion

From the literature review it is clear that sepsis is the systemic response to infection and is defined as having four stages that worsen from the early stage of Systemic Inflammatory Response Syndrome (SIRS) to Severe Sepsis when the patient is critically ill receiving multi-organ support. There is a high mortality rate associated with cancer and severe sepsis. Diagnosing and treating sepsis at an early stage SIRS/Sepsis results in increased survival. Diagnosing sepsis early is challenging as there can be few physical manifestations, however at a cellular level there are changes and early blood markers / indicators of sepsis have been developed. Of these early indicators procalcitonin and its bedside test the PCT-Q has been demonstrated to be valid and reliable in cancer patients.

No marker of sepsis is useful without clinical awareness and sensitivity to the possible changes in a patient's condition. In acute cancer care, this awareness and then effective action are essential. Unfortunately, the evidence and clinical experience demonstrates that clues are missed and an effective response is limited, with vulnerable patients reaching a stage of sepsis when Intensive Therapy Unit (ITU) admission is inevitable and mortality rates are too high (McQuillan *et al* 1998, McGloin *et al* 1999, Goldhill *et al* 1999 Chellel *et al* 2002, Clarke and Aiken 2003, DH 2003, Goldhill *et al* 2005). The next chapter therefore explores the literature relating to the sensitivity triggers for nurses working in acute care.

Chapter 4 Literature review: sensitivity to patient change/deterioration

4.1 Introduction

Previous chapters have emphasised the risk of sepsis for the cancer patient and the imperative to diagnose and treat early if a high mortality rate is to be reduced (Danai *et al* 2006). Nurses are the healthcare professionals who are most often with the patient day and night. Therefore, nurses are key in recognising early signs of change ensuring that recognition is translated into action: contacting others and mobilising an appropriate and timely response. It is essential, that nurses are sensitised to the dangers of sepsis and early changes and that they have the knowledge, skills and confidence to recognise change and mobilise the team.

There is considerable evidence, both empirical and anecdotal, that nurses are able to detect subtle changes in a patient's condition even when overt signs of deterioration are not obvious. Coffee room anecdotes talk of nurses having gut feelings or hunches, or “just knowing” that a patient was “not right”, while more formal accounts in the literature talk of intuition. The work of Patricia Benner and her account of the ability of the expert nurse rapidly to assess the patient's condition and make rapid decisions about the need for action is important here (Benner 1984, 1987, 1992, 1999). Many nursing authors discuss the value of intuition in the rapid detection of the deteriorating patient (Rew 1988, Benner 1992, 1999, Ruth-Sahd 1993 Cioffi 1997, McCutcheon and Pincombe 2001, Smith *et al* 2004). Intuition has had both a positive and a critical press but its role in crisis recognition is important to examine for this study.

It would seem reasonable to assume that most nursing practice is not random or capricious and that the decisions of nurses are based on some body of theory and knowledge, even if this is not always articulated. Flemming and Fenton (2002)

identify knowledge and experience as major influences in nursing practice. Of particular interest for this study is the way nurses respond to subtle changes in the patient and the action they then take. Ruth-Sahd describes intuition as a way of knowing that “allows the nurse to anticipate what may happen in the immediate future, plan ahead, prepare and mobilize others before a crisis occurs” (Ruth-Sahd 2003, p. 130). Intuition has been described in the nursing literature for over twenty years and in this chapter is discussed as it applies to the care of the cancer patient at risk across all wards and with all nurses from the ‘novice’ newly qualified nurse through to the ‘expert’ senior practitioner.

4.2 Intuition and recognising change

As described in chapter three, the early changes shown by the patient who is developing sepsis may be minimal and difficult to quantify. The cancer patient with severe sepsis will eventually develop marked changes in their vital signs and gross manifestations of deterioration such as change in consciousness, respiratory difficulty, absence of urine, but before these late changes there is an opportunity for the bedside nurse to note subtle change and to raise the alarm early. The patient themselves may express that “they don’t feel as well” or the nurse may notice a change in the appearance, demeanour or behaviour of the patient. It is this early stage before the vital signs have changed that is important for the early recognition of sepsis and thus for the present study. The changes that the patient or nurse recognise are caused by a physiological alteration that can be detected using the PCT-Q but the nurse needs to notice and act on this “change” to initiate its use.

There are several steps that are necessary to make the nurse’s intervention in the early stages of sepsis successful. First there is the recognition of change either by the nurse or the patient. Change is a variation in the status quo or the norm. There is evidence that it is easier to recognise subtle change if the nurse “knows” the patient sufficiently well to see an alteration (Noddings and Shore 1984, Logan and Boss 1993, Smith *et al* 2004). For the patient’s voice to be effective the nurse needs to listen actively to the patient and respect their view despite there being no objective

evidence of alteration. There is then a need having noticed a change to follow it through with action. John Dewey in his work "How we think" (1910) describes the way change makes us uncomfortable and disturbs the equilibrium making the reflective thinker take steps to formulate a plan, or consider a solution:

The data at hand cannot supply the solution; they can only suggest it. What then are the sources of the suggestion? Clearly past experience and prior knowledge. If the person has had some acquaintance with similar situations, if he has dealt with material of the same sort before, suggestions more or less apt and helpful are likely to arise (Dewey 1910, p. 12).

Dewey contrasts inertia with active intellectual curiosity that is seeking for answers. In acute cancer nursing this kind of proactive curiosity coupled with a moral intent to improve the patient's situation is essential. Questioning about change is followed by a sifting of prior knowledge in the effort to find a solution. This discomfort followed by a search for further data has been linked with intuition. Intuition is an important phenomenon in this study where acute sudden change needs to be recognised and followed by action. The nurse having been disturbed by intuiting a change has then to be motivated to do something quickly. The nurse's decision involves making a likelihood judgement about whether this patient is going to deteriorate; searching for further data and comparing with similar events experienced previously. Intuition has been described by spiritual leaders, philosophers and artists for thousands of years and has several different definitions in the Oxford English Dictionary. For this study the most relevant definition is the following:

"The immediate apprehension of an object by the mind without the intervention of any reasoning process; a particular act of such apprehension" (OED 2009)

It is the quality of immediacy and understanding that is important to this study where rapidity of detection is so important. Intuition has been described variously by many philosophers, but the description by the Italian philosopher Benedetto Croce (1866-1952 cited in Patankar 1962) is particularly useful. Croce described intuition as the process of consciousness whereby the myriad of objects, images and sensations that are constantly presenting themselves are constructed into forms or structures that

make them intelligible and identifiable and that intuition makes this new consciousness expressible to others (Patankar 1962). For this study it is this rapid identification of change and the ability to translate concern to others that makes Croce's definition of intuition so useful. The Croce definition of intuition therefore consists of three stages:

1. The apprehension or recognition of the phenomenon
2. The cognitive process of classification
3. A choice about what to do with this data, much of it will be discarded, some may be acted upon.

The theoretical assumptions underpinning this study are that people with cancer are susceptible to sepsis and once they have developed it are much more likely to die from it; survival from sepsis is increased the earlier it is diagnosed and treated; the early signs of sepsis are subtle and therefore the nurse needs to be prepared or sensitised to these sudden subtle deviations from the norm. The subtle deviations may not even be consciously recognised and articulated, but there is rather a sense of discomfort of the sort that Dewey describes – the nurse intuits change but must then work out what has changed and what the significance of this might be. Croce's model of intuition is therefore useful to this study where rapid detection is important, the nurse is faced with many competing stimuli and needs to work with others to help the patient.

4.3 Intuition and Nursing

Nursing authors have recognised intuition as an important type of clinical knowledge and have taken a variety of approaches to its study (see table 4.1.) Nurse researchers however do not seem to have related their discussions to the classical definitions of intuition discussed previously. Rather than describing the fundamental process of recognition or apprehension followed by cognitive processing and then the choice to act or not, intuition in the nursing literature has progressed from Benner in 1984 along a different path.

One definition often quoted is “understanding without rationale” (Benner and Tanner 1987), but many authors have described how the process of intuitive judgement may lead to an analysis of cues and further data. Muir (2004) argues that intuition is about pattern recognition, where each new patient or situation will be compared with previous circumstances stored in the nurse’s memory and then compared (Muir 2004, p. 52); this links directly with Dewey’s reference to past knowledge and experience.

In their review of research on nurse intuition, King and Appleton (1997) provide a comprehensive literature review up to the mid 1990s. They describe one of the earliest research studies describing the intuitive component of critical care nurses’ decision making (Pyles and Stern 1983). In that study, intuition was not described by the nurses but rather “gut feelings” particularly associated with something that was going to happen, usually deterioration. They described patients “falling out of the pattern”, where their progress or observations varied from what the nurse would have expected (Pyles and Stern 1983, p. 54). This theme of an early warning of imminent deterioration runs throughout the nursing literature on intuition (Benner and Tanner 1987, Smith 1988, Truman 2003, Rovithis and Parissopoulos 2005). Schraeder and Fisher (1987) like Ruth-Sahd (1993) include the preparatory nature of intuition linking perceptions from the past with an anticipated future. Over ten years later, Benner and colleagues (1999) also describe intuition when exploring the work of critical care nurses as being able to be used as “clinical forethought” so that nurses prepare the environment anticipating possible clinical sequelae that they have encountered previously (Benner *et al* 1999, p. 64). In 2008 the National Patient Safety Agency (NPSA) designed a patient safety initiative to encourage nurses to use forethought or foresight in reducing errors and increasing safety (NPSA 2008). Therefore in the nursing literature there is a concentration on intuition being associated with risk or preventing something negative whereas in the classical literature, intuition is not associated with good or bad but recognition.

4.4 Intuition and uncertainty

There are more studies associated with critical care nurses and intuition than any other specialty of nursing (Pyles and Stern 1983, Smith 1988, Rew 1988, Rew 1990,

Benner *et al* 1992, Polge 1995, Elcock 1997, Benner *et al* 1999, King and Macleod Clark 2002, Aitken 2003). This may be because of the association between intuition and uncertainty and rapidity of decision making (Noddings and Shore 1984, Rew 1986, Benner 1992, Eraut 1994, Easen and Wilcockson 1996, Parker *et al* 1997). It is not just speed of decision making that these studies have in common, but the fact that the patient is in danger. Cioffi (1997) cites Benner and Wrubel (1982) and Benner and Tanner (1987), who demonstrated that nurses use intuition most when patients are at risk. This directly relates to the present study and the patient with cancer and sepsis who is in danger of deteriorating. Before proceeding to look at the research studies examining intuition, King and Appleton review several author's attempts to describe the defining attributes of intuition. These are listed in table 4.1 with definitions from later authors.

Table 4.1: Definitions of intuition as applied to clinical nursing practice

No	Definition	Date	Authors
1	"Intuitive perception in nursing practice is the ability to experience the elements of a clinical situation as a whole, to solve a problem or reach a decision with limited concrete information" (p. 161)	1986	Schraeder and Fischer
2	"knowledge of a fact or truth, as a whole; immediate possession of knowledge; and knowledge independent of the linear reasoning process" (p. 60)	1987	Rew and Barrow
3	"Understanding without a rationale" (p. 23)	1987	Benner and Tanner
4	"A perception of possibilities, meanings, and relationships by way of insight" (p. 63)	1987	Gerrity
5	"process whereby the nurse knows something about a patient that cannot be verbalised, that is verbalised with difficulty or for which the source of knowledge cannot be determined" (p. 52)	1987	Young
6	Six key aspects: "pattern recognition, similarity	1988	Dreyfus and

	recognition, commonsense understanding, skilled know-how, sense of salience and deliberative rationality” (p. 23)		Dreyfus
7	“knowing the patient or client and being involved with his /her care are also key elements which strengthen the nurses’ intuition”	1996	Benner et al
8	“a process of making sense of a situation which often leads to a decision. This process is non-conscious by-passing linear methods of reasoning and, by western cultural standards, is considered to be irrational. Intuition involves the use of a sound, rational, relevant knowledge base in situations that, through experience, are so familiar the person has learned how to recognise and act on appropriate patterns” (p. 671)	1996	Easen and Wilcockson
9	“ lacking underlying conscious processes and as not being able to be explained in a tangible manner” (p. 204)	1997	Cioffi
10	“Unconscious competence” (p. 305)	1999	Turnbull
11	“intuition is a function of experience where cue patterns become so well associated with desired responses (treatment or intervention classes) that the classes are automatically brought to mind, i.e. there is no conscious rule following and rapid association obscures the exact nature of the initiating cues” (p. 996)	2000	Buckingham and Adams
12	“It is intuition that allows the nurse to anticipate what may happen in the immediate future, plan ahead, prepare and mobilize others before a crisis occurs” (p.130)	2003	Ruth-Sahd

13	<p>“Intuition occurs in response to knowledge and is a trigger for nursing action and reflection. Subsequently it has a direct bearing on analytical processes in patient care. If intuition continues to be ignored it will be at the peril of the nursing profession. Practitioners will become entrenched in standardized procedures and routines of care and there will be little opportunity for the flare and skill of nursing judgement to flourish” (p. 6)</p>	2005	Rovithis and Paissopoulos
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Benner and colleagues (1992) used a sample of 105 critical care nurses from neonatal, paediatric and adult units in different hospitals to explore the use of intuition. They grouped nurses into focus groups by their length of experience and expected expertise. In these groups the nurses provided narrative descriptions of episodes in their practice, and some were directly observed in practice. Data was also collected on the nurses’ perceptions of their educational experience and careers. The study drew on the model of skills acquisition developed by Dreyfus and Dreyfus (1988) and also on Benner’s own work on domains of practice (1984). Benner says the findings of the 1992 study highlight the ability of the expert nurse to use intuition in perceiving a situation rapidly and that the expert nurse has an increased ability to use perception and emotion to undertake expert clinical judgement. In this paper Benner likens the nurses’ crisis anticipation to Dreyfus and Dreyfus (1985) six key aspects of intuition that is pattern recognition, similarity recognition, commonsense understanding, skilled know-how, sense of salience and deliberative rationality. Although the link with pattern recognition is key to this study there is a problem with the exclusivity of intuition and the “expert nurse”. As previously described Croce’s interpretation of intuition is available to anyone as to intuit is to perceive and then interpret. It would therefore seem likely that the novice nurse would have the faculty to intuit change but will not have the abundance of patterns or previous experience that the “expert” nurse has. As the novice nurse is often the one at the bedside it is important that the novice nurse is encouraged to have confidence in their intuition of change and to call for help.

4.5 Intuition and somatic feelings

In a further study with 25 critical care nurses from five different hospitals, Rew (1990) found that nurses described intuition using the following terms: knowing, gut feeling, sixth sense, perception and ability to anticipate (Rew 1990). The mystical sense of intuition described in Rew's study as "sixth sense" is often quoted in the literature and may be associated with a cognitive inference where visual and other cues are so rapidly or subliminally assimilated that they are not articulated and hence attributed to something mystical. For this study intuition is used fundamentally and prosaically as the prepared nurse intuiting change and then using past experience to guide present care. This "sixth sense" and "gut feeling" described by nurses in Rew's study are however important in that they are often used by nurses to describe this phenomenon. The somatic feeling associated with intuition especially pre crisis is often quoted and may be because the nurse recognises signs that have previously led to a sudden deterioration, cardiac arrest or death. To return to the Croce definition the somatic feeling often associated with intuition happens immediately after the apprehension of change during the process of cognitive evaluation or classification when a physical feeling often described as "gut feeling" or "skin crawling" is part of the making sense or probability judgements being made. Dewey advocated a heightened awareness of somatic feelings and paying attention to the self (Dewey 1932).

4.6 Psychological aspects of intuition

Rew (1988) studied nurses' use of intuition in clinical practice and, with 56 nurses from critical care, wards and a health centre, looked at their use of intuition as part of the nursing process. Rew grouped the way nurses described the use of intuition into three themed areas: cognitive inference, gestalt intuition and precognitive function (Rew 1988). Rew then looked at the consequent actions nurses took following their intuition, which included searching for more data, validation and corroboration with another nurse, reporting on specific findings and/or interventions (Rew 1988,). This nursing gestalt or knowing the patient has been described by other authors as a preconscious understanding gained from nurse-patient interactions that are then used in practice (Benner 1984, Pyles and Stern 1993, Hicks 2001).

Cioffi (1997) examines the use of heuristics from cognitive psychology as an important element of intuition. Throughout her paper she uses the work of the cognitive psychologists Kahneman and Tversky (1982) on “subjective probability judgements” (heuristics) as a partial explanation for the intuitive judgements of nurses (Cioffi 1997, p. 2). Cioffi suggests that nurses’ clinical experience gives them heuristic knowledge of common and unusual clinical issues, visual memories of patients with particular conditions, and particular clinical events that are memorable because they are out of the ordinary. This knowledge is the nurse’s baseline upon which, in their assessments, they base their subjective probability judgement. Thus Cioffi’s explanation is that nurses working in an uncertain and complex environment use probability assessments rapidly, computing previous events, likely causality and assessment of available associations or exemplars (Cioffi 1997, p. 5). For Cioffi, heuristics are therefore at least a partial explanation of the intuitive judgements of clinical nurses. Similarly, Thompson (1999) describes several authors’ work on probability theory in the decision making of nurses, using the hypothesis that nurses use formal or informal probability estimates of “diagnostic fit” as well as data from the particular context of the patient (Thompson 1999, p. 1225). Useful for this study is the link all of these authors make between this psychological perception of the patient but then the need to collect more data. The intuitive phase is therefore an introduction or perhaps a first step that leads to gathering and analysis of more data in an effort to help the patient.

4.7 Intuition and experience: Expert to novice nurses

Tertiary referral specialist cancer centres have a greater number than is perhaps typical throughout the UK of expert cancer nurses. These cancer nurses may not feel themselves to be skilled in acute care such as the recognition and understanding of sepsis. Conversely, the proficient critical care nurse may not understand the particular vulnerability of the person with cancer. Research on intuition has focused mainly on experienced nurses (Benner 1984, Schraeder and Fischer 1987, Rew 1988, Easen and Wilcockson 1996). King and Macleod Clark (2002) sought to explore intuition in nurses with different levels of expertise and educational background and recruited 30 nurses from acute surgical wards and 31 from two intensive care units.

The study was in three stages: the first was conducted by a nonparticipant researcher observing practice and recording field notes; the second a semi-structured interview based on the nurses' reflexive account of patient episodes, and finally the nurses' perceptions of the development of their expertise and the way that they made decisions (King and Macleod Clark 2002, p. 324). In summary, nurses included intuitive and analytical components in their clinical judgements throughout the different levels of expertise. Expert nurses were confident in their clinical decision making even in rapidly changing situations, and had the ability to use unconscious recognition of very subtle changes in the patient. These expert nurses were also able to stand back and take their intuitive reasoning further and look for concrete or measurable evidence to support their suspicions (King and Macleod Clark 2002, p. 327). For the novices, their intuitive feelings of concern did not so readily lead to an identification of the problem or relevant analysis because of lack of knowledge and experience. For King and Macleod Clark, the difference between nurses was the way they used intuition to analyse and then organise timely and effective multidisciplinary care (King and Macleod Clark 2002, p. 327).

There are limitations to this study in that the conclusions were based on the nurse's self reports and represent just one episode of care. Nonetheless, the comparison between nursing groups is useful, especially the recognition that the novice nurses did experience intuition. One area that doesn't seem to have been reported in the literature but is evident in practice is the issue of expert nurses who have become less motivated to notice change. Experience shows that expertise or long experience can also negatively affect the ability to see a situation afresh and to intuit small change. There are occasions when the novice nurse entering a new field is more observant reacting quickly to change because they are not comfortable in the area. This links with Dewey's description of the inertia that is the antithesis of intuition.

A key factor in the early recognition of the patient with sepsis is the ability for the most junior nurse to be empowered in their clinical practice. Patient emergencies such as sepsis occur at any time of the day or night and it is often the staff nurse or the patient themselves who first notice a change. Several studies have revealed that student nurses have intuitive feelings or "gut feelings" about the patients with whom they work (Orme and Maggs 1993, McCormack 1993, Tabak *et al* 1996, Brooks and

Thomas 1997, King and McCleod- Clark 2002, Ruth-Sahd 2003, Smith *et al* 2004). In a specialist cancer centre there are very few student nurses, there are, however, an increasing number of newly qualified nurses. Research evidence about the novice nurse is therefore both relevant and important to understand. McCutcheon and Pincombe (2001) in a study involving 264 registered nurses reported that novice nurses stated that although they had intuitive feelings they were often afraid to raise them due to their inexperience. Novice nurses also reported that the environment within which they were working would either encourage or discourage or discourage their use of intuition (McCutcheon and Pincombe 2001, p.347). Smith, Thurkettle and dela Cruz (2004) in a study exploring the use of a psychometric instrument to test the intuition of final year student nurses (n=349) concluded that student nurses understood and used / or experienced intuition in a similar way to more experienced nurses. Although the study relied on self report and only 349 (35%) (n= 1000) of questionnaires were returned this study repeats other's findings that novice nurses do and can use intuition, they just have a limited frame of reference. Rolfe (2006b, p. 41) argues that novice nurses can be taught to think and act reflexively and reason about their practice. Much, therefore, may depend on the training of the novice nurse and the environment within which they work.

4.8 Intuition and the patient

The intuition of the patient is another theme in the literature and is of major importance to this study. It is essential that people with cancer who are likely to become septic and may be in hospital or at home are able to recognise the early signs of deterioration and raise the alarm. It is also important that the nurses and multi-professional team working with the patient listen and respect the patient's intuitive feelings. Several studies support the use of nurse and patient intuition (Orme and Maggs 1993, McCormack 1993, King and Appleton 1997). Broom (2009) demonstrated that cancer patients use a wide range of knowledge when managing the plurality of treatments including intuition and embodied knowledge. In interviews in their own homes 20 medical oncology patients were interviewed about their decision making and intuition was repeatedly raised as a critical source of knowledge Broom 2009, p. 1053). Although a small study and focusing on treatment options its

relevance to this review is the way patients talked about knowing their bodies, having gut feelings and intuition about choices.

4.9 Involvement or engagement

Easen and Wilcockson (1996) cite the work of Dreyfus and Dreyfus (1988), arguing that intuition requires the “deep involvement” of the person in the environment. Benner refers to the expert nurse who has a deep understanding of the total circumstances (1984), and Easen and Wilcockson (1996) introduce Noddings and Shore’s work (1984), which links intuition with a direct contact with the whole problem. It seems that this correlation of a deep understanding of the problem or situation of the patient/client is an important key to understanding this aspect of nursing knowledge. Logan and Boss (1993) found a relationship between engagement in care, commitment of the nurse and the use of intuition. Parker and colleagues (1999) corroborate this aspect of being able to appreciate the larger picture in their review of perioperative nurses’ clinical decision making process. Indeed, their study showed that, in spite of brief nurse–patient relationships, expert perioperative nurses were able to combine a highly developed intuitive decision making process with overt caring and concern for their patients. Elcock (1997) supports this view that an important part of the nurse–patient relationship is the ability to connect rapidly with a patient, with this process being accelerated if the situation is critical (Elcock 1997, p. 140). A confounding view of involvement was found by McCutcheon and Pincombe (2001) whose findings varied between those who thought a relationship was essential, those who did not, and those who thought intuitive ability would be improved by a relationship (McCutcheon and Pincombe 2001, p. 346)

The involvement with the patient and the environment does not consist solely of knowledge of the patient, but also the nurse’s awareness of the self. Central to this involvement is the ability of the nurse to have a heightened awareness of the cues patients present because of the nurse’s willingness and ability to become involved in the relationship with the patient. When intuition is described as non-rational or mystical, it is perhaps because it is not viewed as a part of the whole process of patient assessment and care. For intuition to be useful in clinical practice it needs to

be linked to a sound knowledge base and the ability to recognise patterns or deviations in the situation or behaviour. This thought processing, although rapid in onset, does contain rational and deliberative sorting of information to aid the nurse in clinical judgements.

4.10 The environment

Several studies cited above refer to the environment and its influence on nurses' ability to develop intuitive clinical practice. These studies refer to the ability of nurses to learn from each other, especially more senior colleagues (Rolfe 1998b, Hansten and Washburn 2000, McCutcheon and Pincombe 2001, King and Macleod Clark 2002, Aitken 2003). Oral corroboration is an important aspect of reducing the risk that is inherent in practice and will depend on the clinical and organisational milieu within which the nurse is working. In Hedberg and Larsson's study (2003) looking at the experience of six nurses working in a medical ward, a geriatric rehabilitation ward and a primary care centre, participants used collegial verification to validate the patient cues they observed. The nurses also recognised the value of being able to corroborate with more competent colleagues, which mainly took the form of oral testimony (Hedberg and Larsson 2003, p. 219). Manley (2000) describes much of this work as critical companionship and acknowledges that clinical leadership and an empowered organisation are key to such activities.

More recently, the term "community of practice" has been developed from learning theory. Wenger defines the necessary components of such a community as follows:

- Communities of practice enable practitioners to take collective responsibility for managing the knowledge they need, recognizing that, given the proper structure, they are in the best position to do this.
- Communities among practitioners create a direct link between learning and performance, because the same people participate in communities of practice and in teams and business units.
- Practitioners can address the tacit and dynamic aspects of knowledge creation and sharing, as well as the more explicit aspects.

Communities are not limited by formal structures: they create connections among people across organizational and geographic boundaries" (Wenger et al 2002, p. 28).

There remains a lively debate in the literature about whether intuition is an appropriate knowledge area for nursing. In its clinical community and in much of the evidence, however, intuition is seen as a highly valued part of nursing knowledge. Intuition has been described, classified and researched across environments and is part of the art of nursing that alongside other nursing knowledge can be consciously shared, honed and practised in a community of nursing practice as described by Wenger (2002). This sense of a learning community across an organisation or a ward may be useful in challenging barriers between education, practice and research. To make the community a reality other educational components such as personal reflection and supervision are also important and are discussed below.

4.11 Learning about intuition for practice

Demystifying and understanding intuition as a part of the nurse's (or nurses') decision making is essential for clinical practice for three major reasons: first, so that nurses can develop intuitive processing and thus benefit patients; secondly, to aid transparency and understanding for other health care professionals, and thirdly so that the practice of nursing is made transparent (Rolfe 1998a).

Linked with intuition in the nursing literature is a sensitivity, preparedness and reflection on past experience. Johns' (1998) description of "reflection-within-the-moment" is cited as a practice that can be used by the individual nurse during practice, so that the nurse is consciously monitoring themselves during practice. Several authors recommend using scenarios or "stories" from clinical practice to help themselves and learning nurses understand intuitive practice. This presentation of cases together with a deconstruction of the process of decision making can make conscious and overt that which is hidden in practice, so that nurses can develop and teach other skills (Rolfe 1998, Hansten & Washburn 2000). McCutcheon and Pincombe (2001) ask the more experienced nurse to act as a role model in practice, working alongside a learner nurse to consciously explain how in a particular situation they have used intuition. They recognise, however, that in their study of 262 registered nurses there was a lack of reporting of intuition being wrong or misplaced (McCutcheon and Pincombe 2001, p. 347). King and Macleod Clark (2002) also describe how novice nurses worked with more experienced nurses, who

helped them to deconstruct their intuitive concerns and interpret their importance for the patient in relation to other clinical signs and then, importantly, how they might react appropriately to this new analysis (King and Macleod Clark 2002, p. 327). Aitken (2003) recommends the use of professional development coaching, utilising strategies such as teaching rounds and patient case presentations (Aitken 2003, p. 483). Taking clinical education into the classroom, Ruth-Sahd (2003) argues for educators to share their intuitive experiences with their students, to create a climate of creativity and curiosity, and to design learning objectives that concentrate on process and skilled pattern recognition as well as content (Ruth-Sahd 2003, p. 133).

In a tertiary cancer centre where patients are treated actively and there is a high degree of complex treatments all carrying the risk of deterioration it is important that nurses are coached and supported to be aware of their importance in the early detection of cancer. Intuition is an important part of this recognition process and can be taught and encouraged through reflective practice, clinical supervision and sharing experience in formal teaching sessions.

4.12 Conclusion

In order to achieve early recognition of deterioration, nurses need to be aware of the dangers of sepsis in the cancer patient and be sensitised to the early changes of deterioration in their patients. Having recognised the change, nurses then need to instigate further assessment and where necessary alert the multi-professional team and ensure early rescue. In this chapter the literature on nurse and patient intuition, pattern recognition, heuristics, engagement and the therapeutic environment has been explored together with ideas on coaching and education. Each encounter that the nurse has with a person with cancer is unique, but the encounter can perhaps be helped by reflection on relevant literature and previous experience of care. The nurse at the bedside uses all these sources of knowledge to test the live hypothesis: "Is this patient developing sepsis?" The aim of this study was to increase awareness by providing a teaching session that highlighted the dangers of sepsis and then to aid in an early and appropriate response by providing nurses with a tool that could translate their intuitive concerns about the patient to others. Intuition is acknowledged as an important aspect of clinical nursing knowledge and has been variously described by

many nursing authors as a type of consciousness, psychological perception and gestalt, probability judgements, a preparedness, clinical forethought and pattern recognition. The use of intuition is also recognised to be affected by experience, the environment and the involvement with the patient and situation.

In summary, it would seem that intuition is highly important in this study. Intuition here is not seen as something mystical or something that can only be experienced by the most experienced nurse. For this study it is explicitly Croce's model of intuition that is being used (Croce 1872) and Dewey's (1931) description of change: consisting of a sequence of events: intuiting the presence of phenomena, the evaluative classification process and then a choice regarding response to the new data. From the literature review, intuition is described as immediate apprehension or recognition, followed by a cognitive classification and understanding perhaps coupled with somatic feelings, then a decision whether to act on the new data. In the particular context of nursing nurses intuit a large amount of data that they need to process, some will be gross some will be subtle and difficult to articulate. The change that is intuited causes a disturbance or perplexity that then leads to a further examination of the data and reflection on past events / patterns, much new data will be rejected as irrelevant but some may be chosen to act upon. To pursue the quest for further data requires motivation, intellectual engagement and sensitivity to the situation.

This study applies Croce's model of intuition to the nurse who is caring for the person with cancer who is in danger of sepsis. The nurse caring for the patient with cancer intuits a change; this change may be subtle but because the patient is known or there is full engagement the nurse is disturbed by it and may experience somatic feelings. The nurse engages with the patient, listening to them and performing a physical examination and starts the process of evaluation, action and calling for help. For intuition to be used effectively in the early detection of sepsis the nurse needs to be prepared and sensitised to the patient and their particular situation, and to be motivated with the moral intent to help. Experience and a milieu where this type of knowledge is welcomed make it easier for a nurse to openly express their intuitive feelings. Novice nurses do intuit change and should be encouraged to openly voice

their thoughts whilst the experienced nurse must be encouraged to remain alive and motivated to the rapid deterioration of patients. The overall aim of this research was to improve practice in the acute care of people with cancer and specifically to investigate the nurses' role in the early diagnosis of sepsis. The theoretical framework that cancer patients are vulnerable to sepsis and that early diagnosis and treatment reduces morbidity and mortality provided the rationale for designing a study that could harness nurses' use of intuition, as described by Croce, and provide them with an objective tool and education to improve their awareness and recognition of sepsis. The objective tool was also used not just to aid the nurses' assessment but also to help them in communicating with the multidisciplinary team and improving early rescue. The next chapter provides details of the methodology used and interventions employed.

Chapter 5 Methodology

5.1 Introduction

The research reported in this thesis was conceived as a single study with a single clear focus; the improvement of nursing practice in the care of cancer patients who develop sepsis. However, nursing practice is what might be called a complex intervention (MRC Craig *et al* 2008) and, in order to understand and improve nursing practice and patient outcomes in this area, five separate stages of the study were developed. These were not five separate studies, but rather formed an integrated whole, bringing together nurses' ability to intuit subtle changes in patients' condition, to recognise these changes as possible early indications of the onset of sepsis, and to present this to other members of the multi-professional team with the support of a confirmatory blood test. The theoretical framework underpinning this study, as introduced in chapter one, is as follows:

1. The vulnerability of the cancer patients' immune system and increased susceptibility to sepsis;
2. The evidence that early diagnosis and treatment reduces morbidity and mortality in sepsis;
3. Nurses' ability to intuit subtle change pre-cognitively which causes discomfort and a stimulus to act;
4. Education and its ability to raise awareness of risk;
5. Packaging of information using an objective test to aid effective multi professional communication and rescue.

The early recognition and treatment of sepsis therefore consists of three elements: the nurse's knowledge of and commitment to her patient, nurses' knowledge of sepsis, and the tools to allow nurses to mobilise the multi professional team. This chapter describes the methodology chosen for this study and the way that the theoretical framework affected the choice of both design and interventions. Choices

about design and methodology were based on the need to develop and improve practice in the clinical environment and to reflect the complexity of clinical practice. A multiple methods design was chosen to address the research aims and objectives. The chapter first describes the aims of the study and then the rationale for the design chosen and those rejected.

The theoretical assumptions underpinning the research drawing from the literature and clinical experience, were that:

1. Cancer and its treatment make a person more vulnerable to the development of sepsis;
2. Cancer patients are likely to develop sepsis and have a higher mortality rate from it than patients without cancer;
3. Early recognition of developing sepsis is essential if patients are to survive;
4. Early recognition can only lead to improved survival if it is acted on with early and appropriate treatment;
5. The early signs and symptoms of sepsis may be subtle and may not always manifest through measurable changes in vital signs;
6. Nurses are capable of intuiting and recognising subtle changes in the patient's condition but do not always articulate these as signs of early sepsis;
7. When nurses intuit subtle changes but lack objective evidence of the onset of sepsis others may be reluctant to act with the necessary urgency.

Based on these assumptions, the study aimed to investigate the nurses' role in the early diagnosis of sepsis and to provide nurses with a new objective tool and dedicated education to improve early diagnosis and rescue. The overall and subsidiary aims, as introduced in chapter one, from each of the five stages of the research are illustrated below in table 5.1. together with the two interventions.

Table 5.1: Subsidiary and overall research aims linked to each research stage

No.	Subsidiary Research aims	Research stages
1.	<p>Pre-intervention</p> <ol style="list-style-type: none"> 1. The experience of caring for cancer patients deteriorating with sepsis. 2. The experience of communicating with and mobilising the multi-professional team about a patient deteriorating with sepsis. 3. The introduction to a new bedside blood test that may help in identifying sepsis earlier. <p>Post intervention</p> <ol style="list-style-type: none"> 4. Experience of the patient deteriorating from sepsis. 5. The experience of using the PCT-Q in practice 6. Nurses' accounts of the optimal ways of learning and developing their practice. 7. How nurses think an effective multi-professional response with a deteriorating patient can be improved. 8. Nurses' recommendations to improve the early detection and treatment of cancer patients developing sepsis. 	<p>Pre and post - intervention qualitative interviews with 10 nurses of varying cancer and critical care experience.</p> <p>Post-intervention qualitative interviews with 8 of the 10 nurses previously interviewed.</p>
2.	<p>Pre-intervention</p> <ol style="list-style-type: none"> 1. Raising awareness of sepsis. 2. The nurses' knowledge of sepsis: incidence, mortality risk, early diagnostic tests, procalcitonin and its role in the early diagnosis of sepsis. 3. Introduction to the bedside procalcitonin test (PCT-Q). 4. Examples of patients deteriorating with sepsis and nurses finding it difficult to convince the team. <p>Post intervention</p> <ol style="list-style-type: none"> 5. Changes in nurses' awareness and knowledge regarding sepsis: incidence, mortality risk, early diagnostic tests, procalcitonin and its role in the 	<p>Pre and post intervention questionnaires to 177 nurses across the hospital.</p> <p>Post-intervention questionnaires</p>

	<p>early diagnosis of sepsis.</p> <p>6. The nurses' experience of using the PCT-Q in practice.</p> <p>7. The nurses experience of thinking that a patient was deteriorating but finding it difficult to convince other nurses/doctors or other health care professionals. Examples from practice.</p>	<p>completed by 85 of the original 177 nurses.</p>
3a.	<p>1. Ward teaching sessions on the cancer patient and sepsis, associated risks and mortality rate, the evidence on early diagnosis and treatment and assessment tools including procalcitonin.</p> <p>2. Introduction to the use of the PCT-Q bedside test.</p>	<p>Intervention (1)</p>
3b.	<p>1. Introduction of the bedside test PCT-Q in the hospital for the first time. PCT-Q bedside blood test used on all patients that nurses assess as showing early signs of sepsis.</p> <p>2. Each patient recruited for the PCT-Q test to have all other infection markers mapped to be able to compare the efficacy of the PCT-Q test to those usually used in the hospital.</p> <p>3. All patients entered into the study to have episode and hospital outcomes mapped with the objective of comparing outcomes of those who had PCT-Q measured in the study year to outcomes in the three previous years when the PCT-Q test was not available.</p>	<p>Intervention (2)</p> <p>Archival notes review used to compare historical data with study data.</p>
4.	<p>1. Assess if the PCT-Q is used appropriately.</p> <p>2. Assess if using the PCT-Q in sepsis assessment means that sepsis is diagnosed earlier.</p> <p>3. The performance of the PCT-Q compared to the sepsis predictive markers already used by the hospital: White Blood Cell count, C-reactive protein, blood lactate, altered physiological parameters particularly mean arterial blood pressure.</p> <p>4. The effect of introducing the two interventions: education and the PCT-Q on sepsis episodes and outcomes compared to the three previous years.</p>	<p>PCT-Q patient survey with 320 patients and 416 sepsis episodes in patients receiving acute care across the hospital.</p>
5.	<p>Overall Research Aim</p> <p>1. To investigate the nurses' role in the early diagnosis</p>	<p>Integration of all</p>

	of sepsis and to provide nurses with a new objective tool and dedicated education to improve early diagnosis and rescue.	qualitative data and comparison with quantitative data.
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5.2 Primary and Secondary objectives

In chapter three the literature explaining the subtle early signs of sepsis was described together with the evidence that early detection and treatment of sepsis reduces morbidity and mortality and increases survival (Dellinger *et al* 2004, 2008). The primary objective was therefore to diagnose patients' sepsis at an earlier stage, recognising that nurses report a difficulty in convincing colleagues, an objective bedside test was to be introduced to improve multi-professional communication and therefore rescue.

The secondary objectives were to:

1. Learn more about nurses' experience of the cancer patient deteriorating with sepsis and any barriers to effective communication and rescue;
2. Gain an in-depth understanding on nurses awareness of sepsis and its assessment and management and how this could be improved, particularly how nurses felt they learnt optimally;
3. Explore whether nurses' judgement about the patient developing sepsis was accurate and whether they could use the PCT-Q appropriately;
4. Gain an in-depth understanding from the nurses about how they felt the use of the PCT-Q has impacted upon practice and how easy in practice it was to use;
5. Assess whether in the nurses' hands and on cancer patients the PCT-Q was reliable in identifying sepsis compared to WBC, lactate, CRP and mean arterial pressure falls;

6. Evaluate if the use of the PCT-Q as part of clinical nursing assessment and communication resulted in earlier referrals and improved outcomes;
7. Compare the outcomes of patients during the study year to three previous years;
8. Evaluate whether the dedicated education session improved awareness and knowledge about the cancer patient with sepsis.

The primary endpoint of the study was an increase in referrals at an early as opposed to late stage of sepsis. The secondary endpoints were: nurses' increased awareness and knowledge of sepsis as measured by the post-intervention questionnaire; appropriate use of the PCT-Q by ward nurses; an increased understanding of nurses' experience of patient deterioration; and mobilising help from other nurses and multidisciplinary colleagues. Finally, archival data would be examined to look for evidence of improvement in mortality rates for sepsis during the study period.

5.3 Overall study design

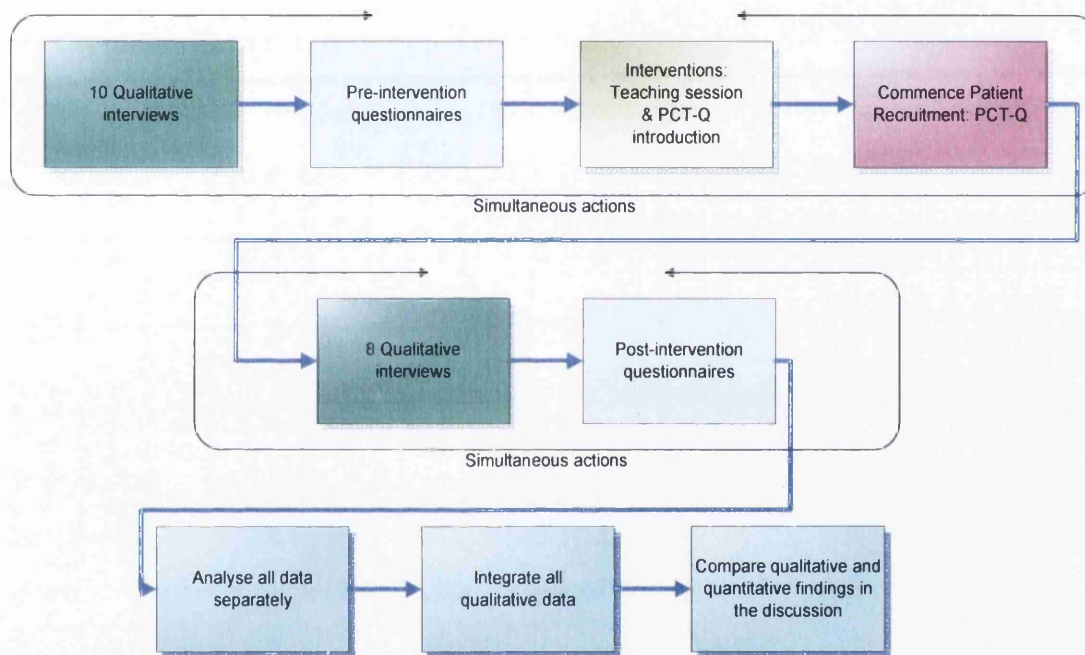
This study focused on improving clinical practice and used a research framework with five stages. The different stages were:

1. Qualitative in-depth interviews, pre and post the introduction of the PCT-Q to gain an in-depth understanding of the nurses' experience both with and without the PCT-Q.
2. Pre and post-intervention questionnaire survey;
3. Two interventions:
 - 3(a) Dedicated education session on sepsis, its assessment, management and predictive markers including procalcitonin and the PCT-Q;
 - 3(b) The introduction of a new bedside blood test the PCT-Q to aid in the early assessment and communication re sepsis.
4. Collection of clinical data on patients who were thought to be developing sepsis and had a PCT-Q test performed and an archival notes review to compare pre and peri-study mortality rates.

- Integration of all qualitative results and comparison with quantitative findings.

The diagram below illustrates schematically how the five stages of the study were designed and implemented.

Figure 5.1: Study Design



5.4 Rationale for study approach

While research suggests that nurses can recognise subtle early changes in a patient's condition, the literature (e.g. Cioffi 2000) and clinical experience suggest this alone may be insufficient to persuade other clinical staff to act. A tool, the PCT-Q, was identified that would enable ward nurses to approach other colleagues with objective evidence of the early onset of sepsis. The PCT-Q is a bedside test which in 35 minutes provides a PCT level between 0 and 10 ng/ml. A PCT-Q value of 0.5 ng/ml is indicative that the patient has the Systemic Inflammatory Response

Syndrome (SIRS); a value of 2 indicates sepsis, and 5 to 10 indicates severe sepsis. The rationale for introducing the tool was, first, to give the nurse more confidence in alerting other colleagues; secondly, there is evidence that other colleagues are more affected by quantitative change rather than description (Koubel 2006). The Critical Care Outreach Team (CCOT) were included in the process of measuring the PCT-Q and would therefore be informed early of a deteriorating patient.

The researcher was keen to improve practice in all areas of the hospital where patients were at risk from sepsis, therefore a large number of patients and nurses were recruited to the study. All patients during the intervention period who consented were eligible, and those who demonstrated early signs of sepsis were recruited into the study. In order to reach all wards a questionnaire was used with 177 nurses. To gain an in-depth understanding of the nurses' experience both with and without the PCT-Q a qualitative interview was conducted pre and post intervention, with ten nurses pre and eight post intervention. The three elements of the study, the investigation of nurses' experience of recognising changes in patients' condition, the raising of knowledge levels and the implementation of the PCT-Q test, each demanded different methodological approaches, and the study could therefore be described as employing multiple methods.

5.5 Multiple method research design

Priorities for nursing research need to be able to reduce the theory–practice gap and nursing research needs to investigate practice-based questions (Cull-Wilby and Pepin 1987, Im and Meleis 1999, Doane 2003, Rolfe 2006b). In a practice-based discipline such as nursing where the questions that need to be asked are complex and multi-factorial, it may be necessary to combine methods to answer a question successfully or improve practice. In the past such a combining of methods would have been questioned, but increasingly it is recognised that such an approach is beneficial to the development of nursing (Weaver and Olson 2006).

5.5.1 Historical background of multiple methods research

Many authors attribute multiple methods design to the psychology research of Campbell and Fiske in 1959. In their work validating psychological traits, Campbell

and Fiske used a multimethod matrix using more than one quantitative research method, and they encouraged other researchers to use multiple data collection methods. Campbell and Fiske decided to use several methods in an attempt to make sure that the variance in their study was accounted for by a particular trait. More researchers then started to combine methods such as interviews and surveys, which had previously only existed separately. Finally, the term triangulation was used by researchers who were keen to use the strengths of different methods to limit the bias in a single method and provide greater illumination of a question or hypothesis (Denzin 1978). Denzin (1978) is credited with first using the term triangulation in his book on sociological methods. Authors who describe the use of mixed designs emphasise the need to be clear about the framework that informs each type of method, analysis, or approach (Duffy 1987, Coward 1990, Mason 2002). Creswell (2003) recommends that all researchers who plan to use a multiple methods design answer four questions before deciding on their research strategy:

1. What is the implementation sequence of the quantitative and qualitative data collection in the proposed study?
2. What priority will be given to the quantitative and qualitative data collection and analysis?
3. At what stage in the research project will the quantitative and qualitative data and findings be integrated?
4. Will an overall theoretical perspective (e.g. gender, race/ethnicity, lifestyle, class) be used in the study?" (Creswell 2003, p. 211)

For the current study, using both qualitative and quantitative methodologies, the researcher's decisions were as follows:

1. The implementation sequence was based on a pragmatic need to ask some questions before designing the post-intervention questionnaire;
2. There was no priority given to any of the research methods, they were all seen as equally important;
3. The analysis of the pre-intervention qualitative interviews informed the questions in the post-intervention qualitative interviews;
4. The overall theoretical perspective used is one of a pragmatic approach to improving a particular part of nursing practice.

5.5.2 Integration of the data

A common theme in the literature is concern regarding the combination of different paradigms or philosophies. Morse (1991) for this reason recommends independent analysis for all methods before merging the data (Morse 1991, p. 121). The challenge to the integration of the data lies primarily in the different paradigms or epistemologies associated with the research design. In qualitative analysis the researcher typically is trying to gain a clearer understanding of the way that a participant constructs their world: a constructivist philosophy (Pearson 1997). Silverman describes this as the researcher “being interested in the precise particulars of ...people’s understandings and interactions” (Silverman 2005, p.9).

Morse (1994) suggests that following qualitative data collection “four cognitive processes are integral to all qualitative analysis: comprehending, synthesising, theorising and recontextualising (Morse 1994, p. 25). Pearson (1997) adds that these stages often occur in an iterative loop, with the researcher returning to an earlier stage again when new questions arise from the analysis (Pearson 1997, p.69). In contrast, quantitative data is analysed in an essentially deductive way, usually involving the testing of one or several hypotheses. The analysis is concerned mainly with the parameters of the findings, for example the number of the same data and then the generalisability of the findings, whether they have occurred by chance, and whether they are representative and able to be applied to another group. Statistical tests are then used to explore the probabilities of the data occurring in a specific population or environment (Polit and Hungler 1999).

5.5.3 Integration of the findings in the present study

The present study accumulated knowledge from each method in an attempt to further understand and improve practice. This approach reflected the essential granularity of nursing practice with its complex combination of propositional and practical knowledge (Wainwright 2003). For example, a nurse needs to understand the pathophysiology of sepsis and safely administer complex antimicrobial therapy while being able to comfort the patient who senses a deterioration in their overall condition. In the same way, the different methods were respected but the findings used together to answer a question that was based on multi-layered clinical practice.

Complex integration was not a problem for the current study. The qualitative findings from the interviews and the open question in the questionnaire were integrated but were clearly from the same paradigm. The two parts of the study involving quantitative data were analysed completely separately and their findings not integrated. Therefore this study which was designed to improve practice used multiple methods but did not require integration of the data.

5.5.4 Advantages and disadvantages of multiple methods research

Johnstone used a mixed methods approach to explore the process and organisational consequences of new surgical techniques in five Australian hospitals and describes the advantages of a “thick” description of the phenomenon being studied (Johnstone 2004, p. 264). For many researchers, multiple methods research increases the scope, rigour, credibility and analytic power of research studies (Erlandson *et al* 1993, Hassard 1993, Sandelowski 2000). Creswell and colleagues (2004) explain that there is a logical and pragmatic benefit of using a multiple methods design in primary care when neither quantitative nor qualitative approaches are sufficient on their own to fully capture the trends and details of the phenomenon. When the two methods are used together they complement each other and provide a more complete analysis (Creswell *et al* 2004, p.7). Finally, Sandelowski (2000) suggests that researchers make choices not by fashion or fad but on the needs of the research question (Sandelowski 2000, p. 254). For the present study the researcher had observed a gap in practice and wanted to both understand the gap and improve practice during the research. The research question was deliberately set in the reality of clinical practice and the design was chosen to be able to answer a complex question embedded in clinical practice with all its variables.

Practical difficulties for the researcher using a multiple methods design are: a longer period of data collection, generation of a large amount of data and integration. Multiple methods research may take longer overall and require more resources. There may also be problems for researchers who wish to publish and editors who prefer to publish only one method or paradigm (Sandelowski 2000, p.254).

5.6 Study setting

The study was set in a tertiary comprehensive cancer centre in England. The centre is a hospital with two sites focusing exclusively on children and adults with cancer. The centre sees approximately 40,000 patients a year with any type of cancer and, as a tertiary centre, receives referrals from the local population but also from across the UK and internationally. The centre is joined to a major translational research institute, developing therapy in the laboratory that is trialled for the first time in humans on the wards. The centre does not provide undergraduate nursing or medical training but does specialise in postgraduate cancer training for nurses, doctors and allied health professionals. There are about 2,000 people employed in the centre with approximately 760 of these being nurses.

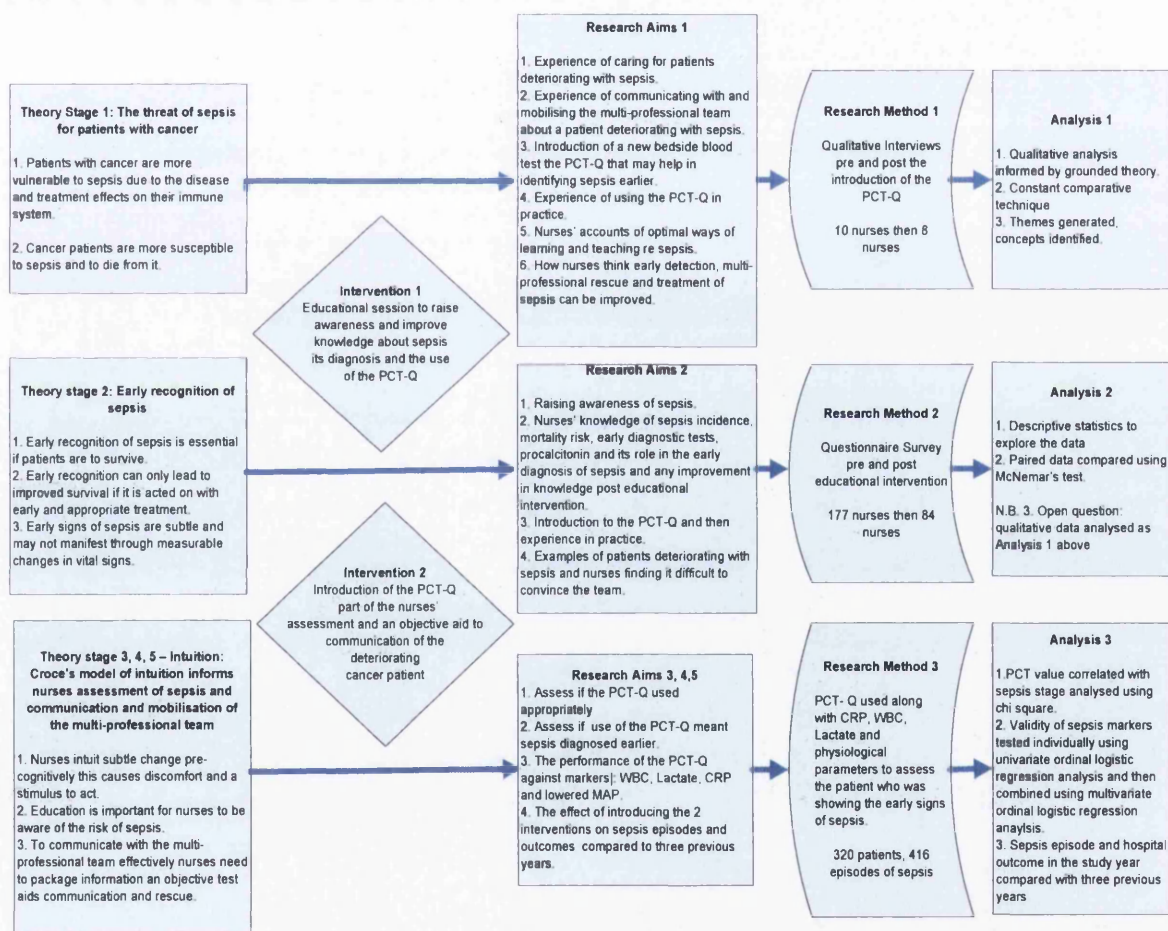
5.6.1 Introduction to the researcher

The researcher is a clinician engaged in research in her own organisation. The researcher has worked with the critically ill person for 23 years, for the last 16 with the critically ill person with cancer. During this time the researcher has always worked clinically, valuing colleagues in the multidisciplinary team and especially fellow nurses. Since 2001, because of the development of Critical Care Outreach Teams the researcher has increasingly worked with ward nursing teams. Working with ward teams she has been conscious of the challenges in everyday clinical practice for nurses working with many patients and families, with fewer nurses and higher expectations placed upon them. The researcher also coordinates several educational modules and therefore works with the most junior clinical nurses in the organisation, as a module leader and teacher but also as a fellow student sharing the challenge of deadlines and balancing work, study and life. The researcher is a passionate enthusiast for nursing and the way it can change people's lives, both during acute illness and also in the chronic setting. As a practising clinical nurse the researcher is however absolutely realistic about the muddle of clinical practice and the delays and difficulties in a system that is being constantly stretched with less resource.

5.7 Individual methods

The following sections describe the three methods that form the study in the order that they commenced: qualitative interviews first; then the questionnaire survey and then the patient PCT-Q part of the study, the two interventions are also described. Each of the three methods was informed by the theoretical framework and assumptions underpinning the study and are illustrated in the diagram below:

Figure 5.2: Study Design: Theoretical Framework, Research Questions and Analysis



5.7.1 Nurse Qualitative Interviews pre and post intervention (research stage one)

Approximately 760 nurses are employed at the host hospital, with 440 nurses who work on the children's wards, outpatient departments and theatres excluded from the Nurse Interview study, as were advanced nurse practitioners. A purposive sample of

10 nurses was selected, from a population of 320 nurses working across the trust who actively work with inpatients receiving acute care, from the most junior staff nurse to senior charge nurse or outreach sister. These nurses were interviewed pre and post the educational and PCT-Q interventions. A purposive sample was chosen to explore the experience of a range of nurses, from the novice cancer nurse to the very experienced. Nurses were also recruited from different wards/units to cover all types of cancer (see appendix 3). Nurses were also recruited from the CCU and Critical Care Outreach Team. The number of nurses was limited to 10 for primarily practical reasons (Thorne 2001, Guest *et al* 2006). In this study the interviews were repeated, thus providing 20 transcripts available for analysis. The roles chosen were not selected to be representative of all cancer nurses, more to reflect the diversity of nursing experience, knowledge and nursing activity involved in the care of the cancer patient developing sepsis.

Table 5.2: Inclusion and exclusion criteria for the nurse interviews and the nurse questionnaire samples.

No	Inclusion criteria	Exclusion criteria
1	Registered nurses	Student nurses
2	Working in an inpatient ward or critical care unit	Nurses working in outpatient areas
3	Likely to be at the hospital six to eight months later.	Nurses working on the children's unit, children's day care
4		Theatre nurses
5		Advanced practice nurses who do not have a bedside role with the inpatient population
6		Nurses working in the palliative care setting.

5.7.2 Nurse recruitment plan

Nurses recruited for interview were initially alerted to the study by advertisements on each ward. Advertisements were used to try to avoid any undue influence by the researcher over the participants. The researcher was not in a line management role with any participants but was senior in the organisation, and it was important that she did not exert any overt pressure. From all nurses who volunteered (n=34), 10 were selected because of their role, experience and ward (each ward at the host hospital reflects a different cancer). These 10 were then sent an invitation letter and Nurse Information Sheet (see appendix 4). Each nurse, according to the National Research Ethics Service (NRES) (2006) good practice guidelines, was given at least 24 hours to think about the study and their participation. Nurses were then questioned by the researcher to ensure that they understood the information sheet and the time commitment over two interviews. One nurse then decided not to participate as she was leaving the hospital within two months; another nurse was recruited from the original 24 volunteers and all participants signed a formal consent form.

5.7.3 Qualitative interviews with nurses

The rationale for the qualitative interviews with nurses was to gain their in-depth experience of working clinically with people with cancer who may be developing sepsis. Each qualitative interview was conducted in private, away from the busy ward areas, in protected time agreed by the nurse's line manager. Each interview session was taped using a purpose-designed transcription unit, with participants double consented before and after each interview. Each participant provided written consent and retained a copy of the participant information sheet and a copy of their consent form. A second copy of their consent form was kept in the research office (see appendix 9a). Each tape was then transcribed, with each transcript being anonymised using a number for identification so that when the post-intervention interviews were conducted the results could be compared and analysed. The tapes and transcripts were stored in a locked cabinet in the research office to ensure confidentiality and safety. The post-intervention interviews were consented and conducted in the same way.

5.7.4 Objectives of the qualitative interviews

The objectives of the qualitative interviews were to gain an in-depth understanding of the following aspects of the nurses' individual experiences of caring for a patient deteriorating with sepsis:

1. Nurses' individual overall experience of caring for patients deteriorating with sepsis
2. Barriers to effective communication and rescue, and their previous experience of informing and mobilising the multi professional team;
3. Nurses' awareness of sepsis and its assessment and management and how this could be improved, particularly how nurses felt they learnt optimally and could teach others;
4. How nurses felt the use of the PCT-Q impacted upon practice and how easy in practice it was to use.

The post-intervention interviews were to be conducted with the same 10 nurses who had been previously interviewed. Two of the nurses had left the hospital, leaving eight post-intervention interviews. The rationale for the post intervention interviews was to interview the nurses post the introduction of the PCT-Q to obtain richer data about its introduction. Themes or questions that were generated from the analysis of the first transcripts were also explored. There was no intent to compare pre and post interviews but rather to integrate all the findings to better understand the lived experience of the nurses. As previously, the eight nurses provided written consent pre and post interview.

5.7.5 Qualitative interviews

Qualitative interviews vary in their epistemological and methodological approach to the collection of data, from the quantitative structured interview to the unstructured qualitative interview, with the semi-structured interview including elements of both paradigms (Parahoo 1997, p. 283-296). The interviews used in this study were qualitative: broad cues gave some form to the interview but, unlike a semi-structured interview, the researcher was keen to have flexibility and less domination. Parahoo

would describe the interviews used in this study as focused qualitative interviews (Parahoo 1997, p.295). The qualitative research interview is of a particular construction resulting in a specific theory and knowledge generation. The information gained from a qualitative interview is actively constructed at the time of the interview by the researcher and the participant (Holstein and Gubrium 1995). The researcher is recognised in qualitative interviews to influence the dialogue and is a part of the interactions that are studied (Fontana & Frey 2000, p.663). Acknowledging the active role of the researcher in unstructured or focused qualitative interviews means that trust, establishing a meaningful rapport, and reflexivity are essential requirements (Cicourel 1974, Fontana and Frey 2000).

In the sepsis study, in an effort to promote trust and rapport, the researcher reminded participants that their data would be anonymised and that nothing they could say would be “wrong”. The researcher repeated to each participant that she was keen to learn from their experience. Some of the participants had previously been taught by the researcher and she was therefore keen to monitor her own behaviour during the interview and ensure that the participants felt at ease, especially when talking about their knowledge and skills.

5. 7.6 Analysis plan for qualitative interviews

The transcripts from the pre-and post-intervention interviews and the qualitative data from the questionnaires were analysed using a qualitative technique utilising a constant comparative strategy (Glaser 1992, Strauss and Corbin 1998, May 1998). The aim of the analysis was to translate the rich and lengthy data from the transcripts into a coherent account linked to theory. Miles and Huberman (1994) describe this process as a sharpening, focusing and organising of the data. The researcher’s critical application to this process has been described as an essential prerequisite, carefully and critically reflecting on the data while reading and coding. May describes this as ‘a highly focused and selective kind of reading’ (May 1998, p.69). The researcher was also influenced by Morse’s work on comprehending, synthesizing, theorising and recontextualising (1994). During the analysis the transcripts were read and re-read in detail and common examples of events or accounts across narratives noted and highlighted using a highlighter pen (for an example see appendix 15).

The emergent themes from the transcripts were then organised and coded using the model described by Tesch (1990) and sorted into general themes, unique and then left over themes and given a numerical key. These codes were collated and indexed on a simple paper grid such as that cited by May (1998) and used by Sirur (1997). The transcripts were then re-read and the codes applied across all transcripts, with more codes being added or previous ones subtracted as appropriate. The 18 interviews provided a large amount of data and the mechanistic use of a grid helped with the process of organising and analysing the data. The process used was therefore inductive and iterative with a constant movement between the transcripts and the grid with frequent additions, subtractions and alterations.

Having performed these steps, the codes were focused further into key themes and concepts. During this analysis deviant or extraordinary cases emerged and were highlighted to be considered as part of the analysis (Silverman 1993). Finally, the data was transformed into key concepts. The process was an iterative one with a constant interaction between the researcher and the data, so that ideas developed as the researcher constantly asked questions of and explored the data. During this process the researcher also asked her primary supervisor to examine the themes and to comment on the emergent themes from the transcripts.

During the whole analytic process a research journal was kept for three main reasons: first, to help the researcher remember issues and ideas that occurred during the reading and coding for the analysis, secondly, to record any key decisions regarding coding or analysis, and thirdly to form part of an audit trail which several authors recommend to ensure rigour and to make overt the researcher's thoughts, decisions and influences on the data (Lincoln and Guba 1985, Koch 1994, Koch 1999, May 1998, Playle 2000, Rolfe 2006c).

5.7.7 Nurse sample to participate in the pre-and post-questionnaire survey (research stages two and five)

For the questionnaire and educational intervention a sample of 177 registered nurses employed as permanent or bank staff was recruited, from all adult inpatient wards at both sites of the hospital. This sample 177 (n=320) represents 55.3% (177/320) of

the “bedside” ward and CCU nurses and included representation from both sites and all inpatient ward areas. The inclusion and exclusion criteria were the same as for the interview participants (see table 5.1).

5.7.8 Recruitment plan for questionnaire survey

Ward sisters were given copies of the questionnaire nurse information sheet (see appendix 5) and a verbal explanation of the aims of the study and details of the interventions. The researcher then met with large groups of ward staff on their ward, in open meetings and in the school of nursing to explain the study, distribute nurse information sheets and ask nurses to think about participating. The week before each teaching session the researcher visited the ward again and distributed more nurse information sheets. The researcher then arranged teaching sessions with the ward sister/charge nurse on the wards at an appropriate time of day, night or weekend. At the time of the teaching intervention the researcher asked all nurses present if they had read and understood the information sheet and were willing to complete the pre and post-intervention questionnaires. On each occasion it was emphasised that they were under no obligation to participate. Willing nurses then formally consented. Over the six month recruitment period, 14 nurses (n=177) did not consent because they knew they would be leaving; 12 of these did attend the teaching session.

5.7.9 The formal education intervention (research stage three)

The formal education session was provided to 177 nurses across the hospital. The aim of the education session was threefold:

1. To heighten awareness of sepsis among nurses directly caring for patients at risk;
2. To ensure nurses were aware of recent evidence about early diagnosis and treatment of sepsis;
3. To teach nurses when and how to use the PCT-Q.

The session was standardised using a PowerPoint presentation that was easily transported and shown in wards by the researcher on her laptop computer (see appendix 7). Each education session took place on a ward or clinical department in the nursing office or in a designated quiet area on the ward. All teaching sessions

were pre-booked to integrate with ward teaching sessions. The researcher was, however, flexible and responsive to the ward's needs: some sessions were cancelled and others were provided at short notice. All sessions were provided by the researcher and, although standardised, different questions and interactions with groups of nurses meant that each session was unique. The summary of the lesson is illustrated in figure 5.2 and provided as a lesson plan in appendix 6.

Figure 5.3: Summary of intervention: education session

1. Incidence and mortality rates worldwide for healthy people and cancer patients who develop severe sepsis;
2. The different stages of the sepsis syndrome: Systemic Inflammatory Response Syndrome (SIRS), sepsis, septic shock, severe sepsis;
3. The pathophysiology of the inflammatory response and severe sepsis;
4. The evidence regarding early diagnosis and treatment;
5. Early predictors of sepsis including procalcitonin;
6. Practical steps for using the PCT-Q.

5.7.10 Questionnaire survey

Before the teaching session any nurse that had consented to the questionnaire survey completed the pre-intervention questionnaire (see appendix 10). The questionnaire was designed to encourage participants to think about and test their knowledge regarding the sepsis syndrome. As no validated questionnaires that could be utilised in the study could be found one was designed for the study. The questionnaire was not designed to measure a concept or behaviour or be generalised to another population. It was explicitly to be used by nurses in order to test their individual knowledge and then for the researcher to assess whether individual knowledge improved following the teaching intervention. The outcome of interest therefore was

the change within the person and the explanatory variable was time and the impact of the teaching session.

5.7.11 Questionnaire design

Before designing the questionnaire the researcher looked at the primary and secondary aims of the research and informed by the literature review, compiled into a list of the information to be gained from the participants. The overall aim of the questionnaire was to give the nurses an opportunity to reflect on their own knowledge before the dedicated teaching session, and for the researcher to see what level of knowledge the nurses had before and after the teaching intervention. The questionnaire was constructed to address the following areas:

1. Biographical data including experience and educational qualifications in cancer nursing;
2. The nurse's confidence in her current knowledge;
3. The standard definitions for the sepsis cascade (this was important as the overall aim of the study was to diagnose sepsis earlier and the researcher therefore wanted to ensure that the nurses were aware of the four stages of the sepsis syndrome);
4. The mortality rate for severe sepsis in healthy adults and then in cancer patients;
5. How the nurse would describe the early signs of sepsis;
6. The immunological blood indicators of sepsis, particularly CRP, WBC, lactate and PCT;
7. The members of the multidisciplinary team that the nurse would contact if concerned about a patient deteriorating;
8. Whether the nurse had had experience of nursing a patient with sepsis; and
9. Whether the nurse had ever had difficulty in convincing others.

These nine areas were then organised into 15 questions presented in four sections, with a logical sequence to each group of questions (Burgess 2001):

1. Biographical details of the nurse including experience and educational qualifications;

2. General questions about the sepsis syndrome including mortality rates in the healthy and cancer patient;
3. Immunological blood indicators of sepsis and PCT;
4. Mobilising the rescue for the patient who has developed sepsis.

Having determined the questions that needed answering, the format of the questions was addressed. Short, simple and precise questions were chosen, asking for only one piece of information at a time (Leung 2001). The questionnaire was semi-structured with a combination of closed and open questions. As the questionnaire was to be administered on the ward with clinical time pressures, the questions were short and precise with eight closed questions (n=15) and two questions that provided a third choice: "not sure". Two further questions asked the participant to insert the mortality rate for sepsis in healthy adults and those with cancer. The remaining five questions were open, the first four asking the participant to list relevant responses, and the fifth asking for experience of a clinical scenario. With closed questions testing knowledge there is the possibility of successfully guessing the answer, therefore these questions were open (Bowling 2006). The questionnaire was deliberately kept simple and short, avoiding any complex branching of questions. All of the closed questions were single item measures to aid both the participant and the analysis. The order of the questions was shaped by asking the easiest questions first and progressing down to specific questions regarding experience (McColl *et al* 2001). The researcher was keen to achieve a good response rate, particularly with the postal response from the post-intervention survey, and was aware that the longer and more complex the questionnaire the less likely it was this would be achieved (Dorman *et al* 1997, Leung 2001, Bowling 2006). The researcher recognised the limitations of this questionnaire in that it did not attempt to explore aspects of knowledge acquisition or the individual aptitude of the participant. As the post-intervention questionnaire was designed to measure change in knowledge over time, the questions were the same, without the addition of the last question inviting the description of a clinical scenario (see appendix 11).

5.7.12 Piloting of the questionnaire

The internal validity of the questionnaire was tested by piloting, first with senior CCU colleagues, to determine whether it made sense and whether there were any missing questions. No additions or corrections were made at this first pilot stage. The questionnaire was then piloted on members of the CCOT who would not be part of the study group and one alteration was suggested: in question eight the word “blood” was added to make it clear that the immunological tests were blood tests. The questionnaire was not, however, pre-tested on the ward nurses. Following analysis it was recognised that one question (question four) was worded in a way that many ward staff did not recognise. Retrospectively, it was clear that it would have been better to pilot the questionnaire on a small number of ward nurses.

5.7.13 Questionnaire survey pre- and post-intervention

All nurses were reassured that the researcher was not interested in individual nurses’ answers but rather trends in the data. Each questionnaire was coded with a participant number and stored on the database so that relevant nurses could be contacted for their post-intervention questionnaires. Having previously consented, the nurses were again provided with a chance not to take part when they arrived for the formal education session. If they agreed to stay they received the pre-intervention questionnaire and were asked to complete it immediately before the education session. Each nurse then put a pre-allotted code on the top of her paper along with the ward and date, handed the completed questionnaire to the researcher and the teaching session began. Nurses took about 10 to 15 minutes to complete the questionnaire depending on their knowledge, skills and confidence level.

5.7.14 Post-intervention questionnaires

The post-intervention questionnaires (see appendix 11) were sent out to all nurses who received the teaching sessions and may have used the PCT-Q test. The questionnaires were sent, using the coded database, to every nurse who took part in an education session and completed a pre-intervention questionnaire. The post-intervention questionnaire was designed to discover whether there had been a change in awareness and knowledge regarding the sepsis syndrome and its early diagnosis,

and also find out about the nurses' experience of using the PCT-Q. These questionnaires were sent out approximately six months after the formal teaching session.

5.7.15 Analysis plan for questionnaire data

The quantitative data from the questionnaires was analysed using the Statistical Package for Social Scientists version 15 (SPSS 15). The demographic data from the first two questions was summarised using frequency tables and pie charts. The two groups contained different numbers (first data set $n=177$ and second $n=85$). Two sets of nominal questions regarding biographical data were analysed using frequency tables and pie charts individually, and then compared using only the nurses in both groups, as the groups contained different numbers (first data set $n=177$, second data set $n=85$). The next two sections of the questionnaire were analysed independently using frequency tables and non-parametric statistical tests, and then the paired data compared using McNemar's test. McNemar's test is used to evaluate categorical measurements taken from the same participants on two occasions, and measures whether there is a significant difference in proportions over time. For this type of analysis the outcome of interest is the within person change, and there may or may not be an explanatory variable. In this study it was time post intervention and possible improvement in knowledge (Peat and Barton 2005). The paired data that could be analysed was only 85 nurses as the remaining 82 nurses did not complete a second questionnaire. The frequency data from the first questionnaire are therefore based on large numbers ($n=177$) but the paired data relies on smaller numbers ($n=85$).

5.7.16 Patient sample: introduction of the PCT-Q (research stage four)

The primary objective of the study as discussed in chapter one was to diagnose sepsis at an earlier stage. The PCT-Q stage of the study was designed with a sample size and regression model to test this. The intention in the PCT-Q arm was to recruit all adult inpatients at the host hospital receiving acute therapy who developed two or more of the indicators of SIRS or sepsis using the ACCP/SCCM classification (see table 5.2) during the study. This sample was chosen for the following reasons

1. All inpatients at the host hospital have cancer;
2. Previous studies have not achieved large samples of adult cancer patients;
3. It was important to study both neutropenic and non-neutropenic patients, as all are at risk of developing severe sepsis and dying.

All patients at the hospital have cancer and all are vulnerable to sepsis, with some being at much greater risk: those who are neutropenic, have comorbid conditions, are elderly, have a low albumin, have high LDH, are undergoing complex multimodality therapy or have been in hospital for a prolonged period (Lyman *et al* 2003, 2005). Over the study period of one year the target population was all inpatients (approximately 651) who were receiving acute treatment and were therefore eligible for rescue therapy. During this period 320 patients were recruited. Each successive patient who was eligible and demonstrated the early signs of sepsis was recruited into the study. Some patients had more than one episode of sepsis during a prolonged neutropenic episode, prolonged CCU stay or separate hospital admission. A second or third episode was characterised as being a new sepsis following a period of stability when physiological parameters and blood tests had returned to normal for at least seven days. At the end of the study period, archival data was used to compare episode and hospital mortality rates.

Table 5.3: Diagnostic signs of SIRS and sepsis

	Signs of SIRS	Signs of Sepsis
1	Temperature $>38^{\circ}\text{C}$ or $<36^{\circ}\text{C}$	SIRS plus a documented infection site
2	Heart rate > 90 beats / minute	Blood cultures do not need to be positive
3	Respiration > 20 /minute or $\text{PaCO}_2 < 32\text{mmHg}$	
4	Leukocyte count $>12,000/\text{mm}^3$, $< 4,000/\text{mm}^3$ or $>10\%$ immature (band) cells	

Source: American College of Chest Physicians (1992)

The inclusion/exclusion criteria for the patient study are given in table 5.3.

Table 5.4: Inclusion and exclusion criteria for the patient study

	Inclusion criteria	Exclusion criteria
1	Patients with cancer over the age of 18	Patients under 18 years of age
2	Inpatients	Outpatients, ward attenders
3	Patients who were for all active treatment	Patients in the terminal stage of their illness
4	Patients who had signs of SIRS or sepsis	Patients who did not have any of the signs of SIRS or sepsis

5.7.17 Patients recruited for PCT-Q stage of the study

Any patient who developed signs of SIRS or sepsis (see table 5.2) and who fulfilled the inclusion criteria (see table 5.3) was eligible for recruitment into the study. The patient would be identified either because they triggered the Modified Early Warning System (MEWS) or because their nurse was concerned about them. The ward or CCU nurse would then contact the CCOT, researcher, night nurse practitioner or

nurse researcher critical care nursing, who would see the patient, explain the study, provide a patient information sheet, gain consent and take blood for centrifuging. As the study continued, other members of the multi-disciplinary team contacted the CCOT to measure the PCT, particularly doctors from the haemato-oncology team and consultant intensivists. All patients who were recruited were then added to the patient database and the patient data set collected. This database included clinical parameters, markers of infection such as a raised or lowered temperature, lowered mean arterial pressure or raised respiratory rate, predictive indicators of infection including WBC, CRP, lactate, the dependent variable their PCT-Q levels, actual microbiological findings, and the clinical course of their illness and final outcome (see appendix 14 for patient data sheet).

5.7.18 Use of the PCT-Q as a tool in the early screening of the cancer patient developing early signs of sepsis

Before the study began, the PCT-Q had not been used in the host hospital. Assessment of the patient developing sepsis was based on patient history, physical examination, bloods for CRP, WBC and biochemistry, a chest x-ray and an arterial or venous blood gas. Finally, a septic screen was performed sending blood, urine, sputum and wound drainage for microbiology. The use of the PCT-Q bedside test was a new intervention and was introduced to ward and CCU nurses using the teaching session intervention. Although nurses would be using the test, it was important that relevant medical staff were aware of it and understand the rationale for its use and how the procalcitonin values relate to the different stages of the sepsis syndrome. The researcher therefore informed key medical staff at the Medical Advisory Committee, multidisciplinary team meetings, journal clubs and teaching sessions. Two of the consultant intensivists who had worked in Australia or attended recent international ITU conferences were aware of the PCT-Q and the relevant evidence.

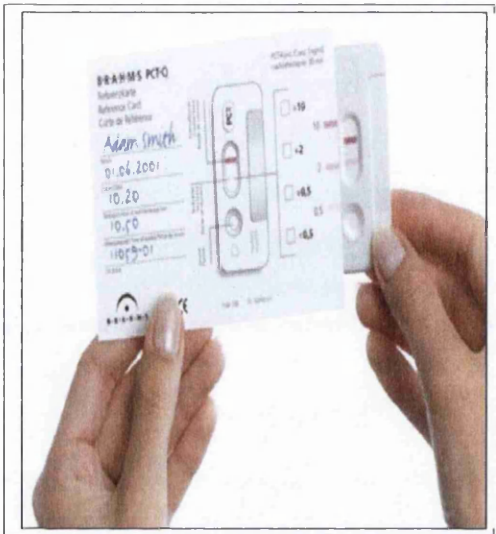
The CCOT, CCU research nurse and nurse night practitioners were taught to use the PCT-Q so that they, with the researcher, were an added resource for ward and CCU nurses. The boxes of the PCT-Q test strips were located on each of the acute wards next to the centrifuge and in the critical care units to facilitate quick and easy access. Any nurse who had received the education session could inform the patient about the

study and, if they consented, proceed to taking a sample of their blood and using the PCT-Q. A minority of patients (32) were too unwell to consent and are discussed in the section in this chapter on consent and ethical issues (5.11). As best practice, all cancer patients who demonstrate the early signs of sepsis have blood taken from their central venous catheters or peripheral veins for microbiological culture; this blood test was taken at the same time. The ward nurse then alerted the CCOT or night nurse practitioner to take the blood for centrifuging. The host hospital has a high percentage of patients engaged in clinical trials; there are therefore several centrifuges located in clinical areas to facilitate pharmacokinetics. The researcher was aware that ward nurses would not have time to take the blood to another ward to centrifuge, hence the provision of the extra nursing resource noted above. It was also important for the CCOT or night nurse practitioner to be aware of patients who might be deteriorating.

A standard operating procedure for the preparation of the blood for the PCT-Q test was displayed on the wall by every centrifuge (see appendix 8). Having centrifuged the blood and separated the red cells from the plasma, the nurse then returned the blood tube to the relevant ward and, together with the ward nurse, placed six drops from the plasma into the relevant area on the PCT-Q test (see figure 5.3). The test takes 30 minutes and the result was documented in the nursing and medical notes, and the relevant multidisciplinary team members were informed of the result. The PCT-Q result was also entered into the patient research database (see appendix 14).



Figure: 5.4: The PCT-Q bedside monitoring kit



The patient data, including cardiovascular, respiratory, blood parameters and PCT-Q results, were recorded in the research study data monitoring sheet kept on the CCU and Step Up Unit (see appendix 14). In recognition that ward nurses would not have time for this extra documentation, the CCOS, night nurse practitioner, critical care research sister and the researcher completed most of this data sheet. The patient's consent form was filed in their own medical notes, with a copy in the research study file (see appendix 13).

5.7.19 Power calculation and sample size justification

The sample size and power calculation was then established. The study had to be sufficiently powered to determine the primary endpoint that is, can the PCT-Q help to increase referrals at an early as opposed to late stage of sepsis. The appropriate sample size helps to avoid type I and type II errors.

However, there were practical constraints to the timing and duration of data collection period (12 months). A bio-statistician at the Royal Marsden was consulted to perform an appropriate power calculation. With 400 incidents, a 95% confidence

interval for the early detection rate (as a proportion of all diagnosis) can be calculated with a width of at most 10%.

If the early detection rate as reflected in the literature is at worst 50%, then with a total of 400 episodes the study will have at least 95% power to detect an increase from the published rate of at least 10%, using an exact two-sided binomial test. If the early detection rate in the literature differs from 50%, then the overall power will increase. However, in order to retain sufficient power for multivariate regression to identify predictors of sepsis, a total of 400 episodes was planned. The early detection of sepsis rate is quoted in different studies as being between 10% and 55% (chapter three). Having established the necessary sample size to achieve statistical significance (400 PCT-Q episodes), a statistical plan was formulated.

The patient data was analysed using SPSS 15. The data was firstly summarised using frequency tables and then using histograms examined for normality. The data comparing PCT value with stage of sepsis and patient variables with sepsis were analysed using chi square tests. The validity of the inflammatory markers WBC, lactate, CRP and PCT were tested individually using univariate ordinal logistic regression analysis and then combined with each other using multivariate ordinal logistic regression analysis.

Table 5.5: Patient data

Variable name	Alternative name/s	Axis for plots, data analysis and tables
Outcome variables: Stage of Sepsis e.g. SIRS versus Sepsis	Early versus late stage of sepsis	Y axis, columns
Intervening variables: outcome of sepsis episode and hospital stay, inflammatory predictors – PCT-Q, WBC, CRP, lactate		Y axis, columns
Explanatory variables: cancer diagnosis, type of treatment, vital signs		X axis, rows

Having decided on the variables, the next stage was to classify them as shown in table 5.6.

Table 5.6: Patient data: classification of variables

Variable label	Type	SPSS measure	Classification for analysis decisions
ID	Numeric	Scale	Not used in analysis
Gender	Numeric	Nominal	Categorical / non-ordered
Age	Numeric	Ordinal	Continuous
Type of cancer	Numeric	Nominal	Categorical / non-ordered
Cancer treatment	Numeric	Nominal	Categorical/ non-ordered
Stage of sepsis syndrome at diagnosis	Numeric	Ordinal	Continuous
Outcome of sepsis episode	Numeric	Nominal	Categorical / non-ordered
Hospital outcome	Numeric	Nominal	Categorical / non-ordered
Highest temperature in past 24 hours	Numeric	Interval	Continuous
Lowest MAP in 24 hours	Numeric	Interval	Continuous
WBC	Numeric	Ratio	Continuous
CRP	Numeric	Ratio	Continuous
Lactate	Numeric	Ratio	Continuous
PCT-Q	Numeric	Interval	Continuous

Having classified the variables, any missing variables were coded as 999. It may, however, have been preferable to use a full stop. Peat and Barton (2005) recommend using a full stop rather than numbers as these can be mistakenly used in the analysis (Peat & Barton 2005, p.12).

The next stage was to decide which statistical tests would be used in the analysis. This decision is based on two factors: the type of variable (as shown in table 5.6) and whether the data was normally distributed. To decide on the distribution each set of data was plotted onto a histogram using a “frequency” test and then the normal distribution curve applied. This would determine whether parametric or non-parametric statistical tests were appropriate. As expected, much of the data was not normally distributed and therefore non-parametric tests were used (Fowler *et al* 2002).

The main aim of this study was to improve the early detection of patients who were deteriorating from sepsis. The blood tests used to detect sepsis were therefore important. In the hospital, before this study, CRP and WBC were the most commonly used indicators, with the critical care team also using lactate measurements. Procalcitonin (PCT) had not previously been used and neither had the PCT-Q – the bedside test. It was essential therefore to be able to compare the blood tests and their reliability and specificity at predicting sepsis. The PCT-Q test had been previously validated, so this study was not designed to test the accuracy of PCT in diagnosing sepsis. The aim was to confirm that, in our patient population, the results of diagnostic tests including PCT-Q were a useful predictor of sepsis stage at diagnosis. It was first thought that a binary logistic regression analysis should be used to test for predictive reliability. However, this was not an appropriate test as all but 11 patient episodes describe the presence of sepsis and the tests needed were therefore to assess early versus late stage diagnosis in a common group. As the outcome variable of interest was the sepsis stage, ranked as 1=SIRS, 2=sepsis, 3=severe sepsis or worse (septic shock, MODS), and as such could be treated as an ordinal variable with ranking equating to severity of illness, an ordinal regression model was finally chosen in which candidate predictive variables would be used to predict for stage of sepsis at diagnosis. The hypothesis being tested here was that the null model is as good at predicting sepsis stage as the model using the candidate predictive variable. The 11 patients who did not have sepsis and the four patients with missing endpoint data were excluded from this analysis.

The dependant variable was the stage of sepsis at diagnosis as defined above. Candidate-independent predictor variables were included in separate analyses

initially. The logit link function was used, since the data were relatively evenly distributed across the three stages of sepsis. Odds ratios for an increased stage of sepsis at diagnosis were calculated for each candidate-independent variable and the 95% confidence interval for the ratio calculated from the standard error of the coefficient, as illustrated in chapter eight.

Variables that were significant predictors of sepsis stage in univariate analysis were then combined in a multivariate model. Initially, all parameters significant on univariate analysis were included in the model, then the change in model fit (assessed using the change in log-likelihood tested against a chi-squared distribution with degrees of freedom equal to the change in number of parameters between the model) was examined for the reduced model, with each parameter removed singly in turn. The model with the fewest parameters for which the overall model fit was not significantly worse was chosen as the best model overall.

5.7.20 Comparison of sepsis related episode and hospital outcomes in the study year to those in the three previous years when PCT-Q not available.

In the study year all patients recruited were entered onto a patient database and a patient data set collected. The database included clinical parameters, markers of infection such as a raised or lowered temperature, lowered mean arterial pressure or raised respiratory rate, predictive indicators of infection including WBC, CRP, lactate, the dependent variable their PCT-Q levels, actual microbiological findings, and the clinical course of their illness and final outcome (see appendix 14 for patient data sheet).

This patient database was then compared to the archived notes for all patients who were recorded on the hospital, Step Up or Critical Care Unit Admission database as referred due to sepsis for the previous three years. The clinical course of the illness, referrals to CCU, episode and then hospital outcomes were recorded. Where there was missing data about a patient on the databases the medical records, nursing care plans and in some cases death certificates were also used.

The data was then compared between the study year and the three previous years with particular reference to any change in overall outcomes. The data was checked

by the researcher and a colleague (Nurse Researcher Critical Care) independently to ensure accuracy. The data for the three previous years was not complete and there were also changes to the delivery of critical care during the years leading up the study year so there are limitations to the interpretation of this data.

5.8 Ethical and research governance considerations

There are important ethical considerations for all research studies with nurses and patients as participants. For the present study the first ethical issue was the acceptability of asking vulnerable patients to consent to the use of their blood in this study. Most of the patients recruited into the study were awake, alert and orientated, and able to enter into a discussion about the study having read the Patient Information Sheet (PIS) (see appendix 12). A small minority of patients had deteriorated rapidly, or were already sedated and mechanically ventilated on the CCU, and were unable to provide consent. It was important to recognise that all patients recruited were potentially going to deteriorate and might be frightened; they were all vulnerable adults.

There are two major factors that the researcher considered regarding the ethics of this study. The first was the legal standing of emergency research and research with incapacitated adults, the second the principles of research ethics and Good Clinical Practice (GCP).

On 1 May 2004 the European Clinical Trials Directive (2001/20/EC) became law as the Medicines for Human Use (Clinical Trials) Regulations. Although these laws only apply to interventional medicines or medical devices trials and there is no current legislation that governs non-medicines studies, it is thought that any Department of Health developments will take as their basis the current medicines legislation (Coats and Shakur 2005). The particular part of the law relevant to this study is found in schedules 1 and 2 in part 5 entitled "Conditions and principles which apply in relation to an incapacitated adult" (HMSO, Medicines for Human Use 2004). The 2004 legislation takes a stepped approach to consent for medical research as follows:

If the person can consent they should be asked to give their informed consent. To have the competence, the person must be able to:

1. Comprehend and retain the information;
2. Believe it;
3. Weigh it up in order to make a choice (HMSO, Medicines for Human Use 2004).

If the patient is unable to perform the above and is therefore legally incapacitated, then for the first time in English law pertaining to adults another person can consent for them. The person is called the personal legal representative and they can be either a family member or friend who, because of their knowledge of the person, can act for them or a professional legal representative, either a doctor unconnected with the trial or another healthcare professional again unconnected with the trial. In 2005 the Mental Capacity Act made it clear that once an appropriate assessment had been undertaken the patient could be provided with care that is judged to be in their best interest (Whitcher 2008). In summary, therefore, a minority of patients involved in this study (35, n=320) were legally incapacitated, but in all cases at least one family member or friend was regularly on the CCU with them. In these cases the family member was informed about the study and asked if they felt that their relative would have consented to have the blood test and for the result to be used in the study. It should be emphasised here that the legal directive is only one part of the ethical consent process. The other areas that were addressed were the risk/benefit balance for the individual patient, the potential for harm and the strength of the scientific evidence supporting the study (Coats and Shakur 2005).

In this study the risk to the patient was minimal. The only intervention was a blood test that would be taken at the same time as other tests and in the majority of cases, especially in CCU, from a central venous access device or arterial cannula. The potential benefit to the patient was another test, supported by many studies as having good reliability and specificity for sepsis, to aid in their diagnosis and treatment. Another good clinical practice issue in research ethics is that patients will usually have more than 24 hours to decide on participation. In emergency research this is impractical it is therefore important that the benefits outweigh the risks for the patient. Finally, all the patient data was anonymised. Several cancer patients who

were well informed and highly involved with their treatment, on developing signs of sepsis a second or third time, asked the CCOT to measure their PCT. On a few occasions a normal PCT was able to reassure the patient.

It was equally important to ensure that nurses were appropriately invited to participate. The researcher was well known and a senior nursing figure in the trust, she only had line responsibility for the CCOT but was aware that she was not without influence. The nurses were, therefore, recruited by their ward teams. They were given time to think about whether they wanted to take part in the study and their time commitment (the teaching session and pre- and post-questionnaire or two qualitative interviews) was made clear verbally and on the Nurse Information Sheet (see appendices 4 and 5). It was made clear to all nurses that there was absolutely no obligation to take part. Formal signed consent was taken from all nurses recruited into the study (see appendix 9, a and b). In practice, as the study gained momentum across what is a small hospital, nurses on different wards regularly asked the researcher when they were going to be invited or why they had not been asked yet.

The study was reviewed by the hospital's Committee for Clinical Research and the Local Research Ethics Committee (protocol number CCR/ LREC 2372).

5.9 Research in own practice area

The challenges associated with conducting research in one's own organisation are recognised. They include the disclosure of information, power and issues such as bias or compromised data that will be discussed in the section on rigour (5.10). Although there are dangers to research on home territory, the researcher was keen to conduct the research in her own organisation for two reasons: first, to improve practice in her own hospital, and secondly, the practical reality of trying to reach 177 nurses in the teaching sessions. The researcher was aware that researchers may be accused of exploiting participants to achieve their own end, in this case an educational qualification. The researcher was however clear that there was an important rationale for the study that of improving practice to reduce the impact of sepsis in the person with cancer.

Oakley (1981) describes most traditional in-depth interviewing as unethical, either deliberately or not, and says that the various techniques used are methods of manipulating the participants. In seeking to counteract this and other perceived exploitations, feminist researchers have sought to work in a way that is more participatory and democratic, with researchers who aim to build collaborative, trusting and friendly relationships with participants (Benmayor 1991). For this study the researcher was aware that the ward and CCU nurses were keen to learn more about sepsis, and she was used to working clinically with nurses on shifts in an open and democratic way. The researcher was, however, mindful of dangers such as bias and collusion and took steps throughout the research to avoid these.

5.10 Issues of rigour

5.10.1 Quantitative research

There were two areas of quantitative research: the questionnaire survey and the PCT-Q patient research therefore issues of validity and reliability are discussed for both. The design of the questionnaire its advantages and limitations have been discussed previously. Its content validity was satisfied in some degree by the pilot. The external validity of the questionnaire survey is satisfied by the random sample of 177 nurses out of the total possible population of 320 nurses. The internal validity of the questionnaire survey was satisfied by the inclusion and exclusion criteria and variables such as the teaching intervention and teacher were controlled. It must be noted that the questionnaire survey only sought to raise awareness of sepsis and increase knowledge in a limited area. Finally the statistical test chosen to analyse the paired data McNemars test was justified as it measures change over time in paired categorical data sets.

The construct validity of the PCT-Q test was satisfied as it was demonstrated in the literature review that procalcitonin and the PCT-Q are a valid and reliable tool for the early diagnosis of sepsis in the neutropenic and non neutropenic adult. External validity was satisfied in that all patients who met the inclusion criteria and exhibited

the early signs of sepsis were recruited to the study. These cancer patients were representative of the total population that is all cancer patients receiving acute potentially curative cancer treatment at the study hospital over one year. Internal validity was satisfied by raising nurses' awareness of sepsis and the PCT-Q therefore increasing active recruitment to the study, and utilising the other markers of sepsis commonly used in the hospital.

The stage of sepsis and PCT-Q level was correlated using the chi square test. The stage of sepsis is internationally defined (Dellinger et al 2004, 8). The validity and reliability of the PCT-Q, lactate, WBC and changes in Blood Pressure in diagnosing sepsis were tested using univariate ordinal logistic regression analysis and then in a combined model using multivariate logistic regression analysis. The reliability of the PCT-Q in the hands of ward nurses was demonstrated with 11 (n=416) PCT-Q tests measured erroneously in patients who never developed sepsis, and 11 patients (n=416) developing sepsis who had not had a PCT-Q performed.

5.10.2 Qualitative data

Issues of rigour are important in all research. Qualitative researchers rejects terms such as validity, reliability and generalisability in favour of plausibility and trustworthiness, and reflexivity (Popay *et al* 1998, Lincoln and Guba 2005, Mays and Pope 2000, Donovan and Saunders 2006, Morse 2006c). Rolfe (2006c), Koch and Harrington (1998) and Sandelowski and Barroso (2002) recommend that judgements about the plausibility of qualitative research are made according to the sense that the author but also the reader can make of the final research report, and not to preordained rules. Rolfe also encourages judgements to be made from the perspective of practice with all of its complexity (Rolfe 2006c, p.309).

5.10.3 Plausibility or trustworthiness of interpretation of the data.

Guba and Lincoln (1989) in the pursuit of "trustworthiness" recommend the criteria of credibility, transferability and dependability. Thus anyone reading the research should be able to recognise the presented phenomena or, if it departs from expectation, be able to see how the researcher has arrived there. Other researchers

have challenged these criteria, concerned that Guba and Lincoln have tried to introduce criteria to equal those used in quantitative research (Smith 1993, Bloor 1997, Sparks 2001, Silverman 2005).

In the present study, the key themes emerging from the data have been clearly described. The data itself has also been presented alongside the analysis as further evidence and an example of an interview transcript is included at Appendix 15. The themes are generated from two different sets of data collection and then integrated where possible. The integration of the findings has been used to obtain a greater understanding of phenomena such as the experience of nurses contacting the multidisciplinary team. The data has also been analysed with reference to previous research, particularly that pertaining to the Medical Emergency Teams and Critical Care Outreach (Cioffi, 2000a,b, Bellomo *et al* 2003, Bellomo *et al* 2004, Ryan *et al* 2004, Goldhill *et al* 2005). In this study the researcher decided not to undertake member validation for two main reasons: first, the practical difficulty of contacting 187 nurses, and secondly, the debate in the literature about the efficacy of this strategy (Gallagher 1995, Silverman 2005, Tobin and Begley 2004, Donovan and Sanders 2006).

5.10.4 The audit trail

Key techniques used to ensure plausibility in qualitative data are openness, transparency of analysis, and the provision of an audit trail (Lincoln and Guba 1999, Mays and Pope 2000). In the present study the researcher has clearly and systematically described the process of the analysis. There is also an audit trail described in the findings chapters that the reader can follow. Another process that has been used with qualitative research is for the coding to be open to scrutiny by others to discuss and refine codes and categories (Barbour 2001). In this study the coding was read and discussed with the researcher's main supervisor and after discussion two themes were changed and combined.

5.10.5 Reflexivity

In qualitative research the qualities and experience of the researcher and the role they play in the research are regarded as important. In much qualitative research the author provides a biography and a reflexive account of their attitude to and effect on the research. The researcher in this study was familiar with the clinical area and there was therefore at potential risk of being biased. The researcher therefore kept a reflexive diary and constantly appraised her role in the study, informed by reading about Gadamer's model of the hermeneutic circle. For Gadamer as described by Rundell (1995), hermeneutics involves the shared activity of communication when the researcher is actively involved in speaking, hearing, listening and keeping silent. For Gadamer the reflexivity of the researcher and research process is essential, so that the researcher is attentive and critical during the actual research process, and there is an openness between the researcher and the participant. Therefore for Gadamer the previous experience and prejudices or beliefs of the researcher must be critically appraised and, together with those of the participants, brought into the hermeneutic circle to inform the final research study (Grondin 1994).

Harding (1987) also argues for the most rigorous performance of qualitative research in particular, with the researcher placed under scrutiny in the same way as the subjects of the research. Utilising this stance would mean that the reader is given explicit information about the researcher, and how her influence and the person she is has shaped the project. Writers such as Lincoln and Guba (1985) and more recently Marcus (1994) and Koch and Harrington (1998) have also noted the essential aspects of reflexivity in research. For Creswell (2003) this reflexivity typifies current qualitative research. He cites Mertens (2003) who, discussing the optimum position of the qualitative researcher, suggests that they are characterised by honesty and openness while also recognising that inquiry is value-laden. For both Creswell and Mertens the personal-self is indistinguishable from the researcher-self (Creswell 2003, p.182). Koch (1999) describes the Gadamerian philosophy of research as a dialogue where you question and develop thoughts and connections, metaphorically writing in the margin, annotating and noting broad social, cultural and gender implications (Koch 1999, p.32). Finally, in a gloss on Gadamer, Koch notes that researchers will have their prejudices but that these are not obstacles,

rather, they are the way we view the world and we take this into the research process (Koch 2006, p. 92).

There is a large body of literature addressing the particular moral stance that the researcher undertaking qualitative research for example embarking upon an ethnographic study would take as opposed to that observed for a quantitative study. Authors however argue that it is too simplistic to ascribe particular moral beliefs to a methodology, but rather that the researcher using any methodology, must question themselves about their research practice, and particularly about how they position themselves in relation to their participants (Morse 1994, Schwandt 2000, Silverman 2005).

In this study there were two groups of participants: registered nurses working on the acute wards or in the CCU and people with cancer who were displaying the first signs of sepsis. For the researcher, her research relationship with the nurses was one that she actively reflected upon before each intervention session. The approach of the researcher was affected by the experience of working clinically with nurses over many years; they have an expertise that often goes unrecognised in the hurly burly of the busy clinical ward. The researcher was well known in the hospital as a clinical nurse consultant but did not have an operational management role with any of the nurses involved as participants.

Although the researcher was aware that the PCT-Q might aid the patient participants' sepsis assessment, she was aware that using their data for her research would not benefit them. It was therefore essential to reassure the majority who were able to consent that their refusal would in no way adversely affect their treatment. The researcher does, however, recognise the difficulties in this relationship, as her experience is that patients are very keen to help. At the study hospital most patients are involved in clinical research and are very familiar with it. This may be seen as an advantage, in that they understand the process, or a problem in that they see it as a part of their care.

5.11 Conclusion

The researcher chose a multiple methods design with a research framework consisting of five stages to better answer a question set in the complexity of practice. The design of the study with its five stages was underpinned by a theoretical framework derived from the literature and experience. Rolfe describes nursing as praxis with the nurse as practitioner involved in research as the “reflexive spiral” where the nurse asks questions about specific practice questions, tests hypotheses, changes practice and then re-evaluates the hypotheses (Rolfe 2006b, p.40). As a clinical practitioner, the researcher wanted to address questions that occur in practice and whose outcomes may in turn improve practice.

In this study, with its range of methods, there is a continuum of methodological perspectives, from the positivist approach used to interpret the patient PCT-Q tests to the interpretive or constructionist approach used in the remainder of the research. It is less common in nursing to use a positivist perspective, as nursing is often asking questions about the how of patient experience or, as in this study, the how of practice. Nursing, as opposed to other healthcare disciplines such as medicine, psychiatry or dietetics, is seeking to look at behaviour or experience from what Edwards (2001) describes as the “first person rather than the third person perspective”. Empirical research depends on observing or measuring, but in nursing there is much that cannot be simply observed as there are inner subjective interpretations not open to view.

This multiple methods study therefore used a combination of qualitative interviewing, quantitative survey, the PCT-Q testing with patients and the introduction of two interventions. The populations that participated were patients with cancer who were becoming acutely ill with sepsis and nurses caring for these patients on general wards and in the CCU.

The primary objective of the study was to diagnose patients’ sepsis at an earlier stage, recognising that nurses report a difficulty in convincing colleagues, an objective bedside test was to be introduced to improve multi-professional communication and therefore rescue.

The eight secondary objectives were to:

1. Learn more about nurses' experience of the cancer patient deteriorating with sepsis and any barriers to effective communication and rescue;
2. Gain an in-depth understanding on nurses awareness of sepsis and its assessment and management and how this could be improved, particularly how nurses felt they learnt optimally;
3. Explore whether nurses' judgement about the patient developing sepsis was accurate and whether they could use the PCT-Q appropriately;
4. Gain an in-depth understanding from the nurses how they felt the use of the PCT-Q has impacted upon practice and how easy in practice it was to use;
5. Assess whether in the nurses' hands and with cancer patients the PCT-Q was reliable in identifying sepsis compared to WBC, lactate, CRP and mean arterial pressure falls;
6. Evaluate if the use of the PCT-Q as part of clinical nursing assessment and communication resulted in earlier referrals and improved outcomes;
7. Compare the outcomes of patients during the study year to three previous years;
8. Evaluate whether the dedicated education session improved awareness and knowledge about the cancer patient with sepsis.

Chapters six, seven and eight illustrate how the findings from each research stage link both to the theoretical framework and the overall and subsidiary aims, and primary and secondary objectives.

Chapter 6 Findings (1): qualitative data from interviews and questionnaires

6.1 Introduction

Over the next three chapters, the findings from each stage of the study will be presented in the order that the findings were generated. As described in the methodology in chapter five and particularly figure 5.2 (p.87) the data generated from the qualitative interviews was used to design the nurse questionnaire and therefore this will be presented first. The next data to be generated was from the nurse questionnaires and is presented in chapter seven. Finally, the patient data using the PCT-Q is presented in chapter eight.

This chapter focuses on analysis of the qualitative data collected from the pre- and post-intervention interviews and the final part of the pre-intervention questionnaire. The qualitative interviews, as discussed in chapter one and five link to the theoretical framework by providing further evidence about the nurses' role in the early assessment of sepsis, blocks to effective communication and rescue, and the need therefore for an objective test. The objectives of the qualitative interviews were to gain an in-depth understanding of the following aspects of the nurses' individual experiences of caring for a patient deteriorating with sepsis:

1. Nurses' individual overall experience of caring for patients deteriorating with sepsis
2. Barriers to effective communication and rescue, and their previous experience of informing and mobilising the multi professional team;
3. Nurses' awareness of sepsis and its assessment and management and how this could be improved, particularly how nurses felt they learnt optimally and could teach others;
4. How nurses felt the use of the PCT-Q impacted upon practice and how easy in practice it was to use.

The post-intervention interviews were to be conducted with the same 10 nurses who had been previously interviewed. Two of the nurses had left the hospital, leaving eight post-intervention interviews. The rationale for the post intervention interviews was to interview the nurses post the introduction of the PCT-Q to obtain richer data about its introduction. Themes or questions that were generated from the analysis of the first transcripts were also explored. There was no intent to compare pre and post interviews but rather to integrate all the findings to better understand the experience of the nurses.

The method used to analyse the data was a constant comparative technique using elements from grounded theory. The principles behind this analysis were to remain true to the authors of the text and to provide a transparent audit trail to guide the reader through the findings. A process of reading the transcripts to gain a general overview was followed by a more detailed and critical re-reading, from which individual topics were identified. Following a further reading, these topics were amalgamated into broader categories, which were listed and examined for any inter-relationships. Out of this process, larger themes emerged. The majority of the themes reflect a broad consensus across the data; there were “contrary cases” relating to some of the themes. There were also “leftover” themes, only expressed by one participant but so dominant in their testimony that they were retained as a theme. Each collection of data, for example all the pre-intervention interviews, were analysed first as an independent data set. Having analysed all three sets they were brought together and a final analysis of the central themes was undertaken. This chapter provides a summary of this analytic process.

6.2 First data set: analysis of the pre-intervention interview transcripts

The first data to be collected and analysed were the transcripts from the pre-intervention qualitative interviews. Ten nurses with varying experience, education and years in nursing from across the hospital were interviewed and asked to describe their experience of the following:

1. Personal experience of noticing the early changes that occur in the person with cancer as they start to develop sepsis;
2. Personal experience of mobilising the multidisciplinary team to rescue the patient;
3. Early thoughts about the use of a nurse-performed bedside test which helps to diagnose sepsis at an early stage.

The nurses' demographics and educational characteristics are shown in table 6.1.

Table 6.1: Demographics of the 10 nurses involved in pre- and post-intervention qualitative interviews

No	Qualified in nursing	Cancer nursing experience	Critical Care nursing experience	Educational qualifications	Sex
1	9 years	7 years	6 years	RN, Oncology Diploma, currently undertaking BSc Critical Care nursing	F
2	5 years	2 years	0	RN, Oncology Diploma	F
3	13 months	6 months	0	RN	F
4	3 months	3 weeks	0	RN	F
5	4 years	4 years	0	RN, Oncology Diploma	F
6	2 years	2 years	0	RN, Oncology Diploma	F
7	6 years	4 years	0	RN	F
8	4 years	16 months	2 years	RN, Advanced Diploma Nursing, currently undertaking BSc Critical Care nursing	M
9	20 years	4.5 years	0	RN, Oncology	F

				Diploma	
10	17 years	13 years	16 years	RN, ENB ITU, ENB Teaching & assessing	M

The taped interviews were transcribed and then read through in an attempt to get an impression of the whole. During this first reading the researcher often made notes in the margins of the transcripts. Following this first read through some notes were made in a research notebook, for example: “The two newly registered nurses both mature students – is this important, relevant or not?”; “I speak too much in some of the interviews – long bits for SD”; and “glad I read the stuff about novice nurses and intuition – useful in transcript four”. Having read through all 10 transcripts once, each was then read in a more concentrated way, making detailed notes and underlining passages that seemed important to the participant. The researcher used the guidance provided by Tesch (1990, p.121) in clustering these topics into major, unique and leftover. A table was constructed with topics placed in columns; these topics were recalled from the second read through. The transcripts were then read again. The researcher was guided by the principles of qualitative analysis in the area of identifying important topics. If only one of the 10 nurses identified that something was important to her then that was not lost to the analysis. Therefore, if one nurse mentioned one topic several times, that topic was retained.

Table 6.2: Major topics raised by nurses

No	Topic Major	No of times
1	Obs / urine output / rigors	35
2	Bloods / antibiotics / u&es	15
3	Awareness of risk / treatment they have had / Hickman lines	12
4	Perseverance and follow through	12
5	Compare them to how they were previously / know the patient well	12
6	Their colour may be different / they don't look right compared to how They were previously / know the patient well	11
7	Don't engage in conversation in the same way / slight change in behaviour / drowsy	11

8	Experience	10
9	Generally docs come quickly / take you seriously	9
10	Be fantastic to use something to confirm / concrete / values & measurements	9
11	The patient says they don't feel right / feel needy	7
12	Frustration	7
13	Outreach team very good / very helpful	6
14	Would inform docs early.	6
15	A sense about it / there was just something not right	6
16	The higher the nurses grade the more MD team take notice	5
17	Reinforce to the nursing team that I am worried	5
18	Patients go off very quickly	5
19	Send septic screen swabs etc	4
20	Looked after lots of patients – build up experience of when not right	4
21	Fluid resuscitation	4
22	Nursing intuition	3
23	Not just experience how you apply it and learn	3
24	New nurses scared of septic patient	3
25	Not worried about looking silly	3
26	Previous experience different not as much sepsis	2
27	PCT-Q as long as not too much work	2
28	Unique – nurses not being able to start the rescue start a'biots / fluids etc until we have a docs signature	2
29	Unique – sense that you are waiting for the patient to do something	2
30	Unique – easier access to MDT in CCU	2
31	Quieter	2
32	Encourage nurses to act	1
33	Reflection	1
34	EWS	1
35	PGD	1
36	Leftover: comparison of data not all BP drop = sepsis	1

37	Leftover: some patients just not good performers	1
38	Leftover: skin temperature	1
39	Leftover: vulnerable to sepsis	1
40	Leftover: full assessment	1

Having identified 40 topics from the 10 transcripts, the transcripts were read again to ensure no topics had been missed. The 40 topics were then reorganised and reduced into categories that reflected grouping of related topics. An example of this was the grouping together of topics 5, 6 and 7 from table 6.2 and a new category emerging which was broadly to do with observed changes in the patient. It appears as category 2 in the table 6.3. The reduction of topics into categories resulted in a decrease from the original 40 topics to 21 categories.

Table 6.3: Amalgamation of 40 topics into 21 categories ordered by frequency of occurrence in interviews

No	Categories	No of times
1	Obs / urine output / full assessment / rigors / comparison of data not all BP drop = sepsis	37
2	Their colour may be different / they don't look right , ask them/ know they were previously/ know the patient well / quieter / skin temperature / Don't engage in conversation in the same way / slight change in behaviour / drowsy	25
3	Experience / looked after lots of patients – build up experience of when not right / a sense about it / there was just something not right / sense that you are waiting for the patient to do something	22
4	Bloods / antibiotics / u&es	15
5	Perseverance and follow through / Not worried about looking silly	15
6	Would inform docs early / generally docs come quickly / take you seriously	15
7	Awareness of risk / treatment they have had / Hickman lines / vulnerable to sepsis	13
8	Compare them to how they were previously / know the patient well	12
9	Be fantastic to use something to confirm / concrete / values & measurements / Encourage nurses to act / PCT-Q as long as not too much work	12

10	Send septic screen swabs etc / fluid resuscitation / nurses not being able to start the rescue start a'biots / fluids etc until we have a docs signature / PGD	11
11	The patient says they don't feel right / feel needy	7
12	Frustration	7
13	Outreach team very good / very helpful / EWS	7
14	Not just experience how you apply it and learn / reflection / nursing intuition	7
15	The higher the nurses grade the more MD team take notice	5
16	Reinforce to the nursing team that I am worried	5
17	Patients go off very quickly	5
18	New nurses scared of septic patient	3
19	Previous experience different not as much sepsis	2
20	Easier access to MDT in CCU	2
21	Some patients just not good performers	1

The 21 categories were then examined again to identify any interrelationships between categories. This further analysis revealed more interrelationships, resulting in the reduction of the previous 21 categories to 8, as illustrated in table 6.4.

Table 6.4: Categories derived from the previous 21 categories

These eight categories were then examined again, together with how they appeared in the transcripts and with regard to the literature, and were given a thematic meaning label.

1	Their colour may be different / they don't look right ask them compared to how they were previously / know the patient well / quieter / skin temperature / Don't engage in conversation in the same way / slight change in behaviour / drowsy // experience / looked after lots of patients – build up experience of when not right / a sense about it / there was just something not right / sense that you are waiting for the patient to do something // Compare them to how they were previously / know the patient well // The patient says they don't feel right / feel needy // some patients just not good performers	25 +22 +12 +7 +1 = 67
2	Obs / urine output / full assessment / rigors / comparison of data not all BP drop = sepsis // Bloods / antibiotics / u&es	37 +15 = 52
3	Awareness of risk / treatment they have had / Hickman lines / vulnerable to sepsis // patients go off very quickly	13 + 5 = 18
4	Would inform docs early / generally docs come quickly / take you seriously // perseverance and follow through / Not worried about looking silly // reinforce to the nursing team that I am worried // the higher the nurses grade the more MD team take notice // Outreach team very good / very helpful / EWS // easier access to MDT in CCU	15 + 15 + 5 + 5 +7 + 2 = 49
5	Be fantastic to use something to confirm / concrete / values & measurements / Encourage nurses to act / PCT-Q as long as not too much work	12
6	Send septic screen swabs etc / fluid resuscitation / nurses not being able to start the rescue start a'biots / fluids etc until we have a docs signature / PGD // Frustration	11 + 7 = 18
7	Not just experience how you apply it and learn / reflection / nursing intuition // new nurses scared of septic patient	7 + 3 = 10
8	Previous experience different not as much sepsis	2

6.3 First data set: themes

6.3.1 Importance of continuity

The first theme shared by most participants concerned the way nurses recognise a change in the patient that is not related to measuring their biological parameters. This change was dependent on knowing the patients and being able to identify a change. A contrary case was also identified from the most junior nurse in the cohort (TS.04) who felt that she was too inexperienced to use anything other than overtly quantifiable measurements.

“I haven’t had the experience and I am only probably going on what I have read and this and what I know to be erm..normal..erm but I thought she was worse but I would not have pushed the issue if it wasn’t for the respirations... for me as, for me as a newly qualified nurse I that really is all I have to go on, measurements, and that’s all I have to go on”. (TS. 04)

“...because we get to know the patients quite well and we can pretty much tell if something is not quite right, erm and it’s kind of just looking at areas, erm such as redness at Hickman sites or central venous sites”. (TS. 02)

“Dunno, sometimes you just look at them and they look not quite how they were before, if you ’cause, sort of, the nice thing is having patients coming in routinely for their chemo, you know... you know what they’re like when they are well”. (TS. 05)

“...mmm they’re not as well as they were... just, just generally you felt that their demeanour was different to what it was... that they were just a little bit flatter in themselves, I suppose... well that all depends on your prior observations of patients... sometimes that can be difficult, when you come on and... you haven’t met the patient before”. (TS. 07)

“...it might just be a change in the person one of our patients, you will remember him (name) he went to CCU, he used to always come out of his room and give us chocolates, and the first sign that he wasn’t well was that he didn’t try to come out of his room”. (TS.02)

“sometimes it can just the general... how they... how they respond to you. If someone isn't feeling well because they're becoming septic, they won't be feeling well... so they might be slightly distracted when you speak to them, tired... erm, maybe not always in as good humour as they normally are”. (TS.10)

6.3.2 Making a diagnosis: vital signs

The next dominant theme was nurses recognising which changes in vital signs were likely to mean a diagnosis of sepsis. The changes the nurses discussed are all cited as important signs of SIRS (Bone 1992, Dellinger 2004, 2008). Nurses discussed suspecting sepsis based on changes in heart rate, blood pressure, temperature, presence of rigors and alteration of urine output:

“...but you could say this patient has dropped their blood pressure... or their pulse is faster, or their breathing has deteriorated”. (TS. 01)

“So I guess sepsis-wise I guess you kind of do an observation, you're looking at erm things like er... temperature obviously temperature's quite important pulse rate and er pulse being raised... and er rigoring that's usually quite a good one that gives a good indication and a drop in blood pressure, erm their pallor...” (TS.02)

“Um, I think probably one of the hallmarks that I've always looked for say temperatures, erm, you know, escalating temperatures... or patterns of temperatures. Other things that I've usually got worried about are usually say drops in blood pressure... which just seem really quite out of the blue and just don't seem to... looking at just really basic like oxygenation you know...” (TS. 08)

“You know, spike and be septic at some point erm and the doctors said they would actually wait for her to spike a temperature before would start her on antibiotics, which at the time I thought ...well from just knowing patients go...you know...how quickly they can become septic. I don't know I just felt a bit frustrated, you know”. (TS.02)

Two nurses, both new graduates, commented on the importance of using changes in the patient's cardiovascular parameters:

“...usually they come in and you know we’re given the background on that patient so immediately you know the patient is septic... so the onus wouldn’t be on me to recognise it... their vital signs, um their temperature going above thirty eight. Things like that erm... and the... pulse not going over um maybe a hundred. Well it all depends on the individual really what’s not normal and what’s not for them. Whether the patient’s become tachycardic or maybe bradycardic and um blood pressure”. (TS 03)

6.3.3 Contacting others

The third theme was contacting others to help. This might either be senior nurses on the ward, doctors or the CCU outreach team. Contributing to this theme was the willingness of others to listen and the different professional teams or tactics the nurses used to get help. The changes in the patient associated with sepsis would result in the nurse mobilising senior members of the nursing team, doctors and the multidisciplinary team quickly. There was a mixed response to this with some nurses noting their frustration (TS01) whilst others felt it was better in the study hospital (TS.07) is a perception that the doctors in the hospital respond quickly, but this may be dependent on the seniority of the nurse that calls them. The outreach team were also perceived as a useful part of the rescue team:

“...and I think it’s probably the most frustrating thing, as a nurse, because you can’t we’re so ...medical doctors are very scientific. The way they deal with figures and they do, you know so they can ...they can you know ..they like facts and they like to act on those and that’s the way it should be. But I think that when we are with patients all the time I think you feel and see more than just...just the observations you are doing with regard to measurement and erm I think sometimes you do take...you go to the doctors and erm say so and so from an observation point of view but I’m really worried about them ...and it is quite frustrating you almost have to wait for that patient to do something so you could pull them...”(TS.01)

“The doctors are pretty good actually... erm and they tend to listen to us I think. I don't know what it's like, whether it's different hospitals, but here I think the doctors do rely on us to tell them. And a lot of them they come here and they really haven't a clue and you have to kind of teach them the ways”. (TS. 05)

“I think sometimes with the doctors... they do listen to you yes, the majority do. I think maybe sometimes they might be... times when I feel that perhaps they've sort of sat on things and... but generally, generally I think the doctors are very good. I think they do listen to you”. (TS. 09)

“And I know, I think I suppose it very much depends on the nurse as well. You know... it depends on what... How they sort of value your input depending on what type of person you are and whether you've made sense in the past”. (TS. 05)

“...I think here it goes better it does in other hospitals, because I do think that the doctors take you seriously. I do because I think in general they... they value nurses' opinions in the Marsden, because we tend to be more qualified... you know, in that specialty. It normally goes quite well and if I was seriously worried about that patient, then I would express that... erm quite urgently”. (TS. 07)

“Yeah even now, like, as a newly qualified... if a doctor is around and they're there I will tell them, but they wouldn't be my first port of call if something was going wrong I would probably go to like for instance (senior staff nurse name) who's on today”. (TS. 04)

“...oh yeah the outreach girls are good aren't they. I do think that, even if it's a ridiculous, you know query that they're more than helpful... and if they are making a suggestion that perhaps you should have thought about they do it so nicely that, you know... they are very good”. (TS 07)

6.3.4 Awareness of sepsis risk in the cancer patient

The next theme was the awareness of risk about sepsis developing. Nurses talked about the increased risk of sepsis in people with cancer and the increased risk posed by a particular treatment or an indwelling catheter. Nurses were also aware that people with cancer who become septic deteriorate very quickly.

“I think within, especially within the field of haemato-oncology you expect these patients to have some degree of bone marrow depression and I think any patient who has been vulnerable to this you would expect them to be vulnerable to infection, indeed to developing sepsis or septicaemic shock...”

(TS. 01)

“So I suppose the main thing is to make sure that we’re dealing... obviously sepsis happens quite quickly and so erm got to deal with it quite quickly as well...” (TS.02)

“I would always err on the side of sepsis, because I know that you have to act quickly... probably because I know how quickly the patient can deteriorate...” (TS. 06)

6.3.5 Introduction of a new predictive bedside test

In response to the researcher’s introduction of the PCT-Q, nurses were generally keen to have a tool to use to diagnose sepsis early. As can be seen in the passages from transcripts 02 and 10, there was a need for it to be easy to use. There was one contrary case in which, although the nurse was supportive of the tool, they were keen that “it did not stop nurses looking at their patients” (TS.10).

“And we know and like, you know, you’ve seen... the first hour is crucial to optimise the patient, so I think erm it would be brilliant to have something to maybe initiate treatment sooner...” (TS. 01)

“Sounds like a good tool, I think yeah if we’re obviously educated and taught how to use it. Yeah definitely. Erm but I think that with anything that is obviously too complicated or means too much work, it does tend to... but I think something like that definitely. Mmm it certainly would help probably new members of the staff coming onto the ward as well to erm understand sepsis and probably not be so afraid of it as well...” (TS. 02)

“Then that would be something we could do straight away without... having to, you know, wait for the doctors to come up and for them to say, yes that’s okay for you to do that. ‘Cause then we’ve got even more, sort of, something to back our argument as well with when you phone the doctors...” (TS. 05)

“I definitely think it would be helpful because erm..it would be easier to ..it would be easier to insist and to be able to plan what’s going on for a start..with the patient and act, to act quickly and to have hard evidence almost, to say you know this is what’s going on, rather than, there being erm..it being a bit wishy washy” TS.06.

“I think it would be useful... as long as it didn’t... I mean I think that any, any tool that could be used to set off early alarms about a patient’s condition... will be useful. And preventing them deteriorating and becoming so unwell... as long as it didn’t discount the value of what the nurse actually sees on examination... it doesn’t stop nurses looking at their patients...” (TS.10)

6.3.6 Septic screen

The fifth theme concerned collecting microbiological samples from the patient. Three of the nurses described taking samples of urine, blood and a septic screen for microbiological analysis:

“I probably take... if they had a pyrexia, I’d probably take some blood cultures and do some extra bloods...” (TS. 09)

“Then do a full screen... if they’re producing any sputum, cultures erm... and then if they’ve got any wounds, swab those. And other breaks in the skin or stomas, that sort of thing... if they’ve got diarrhoea, send a stool sample”. (TS. 05)

“You would take if necessary, you would take bloods, you would send off a CRP... you would do a full screen...” (TS.01)

6.3.7 Clinical confidence based on experience, reflection and education

Nurses commented on their confidence level in recognising sepsis and mobilising the rescue team, and that this generally had improved over time. They also noted the benefit of increased knowledge, education, nursing intuition and reflection:

“...erm but it was very frustrating that, you know, you knew there was something wrong but you couldn’t obviously put it in... I wasn’t confident

enough to erm push my case and present that case to the doctors in a sort of medical mode... I think I've learnt to give facts... and to be able to arrange those facts in a way where it highlights my concern, but it also gives a basis on... for people to go to the patient with knowledge already about what we're actually looking for". (TS. 10)

"I think general experience and learning and having sessions... on the diploma course... because... and the other thing as well is I've worked a lot with neutropenics in chemotherapy..." (TS. 09)

"All the time I go home and think erm... Oh I could do this differently next time, or I'm happy with what I did. I do that all the time. I mean things..some... sometimes if I feel not completely happy with things I'd come back and talk to someone about it and if I feel it important I'll come back and talk to someone about it..." (TS.03)

6.3.8 Frustration about limitations to practice

Although this was only directly stated by one nurse (TS.02), she mentioned it several times.

"Erm, probably the most frustrating thing is when patients do go septic not you know having a, erm... I don't know, we've got the guidelines in the protocol we obviously can't administer any kind of therapy until we've got a doctor's signature and... I know I was at the EBMT not so long ago, where one of the hospitals in Dublin have got... Patient Group Directions... and I er really, I thought that was a very good idea" (TS.02)

6.3.9 More patients with sepsis at this hospital

Creswell encourages the researcher to analyse material that is expected, surprising and addresses a larger theoretical perspective (Creswell 2003, p.193). The researcher was surprised that two nurses commented that they saw more sepsis in the study hospital. They weren't sure, however, if this was because they were more experienced or due to different patient populations or treatments.

6.3.10 Summary of themes from first data set transcripts

Having identified the nine themes listed below in figure 6.1 the researcher then read through all 10 transcripts again to assess whether there were any important topics that were not included in the nine identified themes.

Figure 6.1: Nine themes from pre-intervention interview transcripts

1. Importance of continuity
2. Making a diagnosis: vital signs
3. Contacting others
4. Awareness of sepsis risk in the cancer patient
5. Introduction of a new predictive bedside test
6. Septic screen
7. Clinical confidence based on experience, reflection and education
8. Frustration about limitations to practice
9. More patients with sepsis at this hospital.

6.4 Second data set: analysis of the post-intervention interview transcripts

The same process was undertaken with the post-intervention interviews. Eight months later, two nurses had left and there were therefore eight post-intervention interviews. The demographics of the eight participants are shown in table 6.5

Table 6.5: Demographics of nurses interviewed post-intervention

No	Qualified in nursing	Cancer nursing experience	Critical care nursing experience	Educational Qualifications	Sex
1	9 years	7 years	6 years	RN, Oncology Diploma, currently undertaking BSc Critical Care nursing	F
2	5 years	2 years	0	RN, Oncology Diploma	F

3	13 months	6 months	0	RN	F
4	3 months	3 weeks	0	RN	F
5	4 years	4 years	0	RN, Oncology Diploma	F
7	6 years	4 years	0	RN	F
8	4 years	16 months	2 years	RN, Advanced Diploma Nursing, currently undertaking BSc Critical Care nursing	M
10	17 years	13 years	16 years	RN, ENB ITU, ENB Teaching & assessing	M

These eight transcripts were read and re-read, and emerging topics were noted in a table. Following further examination of the transcripts these topics were reduced to 12 topic areas (see table 6.6).

Table 6.6: Reduction of first table of topics from the post-intervention interviews

1	Early observations the appearance of the patient, looks a bit different, they don't feel as well as have they done but there is no clinical change. Patient doesn't look right / feel right. / Just the general looking at them, sort of general inspection of the patient. / patients appearing not quite right / he was doing OK and then he became sort of generally unwell, nothing you could put your finger on you just sensed that there was something not quite right with him, he looked a little more distressed, just a bit slow to respond, / those kind of initial things when you look at the patient and you see that there's something not right.	1 + 1+1 +1+1
2	You use the SIRS guidelines like their respiratory rate, is it fast? Are they febrile, tachycardia, normally there are subtle changes in their HR and breathing. Tachycardic and respiratory wise. Vital signs, urine output, blood results. Rapid rising temperature, drop in blood pressure, in their boots sometimes so that you couldn't record it, their temp you'd check it and it would be 39 and then 39.5 really quite rapid and resps go up and tachycardic. Temperature, respiratory rate and the pulse and blood pressure. Temp rises, low BP, tachycardia.	1+1+1+1 +1+1
3	Sometimes you look at someone and they look fine... but their blood results are all up the creek. Blood results, you know sort of escalating white cell counts, finding they were needing a lot more colloid filling, patients appearing not quite right.	1+1
4	The colour change, we had one that flushed that went really red, mostly I've seen them go the other way, like pale, but we had one man that went bright red.	1
5	Asking the patient... the patient is always very aware that something is changed or wrong.	1
6	If they've spiked a temperature we have been on the ball and taken a PCT-Q as well. I've never used it myself, have seen the research nurse taking samples doing PCT and dialogue in handover, on the CCU course I had to do a paper on Sepsis and PCT came up, numerous entries by the anaesthetists and sometimes the values are written down on our observations charts. PCT I have probably used it for the last 12 months and that's from picking up patients me and on the	1 + 1+1 +1+1+1

	pts that the ward nurses are concerned about. PCT-Q is used and everyone knows about it I think it's been a significant test/ the doctors have been a bit more proactive. Actually only the once...	
7	I haven't used the PCT-Q maybe it has been done but I honestly haven't been with a patient who has been infected. I have heard the outreach team talking about it; they do sometimes come and take bloods. I don't think we have used it on the ward at all but I have seen people coming up to do it, and hearing the outreach nurses talking about other patients on the ward and having their blood taken for that. I haven't but I know it was about signs of early sepsis.	1+1
8	PCT-Q it was one of the early signs of sepsis and you were trying to work out whether there was an accurate way of... I understand it's an early indicator of sepsis, it's a marker and is elevated when pts go into what we call the sepsis cascade and it can give us a level of this cascade, from the early stages through to severe sepsis and septic shock. It would give us an idea of perhaps how severe the septic episode is, we can use it regularly to see changes in the PCT.	1+1+ 1
9	Above 5 and a maximum of 10 with severe sepsis. Over 2, not sure how significant under 2 is. Something like 10 was indicative of say 2 or more organ systems being involved or something quite definitive.	1+1+ 1
10	Very quick and easy to use, very user-friendly, no problem at all.	1 +1
11	The first thing is to be aware of what patients are at risk, you have to think ahead and be proactive. Often patients may sense change before anything so consider what they are saying, go with the patient if they are not as chatty as normal then do the extra observations.	1
12	Teaching junior nurses early signs, to ask the patient how they are feeling.	1
13	Recommendations for care.	1

The thirteen topics were then used while re-reading the eight transcripts and further reduced to nine categories (see table 6.7).

Table 6.7: Categories of data obtained from further analysis

1	Early observations the appearance of the patient, looks a bit different, they don't feel as well as have they done but there is no clinical change. Patient doesn't look right / feel right. / Just the general looking at them, sort of general inspection of	1 + 1+1 +1+1+
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	<p>the patient. / patients appearing not quite right / he was doing OK and then he became sort of generally unwell, nothing you could put your finger on you just sensed that there was something not quite right with him, he looked a little more distressed, just a bit slow to respond, / those kind of initial things when you look at the patient and you see that there's something not right. The colour change, we had one that flushed that went really red, mostly I've seen them go the other way, like pale, but we had one man that went bright red.</p>	4
2	<p>You use the SIRS guidelines like their respiratory rate, is it fast? Are they febrile, tachycardia, normally there are subtle changes in their HR and breathing. Tachycardic and respiratory wise. Vital signs, urine output, blood results. Rapid rising temperature, drop in blood pressure, in their boots sometimes so that you couldn't record it, their temp you'd check it and it would be 39 and then 39.5 really quite rapid and resps go up and tachycardic. Temperature, respiratory rate and the pulse and blood pressure. Temp rises, low BP, tachycardia. Tachycardia, temperature, vital signs raised temp etc</p>	2
3	<p>Sometimes you look at someone and they look fine... but their blood results are all up the creek. Blood results, you know sort of escalating white cell counts, finding they were needing a lot more colloid filling, patients appearing not quite right.</p>	
4	<p>Asking the patient... the patient is always very aware that something is changed or wrong.</p>	
5	<p>If they've spiked a temperature we have been on the ball and taken a PCT-Q as well. I've never used it myself, have seen the research nurse taking samples doing PCT and dialogue in handover, on the CCU course I had to do a paper on Sepsis and PCT came up, numerous entries by the anaesthetists and sometimes the values are written down on our observations charts. PCT I have probably used it for the last 12 months and that's from picking up patients me and on the pts that the ward nurses are concerned about. PCT-Q is used and everyone knows about it I think it's been a significant test/ the doctors have been a bit more proactive. I haven't used the PCT-Q maybe it has been done but I honestly haven't been wit a patient who has been infected. I have heard the outreach team talking about it; they do sometimes come and take bloods. I don't think we have used it on the ward at al but I have seen people coming up to do it, and hearing the outreach nurses talking</p>	+6,7,8, 9,10.

	<p>about other patients on the ward and having their blood taken for that. I haven't but I know it was about signs of early sepsis. Actually only the once. ...PCT-Q it was one of the early signs of sepsis and you were trying to work out whether there was an accurate way of... I understand it's an early indicator of sepsis, It's a marker and is elevated when pts go into what we call the sepsis cascade and it can give us a level of this cascade, from the early stages through to severe sepsis and septic shock. It would give us an idea of perhaps how severe the septic episode is, we can use it regularly to see changes in the PCT PCT-Q it was one of the early signs of sepsis and you were trying to work out whether there was an accurate way of... I understand it's an early indicator of sepsis, It's a marker and is elevated when pts go into what we call the sepsis cascade and it can give us a level of this cascade, from the early stages through to severe sepsis and septic shock. It would give us an idea of perhaps how severe the septic episode is, We can use it regularly to see changes in the PCT. Above 5 and a maximum of 10 with severe sepsis. Over 2, not sure how significant under 2 is. Something like 10 was indicative of say 2 or more organ systems being involved or something quite definitive Very quick and easy to use, very user-friendly, no problem at all.</p>	
6	<p>The first thing is to be aware of what patients are at risk, you have to think ahead and be proactive. Often patients may sense change before anything so consider what they are saying, go with the patient if they are not as chatty as normal then do the extra observations.</p>	
8	<p>Getting help, mobilising the team, the best way to get help from doctors.</p>	
9	<p>Recommendations for care of the patient with sepsis.</p>	

6.5 Second data set: themes analysis of the post-intervention interview transcripts

By combining and reducing the topics further, particularly the data around the use of the PCT-Q, the nine topic areas were reduced to seven categories. The data in these categories were then further examined with the transcripts again and each category given an overall theme.

6.5.1 Patient does not look right

The first theme was about the early clinical signs or observations that led the nurse to think something was wrong. Five of the eight nurses interviewed talked about a general change that was difficult to quantify but led the nurse to monitor the patient more carefully. An example of an actual patient scenario was given by nurse 10:

“He was doing OK and then he became sort of generally unwell, clammy... there was nothing palpable that you could put your finger on you just sensed that there was something not quite right with him, he looked a little more distressed even though he was comfortable he was just a bit slow to respond...” (TS. 10)

One contrary case was noted, with the nurse (TS.03) noting that there can be times when there are no obvious changes in the patient and that it is their blood results that are the first sign of a problem:

“Sometimes you look at someone and they look fine... but their blood results are all up the creek...” (TS. 03)

Several nurses noted that knowing the patients helped in identifying changes, and the nurse who had transferred to the outpatient setting raised the difficulty of not having met the patient before:

“It’s a bit harder than on the wards because you’ve looked after them and seen them deteriorate... sometimes they come in and you’ve never met them before...” (TS.07)

6.5.2 Making a diagnosis

Six of the eight nurses then described the early quantifiable changes that they associate with the onset of the sepsis cascade. As in the pre-intervention interviews, these changes were mainly those cited as the changes that indicate SIRS. Two nurses described these changes as occurring very rapidly:

“They go quite quickly especially on BE, get like a real rapid rising temperature, a drop in blood pressure, in their boots sometimes so that you couldn’t record it, their temperature you would check it and it would be 39.0 and then 39.5 really quite rapid...”(TS. 04)

“...and overall the... with the temperature, with the blood pressure with the urine output, with the fluid requirements or whatever. Because this isn't normal for the patient. There's been an actual change with them... with the patient's breathing, or going along and improving and then all of a sudden this is started to happen...” (TS.10)

The most junior of the nurses interviewed (one year after registration) reflected that she was very dependent on monitoring the observations:

“Erm it's funny 'cause I've been a nurse a year and I'm still stuck on the obs. Sometime they'll look a bit different and you'll think Oh there's something not quite right there, but I would still just go and do their obs and see what's going on... because I haven't got the experience behind me... I wouldn't know that it was sepsis or something else...” (TS.04)

6.5.3 Ask the patient

One nurse noted that it was important to ask the patient, that they were always aware that something was wrong.

“The patient's usually maybe the first one that actually indicates that there's something wrong. They may not verbalise it, but initially they will probably, eventually say if you start to show concern, people might say: “Actually I don't feel... I feel sick...” (TS. 10)

6.5.4 The use of the PCT-Q

The next area explored was the use of the PCT-Q bedside test. Before asking about the PCT-Q it was interesting to note that one of the nurses who worked in the blood and marrow transplant wards had already mentioned the use of the PCT-Q in the management of the early phase of sepsis:

“If they have spiked a temperature we've been on the ball and taken a PCT-Q as well...” (TS. 02)

Five of the nurses interviewed had seen the PCT-Q being used in clinical practice on their wards. These nurses all knew what it was for and when it was being used, even if they had not actually used it themselves. Of the nurses who had not seen it used, one said she had not looked after a septic patient but had seen the outreach team

talking about it, one had transferred into the outpatient clinic setting, and a third had been off work due to sickness for the previous eight months. Of the nurses who were familiar with the PCT-Q being used on their units, some had used it much more than others. One nurse had only used it once, whereas others had used it regularly as part of their care. Of the nurses who used it regularly, two were based on the blood and marrow transplant unit and therefore nursing the most at-risk patients and one was an outreach nurse. The nurse on the transplant unit said the following:

“PCT-Q is used and everyone is quite aware of it and knows all the... I thinks it’s been a significant test... the doctors have been more proactive in how they treat the patient. It’s also good for us; it’s a good indication of er... how kind of septic, and possibly you know potentials of what could happen there”. (TS.02)

The same nurse also noticed that a significant PCT-Q result correlated with patients being admitted to high dependency care areas. The CCU outreach nurse interviewed was expected to have had most contact with the test, as the outreach team helped ward nurses ensure the test was performed. This was confirmed by her interview, and perhaps as expected she reflected that the change to practice had taken off slowly at first but then gathered pace:

“I think initially it probably wasn’t used as regularly, so we didn’t feel the benefits as much, but once everyone understood what the study was about it was used very frequently... and often when patients were unwell it did correspond... there were a couple of... bizarre results but apart from a few isolated episodes it did correlate and especially when we did repeat studies on the patient, the changes correlated with their symptoms...” (TS. 01)

To be useful in clinical practice any additional test needs to be easy to use. It was therefore important that the nurses said the PCT-Q was very quick and easy to use. The nurses were asked about the significance of PCT levels; four out of the five nurses who had used it regularly were able to discuss correctly the differing levels between 2 and 10, with the fifth saying she couldn’t remember. Finally it was interesting to note that even the nurses who had not experienced the PCT-Q had all heard of it and could describe the reasons for its use:

“It is about some changes that would show early sepsis that in patients who were septic but clinically it wasn’t as evident...” (TS. 07)

6.5.5 How nurses learn

Nurses were asked about what were the most important ways they learnt about and developed their practice. All of the nurses responded that experience was very important. They also cited reflection as important, actually looking after a septic patient and then reflecting on that when you meet another patient who is septic:

“Because once you actually see one, I mean one patient actually become quite ill, it always leaves you with a lasting impression of what actually happened with that sort of patient. What were they actually doing, it always leaves you with a lasting impression as to how you can actually... Oh you know he’s doing this I always remember that patient before he did the same thing...” (TS.08)

Four nurses also talked about how important education was in helping them to develop their clinical skills:

“I got a hell of a lot out of an essay I did on multiple myeloma... and I learnt so much from that...” (TS. 05)

“I think general experience and learning and having sessions ...on the diploma course...because...and the other thing as well is I’ve worked a lot with neutropenics in chemotherapy”. (TS. 09)

Four nurses reflected on the importance of learning from other more experienced nurses. Senior staff nurses and the outreach team were cited, and also an example of working with one of the teaching sisters. Nurse 10 also recommended using patient scenarios in clinical teaching to support nurses in a structured way:

“...erm, both by example and by actually working with patients by being exposed to those situations with support erm... and the nurse should be supported and [the clinical scenario] should be used, whenever possible, as a teaching tool as well...” (TS.10)

Nurses were then asked how they teach junior nurses about identifying sepsis at an early stage. One of the eight nurses talked about the importance of being aware of

which patients would be most at risk. Two of the nurses recommended talking to the patient about how they feel, with one nurse recommending the following:

“Go with the patient if they are not as chatty as normal then do extra observations”. (TS. 01)

One nurse talked about working with junior nurses on the ward and helping them, as she felt it was quite difficult for them to know what was important. The same nurse also thought that having an appropriate care plan that you could “walk the nurse through” might be helpful.

“So kind of go through everything with the student, really basic every single, sort of possible you know screening tool... I think sometimes when you are new you haven’t got any idea how you prioritise things”. (TS. 05)

For the nurse working in the outpatient setting her focus was very much on the patient knowing about the risks of chemotherapy and about the early signs of sepsis developing:

“erm... well the main experience we’d have with that is chemotherapy patients... to require them to be aware of a temperature, rigors. Normally we’d advise them if they’d a temperature of greater than thirty-eight or felt unwell to get in touch. Then at that point they’d be admitted for some treatment”. (TS. 07)

6.5.6 Contacting others to help

The next part of the interviews concentrated on nurses getting an effective multidisciplinary response if concerned about a patient. One nurse used a technique that he termed “planting”:

“I think probably planting which is very very subtle ways of going up to doctors and saying: “look you know, what do you think your opinion is about... I’ve just seen this and I’ve seen this, what do you think?” It’s probably something which I call planting, whereas being quite confrontational with doctors... so what you’re doing is actually really getting them to... it’s almost like a lead on... an encouragement come and

have a look, rather than being very obvious and confrontational about it”.

(TS. 08)

Another nurse (TS.10) said he felt that it was important nurses know that they are “empowered” at this hospital and their opinion matters. He also suggested that there is a way to talk to doctors that will get their attention more successfully:

“When they go to get in touch with the doctor to have the accurate bullet points of what has happened with the patients. So they’re able to liaise with the doctors or with the multidisciplinary team... so that they get a quick response to what is happening to the patient... To be a professional to have it all with them when they do go to them”. (TS. 10)

“ I think I’ve learnt to give facts...very strong definitive facts ...and to be able to arrange those facts in a way where it highlights my concern, but it also gives a basis on...people to walk into the ...go to the patient with knowledge already about what we’re actually looking for”.(TS.10)

The other nurses all talked about using the CCU outreach team, the site nurse practitioner or more senior nurses on the ward to ensure that they got a quick response.

6.5.7 Practice improvement

In the final section, the nurses were asked if there was anything they would recommend to improve the early diagnosis and treatment of cancer patients who were deteriorating. Only one of the nurses couldn’t think of anything to recommend and she felt that, compared to a general hospital, everything in the current hospital was done very efficiently. The other seven nurses made different suggestions which are listed in table 6.8

Table 6.8: Suggestions made by seven nurses regarding possible practice improvement

Transcript / Nurse	Suggestion / recommendation
TS. 01	For some nursing teams to be able to take more responsibility for the acute monitoring of a patient who is deteriorating, and to increase acute care

	skills training for some wards
TS. 02	Patient Group Directions (PGD): if the nurse had a PGD for antibiotics they could give the drug as soon as sepsis was identified, and therefore reduce the delay to starting treatment
TS. 04 *	If you are a more junior nurse to ask for help in a particular way that will mean people are less likely to delay and more likely to come immediately to help you
TS. 05	Work already ongoing to link up the Early Warning System (EWS) with the observation chart and possibly in the future to be linked with the new Transitional Care Unit as many acute patients will be admitted through there
TS. 07	To increase the education and empowerment of patients and relatives to get help as soon as they are starting to feel unwell and not to delay being seen by a hospital
TS. 08	The EWS and linking that with education and “planting” from the Outreach nurses
TS. 10	Nurse education and practice in how to present their patients perhaps linked with the EWS

*Nurse 04 recounted a scenario that she had learnt from and, as a result, had changed her practice:

“With one patient I didn’t have any backing, I’m sorry its going to sound like I am having a go at everyone it was just before handover... I went into this patient, it was the one who went red. I hadn’t seen that before I didn’t know what was going on, his temperature was shooting up and his blood pressure was coming down.... he wasn’t feeling well, I wasn’t happy with him, in fact it was the first sepsis I had seen on the ward. I went in to the staff room to let the nurses know... and no one, in fact one of them said, “oh he always looks like that”, I’m like no he really doesn’t look well, so no one was really I think cause they see it quite a lot they were quite blasé about it... they weren’t necessarily thinking that I haven’t got the experience to deal with it. I think I had already phoned the doctor and he had said to keep an eye on him... I went back to the patient... his temperature had gone up again... blood pressure was still the same really really low, so I went back

and phoned the doctor again and said please can you come... and then one of the F grades came... she didn't sort of take over, but she helped me with him... After that that woke me up 'cause I realised that you're not always going to get help unless you actually specifically ask for it. So after that I wouldn't go in there and say: "I'm a bit worried about so and so". I'd say: "Can you come and help me?". (TS.04)

6.5.8 Summary of themes from second data set

The seven themes from the post-intervention interviews are shown in figure 6.2.

Figure 6.2: Themes from the post-intervention interviews

1. Patient does not look right
2. Making a diagnosis
3. Ask the patient
4. The use of the PCT-Q
5. How nurses learn
6. Contacting others to help
7. Practice improvement

6.6 The third data set: analysis of the qualitative data from the pre-intervention questionnaires

The next data to be analysed were the qualitative texts from the pre-intervention questionnaires, of which 177 were completed. Of these, 75 nurses chose to complete question 15, which asked for a free text answer (see appendix 10). The preceding question 14, which required a "yes/ no" answer, was as follows:

"Have you ever had the experience of thinking that a patient was deteriorating but finding it difficult to convince other nurses/doctors or other health care professionals?"

This was then followed by the last question, question 15:

If you have had any such experience please could you give an example below:

The texts from these 75 questionnaires, which ranged in length between one sentence and a short paragraph, were analysed in the same way as described previously. After the first reading of these 75 answers 18 topics were identified. The topics are shown in table 6.9 in order of the frequency raised.

Table 6.9: Topics from pre-intervention questionnaires

No	Theme	No of times raised
1	Times when nurse concerned that patient exhibiting signs of sepsis but difficult to convince medical colleagues	17
2	Description of what happens to the patient in the early stages of sepsis	15
3	Gut feeling, nurse intuition, know the patient not right	8
4	Haematology patients singled out as at risk or being the one that developed sepsis	8
5	The patient who first verbalises that there is something wrong	7
6	Bad memories – reflections on times when sepsis not recognised earlier enough, or difficult to get help and the patient died	6
7	Patients who had few hard signs but were unwell, but the nurse could not convince doctors or nurses to act quickly enough	5
8	Either a nurse or doctor did not want the nurse to refer the patient to CCU or outreach and then later the patient deteriorates	3
9	A junior nurse unable to mobilise rescue but helped in this by senior nurses, outreach or senior ward nurses	3
10	Not many changes therefore difficult to convince medical or nursing team	2
11	Very few early signs but patients clearly deteriorating	2
12	Earlier intervention may be more beneficial to the patient	2
13	Team members all cooperative and coordinated response	1
14	Junior nurse could not convince colleagues	1
15	The need to encourage doctors to listen to nurses	1
16	Delays in transfer to CCU	1
17	Difficulty in convincing specialised colleagues that sepsis may be an issue in patients with cerebral metastases	1

18	Only senior nurses allowed to use EWS (in previous hospital)	1
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The texts were then read again and the topics amalgamated, with the number reducing to 11 (see table 6.10):

Table 6.10: Topics from pre-intervention questionnaires reduced on second reading

1	Times when nurse concerned that patient exhibiting signs of sepsis but difficult to convince medical colleagues. Sometimes in the early stage pts few clinical signs but unwell and nurse could not convince doctor or nurse to act quickly. Junior nurse found it difficult to convince colleagues that patient was deteriorating. Earlier intervention would be beneficial for the patient. The need to encourage doctors to listen to nurses.	17 + 5 + 2 + 2 + 1 + 2 + 1 = 29
2	Description of what happens to the patient in the early stages of sepsis	15
3	Gut feeling, nurse intuition, know the patient not right	8
4	Haematology patients singled out as at risk or being the one that developed sepsis	8
5	The patient who first verbalises that there is something wrong	7
6	Bad memories – reflections on times when sepsis not recognised earlier enough, or difficult to get help and the patient died	6
7	Either a nurse or doctor did not want to allow referral or transfer to CCU and then later the patient deteriorates	3 + 1 = 4
8	Junior nurses felt unable to initiate rescue but helped in this by senior nurses from the ward or outreach team	3
9	Team members all cooperative and coordinated response	1
10	Difficulty in convincing specialised colleagues that sepsis may be an issue in pts with cerebral mets	1
11	Only senior nurses allowed to use EWS in previous hospital	1

These eleven topics were then re-examined for any interconnecting themes, which resulted in a further reduction to six clusters.

5. Twenty-nine nurses described finding it difficult in clinical practice to convince either their senior nursing colleagues or medical staff to intervene

quickly. There was a general recognition that the nurse recognised that the patient was unwell but, because there was as yet little physical change, it was difficult to convince colleagues. There was also a plea for doctors to listen to nurses. Three nurses described reflecting back and remembering when they were junior nurses feeling unable to effectively mobilise help, but gave examples of senior nurses (for example the “PART team” (Patient at Risk Team) or experienced nurses on the bone marrow transplant unit) who were able to help them.

“Has been many cannot remember one specific incident, feel that sometimes when patients are starting to deteriorate the medical team sits on them too long”. (Q.12)

“The patient looked and felt unwell. He had an increasing tachycardia, respiratory rate and was hypotensive 90/50 but had a temperature of 36 degrees Celsius and so the SHO didn’t think he was developing sepsis and did not want to start antibiotics”. (TS.21)

“Doctors often want to “watch and wait” instead of respond early”. (Q.142)

“When difficult to convince doctor got Patient At Risk Team (PART) nurses involved (team of experienced ITU nurses, that are around to support nursing team) of whom did ABGs and convince doctors that patient needed to be in a more suitable environment”. (Q.27)

2. There were fifteen responses where nurses used this question to describe the patient’s condition when developing the early signs of sepsis. These answers provide descriptions of the changes in cardiovascular, respiratory and urological changes and the changes that nurses notice before parameters change, with the following cited: “sweaty”, “pallor”, “restlessness”, “lethargy” and seeming “unwell”. Eight different nurses described using nursing intuition, gut feeling and knowing that the patient “not right”. Several nurses noted that they noted a change because they knew the patient well.

“I was working for surgical ward one patient was suddenly collapsed. Sweating ++, tachycardic, BP was low temp it was 40 degrees Celsius, patient looks pale, patient was confused”. (Q. 28)

“Too many to give actual specific, but general picture of raise respiratory rate, pyrexia, low BP, decreasing urine output”. (Q.56)

“Gut feelings, prior to septic episode patient observations generally slight increase in resps, small drop in saturation reported to doctors then patient rapidly deteriorate two hours later”. (Q.67)

“The experienced practitioner has “intuition”. Sepsis may be “brewing” but clinical signs not yet present”. (Q.15)

“When you have been looking after the same patient for a few days, you know how they are. When there is something “just not right” nurses intuition”. (Q.41)

2. Eight nurses also gave examples of the haematological patients that had developed sepsis.

“Haematology patient leukaemia neutropenic” (Q.76)

“A haematology patient with neutropenia was in my care being treated with antibiotics for sepsis. She became gradually more unwell but took a long time to show physical indicators typical to severe sepsis...” (Q.71)

3. Seven nurses noted that it was the patient themselves who first raised the alarm that there was something wrong.

“Patient was restless and kept saying that something was wrong but obs were stable”. (Q.50)

“Mr.X. said he “felt unwell/strange” observations tachy pyrexia approx 37.3-37.5 BP up patient looked unwell...” (Q.15)

4. Six nurses reflected on times when early intervention had not occurred or where it was difficult to get people to help or to be transferred to the CCU and the patient had died.

“Elderly lady on medical ward who was deteriorating she was more confused and seemed more listless her vital signs were only slightly worse and her temperatures only 37.8 degrees Celsius. It took several hours to get

a doctor he still didn't take it seriously she did eventually start antibiotics that 24 hours later and she died a week later". (Q.131)

"When I was fairly newly qualified I looked after a patient on an admissions ward who became septic and went into DIC – they subsequently died. I felt from early on that the patient deteriorating but could not quantify the and I could not persuade the HO to review the patient. Neither he nor I realised the speed with which these patients deteriorate". (Q.158)

5. Finally there were three nurses who described three different subjects: one felt she worked in an area where there was a good coordinated response; a second worked in an area where sepsis is unusual and felt she needed to highlight the risk; and finally a nurse said the only nurses allowed to use the Early Warning System and refer to the CCU teams were senior nurses on the ward.

"In this set-up the team members have been quite cooperative when it comes to issues regarding deteriorating in patient's condition and necessary measures". (Q.104)

"Patients with Ca cervix and brain mets. My colleagues kept relating temperatures with brain mets and not with sepsis". (Q.43)

"At time "emergency warning system" under discussion and only nurse practitioners were to assess using it. Patient deteriorated – this was not at this trust and early in my career". (Q.52)

On a further reading of these six clusters, the following five key themes were generated from the data:

- 1. There is difficulty in getting help from doctors, but help from senior nurses.**
- 2. Early changes are either measurable or less tangible.**
- 3. Haematology patients are at greater risk from sepsis.**
- 4. It is the patient who first raises the alarm.**
- 5. Reflections on times when failure to get help resulted in a patient's death.**

There were three leftover topics, that were important to individual nurses but did not seem to fit into an overall theme:

- 6. A description of a good coordinated response.**
- 7. Highlighting the risk of sepsis in a ward where it is rarely seen.**
- 8. In a previous hospital only senior nurses allowed to use MEWS and contact outreach.**

6.7 Analysis of the three data sets combined

Having analysed the three data sets, the key themes were brought together for further examination:

First data set

1. Importance of continuity
2. Making a diagnosis: vital signs
3. Contacting others
4. Awareness of sepsis risk in the cancer patient
5. Introduction of a new predictive bedside test
6. Septic screen
7. Clinical confidence based on experience, reflection and education
8. Frustration about limitations to practice (leftover)
9. More patients with sepsis at this hospital (leftover)

Second data set

1. Patient does not look right
2. Making a diagnosis
3. Ask the patient
4. The use of the PCT-Q
5. How nurses learn
6. Contacting others to help
7. Practice improvement

Third data set

1. Difficulty in getting help from doctors but helped by senior nurses
2. Early changes either measurable or less tangible

3. Haematology patients at greater risk from sepsis
4. It is the patient who first raises the alarm
5. Reflections on times when failure to get help resulted in a patient's death
6. Description of a good coordinated response (leftover)
7. Highlighting risk of sepsis in a ward where it is rarely seen (leftover)
8. Only senior nurses allowed to use MEWS and contact outreach (leftover)

These themes were placed into a table to make it easier to identify interrelated themes. Where connections were identified, the themes were highlighted by a colour pen as illustrated in table 6.11.

Table 6.11: Interrelated themes highlighted

No	Theme from 1 st cohort of data	Theme from 2 nd cohort of data	Theme from 3 rd cohort of data
1	Importance of continuity	Patient does not look right	Difficulty in getting help from doctors but helped by senior nurses.
2	Making a diagnosis: vital signs	Making a diagnosis	Early changes either measurable or less tangible.
3	Contacting others	Ask the patient	Haematology patients at greater risk from sepsis.
4	Awareness of sepsis risk in the cancer patient	The use of the PCT-Q	It is the patient who first raises the alarm.
5	Introduction of a new predictive bedside test.	How nurses learn	Reflections on times when failure to get help resulted in a patient's death.
6	Septic screen	Contacting others to help	
7	Clinical confidence based on experience, reflection and education.	Practice improvement.	
	Leftovers	Leftovers	Leftovers
	Frustration about limitations to practice.	As a junior nurse learning from a difficult experience to ask for help in a particular way that will have a more immediate effect.	Description of a good coordinated response
	More patients with sepsis at this hospital.		Highlighting risk of sepsis in a ward where it is rarely seen
			Only senior nurses allowed to use MEWS and contact outreach

This highlighting of related themes resulted in a reduction from 19 major themes to eight, as shown in table 6.12.

Table 6.12: Key themes from all data sources

No	Theme
1	Knowing the patient: the importance of nursing continuity: recognition of early changes either measurable or less tangible
2	Making a diagnosis of sepsis: using vital signs, urine output, septic screen and the PCT-Q
3	Contacting others to help: difficulty in persuading doctors at an early stage but senior nurses able to help, one example of a good coordinated response
4	Asking the patient: they always know something is wrong and are often the first to raise the alarm
5	Being aware of (the risk of) sepsis: even on wards that rarely see it, and that haematology patients are more at risk
6	Nurses learning: develop confidence using reflection, experience and education and how they teach others
7	Reflecting on failure: failure to get help early resulted in a patient's death.
8	Improving practice

6.8 Integration of the three qualitative data sets

The three sets of qualitative data obtained from the two sets of interviews and the pre-intervention questionnaire were all analysed independently using a constant comparative technique informed by grounded theory. Important topics were identified by reading and re-reading the transcripts. Topics were identified either because they were mentioned by several nurses or were cited by only one nurse but were central to that account. For each data set, the topics were then reduced to broader categories by amalgamating several topics. Several themes were identified on re-reading the data by using these categories and looking for interrelated connections. For each data set a group of seven to nine themes was identified. For

each data set leftover themes were also recorded. The three sets of themes were then placed in a table and interconnections identified using a coloured highlighter. The final result was a distillation of 21 themes into eight overarching themes across all the qualitative data. These eight themes are shown above in table 6.12. The importance of these themes and their links to nursing theory, literature and clinical experience will be discussed in chapters nine and ten.

6.9 Conclusion

The overall aim of the study was to improve the early diagnosis of sepsis and communication with the multi-professional team by introducing a dedicated education session and an objective test. The objectives of the qualitative interviews were to gain an in-depth understanding of the following aspects of the nurses' individual experiences of caring for a patient deteriorating with sepsis:

The nurses' experience of barriers to effective communication with and mobilising the multi-professional team; nurses' awareness of sepsis its assessment and management and how this could be improved; and finally their thoughts about the introduction of the PCT-Q and their experience of using it to aid communication and mobilisation of the team. As can be seen from table 6.12 above these objectives were achieved. These findings also support the theory as described in chapter one: that nurses intuit subtle change and want to act, and that there is a need to improve communication and multi-professional rescue with the nurses substantiating the evidence that "packaging" of information is necessary, thus the introduction of the objective tool the PCT-Q to aid communication inter and between professionals.

Chapter 7 Findings (2): nurse questionnaire data

7.1 Introduction

The next data to be analysed were the pre- and post-intervention questionnaires. The nurse questionnaire survey links to the theoretical framework by testing the nurses' knowledge of sepsis pre and post the educational intervention. This part of the study was therefore designed to raise the awareness of sepsis during the study and to increase nurses' knowledge about sepsis and the PCT-Q. The questionnaires were the same except that the first included an invitation in question 15 to describe a clinical scenario when a patient was deteriorating. The first questionnaire was completed by 177 nurses. These questionnaires were completed during the first 10-15 minutes of the teaching session. The post-intervention questionnaires were sent to every nurse who had received the teaching session but only 85 of these were returned. Of the original 177, 32 nurses had left the trust and were not able to receive a questionnaire. This left 145 nurses. A reminder letter was sent but only 85 were returned. This was a 58.6% return of the post-intervention questionnaires. As there was only a limited response to the post-intervention questionnaire it was important to compare the nurses who did respond the second time with those who did not, to ascertain whether there was a major systematic difference between the two groups. The differences are summarised below in table 7.1 but, as demonstrated, there is no significant difference and the reasons for non response are therefore presumed to be due to chance rather than any more systematic difference. For the rest of the data in this chapter, the important assessment is the within person/group change in the 85 nurses who completed both questionnaires.

7.2 Demographics

The first section of the questionnaire consisted of demographic information. In both questionnaires the population of nurses was well distributed across all wards on both sites of the trust, with more nurses from the acute areas such as CCU (36 nurses

(20.3%) answering the first and 21 (24.7%) the second) and the bone marrow transplant unit (30 nurses (16.9%) answering the first and 16 (18.8%) the second).

Table 7.1: Which ward was the nurse from?

Questionnaire 1

Ward	Frequency	%
CCU	36	20.3
Haemato-oncology	30	16.9
GI and GU & Neuro	17	9.6
Private Patients	16	9.0
Breast	14	7.9
MDU & OPD	12	6.8
Sarcoma, Haem-onc	11	6.2
Drug Development	9	5.0
Palliative Care	8	4.5
Gynae-onc	6	3.4
CCU Outreach	5	2.8
Elsewhere	5	2.8
Night Sister	4	2.2
Rehabilitation	3	1.7
Head & Neck	1	.56
Total	177	100.0

Questionnaire 2

Ward	Frequency	%
CCU	21	24.7
Haemato-oncology	16	18.8
GI, GU, & Neuro	4	4.7
Private Patients	8	9.4
Breast	4	4.7
MDU & OPD	6	7.0
Sarcoma, Haem-onc	6	7.0
Drug Development	5	5.9
Palliative care	4	4.7
Gynae-onc	0	0
CCU Outreach	5	5.9
Elsewhere	2	2.3
Night Sister	2	2.3
Rehabilitation	1	1.2
Head & Neck	1	1.2
Total	85	100.0

7.3 Experience working with cancer patients

Question one asked how long each nurse had worked with cancer patients. As can be seen from the pie charts below, the greatest number of nurses in both samples had worked with cancer patients for two to four years (40% in the first questionnaire and 34.12% in the second). Post intervention there were more nurses who had only worked one to two years, but also more nurses who had worked with cancer patients for five to ten years.

Table 7.2: Cross tabulation of pre and post experience

		Pre: How long have you worked with cancer patients?	Post: How long have you worked with cancer patients?
N	Valid	177	85
	Missing	0	92

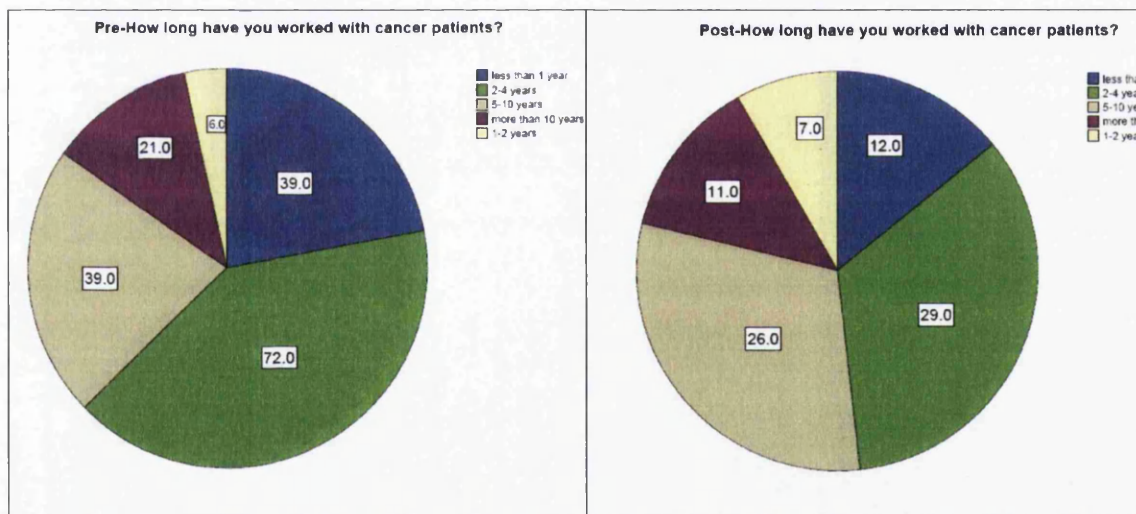
Pre: How long have you worked with cancer patients?

	Frequency	Percent	Cumulative Percent
less than 1 year	39	22.0	22.0
2-4 years	72	40.7	62.7
5-10 years	39	22.0	84.7
more than 10 years	21	11.9	96.6
1-2 years	6	3.4	100.0
Total	177	100.0	

Post: How long have you worked with cancer patients?

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	less than 1 year	12	6.8	14.1	14.1
	2-4 years	29	16.4	34.1	48.2
	5-10 years	26	14.7	30.6	78.8
	more than 10 years	11	6.2	12.9	91.8
	1-2 years	7	4.0	8.2	100.0
	Total	85	48.0	100.0	
Missing	System	92	52.0		
Total		177	100.0		

Figure 7.1: Length of time working with cancer patients: numbers represent frequencies



7.4 Post-registration cancer qualifications

Question two asked nurses if they had any post-registration cancer qualification. They were asked for a yes or no answer. There was a greater number of nurses in the second sample that had a cancer qualification (64.71% versus 57.39% in the first sample).

Table 7.3 Post-registration cancer qualifications

		Pre: Post-reg qualifications	Post: Post-reg qualifications in cancer
N	Valid	177	85
	Missing	0	92

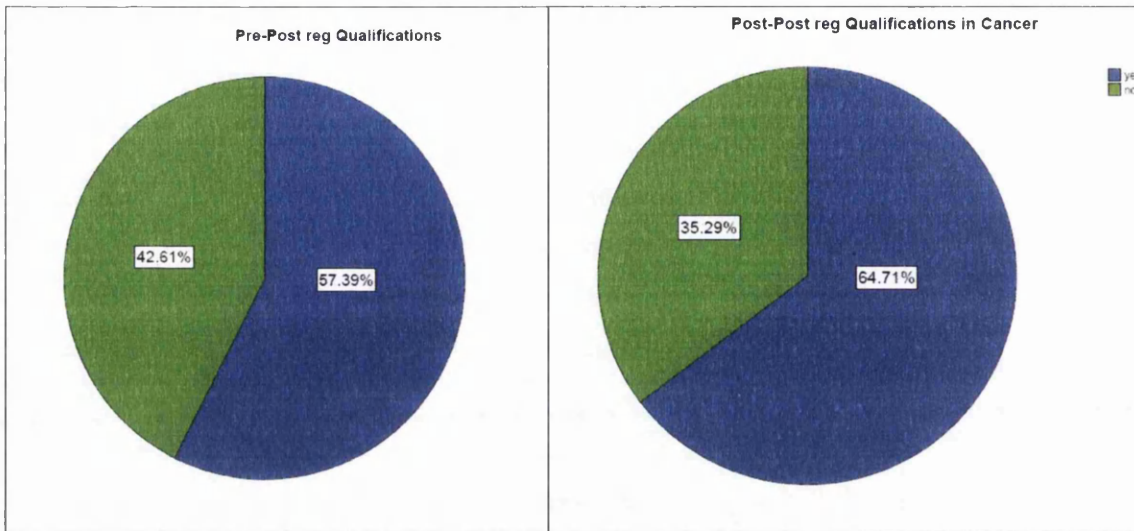
Pre: Post-reg qualifications

		Frequency	Percent	Cumulative Percent
Valid	yes	101	57.1	57.1
	no	75	42.4	99.4
	99.00	1	.6	100.0
	Total	177	100.0	

Post: Post-reg qualifications in cancer

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	yes	55	31.1	64.7	64.7
	no	30	16.9	35.3	100.0
	Total	85	48.0	100.0	
Missing	System	92	52.0		
Total		177	100.0		

Figure 7.2: Post-registration qualifications in cancer



7.5 Types of post-registration qualification

Nurses were asked to record their various post-registration cancer nursing qualifications.

Table 7.4: Have you undertaken any post-registration education?

Questionnaire 1

Course	Frequency	%
None other	128	72.3
Haemato-oncology module	11	6.2
Foundations of cancer module	16	9.0
2-3 cancer modules	6	
1 & 2	1	.6
Cert in cont prof dev	1	.6
Dip in cancer	1	.6
Short courses	5	2.8
Chemotherapy	3	1.7
BSc nursing	2	1.1
MSc Advanced Nursing	2	1.1
Missing	1	.6
Total	177	100.0

Questionnaire 2

Course	Frequency	%
None other	59	69.4
Haemato-oncology module	2	2.4
Foundations of cancer module	9	10.6
2-3 cancer modules	6	7.0
1 & 2	1	1.2
Cert in cont prof dev	2	2.4
Dip in cancer	1	1.2
Short courses	5	5.9
Chemotherapy	2	2.4
Critical Care Module	2	2.4
Total	85	100

7.6 How up to date was nurses' knowledge?

The next section of questions addressed nurses' knowledge regarding the sepsis syndrome. The first asked whether they felt their knowledge could be improved. A majority felt that their knowledge could be improved (131 nurses, 74%, n=177, 1 nurse did not answer this question) while 39 nurses felt that their knowledge was not up to date and six nurses felt that it was up to date.

Table 7.5: Do you feel your knowledge is up to date regarding the sepsis syndrome?

Questionnaire 1

Variable	Frequency	%	Cumulative %
No	39	22.0	22.2
yes	6	3.4	25.6
Could be improved	131	74.0	100.0
Total	176	99.4	
Missing	1	0.6	
Total	177	100.0	

Questionnaire 2

Variable	Frequency	%	Cumulative %
No	6	7.1	7.1
Yes	17	20.0	27.1
Could be improved	62	72.9	100.0
Total			
Missing			
Total	85	100.0	

This is an interesting set of answers, (perhaps as might be expected), with slightly more nurses in the second sample being more experienced and more qualified (39% of the first sample said that their knowledge was not up to date while only 6% said so in the second sample). It is tempting to wonder whether the second sample reflects the fact that these nurses had received the teaching intervention. Post-intervention, 20% of nurses versus 6% in the same group pre-intervention answered yes, that their knowledge was up to date. As can be seen below in table 7.6, this change did reach statistical significance.

Table 7.6: Crosstabulation

Pre: Do you feel your knowledge is up to date regarding the sepsis syndrome? * Post: Do you feel your knowledge is up to date regarding the sepsis syndrome? Crosstabulation

			Post: Do you feel your knowledge is up to date regarding the sepsis syndrome?			Total
			No	Yes	could be improved	
Pre: Do you feel your knowledge is up to date regarding the sepsis syndrome?	no	Count	1	3	7	11
		% of Total	1.2%	3.6%	8.3%	13.1%
	yes	Count	0	0	2	2
		% of Total	0.0%	0.0%	2.4%	2.4%
	could be improved	Count	5	13	53	71
		% of Total	6.0%	15.5%	63.1%	84.5%
Total		Count	6	16	62	84
		% of Total	7.1%	19.0%	73.8%	100.0%

Chi-Square Tests

	Value	df	Asymp. Sig. (2-sided)
McNemar-Bowker Test	11.400	3	.010
N of Valid Cases	84		

7.7 Different stages of the sepsis syndrome

Question four asked nurses to describe the different stages of the sepsis syndrome.

Table 7.7: Standard definitions

Pre: Describe standard definitions for different parts of sepsis cascade

		Frequency	%	Cumulative %
Valid	1 correct	22	12.4	21.4
	2 correct	5	2.8	26.2
	3 correct	10	5.6	35.9
	4 correct	2	1.1	37.9
	nil	26	14.7	63.1
	don't know	25	14.1	87.4
	don't understand/don't know what this means	13	7.3	100.0
	Total	103	58.2	
Missing	99.00	74	41.8	
Total		177	100.0	

Post: Describe standard definitions for different parts of sepsis cascade

		Frequency	%	Cumulative %
Valid	1 correct	6	3.4	9.7
	2 correct	11	6.2	27.4
	3 correct	7	4.0	38.7
	4 correct	16	9.0	64.5
	5 correct	6	3.4	74.2
	nil	13	7.3	95.2
	don't know	1	.6	96.8
	don't understand/don't know what this means	2	1.1	100.0
	Total	62	35.0	

Missing	missing	23	13.0	
	System	92	52.0	
	Total	115	65.0	
Total		177	100.0	

Table 7.8: Change in number of correct definitions

N	Valid	43
	Missing	134

Change in number of correct definitions

		Frequency	%	Valid %	Cumulative %
Valid	Decrease	5	2.8	11.6	11.6
	No change	12	6.8	27.9	39.5
	Increase	26	14.7	60.5	100.0
	Total	43	24.3	100.0	
Missing	System	134	75.7		
Total		177	100.0		

These stages are well described in the literature and have been the standard definitions used since 1992 (Bone *et al* 1992). This question proved to be very difficult for nurses to answer; with 74 nurses (41.8%) not answering the question and 13 nurses (7.3%) writing that they didn't know what the question meant. Of the nurses that did answer this question, only two got the four stages correct. Ten got three stages, five got two stages correct and twenty-two got one stage correct. There was an increase in knowledge post intervention, with 14.7% of nurses' knowledge increasing (see table7.7).

7.8 Average mortality rate in healthy adults

Question five asked nurses to provide the average mortality rate for severe sepsis in healthy adults. Only 20 nurses (11.3%) answered this question correctly in the first

questionnaire. In the second questionnaire the number increased to 28 (32.9%) but remained small. The change does reach statistical significance.

Table 7.9: What is the mortality rate for severe sepsis in previously healthy adults?

Questionnaire 1

Variable	Frequency	%	Cumulative %
Correct 35-45%	20	11.3	11.3
incorrect	157	88.7	100.0
Total	177	100.0	

Questionnaire 2

Variable	Frequency	%	Cumulative %
Correct 35-45%	28	32.9	38.9
incorrect	44	51.8	100.0
Total	72	84.7	
missing	13	15.3	
Total	85	100.0	

Again, crosstabulating both results and using McNemar to compare the two sets of data, there is a statistically significant difference ($p < .001$) with a greater percentage of nurses after the intervention being able to answer this question correctly (6.9% in the first versus 38.9% in the second), for nurses who answered both questionnaires. It is important to note that although the knowledge acquisition improved there were still 51.9% of the nurses after the teaching that got this answer wrong.

Table 7.10: Crosstabulation

Pre: What is the mortality rate for severe sepsis in previously healthy adults * Post: What is the mortality rate for severe sepsis in previously healthy adults Crosstabulation

			Post: What is the mortality rate for severe sepsis in previously healthy adults		Total
			35-45%	Incorrect	
Pre: What is the mortality rate for severe sepsis in previously healthy adults	35-45%	Count	2	3	5
		% of Total	2.8%	4.2%	6.9%
	incorrect	Count	26	41	67
		% of Total	36.1%	56.9%	93.1%

Total	Count	28	44	72
	% of Total	38.9%	61.1%	100.0%

Chi-Square Tests

	Value	Exact Sig. (2-sided)
McNemar Test		.000(a)
N of Valid Cases	72	

a Binomial distribution used.

7.9 Average mortality rate with sepsis

Question six asked nurses to provide the average mortality rate for the person with cancer who develops severe sepsis. In the first questionnaire, the question was answered by all nurses except one but answered incorrectly by a majority (168 or 94.9%). In the second questionnaire, as shown below, more nurses were correct but 70.6% were still wrong, with 15.3% not answering this question. The improvement is statistically significant ($p=0.035$). The correct answer is between 55% and 65%.

7.11: Average mortality rate for person with cancer who develops sepsis

Questionnaire 1

Variable	Frequency	%	Cumulative %
Correct 55–65%	8	4.5	4.5
Incorrect	168	94.9	100.0
Total	176	99.4	
Missing	1	.6	
Total	177	100.0	

Questionnaire 2

Variable	Frequency	%	Cumulative %
Correct 55–65%	12	14.1	16.7
incorrect	60	70.6	100.0
Total	72	84.7	
Missing	13	15.3	
Total	85	100.0	

Table 7.12: Crosstabulation

Pre: What is the mortality rate for severe sepsis in cancer patients * Post: What is the mortality rate for severe sepsis in cancer patients Crosstabulation

		Post: What is the mortality rate for severe sepsis in adults with cancer		Total
		55-65%	incorrect	55-65%
Pre: What is the mortality rate for severe sepsis in people with cancer	55-65%	0	3	3 (4%)
	incorrect	12	56	68 (96%)
Total		12 (17%)	59 (83%)	71

Chi-Square Tests

	Value	Exact Sig. (2-sided)
McNemar Test		.035(a)
N of Valid Cases	71	

a Binomial distribution used.

7.10 Early signs of sepsis

The next section of the questionnaire concentrated on the early diagnosis of sepsis. Question seven asked nurses to describe the early signs of sepsis, listing as many as possible. In total 15 variables were listed as shown in table 7.13, with the frequency with which they were mentioned by nurses. The two sets of answers are very similar with few noticeable differences, but there is an important difference with tachypnoea. In the first questionnaire only 28.2% of the nurses (50) identified that tachypnoea is an important early sign of sepsis, whereas in the post-intervention questionnaire 60% (51) of nurses identified tachypnoea (and of these 51, 31 had not

identified tachypnoea pre-intervention). The major clinical signs such as pyrexia, hypotension and tachycardia were answered equally well in both samples.

Table 7.13: Listing early signs of sepsis

Questionnaire 1

No	Variable	No of nurses that specified this variable	% of nurses that specified this variable
1.	Pyrexia	170	96%
2.	Hypotension	140	79.1%
3.	Tachycardia	135	76.3%
4.	Oliguria/Anuria	56	31.6%
5.	Tachypnoea	50	28.2%
6.	Drop in Oxygen saturations	38	21.5%
7.	Raised white cell count	35	19.8%
8.	Hypothermia	29	16.4%
9.	Malaise	27	15.3%
10.	Clammy	22	12.4%
11.	Rigors	20	11.3%
12.	Altered consciousness	20	11.3%
13.	Raised CRP	14	7.9%
14.	Vasoconstriction	9	5.1%
15.	Vasodilation	7	4.0%

Questionnaire 2

No	Variable	No of nurses that specified this variable	% of nurses that specified this variable
1.	Pyrexia	77	90.6%
2.	Hypotension	66	77.6%
3.	Tachycardia	71	83.5%
4.	Oliguria/Anuria	27	31.8%
5.	Tachypnoea	51	60%
6.	Drop in Oxygen saturations	15	17.6%
7.	Raised white cell count	21	24.7%
8.	Hypothermia	25	29.4%
9.	Malaise	8	9.4%
10.	Clammy	11	12.9%
11.	Rigors	8	9.4%
12.	Altered consciousness	20	23.5%
13.	Raised CRP	5	5.9%
14.	Vasoconstriction	6	7.1%
15.	Vasodilation	7	8.2%

Table 7.14: Crosstabulation

Pre and Post: Describe early signs of sepsis developing – Tachypnoea Crosstabulation

		Post: Describe early signs of sepsis developing – Tachypnoea		Total
		yes	no	
Pre: Describe early signs of sepsis developing – Tachypnoea	yes	20	9	29
	no	31	23	54
Total		51	32	83

p-value from McNemars test = 0.001

7.11 Immunological and blood indicators

Question eight asked nurses to list three immunological/blood indicators of sepsis. In sample one, 154 nurses answered this question with 23 nurses not answering. In sample two, 81 of the nurses answered with only 4 missing. Overall the two sets of answers are not significantly different; however there are more correct answers in questionnaire two than in one if you look at those nurses being able to provide more than three indicators, as shown below in the frequency tables.

7.15: List the immunological predictors of sepsis

Questionnaire 1

Variable	Frequency	%	Cumulative %
0 right	19	10.7	12.3
1 right	60	33.9	51.3
2 right	54	30.5	86.4
3 right	20	11.3	99.4
4 right	1	.6	100.0
Total	154	87.0	
missing	23	13.0	
Total	177	100.0	

Questionnaire 2

Variable	Frequency	%	Cumulative %
0 right	3	3.5	3.7
1 right	20	23.5	28.4
2 right	28	32.9	63.0
3 right	28	32.9	97.5
4 right	2	2.4	100.0
Total	81	95.3	
missing	4	4.7	
Total	85	100.0	

The following table lists the indicators noted and the frequency with which they were noted:

Table 7.16: Blood indicators listed

Questionnaire 1

No	Indicator of sepsis	No of nurses who listed the variable	% of nurses who listed the variable

Questionnaire 2

No	Indicator of sepsis	No of nurses who listed the variable	% of nurses who listed the variable

1	White blood cells / neutrophil count	105	59.3%
2	CRP	74	41.8%
3	PCT	23	13%
4	Erythrocyte Sedimentation Rate (ESR)	5	2.8%

1	White blood cells / neutrophil count	68	80%
2	CRP	51	60%
3	PCT	34	40%
4	Erythrocyte Sedimentation Rate (ESR)	5	5.9%

As can be seen from the frequency tables, more nurses in the second questionnaire raised all four indicators, in particular WBC and PCT.

Table 7.17: Crosstabulation

Pre: List three immunological/blood indicators of sepsis and severe sepsis * Post: List three immunological/blood indicators of sepsis and severe sepsis Crosstabulation
Count

		Post: List three immunological/blood indicators of sepsis and severe sepsis					Total
		0 right	1 right	2 right	3 right	4 right	0 right
Pre: List three immunological/blood indicators of sepsis and severe sepsis	0 right	0	2	4	0	0	6
	1 right	2	6	7	7	0	22
	2 right	1	7	10	16	0	34
	3 right	0	2	3	1	1	7
	4 right	0	0	0	0	0	0
Total		3	17	24	24	1	69

Chi-Square Tests

	Value	df	Asymp. Sig. (2-sided)
McNemar-Bowker Test	14.473	6	.025
N of Valid Cases	69		

7.12 Making a difference to morbidity and mortality rates

Question nine asked nurses to indicate whether they thought identifying sepsis early made a difference to morbidity and mortality rates. As can be seen in the table below, a majority of nurses felt early identification did make a difference with no statistical difference between the two questionnaires.

Table 7.18: Does identifying sepsis early make any difference to morbidity and mortality rates?

Questionnaire 1				Questionnaire 2			
Variable	Frequency	%	Cumulative %	Variable	Frequency	%	Cumulative %
Yes	174	98.3	98.3	Yes	84	98.8	98.8
No	1	0.6	98.9	No	1	1.2	100.0
Not sure	2	1.1	100.0	Not sure			
Total	177	100.0		Total	85	100.0	

Table 7.19: Crosstabulation

Pre: Do you think that identifying sepsis at an early stage makes any difference to mortality and morbidity * Post: Do you think that identifying sepsis at an early stage makes any difference to mortality and morbidity Crosstabulation

		Post: Do you think that identifying sepsis at an early stage makes any difference to mortality and morbidity		Total
		yes	No	yes
Pre: Do you think that identifying sepsis at an early stage makes any difference to mortality and morbidity	yes	82	1	83
	no	1	0	1
	not sure	1	0	1
Total		84	1	85

Chi-Square Tests

	Value	df	Asymp. Sig. (2-sided)
McNemar-Bowker Test	.	.	.(a)

N of Valid Cases	85		
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a Computed only for a PxP table, where P must be greater than 1.

7.13 Awareness of CRP and procalcitonin tests

Question ten asked nurses whether they had heard of CRP and procalcitonin blood tests.

Table 7.20: CRP and procalcitonin tests

Questionnaire 1

Variable	Frequency	%	Valid %	Cumulative %
PCT Yes	100	56.5	56.5	56.5
PCT No	50	28.2	28.2	84.7
CRP	27	15.3	15.3	100.0
Total	177	100.0	100.0	

Questionnaire 2

Variable	Frequency	%	Valid %	Cumulative %
PCT Yes	81	95.3	95.3	95.3
PCT No				
CRP	4	4.7	4.7	100.0
Total	85	100.0		

Table 7.21: Crosstabulation

Pre: Have you heard of PCT and CRP * Post: Have you heard of PCT and CRP

Crosstabulation

Count

		Post: Have you heard of PCT and CRP		Total
		Yes	crp	
Pre: Have you heard of PCT and CRP	yes	49	2	51
	no	16	1	17
	crp	16	1	17
Total		81	4	85

Chi-Square Tests

	Value	df	Asymp. Sig. (2-sided)
McNemar-Bowker Test	.	.	.(a)
N of Valid Cases	85		

a Computed only for a PxP table, where P must be greater than 1.

As can be seen from the frequency tables above, (and perhaps as to be expected given the practical application using PCT in the study), the difference between the two sets of answers is statistically significant. In the first questionnaire, 100 nurses (56.5%) of nurses had heard of PCT and in the second 81 nurses (95.3%).

7.14 Knowledge of using the PCT-Q

Question 11 asked nurses if they knew how to use the PCT-Q test and, as is illustrated below, only 11 nurses before the study knew how to use the PCT-Q.

Table 7.22: How to use the PCT-Q

Questionnaire 1

Variable	Frequency	%	Valid %	Cumulative %
No	165	93.2	93.2	93.2
Yes	11	6.2	6.2	99.4
Not sure	1	0.6	0.6	100.0
Total	177	100.0	100.0	
		0		

Questionnaire 2

Variable	Frequency	%	Valid %	Cumulative %
No	35	41.2	41.2	41.2
Yes	48	56.5	56.5	97.6
Not sure	1	1.2	1.2	98.8
Total	85	100.0	100.0	

Table 7.23: Crosstabulation

Pre-Do you know how to use the PCT-Q * Post-Do you know how to use the PCT-Q

Crosstabulation

		Post: Do you know how to use the PCT-Q				Total
		no	Yes	not sure	forgotten	
Pre: Do you know how to use the PCT-Q	no	32	47	1	0	80
	yes	3	1	0	1	5
Total		35	48	1	1	85

Chi-Square Tests

	Value	df	Asymp. Sig. (2-sided)
McNemar-Bowker Test	.	.	.(a)
N of Valid Cases	85		

a Computed only for a PxP table, where P must be greater than 1.

As can be seen from the frequency tables above, there is a statistically significant difference with 165 nurses (93.2%) of nurses in the first questionnaire not knowing how to use the PCT-Q and 35 (41.2%) in the second sample.

7.15 Contacting healthcare professionals

The final section of the questionnaire concentrated on the care of the patient once sepsis has been diagnosed. Question 12 asked the nurses to list which healthcare professionals (HCP) they would contact if one of their patients was developing sepsis. As can be seen from the frequency tables below, the major differences are:

1. Contacting the CCU outreach team, with 106 nurses (59.9%) contacting them in the first questionnaire and 64 (75.3%) in the second;
2. Contacting the medical team, with 102 nurses (57.6%) contacting them in the first questionnaire and 81 nurses (95.3%) in the second; and
3. In the first questionnaire eight nurses (4.5%) would contact the CCU and in the second sample 13 nurses (15.3%).

Table 7.24: How many HCPs contacted

Pre: How many contacted? If one of your patients was developing the early signs of sepsis who would you contact? * Post: How many contacted? If one of your patients was developing the early signs of sepsis who would you contact? Crosstabulation

		Post: How many contacted? If one of your patients was developing the early signs of sepsis who would you contact?						Total
		1	2	3	4	5	6	
Pre: How many contacted? If one of your patients was developing the early signs of sepsis who would you contact?	1	0	4	4	3	1	1	13
	2	3	13	11	6	2	0	35
	3	0	12	7	3	4	0	26
	4	0	3	2	0	0	0	5
	5	0	2	1	1	0	0	4
	Total		3	34	25	13	7	1

Chi-Square Tests

	Value	df	Asymp. Sig. (2-sided)
McNemar-Bowker Test	13.186	11	.281
N of Valid Cases	83		

Post-intervention change in number of people contacted if patient showing early signs	Frequency	Percent
Fewer than pre-intervention	24	28.9%
Same as pre-intervention	20	24.1%
More than pre-intervention	39	47.0%
Total	83	100.0%

Table 7.25: Which HCPs would you contact if your patient was developing sepsis?

Questionnaire 1

No	Member of staff	Numbers of nurses who cited this group	% of nurses who cited this group
1	CCU outreach nurse	106	59.9%
2.	Medical team	102	57.6%
3	Nurse in charge	91	51.4%
4	Senior house officer (SHO)	84	47.5%
5	Oncology specialist registrar	39	22%
6	Anaesthetist	24	13.6%
7	Critical Care Unit	8	4.5%

Questionnaire 2

No	Member of staff	Numbers of nurses who cited this group	% of nurses who cited this group
1.	CCU outreach nurse	64	75.3%
2.	Medical team	81	95.3%
3.	Nurse in charge	44	51.8%
4.	Senior house officer (SHO)	27	31.8%
5.	Oncology specialist registrar	18	21.2%
6.	Anaesthetist	13	15.3%
7.	Critical Care Unit	13	15.3%

7.16 Experience of nursing patients with severe sepsis

Question 13 asked nurses whether they had nursed a patient who had developed severe sepsis. A majority of nurses (145 or 81.9%) answered positively, 23 (13%) had not nursed a patient with sepsis and 8 (4.5%) were not sure. In the second sample the answers were very similar, with 71 nurses answering positively (83.5%), 11 (12.9%) had not and 3 nurses (3.5%) were not sure. There was no significant change between the pre- and post-intervention answers.

Table 7.26: Have you nursed a patient who has developed severe sepsis?

Questionnaire 1

Variable	Frequency	%	Valid %	Cumulative %
Yes	145	81.9	81.9	81.9
No	23	13.0	13.0	94.9
Not sure	8	4.5	4.5	99.4
Missing	1	.6	.6	100.0
Total	177	100.0		

Questionnaire 2

Variable	Frequency	%	Valid %	Cumulative %
Yes	71	83.5	83.5	83.5
No	11	12.9	12.9	96.5
Not sure	3	3.5	3.5	100.0
Missing				
Total	85	100.0	100.0	

Table 7.27: Crosstabulation

Pre: Have you nursed a person with cancer who has developed severe sepsis? * Post: Have you nursed a person with cancer who has developed severe sepsis? Crosstabulation

		Post: Have you nursed a person with cancer who has developed severe sepsis?			Total	
		yes	No	NOT SURE		
Pre: Have you nursed a person with cancer who has developed severe sepsis?	yes	Count	62	9	3	74
		% of Total	72.9%	10.6%	3.5%	87.1%
	no	Count	5	1	0	6
		% of Total	5.9%	1.2%	.0%	7.1%
	NOT SURE	Count	4	1	0	5
		% of Total	4.7%	1.2%	.0%	5.9%
Total		Count	71	11	3	85
		% of Total	83.5%	12.9%	3.5%	100.0%

Chi-Square Tests

	Value	df	Asymp. Sig. (2-sided)
McNemar-Bowker Test	2.286	3	.515
N of Valid Cases	85		

7.17 Problems convincing others

Finally, question 14 asked the nurses whether they had ever experienced a time when they thought that a patient was deteriorating but had had problems convincing others. As is illustrated clearly with the frequency tables below, the nurses were very closely divided with 83 (46.9%) of nurses having had difficulty convincing others and 91 nurses (51.4%) who had not. Three nurses did not answer this question.

Table 7.28: Have you had a time when a patient was deteriorating but you found it difficult to convince others?

Questionnaire 1

Variable	Frequency	%	Valid %	Cumulative %
Yes	83	46.9	46.9	46.9
No	91	51.4	51.4	98.3
Missing	3	1.7	1.7	100.0
Total	177	100.0	100.0	

Questionnaire 2

Variable	Frequency	%	Valid %	Cumulative %
Yes	55	64.7	64.7	64.7
No	29	34.1	34.1	98.8
Missing	1	1.2	1.2	100.0
Total	85	100.0	100.0	

Table 7.29: Crosstabulation

Pre: Have you ever had the experience of thinking that a patient was deteriorating but finding it difficult to convince other nurses/doctor or other HCPs? * Post: Have you ever had the experience of thinking that a patient was deteriorating but finding it difficult to convince other nurses/doctor or other HCPs? Crosstabulation

		Post: Have you ever had the experience of thinking that a patient was deteriorating but finding it difficult to convince other nurses/ doctor or other HCPs?			Total
		yes	no	not sure	Yes
Pre: Have you ever had	yes	31	15	0	46

the experience of thinking that a patient was deteriorating but finding it difficult to convince other nurses/doctor or other HCPs?					
	no	22	14	1	37
Total		52	29	1	85

Chi-Square Tests

	Value	df	Asymp. Sig. (2-sided)
McNemar-Bowker Test	2.324	2	.313
N of Valid Cases	83		

Although there was a higher percentage of nurses in the second questionnaire that answered yes (64.7 % as compared to 46.9%), the change between pre- and post-intervention answers was not statistically significant.

7.18 Conclusion

The questionnaire survey achieved the aims reflected in the secondary research objectives to the extent that the researcher did reach nurses across the trust on all wards and on all shifts and therefore improved the awareness of sepsis and the PCT-Q. The PCT-Q was used 416 times in 320 patients and there is evidence therefore that nurses were alert to the possibility of sepsis, although there was no historical data for comparison. The educational intervention and questionnaire survey were also designed to measure improvement in knowledge and this was achieved in some areas. There were five answers demonstrating an improvement that is statistically significant between pre- and post-intervention questionnaires:

1. The mortality rate for severe sepsis in previously healthy adults;
2. The mortality rate for severe sepsis in patients with cancer;
3. The nurse's knowledge of PCT and CRP;
4. How to use the PCT-Q;

5. Which HCPs would you contact if your patient was developing sepsis?

There were four areas where an improvement was demonstrated but did not reach statistical significance:

1. List the different stages of the sepsis syndrome;
2. Tachypnoea as an early sign of sepsis;
3. List three indicators of sepsis;
4. A time when a patient was deteriorating but difficult to convince others.

There were three questions that were used to gain demographic detail about the sample and are therefore not useful in comparing knowledge acquisition. The demographic data did illustrate that there was no significant difference between the two samples. Therefore the total number of questions that could be used to test knowledge on the sepsis syndrome is $14 - 3 = 11$.

Across the trust, 177 nurses received a dedicated teaching session on sepsis that was based on the latest evidence. Ten of these sessions were provided to nurses who mainly work at night and had received less formal education. The sessions also gave many nurses the opportunity to informally discuss problems and their recommendations for practice, which have since been implemented across the trust (see chapter nine, section 9.22).

The researcher is aware, however, that providing a teaching session may not mean an increase in knowledge or practice improvement. The questionnaires were used as a device to allow individual nurses to compare their own learning over time and for the researcher to compare anonymised knowledge acquisition.

Looking at the 11 questions that could be used to test knowledge acquisition, nine showed an improvement with five reaching statistical significance. Finally, 177 nurses were introduced to the PCT-Q and taught how to use it in readiness for the patient part of the study

There was also a demonstrable improvement in knowledge after eight months. The limitations, however, are that there were four questions in the second questionnaire that showed only small improvement and there was only a 58.6% return of that

questionnaire, despite a reminder letter. Finally, the questionnaires only assessed one dimension of knowledge acquisition and may not correlate with an improvement in practice.

Chapter 8 Findings (3): patient data and use of the PCT-Q to assess early sepsis

8.1 Introduction

This chapter provides the findings of using the PCT-Q in patients who were thought to be developing sepsis. This patient part of the study links to the theoretical framework and aims by exploring the nurses' ability to assess deterioration due to sepsis and intuit subtle change, even in the absence of overt clinical signs. Croce's model of intuition is used to explain the way nurses' are affected by a change in the patient, and then go on to analyse and communicate the change to others. To aid in this assessment an objective test was introduced the PCT-Q. In this chapter further findings are provided about the ability of nurses to use an objective test and its effect on mobilising the multi-professional team to improve early rescue. This study was not designed to test the validity and reliability of the PCT-Q, (previously comprehensively demonstrated as described in chapter two), but as the PCT-Q has not previously been used by ward and CCU nurses its reliability in their hands was compared with the markers currently used in the hospital. Finally because the patient data on episode and hospital outcome was collected data in the study year was to be compared to the three previous years.

As described in chapter three, the sepsis cascade has been defined as having four stages from the earliest SIRS with subtle or no obvious change, to sepsis, the next stage where there may be few signs and other causes of an acute inflammatory event are excluded, through to severe sepsis and septic shock and the last stage of Multi-Organ Dysfunction Syndrome (MODS) when the patient is critically ill requiring all support. The aim of this study was to diagnose a greater proportion of people with cancer at the early stages: SIRS or sepsis.

As described in chapter five any patients who a nurse felt were deteriorating and exhibiting signs of SIRS or sepsis were asked for consent to take blood to measure their PCT-Q and use their data in the research study. Over the study period, approximately 12 months, a total of 320 patients were recruited. There were however

416 sepsis episodes, as several patients had more than one episode. To be included as a separate sepsis episode the patient had to have recovered from the first, and the two events needed to be separated by at least seven days. Patient characteristics are shown in the frequency tables below:

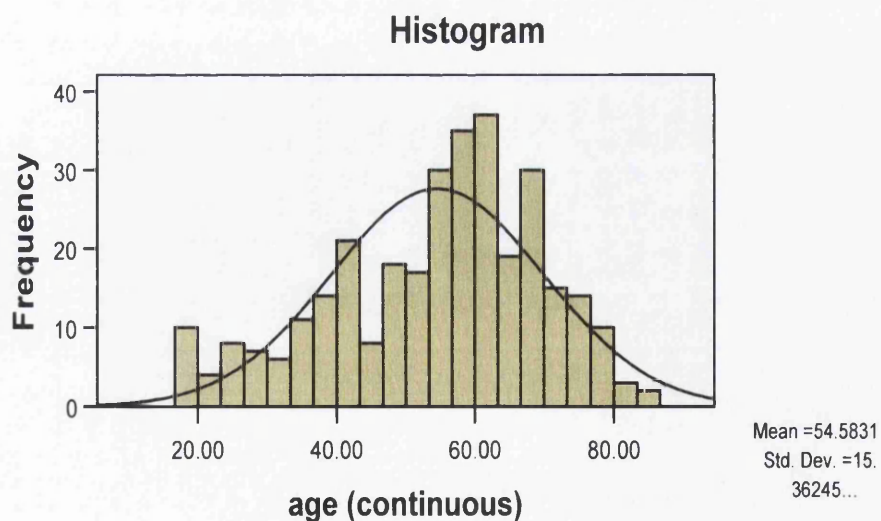
Table 8.1: Gender of patients recruited into the study

Gender	Frequency	Percent
Male	176	55.0%
Female	144	45.0%
Total	320	100.0%

Table 8.2: Gender of patients in whole data set including repeat episodes

Gender	Frequency	Percent
Male	233	56.0%
Female	183	43.9%
Total	416	100.0%

Table 8.3: Distribution of patient population by age



As can be seen from the table above, the mean age of the patients recruited into the study was 54.6 years.

Table 8.4: Distribution of patient population by type of cancer

Category	Diagnosis	Frequency	Percent
Haemato-oncology	Acute Leukaemia	88	21.2
	Lymphoma	78	42.8
	Myeloma	47	11.3
	Chronic Leukaemia	9	2.2
	Myelofibrosis/myeloproliferative disorder	3	0.7
Gastro-intestinal	Upper GI	45	10.8
	Lower GI	15	3.6
	Carcinoid	1	0.2
Solid Tumours	Urology	26	6.3
	Breast	25	6.0
	Gynaecology	21	5.0
	Head & Neck	15	3.6
	Sarcoma	12	2.9
	Neuro-oncology	7	1.7
	Multiple primary	7	1.7
	Thyroid	2	0.5
	Melanoma	1	0.2
	Unknown primary	Unknown	2
Total		416	100%

As expected, the highest proportion of patients recruited into the study was those with the greatest risk of sepsis: patients with haematological cancer. Leukaemia represents the largest group (96 patients or 23.4%); lymphoma 78 patients (18.8%); and myeloma 47 patients (11.3%). The haematological cancers therefore represent 222 patients (n=320) or 53.5% of the whole sample. Of the patients with solid tumours, the largest proportion in the sample are those patients with upper gastrointestinal cancer (upper GI) at 45 patients (10.8%). Patients with upper GI cancer tend to be older and to have co morbid conditions such as ischaemic heart disease, chronic pulmonary disease and diabetes, and are at greater risk of developing sepsis.

Table 8.5: Distribution of patient population by cancer treatment

Cancer Treatment	Frequency	Percent
Chemotherapy	186	44.7
Allogeneic transplant	46	11.8
Autologous transplant	44	10.6
Surgery	89	21.4
Chemo/radiotherapy	7	1.7
Chemo/surgery	5	1.2
Chemo/radio/surgery	5	1.2
Endocrine therapy	3	0.7
Interferon therapy	1	0.2
Nil for last 3 months	23	5.5
Total	416	100.0

As described in chapter three, several factors predispose patients to developing sepsis. Some are patient characteristics such as age, cancer diagnosis and the presence or absence of comorbid conditions. There are also treatment-related factors, and in table 8.5 above it is clear that the largest group of associated treatment is chemotherapy, with 186 patients (n=320) or 44.7% having received chemotherapy. Perhaps surprisingly, patients having surgery and those who have had a blood or marrow transplant have a similar incidence to those who had surgery (89 patients or 21.4%) and those who had a transplant (90 patients). This may be explained by the fact that many of the patients who have had surgery are from the upper GI group who are older, have co morbid conditions and receive chemotherapy prior to surgery.

8.2 Stage of the sepsis syndrome at diagnosis

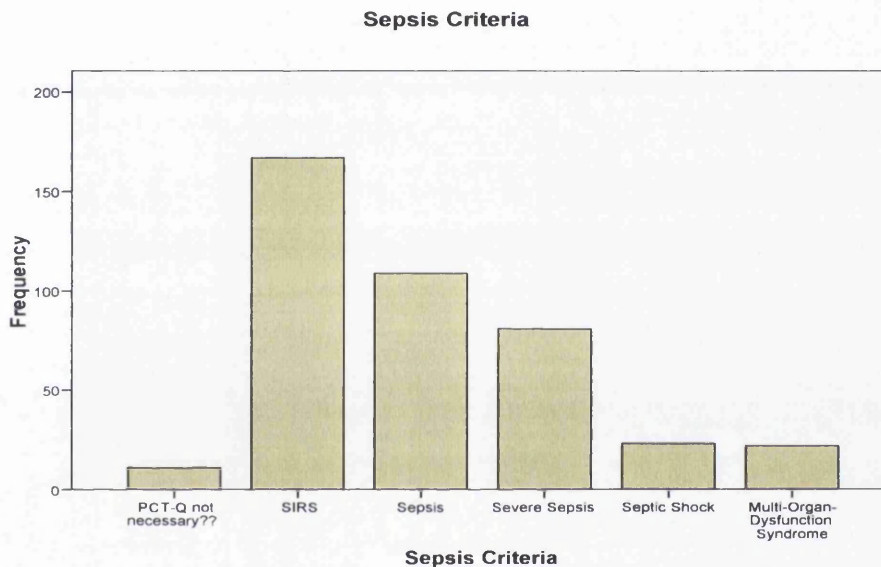
Data from the 420 sepsis episodes was explored firstly for the stage of the sepsis syndrome at which the patient was referred and assessed. Table 8.6 and figure 8.1 illustrate the stage of the sepsis syndrome at diagnosis.

Table 8.6: The stage of the sepsis syndrome at diagnosis

Sepsis Criteria	Frequency	Percent
PCT-Q not appropriate	11	2.6
SIRS	163	39.2
Sepsis	112	26.9

Septic Shock	23	5.5
Multi-organ Dysfunction syndrome (MODS)	22	5.3
Total	413	99.3
missing	3	0.7
Total	416	100.0

Figure 8.1: The stage of the sepsis syndrome at diagnosis



The frequency table and bar chart above illustrate that most patients in the study were identified at the earliest two stages of the syndrome, with 163 patients (n=420) or 39.2% satisfying the SIRS criteria and 112 patients (26.9%) identified at the sepsis stage. There is no physical difference between SIRS and sepsis; the definition sepsis is used when everything that may have caused the change in the patient's condition (for example bleeding or pancreatitis) has been eliminated and the deterioration is thought to be due to infection. Therefore, accumulatively, 66.1% of the patient episodes were identified at an early stage before the severe sepsis and multi-organ stages. For clarity of illustration, all further data was therefore reclassified into early or late sepsis: "early" including SIRS and sepsis and "late" including severe sepsis, septic shock and MODS. Table 8.7 uses crosstabulation to examine the possible relationship between early and late diagnosis and the stage of sepsis at diagnosis.

Table 8.7: Sepsis Endpoint Early Sepsis Crosstabulation

		EarlySepsis		Total
		No	Yes	
Sepsis Endpoint	SIRS	0	167	167
	Sepsis	0	108	108
	Severe Sepsis	126	0	126
Total		126	275	401
% within Sepsis Endpoint		31.4%	68.6%	100.0%
95% confidence interval for percentage			(63.8%, 73.1%)	

Table 8.8 provides information on the immediate interventions needed by patients during the sepsis episode lasting 12–72 hours. As illustrated, only 9.6% (40, n=416) of patients required no further acute care intervention, although a further six patients (1.4%) were able to be discharged from the CCU or Step Up unit, and nine patients were discharged from outreach. The highest percentage of patients needed further interventions with 180 patients (43.7%) requiring ongoing review by the CCOT. There were 56 patients (13.4%) identified as needing an intervention or escalation in their care; they were transferred from the rehabilitation unit to the ward (one patient), to theatre (one patient), from the ward to the Step Up or CCU (54 patients). There were 115 patients (27.6%) identified as still needing to remain in the CCU or Step Up Unit.

8.3 Outcome of the sepsis episode

Table 8.8: Outcome of sepsis episode

Intervention	Frequency	Percent
Observe and monitor	40	9.6
Outreach team review	180	43.3
Remaining in CCU/Step Up	115	27.6
Admission to Step Up/CCU	41	9.9
Transfer from Step Up to CCU	13	3.1
Discharged from Outreach	9	2.2
Discharged from Step Up/CCU	6	1.4
Care goals reviewed not for acute care	5	1.2

To theatre for drainage of septic collection	1	0.2
Transfer to ward from Rehabilitation Unit	1	0.2
Withdrawal of treatment	1	0.2
Missing	3	0.7
Total	416	100.0

Table 8.9: Hospital outcome for all patients recruited to the study

Outcome of hospital stay	Frequency	Percent
Survived to leave hospital	297	71.4
Died in CCU (18 severe sepsis)	44	10.6
Died in hospital ward – cancer	32	7.7
Died in hospital ward – acute (14 non sepsis, 1 severe sepsis) illness	15	3.6
Died in CCU – cancer	12	2.9
Died in Step Up – critical illness (1 severe sepsis)	9	2.0
Died in another hospital	4	0.9
Discharged to another hospital/hospice	4	0.9
Total	416	100.0

As can be seen from table 8.9, a majority of patients survived to leave hospital (297 or 71.4%). There were four patients discharged to another hospital and one to a hospice (0.18%). Of the 115 patients (27.6%) who died, 47 died directly as a result of their disease (11.3%) and 68 (16.3%) as the result of a critical illness. Another 20 (4.8%) deaths were due to sepsis: most on the CCU (18), one on a general ward and one on the Step Up Unit.

8.4 Physiological parameters as an assessment of sepsis

The next data to be analysed were the alterations to the patient's physiological parameters as a result of sepsis. In the analysis of the questionnaires the nurses cited a high temperature as one of the most important indications of sepsis. The sepsis literature, however, and particularly the definitions of SIRS and sepsis, indicates that there may be a high or low temperature. In table 8.10 the temperature findings of the patients are correlated with the stage of the sepsis syndrome. Patients were categorised into low (<36), normal (36 to <38) and high (>=38) temperature groups

and a chi-squared test was used to explore the link between temperature and sepsis stage. As can be seen from the results, there is no statistically significant correlation between sepsis and temperature.

Figure 8.2: Temperature frequencies

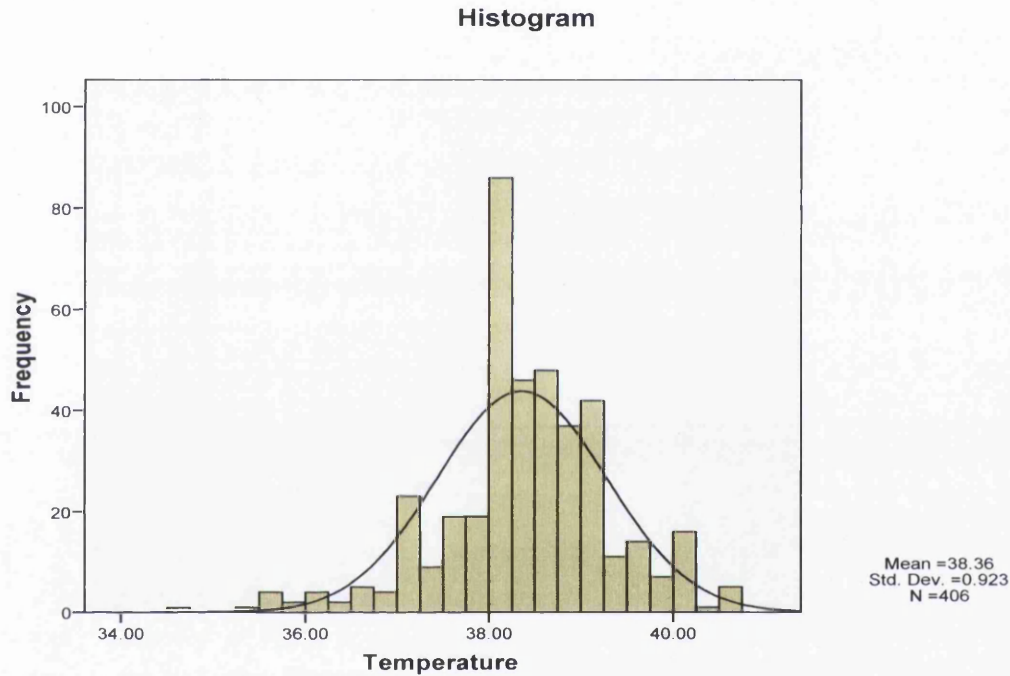


Table 8.10: Correlation of temperature with SIRS/Sepsis

			Early Sepsis		Total
			Late diagnosis	Early diagnosis	Late diagnosis
Temp Continuous	Low	Count	2	5	7
		% within EarlySepsis	1.6%	1.8%	1.8%
	Normal	Count	24	52	76
		% within EarlySepsis	19.2%	19.1%	19.1%
	High	Count	99	211	311
		% within EarlySepsis	72.6%	78.7%	78.9%
Total		Count	125	268	393
		% within EarlySepsis	100.0%	100.0%	100.0%

p-value from Chi-squared test=0.981

Table 8.11: Correlation of MAP with SIRS/Sepsis

			Early Sepsis		Total
			Late diagnosis	Early diagnosis	Late diagnosis
Map Continuous	Low	Count	76	104	180
		% within EarlySepsis	60.8%	38.7%	45.7%
	High	Count	49	165	214
		% within EarlySepsis	39.2%	61.3%	54.3%
Total		Count	125	269	394
		% within EarlySepsis	100.0%	100.0%	100.0%

P<0.001 (chi-squared)

The mean arterial pressure (MAP) was then correlated with the stage of the sepsis syndrome. MAP was grouped into low/high/normal and a Chi-squared test used to check for relationship with sepsis stage at diagnosis (see table 8.11). A low MAP has a statistically significant correlation ($p < 0.001$) with the late stages of sepsis. This is to be expected, as a characteristic of increasing sepsis is the release of anaphylotoxins such as Bradykinin, which have a profound vasodilation effect and rapidly lower the blood pressure.

8.5 Ordinal regression analysis of the blood predictors of sepsis and MAP

The main aim of this study was to improve the early detection of patients who were deteriorating from sepsis. As explained in the methods chapter in the hospital, before this study, CRP and WBC were the most commonly used indicators, with the critical care team also using lactate measurements. Procalcitonin (PCT) had not previously been used and neither had the PCT-Q – the bedside test. It was essential therefore to be able to compare the blood tests and their reliability and specificity at predicting sepsis. The aim was to confirm that, in cancer patients, the results of diagnostic tests including PCT-Q were a useful predictor of sepsis stage at diagnosis. The first indicator to be assessed was the Mean Arterial Pressure (MAP), which was included as a categorical predictive variable with values of low (<70) and high (>70).

Table 8.12: Crosstabulation of MAP by sepsis stage

		Sepsis Endpoint			Total	
			SIRS (1)	Sepsis (2)	Severe Sepsis (3)	
MAP	Low <=70	(N)	53	51	76	180
		(% of MAP low)	29%	28%	42%	
	High >70	(N)	110	55	49	214
		(% of MAP high)	51%	26%	23%	
	All episodes	(N)	163	106	125	394
		(% of all episodes)	41%	27%	32%	

Model fitting information	-2 Log Likelihood	Change in -2 Log likelihood	df	Sig.
Null model	45.091			
MAP model	21.660	23.431	1	.000

Parameter estimates	Category	Odds ratio	Sig.	95% confidence interval	
MAP	Low	2.50	<0.001	1.72	3.64
	High	1			

The hypothesis being tested here was that the null model is as good at predicting sepsis stage as the model using MAP. This highly significant result (p=0.000) shows that MAP is a good predictor of sepsis stage. The null model is one where no predictive variables are used, so all episodes are assumed to carry the same risk for sepsis stage. The quoted odds ratio is for the relative odds of an increase in sepsis stage by one category for low versus high MAP. This model assumes that the odds ratio is the same for SIRS: sepsis/severe sepsis as it is for SIRS/sepsis: severe sepsis. That is, that the risk increase is the same for each step of sepsis severity. The model fitting process showed that MAP was a significant predictor of sepsis stage, with low MAP associated with an increased risk of later-stage sepsis (OR 2.5) compared to high MAP.

The next indicator to be assessed was the white blood cells (WBC). The WBC data was grouped into low (<4), normal (4.1 – 11.9) and high (>12).

Table 8.13: Crosstabulation of WBC by sepsis stage

			Sepsis Endpoint			Total
			SIRS	Sepsis	Severe Sepsis	
WBC	Low	N	46	83	83	212
		% of WBC low	22%	39%	39%	
	Normal	N	65	12	15	92
		% of WBC normal	71%	13%	16%	
	High	N	55	13	28	96
		% of WBC high	57%	14%	29%	
Total		N	166	108	126	400
		% of total	42%	27%	32%	

Model Fitting Information	-2 Log Likelihood	Chi-Square	df	Sig.
Null model	111.87			
WBC model	53.51	58.36	2	0.000

Parameter estimates	Category	Odds ratio	Sig.	95% confidence interval	
WBC	Low	5.98	0.000	3.59	9.97
	Normal	1			
	High	2.03	0.016	1.14	3.63

WBC was a significant predictor of sepsis stage, with both low and high WBC carrying an increased risk of late-stage sepsis. The risk was greatest in patients with low WBC (OR 5.98).

The next predictor to be assessed was lactate, which was divided by the median value of 1.4 into low (< 1.4) and high (>1.4):

Table 8.14: Crosstabulation of lactate by sepsis stage

		Sepsis Endpoint			Total	
			SIRS	Sepsis	Severe Sepsis	
Lactate	Low<1.4	N	87	45	54	186
		% of low	47%	24%	29%	
	High>1.4	N	55	40	59	154
		% of high	36%	26%	38%	
Total		N	142	85	113	340
		% of all	42%	25%	33%	

Model Fitting Information	-2 Log Likelihood	Chi-Square	df	Sig.
Null model	25.91			
Lactate model	21.18	4.73	1	0.030

Parameter estimates	Category	Odds ratio	Sig.	95% confidence interval	
Lactate	Low<=1.4	1			
	High>1.4	1.55	0.030	1.04	2.31

Lactate is also a statistically significant predictor of sepsis, with high lactate carrying a small but significant increase in risk of later stage sepsis (OR 1.5).

The lactate level significant for predicting severe sepsis in the literature is >4 (Bakker and Jansen 2007, Trezeciak *et al* 2007, Robson and Daniels 2008). Therefore a further analysis was conducted, recategorising lactate values <4 or >4 (with the highest value in the study being 7.5c1).

Table 8.15: Crosstabulation of lactate using <4 or >4 values

		Sepsis Endpoint			Total	
			SIRS	Sepsis	Severe Sepsis	
Lactate	Low < 4	N	139	75	95	309
		% of low	45%	24%	31%	
	High > 4	N	3	10	18	31
		% of high	10%	32%	58%	

Total		N	142	85	113	340
		% of all	42%	25%	33%	

Model Fitting Information	-2 Log Likelihood	Chi-Square	df	Sig.
Null model	36.18			
Lactate model	21.71	14.47	1	0.000

Parameter estimates	Category	Odds ratio	Sig.	95% confidence interval	
Lactate	Low < 4	1			
	High > 4	3.75	0.000	1.79	7.84

A high lactate >4 was seen to be a statistically significant indicator (p=0.000) of sepsis.

CRP was classified according to the median as low (<168) or high (>168).

Table 8.16: Crosstabulation of CRP by sepsis stage

			Sepsis Endpoint			Total
			SIRS	Sepsis	Severe Sepsis	
CRP	Low	N	69	47	44	160
		% of low	43%	29%	28%	
	High	N	62	49	56	167
		% of high	37%	29%	34%	
Total		N	131	96	100	327
		% of all	40%	29%	31%	

Model Fitting Information	-2 Log Likelihood	Chi-Square	df	Sig.
Null model	22.80			
CRP	21.11	1.68	1	0.194

Parameter estimates	Category	Odds ratio	Sig.	95% confidence interval	
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CRP	Low	1			
	High	1.30	0.195	0.87	1.95

Although high CRP was apparently associated with later stage sepsis (OR 1.3) the link was not significant (p=0.2)

PCT was classified as either positive or negative.

Table 8.17: Crosstabulation of PCT by sepsis stage

			Sepsis Endpoint			Total
			SIRS	Sepsis	Severe Sepsis	
PCT	Positive	N	77	59	89	225
		% of positive	34%	26%	40%	
	Negative	N	90	49	37	176
		% of negative	51%	28%	21%	
Total			167	108	126	401
			42%	27%	31%	

Model Fitting Information	-2 Log Likelihood	Chi-Square	df	Sig.
Null model	39.75			
PCT	22.64	17.11	1	0.000

Parameter estimates	Category	Odds ratio	Sig.	95% confidence interval	
PCT	Positive	2.18	0.000	1.50	3.16
	Negative	1			

PCT is significantly correlated with sepsis, with a positive PCT reading giving a two times greater odds of developing later stage sepsis.

Of the five indicators, CRP is the only one that does not reach statistical significance. Of the other four, the one indicating the highest risk is a low WBC, at six times the risk, then low MAP, positive PCT and high WBC all carry a similar

level of risk with odds ratios of 2.5, 2.2 and 2.0 respectively, and finally the lowest risk increase is given by high lactate with an odds ratio of 1.5.

To compare the four indicators with each other statistically, a multivariate ordinal regression analysis was then performed, as shown below in tables 8.18 and 8.19. Backwards model selection was used, with initially all four variables being included in the model, and a reduced model with one variable omitted in turn evaluated in comparison to the full model.

Table 8.18: Model fitting information

Model Fitting Information	-2 Log Likelihood	Chi-Square	df	Sig.
MAP, PCT, Lactate and WBC (Full model)	132.52			
MAP, Lactate, WBC (PCT omitted)	96.06	36.46	1	<0.001
WBC, MAP, PCT (Lactate omitted)	109.95	22.57	1	<0.001
Lactate, PCT, MAP (WBC omitted)	60.31	72.22	2	<0.001
Lactate, PCT, WBC (MAP omitted)	91.91	40.62	1	<0.001

All four terms remained significant, as the removal of any one term resulted in a significant decrease in model fit.

Table 8.19: Multivariate Model

Parameter Estimates		Odds ratio	Sig.	95% Confidence Interval	
PCT	Positive	1.84	0.007	1.186	2.864
	Negative	1			
Lactate	Low<=4	1			
	High>4	2.97	0.006	1.356	6.493
WBC	Low	5.39	0.000	3.050	9.528
	Normal	1			
	High	1.80	0.066	0.962	3.378
MAP	Low	2.17	0.000	1.406	3.358
	High	1			

Parameter estimates from the multivariate model remained comparable to those obtained from univariate regression, with the exception of high WBC for which the odds ratio, although of similar magnitude (1.8 compared to 2.0 from univariate regression), was no longer significant compared to normal WBC.

8.6 Conclusion

The aims of the PCT-Q arm of the study were to assess if the PCT-Q was used appropriately and whether its use meant that sepsis was diagnosed at an early stage. The findings demonstrate that the nurses were using the PCT-Q appropriately the majority of the time (398, n=416). The performance of the PCT-Q was also assessed against the markers previously used in the host hospital. Finally patient outcome data was compared from the study year with three previous years. Analysis of the patient data revealed that 66% patients were identified at an early stage of their sepsis. The patients at the greatest risk of sepsis were those with a diagnosis of haematological cancer. The greatest proportion of patients (71.3%) were overseen by the CCU outreach team and survived to leave hospital. Of those who were admitted to the CCU or Step Up, 65 patients died of their critical illness. A further 20 patients died of severe sepsis 18 on CCU, one on Step Up and one on the ward. Of the physiological parameters that correlated most significantly with the development of sepsis, the MAP was most significantly correlated. Of the blood indicators of sepsis, CRP, previously the most commonly used indicator by general ward teams, was the least specific and reliable. Conversely, a low WBC, a high lactate and a high PCT all reached statistical significance when correlated with sepsis. Unexpectedly in one case the PCT-Q was requested by a patient. This young patient had been diagnosed with sepsis twice with the PCT-Q and suffered severe sepsis requiring mechanical ventilation and haemofiltration. Having recovered from both of these episodes and back on the ward she again felt ill and requested the PCT-Q. Her procalcitonin level was very low and her MEWS score was low, she visibly relaxed and went on to be discharged from hospital two weeks later.

Chapter 9 Discussion

9.1 Introduction

In this chapter the findings from the three data sets are discussed. They are presented in the same order as the research was undertaken and the findings are related to the theoretical framework that informed the whole study. The qualitative data from both sets of interviews and the questionnaire, the quantitative data from the questionnaire, and the PCT-Q data are discussed in that order. The data are discussed as they relate to the overall aims of the study, the literature and to clinical practice. As discussed in chapter five data integration in a multiple methods study can be regarded as problematic. In this study however the only data to be combined are the qualitative findings from the two interviews and the questionnaires (chapter six, section 6.7 and 6.8).

9.2 The interview and questionnaire qualitative data

The aims of the qualitative part of the research were twofold. First, to gain an understanding of the experiences of ward and CCU nurses as they care for and recognise the cancer patient developing early sepsis and, secondly, to understand their experiences in mobilising the multidisciplinary team. The only other published research relating to the former is a study investigating the experience of nurses caring for newborns with sepsis (Rubarth 2003). Research studies directly relating to the second aim are also limited, the most important being Cioffi's (2000) study looking at 32 nurses' experience of calling the Medical Emergency Team (MET) in Australia (2000,a,b). A small number of studies investigating critical care outreach are also relevant (Ryan *et al* 2004, McBride *et al* 2005, Jones *et al* 2006).

The data from the two sets of interviews and the free text from the questionnaires were initially analysed separately (see chapters six and seven), but there were clear themes that were common to all three data sets. Some of these themes have been

discussed in chapter six, but the major overarching themes that ran throughout the qualitative data were:

1. **Knowing the patient: the importance of nursing continuity**
2. **Making a diagnosis of sepsis**
3. **Contacting others to help**
4. **Asking the patient**
5. **Being aware of (the risk of) sepsis**
6. **Nurses learning**
7. **Reflecting on failure**
8. **Improving practice.**

9.3 Key themes for practice

The themes identified during this study are key enablers for nurses to use with confidence, to believe in their assessments and effectively manage care.

9.3.1 Knowing the patient: the importance of nursing continuity

One of the key themes to come out of the qualitative data was the importance of the nurse being able to distinguish early changes in the patient as they began to deteriorate. In many instances they attributed this ability to the fact that they knew the patient well. They had got to know the patient as a person and therefore noticed quickly when the person had changed their behaviour, demeanour or appearance. Patients most at risk from sepsis, for example those with haematological cancer or those with solid tumours who have received multimodality treatment, will have been in hospital for weeks or returned several times for successive cycles of treatment. The nurses gave several examples of patients' behaviour changing. For example:

“...it might just be a change in the person one of our patients, you will remember him (name) he went to CCU, he used to always come out of his room and give us chocolates, and the first sign that he wasn't well was that he didn't try to come out of his room”. (TS.02)

These changes in behaviour lead the nurse to take action, such as a closer examination of the patient. Observation is thus linked to critical thinking and action.

In acute care it could be argued that this is one of the most important qualities or skills for a nurse to develop. For patients who are at risk of developing a life-threatening infection or a haemorrhage it is important that the nurse, who is the healthcare professional most often with the patient, notices any small changes in their demeanour, behaviour or appearance. It is often the nurse who will start and coordinate the whole process of rescue. Eventually changes in the patient developing sepsis will become obvious, but the imperative is to discover patients earlier and get help mobilised effectively. The evidence described in chapter three shows that, the earlier the person with sepsis is treated, the greater their chance of survival. Recognition of subtle changes in the person that herald deterioration is an essential part of nursing care.

9.3.2 Knowing the patient: the literature

Knowing patients as individuals and knowing how they usually behave is an important part of the nurse-patient relationship. For this skill and knowledge to be embedded in clinical practice the nurse needs to recognise the need to get to “know” the patient as a person, and the organisation needs to promote continuity of nursing. Liaschenko and colleagues (1999) describe getting to know the patient as a person as essential knowledge that nurses bring to the clinical arena:

“Person knowledge is a potent reminder that the life being lived is the life of the recipient of care”. (Liaschenko et al 1999, p. 39).

An important aspect of the data provided by the nurses in the study is the individuality of behavioural change, so that the nurse is not saying that all patients who go quiet or exhibit a particular type of behaviour are in danger; rather they are reflecting on the individual change in a particular patient. Getting to know a patient in this way requires that the nurse actively and consciously develops a therapeutic relationship with the patient.

For Morse and colleagues (2006), for the relationship to be therapeutic the key characteristic is:

“the engagement, the identification of the nurse with the patient”. (Morse et al 2006, p. 85). They propose a model for nurse-patient engagement that is linked with

nursing actions; they acknowledge that engagement in “first level responses” with the patient requires more energy but assert that this is more rewarding for both patient and nurse. To have an insight into how an individual person is experiencing their cancer and interpreting their illness, nurses need to recognise that this experience is an individual and dynamic phenomenon (O’Connor *et al* 1995). Nightingale (1859) in the chapter “Observation of the sick” in her Notes on Nursing directs nurses to appreciate the difference between individual patients:

“Again the nurse must distinguish between the idiosyncrasies of patients. One likes to suffer out all his suffering alone, to be as little looked after as possible. Another likes to be perpetually made much of and pitied, and to have some one always by him. Both these peculiarities might be observed and indulged much more than they are”. (Nightingale 1859, p.25).

There are common themes that emerge in working with cancer patients or reading the lay literature, but it cannot be assumed that a particular patient will interpret their experience in a standard way. The way for a nurse to gain this understanding is to listen to how the person is interpreting his or her own experience. This means that the nurse must actively ask and then listen and learn from the patient. As nurses, we need to be aware that the expert on how it feels to have this diagnosis, to be undergoing treatment at this time, is the patient.

This finding of the importance of nurse expertise and continuity is an important factor in planning appropriate services for patients with a life-threatening condition. As was reflected upon by one of the outpatient nurses in this study, not knowing the patient makes change recognition more difficult. The retention of expert clinical nurses at the bedside is therefore a key contribution to safe and effective patient care.

9.4 Asking the patient (they always know if there is something wrong)

The next key theme, which links with getting to know the patient as a person, is the nurses' view that the patient always knows if there is something wrong. This may be particularly true when dealing with the “expert patient”, as many cancer patients

receiving acute care become experienced in their care. Again, knowing the patient and being intelligently sensitive to their experience, their current emotional state and their needs is essential. Especially in acute care, the patient is often attuned to the subtle variations of their clinical condition. Cioffi (2000a), in her study looking at why nurses called the Medical Emergency Team (MET) in two hospitals in Australia, included patients' recognition of their own deterioration as one of the four main reasons that nurses alerted the MET. The nurses interviewed in her study commented that the patients reported feeling "different" or "worse than a previous day" (Cioffi 2000a, p. 264). The nurses in Cioffi's study also reported that patients sometimes voiced feeling a sense of doom or fear.

Paradoxically, there are also times when a cancer patient, either consciously or unwittingly, does not act upon their physical deterioration. Patients may stay at home without contacting the hospital when their symptoms such as oral toxicity or severe diarrhoea have reached life-threatening levels. In clinical practice talking to patients about these times, some did not want to trouble the hospital while others were desperate to avoid or delay more hospitalisation. Clinical care is seldom about absolutes but about finding a way to work through the muddle and complexity of practice while acknowledging the individuality of each patient, their family and each nurse in practice. Rolfe describes clinical practice as "a series of unique encounters, each of which is different from all others" (Rolfe 2006b, p. 39).

For many patients undergoing major cancer treatment, there has been a substantial threat to personal control and safety and they are therefore exquisitely aware of a deterioration or change and will often voice this change to the nurses at the bedside.

"The patients usually maybe the first one that actually indicates that there's something wrong. They may not verbalise it, but initially they will probably, eventually say if you start to show concern, people might say: "Actually I don't feel... I feel sick..." (TS. 10)

This experienced clinical nurse indicated that it is not just a matter of respecting that the patient will know, but giving the patient time to vocalise how they are feeling. All nurses have probably been guilty on a busy clinical

day of saying to patients or colleagues, “how are you feeling, are you okay?” and not listening or allowing time for a reply.

Nightingale has this advice for nurses when speaking to patients:

“Always sit down when a sick person is talking business to you, show no signs of hurry, give complete attention and full consideration if your advice is wanted, and go away the moment the subject is ended” (Nightingale 1859, p. 28).

The end of this statement by Nightingale is interesting and perhaps reflects changing attitudes to practice over the intervening years. Sometimes it is following a silence or a seeming end to an exchange that the researcher has experienced the patient starting to voice their fears.

9.5 Making a diagnosis of sepsis

All of the nurses interviewed (10) and 15 of those answering the free text question in the survey (n=85) included assessing the vital signs in their experience of working with the cancer patient developing sepsis. It is notable that more nurses (23) cited a raised temperature than any other sign. This is interesting because, although it is an important warning sign in infection it is of less use as a prediction of sepsis, as illustrated by the quantitative patient data analysis in this study.

Nurse interview 21 and 2 demonstrates that it is not only nurses who can erroneously rely on a change in temperature:

“The patient looked and felt unwell. He had an increasing tachycardia, respiratory rate and was hypotensive 90/50 but had a temperature of 36 degrees Celsius and so the SHO didn’t think he was developing sepsis and did not want to start antibiotics”. (TS. 21)

“You know, spike and be septic at some point erm and the doctors said they would actually wait for her to spike a temperature before would start her on antibiotics, which at the time I thought... well from just knowing patients go... you know... how quickly they can become septic. I don’t know I just felt a bit frustrated, you know”. (TS.02)

It is encouraging that many nurses (19) also mentioned a drop in blood pressure, as this is an important sign of sepsis as illustrated by patient data from this study.

Finally, there were fewer nurses (11) who mentioned changes in respiratory rate as an important predictor of sepsis. This finding was reflected in the questionnaire findings and is a concern, as an increase in respiratory rate is a important indicator of rapid deterioration (Goldhill *et al* 1999, Subbe *et al* 2003). Chellel and colleagues confirmed many CCU outreach teams' findings that the charting of physiological observations is poor and that respiratory rate recording is often missed (Chellel *et al* 2002, DH 2003, Ryan *et al* 2004, McBride *et al* 2005).

9.6 Contacting others to help

The lack of effective communication between teams, anecdotally and reflected in the literature, is a barrier to treatment of patients as they deteriorate on the ward (Brennan *et al* 1991, McQuillan *et al* 1998, Goldhill *et al* 1999, Hillman *et al* 2001, Goldhill 2005, Hillman *et al* 2005, Tourangeau *et al* 2006). Nurses were therefore asked about their experience of convincing others and mobilising the multidisciplinary team. Five issues emerged in response to this question:

1. There were sometimes difficulties with convincing doctors to act quickly;
2. In this specialist cancer hospital there was the feeling among nurses that the doctors did listen and also learnt from experienced cancer nurses on the wards;
3. Senior clinical nurses did not always listen to the more junior nurse on the ward;
4. Nurses and doctors do not share the same language and this sometimes creates difficulties;
5. Ward nurses get around the difficulties in communication by using more senior or specialist nurses such as the Outreach or Patient at Risk Team (PART).

Thirty-five (n=85) nurses reflected on difficulties with convincing medical colleagues to act quickly.

Several nurses reflected back to a time when they were more junior:

“When I was fairly newly qualified I looked after a patient on an admissions ward who became septic and went into DIC – they subsequently died. I felt from early on that the patient deteriorating but could not quantify the... and I could not persuade the HO to review the patient. Neither he nor I realised the speed with which these patients deteriorate”. (Q.158)

“When difficult to convince doctor got PART nurses involved (team of experienced ITU nurses, that are around to support nursing team) of whom did ABGs and convince doctors that patient needed to be in a more suitable environment ITU”. (Q.27)

In many instances these nurses will be liaising with the most junior clinical doctor who, because of alterations to clinical training, may be less clinically prepared than previously (Goldhill 2005). There is also perhaps a characteristic among junior doctors to try to manage the patient themselves without recourse to other teams and specialists (Brennan *et al* 1991, McQuillan *et al* 1998, Goldhill *et al* 1999, Hillman *et al* 2001, Goldhill 2005).

“...and I think it’s probably the most frustrating thing, as a nurse, because you can’t... we’re so... medical doctors are very scientific. The way they deal with figures and they do, you know so they can... they can you know... they like facts and they like to act on those and that’s the way it should be. But I think that when we are with patients all the time I think you feel and see more than just... just the observations you are doing with regard to measurement and erm I think sometimes you do take... you go to the doctors and erm say so and so from an observation point of view but I’m really worried about them... and it is quite frustrating you almost have to wait for that patient to do something so you could then pull them...”
(TS.01)

In contrast to the literature and the questionnaire data, the majority of the nurses interviewed did not recall problems in collaboration with their clinical colleagues.

“I think here it goes better than it does in other hospitals, because I do think that the doctors take you seriously. I do because I think in general they... they value nurses’ opinions in the -----, because we tend to be more

qualified... you know, in that specialty. It normally goes quite well and if I was seriously worried about that patient, then I would express that... erm quite urgently". (TS. 07)

It is possible, however, that, because a majority of the nurses interviewed were fairly senior clinical nurses (average of seven years qualified) and had worked with cancer patients for an average of 3.8 years, they had devised a way in practice of ensuring effective communication. The nurses answering the questionnaire came from a much more diverse group, with 39 nurses having been qualified less than a year and their mean experience of working with cancer patients 2.3 years. The most junior nurse interviewed reflected that she had found it difficult sometimes to get senior clinical nurses to help. She had used this experience and reflected on a way to improve the response to her call for help:

"With one patient I didn't have any backing, I'm sorry its going to sound like I am having a go at everyone it was just before handover... I went into this patient, it was the one who went red. I hadn't seen that before I didn't know what was going on, his temperature was shooting up and his blood pressure was coming down... he wasn't feeling well, I wasn't happy with him, in fact it was the first sepsis I had seen on the ward. I went in to the staff room to let the nurses know... and no one, in fact one of them said, "oh he always looks like that", I'm like no he really doesn't look well, so no one was really I think cause they see it quite a lot they were quite blasé about it... they weren't necessarily thinking that I haven't got the experience to deal with it. I think I had already phoned the doctor and he had said to keep an eye on him... I went back to the patient... his temperature had gone up again... blood pressure was still the same really really low, so I went back and phoned the doctor again and said please can you come... and then one of the F grades came... she didn't sort of take over, but she helped me with him... After that that woke me up 'cause I realised that you're not always going to get help unless you actually specifically ask for it. So after that I wouldn't go in there and say: "I'm a bit worried about so and so. I'd say: can you come and help me"". (TS.04)

This nurse graphically demonstrates two important issues in obtaining timely and effective help: first, the complacency of nurses who have worked in a high-risk

setting for a number of years, and secondly the importance of “framing” information or communication in a way to get an active response.

Having recognised deterioration quickly it is essential that there is an effective and timely response including a thorough assessment and effective communication with the team. Studies have demonstrated that there are deficits in medical and nursing patient assessment and effective, timely communication about change (McQuillan *et al* 1998, McGloin *et al* 1999, Chellel *et al* 2002, DH 2003, Ryan *et al* 2004, McBride *et al* 2005).

Nurses in this study recognised a need to quantify evidence to convince the doctor of deterioration:

“When they go to get in touch with the doctor to have the accurate bullet points of what has happened with the patients. So they’re able to liaise with the doctors”. (TS.10)

“I think probably planting... which is a very subtle way of going up to doctors and saying look you know, what do you think your opinion is about... I’ve just seen this and I’ve seen this, what do you think? ...it’s an encouragement, come and have a look. Rather than being very, very obvious and very, very confrontational about it”. (TS 08)

“I think I’ve learnt to give facts... very strong definitive facts... and to be able to arrange those facts in a way where it highlights my concern, but it also gives a basis on... people to walk into the... go to the patient with knowledge already about what we’re actually looking for”. (TS. 10)

Andrews and Waterman (2005) provide two reasons for this: first, that busy doctors need to prioritise which patients to see, and secondly that precise information makes it easier to determine treatment. Several authors connect the inability of nurses to objectively present deterioration as being linked to a lack of applied physiological knowledge (Clarke 1995, Jordan and Reid 1997, Prowse and Lynne 2000, Clancy *et al* 2002, Clarke and Aiken 2003). In addition to greater applied physiology knowledge, the nurses in this study indicated a need to learn to present or package their data to medical colleagues in a particular way. They discussed presenting factual evidence in bullet points, in a more scientific way. The Early Warning Score

(EWS) or Modified Early Warning Score (MEWS) provide nurses with a way of identifying and monitoring at-risk patients (Goldhill and McNarry 2004, Andrews and Waterman 2005, Ridley 2005). These models or packages of information fulfil some of the functions that nurses felt were important, but they do not address the issues of confidence or ability to influence colleagues or as the nurse interviewed described it, “planting” (TS 08).

9.7 Improving practice: use of the PCT-Q

Of the 85 nurses who returned their post-intervention questionnaire, 48 (56.5%) said they knew how to use the PCT-Q compared to 6.2% (11 nurses) in the pre-intervention questionnaire.

Nurses were asked in the post-intervention interviews and questionnaires about their experience of using the PCT-Q. All nurses who had used the PCT-Q felt that it was useful in practice and easy to use.

The CCU outreach nurses would have used the PCT-Q most, and one of this team was represented in the interview sample:

“I think initially it probably wasn’t used as regularly, so we didn’t feel the benefits as much, but once everyone understood what the study was about it was used very frequently... and often when patients were unwell it did correspond... there were a couple of... bizarre results but apart from a few isolated episodes it did correlate and especially when we did repeat studies on the patient, the changes correlated with their symptoms”. (TS. 01)

Nurses who worked in the bone marrow transplant unit were the bedside nurses who had most experience of using it, and they felt that it had become integrated into their care:

“PCT-Q is used and everyone is quite aware of it and knows all the... I think it’s been a significant test... the doctors have been more proactive in how they treat the patient. It’s also good for us; it’s a good indication of

er... how kind of septic. and possibly you know potentials of what could happen there". (TS.02)

This comment illustrates not only that the PCT-Q had become integrated into nursing care, but that it had achieved one of the aims of using it that is convincing others to act. This response was of course very soon after the PCT-Q had been introduced and the researcher was concerned that over time its use and effectiveness might diminish. The researcher was therefore pleased to hear, two years later in 2008, one of the haematology consultants referring to the use of the PCT-Q during the formal external assessment of the Blood and Marrow Transplant Unit's European accreditation.

9.8 Nurses learning

During the pre-and post-intervention interviews, the ten and then eight nurses were asked about how they learnt in clinical practice and especially about the care of cancer patients developing sepsis. All ten nurses cited experience, reflecting on that experience and remembering particular patients who had deteriorated:

"Because once you actually see one, I mean one patient actually became quite ill, it always leaves you with a lasting impression of what actually happened with that sort of patient. What were they actually doing, it always leaves you with a lasting impression as to how you can actually... Oh you know he's doing this I always remember that patient before he did the same thing". (TS.08)

"When you have been looking after the same patient for a few days, you know how they are. When there is something "just not right" nurses intuition". (Q.41)

This theme of learning from experience and then using that learnt pattern intelligently with each unique patient was shown to be a core focus of nursing clinical development. Another factor that nurses cited in helping them to learn was working with others, notably the teaching sisters/charge nurses or lecturer practitioners and the CCU outreach team. They also mentioned studying on post-basic courses and even, in one case, writing an essay:

“I got a hell of a lot out of an essay I did on multiple myeloma.... and I learnt so much from that”. (TS. 05)

“I think general experience and learning and having sessions... on the diploma course... because... and the other thing as well is I’ve worked a lot with neutropenics in chemotherapy”. (TS. 09)

The nurses were also asked about what they would teach others in practice. There was generally discussion about learning in practice, reflection, mentoring, role modelling, use of the MEWS and the outreach team. Several nurses discussed the problems of communicating with doctors and teaching nurses different ways to communicate

9.9 Improving practice: reflection and intuition

Reflection or “recognition behaviour” is important when patients are especially vulnerable to deteriorating quickly and is a necessary attribute for nurses working with the critically ill and in accident and emergency and coronary care. Cioffi (1997) describes nurses using visual memories of common and unusual events to help them when working in uncertain and complex environments. Benner describes this phenomenon as a clustering of past experiences to prepare the mind (Benner 1984). Muir (2004) describes nurses using pattern recognition, where each new patient or situation will be compared with previous circumstances that have been stored in the nurse’s memory and then compared for their similarity (Muir 2004, p. 52). Reflection on previous experience and using it to inform new clinical scenarios has also been termed “reflection within the moment” where the nurse consciously monitors herself during practice (Johns 1998, p. 14).

Nurses in this study however illustrate the importance of this recognition behaviour in less acute areas. Nurses working in general oncology wards experience more challenges in recognising the “pattern” quickly. There is a higher patient-to-nurse ratio and a much greater diversity of focus. On general wards nurses see less acute deterioration than in a CCU and therefore may be less attuned or ready to recognise it. There is also currently a concentration on reduction of length of stay with greater

turnover and acuity of patients on general wards in the UK (DH 2000, Goldhill 2001, Ryan *et al* 2004, NHS Institute for Innovation and Improvement 2008).

Some nurses in the study described reflection as intuition. Intuition has been linked to clinical practice for many years and is cited in both the medical and the nursing literature. In the medical literature, Alam and Talha (2005) contrast intuition with the evidence-based practice movement, linking intuition with an unexamined clinical experience. Edwards (2004), however, in a short letter to the *Lancet*, exhorts medical colleagues not to ignore intuition but to use it in combination with evidence:

However good our medical systems are, I think the use of intuition and other subliminal signals to our consciousness should not be ignored in our efforts to make medical care as efficient and safe as possible. By all means go for evidence, but do not rule out intuition. They both have their place. (Edwards, 2004, p.387)

More recently, Berwick has challenged hierarchies of evidence, using as an example the problems of using a randomised controlled trial to prove the efficacy of medical emergency teams (Hillman 2005). Berwick concludes that to effect healthcare improvement alternative evidence such as qualitative methods, anthropology and learning from experience need to be used – and viewed as not just as important as the randomised controlled trial but in some cases superior (Berwick 2008, p.1,184).

In the nursing literature, there is more research linked with critical care and intuition than any other branch of nursing (Pyles and Stern 1983, Smith 1988, Rew 1988, Rew 1990, Benner *et al* 1992, Polge 1995, Elcock 1997, Benner *et al* 1999, King and Macleod Clark 2002, Aitken 2003). The key finding that links these studies is rapidity of decision making in an uncertain situation. The nursing literature is divided: some authors, as in the medical literature above, criticise intuition for being anti-science, dependent on the individual or problematic when seen in terms of clinical governance or accountability (Cash 1995, Walsh 1997, Turnbull, 1999). Others see it as an important part of practice, with authors such as Cader *et al* (2005) arguing that nurses use a “cognitive continuum theory” using intuition, analysis or application of evidence depending on the situation (Cader *et al* 2005, p. 403). Donald Schön and Chris Argyris at Massachusetts Institute of Technology theorised

that people have a mental map that they use to act in a certain circumstance. They also suggest that people take an action but use a different explanation if called upon to explain their actions (Argyris & Schön 1974). Schön went on to develop his most acclaimed series of works, developing critical self-reflection in practice. Like John Dewey (1933, p. 123) Schön saw the practitioner's repertoire of images, ideas, examples and actions as essential to reflective thought:

When a practitioner makes sense of a situation he perceives to be unique, he sees it as something already present in his repertoire. To see this site as that one is not to subsume the first under a familiar category or rule. It is, rather, to see the unfamiliar, unique situation as both similar to and different from the familiar one, without at first being able to say similar or different with respect to what. The familiar situation functions as a precedent, or a metaphor, or... an exemplar for the unfamiliar one. (Schön 1983, p.138)

As discussed in chapter four, the phenomenon of intuition has been described variously in the nursing literature but for the purposes of this study it is Croce's definition of intuition that is important: that we intuit anything (static or changing) first at a pre-cognitive level – we intuit the presence of something(s) before we apply a conceptual structure from which we identify them (Croce 1872). Therefore when nurses talk about intuition all they mean by this is that they have some awareness of something. Although they may not articulate this, they then fall victim to Dewey's idea of discomfort – something, either the presence of some subtle cue or the phenomenon of change – creates discomfort which is the stimulus to action (Dewey 1931). The ability to intuit and react appropriately is improved when the nurse knows the patient. Nursing continuity and commitment to the patient as a person is therefore essential to reduce the risk for the cancer patient developing sepsis.

Intuition is useful at times of uncertainty and rapid deterioration, but needs to be coupled even in the most acute situation with practical evidence-based guidelines. A good example of this would be the Advanced Life Support (ALS) guidelines. Many nurses and doctors experienced in emergency care have an intuition that a person is just about to have a cardiac arrest, apparently intuiting very subtle signs in the patient. This must be followed by the rigorous application of the ALS guidelines if

the patient is to have a chance of survival (UKRC 2007). Nursing in acute situations requires decisions to be made at times of uncertainty and it seems that it is these unusual circumstances that are more likely to lead to the use of intuition (Benner *et al* 1999).

9.10 The questionnaire data: 177 pre-intervention questionnaires and 85 post-intervention

The research aims for the questionnaire part of the research were: first, to increase the overall awareness of the risk of sepsis and its consequences for cancer patients across a wide range of nurses across the trust; secondly, to increase the knowledge base of nurses who were caring for patients at risk from sepsis; and thirdly to introduce the PCT-Q across the trust.

A pre-intervention questionnaire was completed by 177 nurses (Q1). These questionnaires were completed at the time of the teaching session. The post-intervention questionnaires (Q2) were sent out eight months later to every nurse who had received the teaching session, 18 of the nurses had left the hospital and despite two reminder letters only 85 questionnaires were received back. There was therefore a 58.6% return of Q2, Although disappointing this is still a good number as response rates to postal questionnaires are often as low as 28-35% (Kaplowitz *et al* 2004, Edwards *et al* 2009).

9.10.1 The questionnaires

The questionnaires were the same apart from an additional question in the first questionnaire. The questionnaires were designed to be quick to complete, with 15 questions in the first and 14 in the second. Q1 and Q2 (see appendices 10 and 11) were the same pre and post intervention apart from the last section. In Q1 the nurses were asked to include a free text answer on their experience of caring for someone with sepsis and mobilising the multidisciplinary team. Both questionnaires had three sections: (a) a section on knowledge of the sepsis syndrome; (b) the serum markers of sepsis; and (c) sepsis and using the PCT-Q experience. The intervention was a 40-

minute PowerPoint teaching session on the sepsis syndrome, risk factors, incidence, mortality rates, immunological markers and the PCT-Q (see appendix 7).

9.11 Nurse demographic information

9.11.1 Experience of working with cancer patients

In the pre-intervention sample (n=177), the mean period of time that nurses had worked with cancer patients was 2.33 years, and 39 nurses had less than one year's experience and 21 nurses had more than ten years' experience. In the post-intervention sample (n=85) the mean experience was slightly higher at 2.67 years, while 12 nurses had less than one year's experience and 11 more than ten years'.

9.11.2 Nursing location

In both samples the nurses were well distributed across all wards of the trust, but there were more nurses from the acute areas such as CCU and the bone marrow transplant units.

9.11.3 Post registration qualifications in cancer nursing

There were a greater number of nurses in the second sample that had a cancer qualification (64.71% versus 57.1%) in the first sample. The qualifications ranged from stand-alone diploma modules to two nurses with a Masters Science degree.

9.12 Knowledge regarding sepsis

In Q1, 39% of nurses answered that their knowledge was not up to date on the sepsis syndrome, compared to 6% in Q2. More than double the number of the second group (20% versus 6%) answered yes, that their knowledge was up to date. Nurses were then asked to describe the four stages of the sepsis syndrome. These stages are well described in the literature and have been the standard definitions used since 1992 (Bone *et al* 1992, Dellinger *et al* 2004, 2008). This question proved to be difficult for nurses to answer. In Q1, 74 nurses did not answer this question and 13 wrote that they did not understand the question. In Q2, 23 nurses did not answer and two did not understand. A greater number of nurses in Q2 were able to provide more than the

first three stages of the sepsis syndrome. In Q1 only 1.1% achieved more than three, while in Q2 25.9% had achieved four or five stages. These were, however, small numbers and the difference did not reach statistical significance.

On being asked about the mortality rate for healthy people with sepsis, in Q1 20 nurses (11.3%) answered this question correctly. In Q2 the number improved to 28 (32.9%) and did reach statistical significance ($p < .001$). Although the knowledge had improved, 59% of answers were still wrong after the intervention. For mortality rates for the person with cancer, in Q1 91 nurses (71%) answered correctly with 49 abstaining. In Q2, 53 (84%) answered correctly with 16 missing answers. The improvement is statistically significant, but it is disappointing that there were 16 nurses who did not answer.

The next question asked nurses to list the early signs of sepsis. The two questionnaires had similar answers with one important difference: tachypnoea. In Q1 only 28.2% of the nurses identified that tachypnoea is an important early sign of sepsis, whereas in Q2 60% of the nurses identified tachypnoea. This is an important improvement as the respiratory rate is one of the most important signs of critical deterioration (Goldhill *et al* 1999, Subbe *et al* 2003), but in practice it is often not recorded or poorly recorded (Chellel 2002, DH 2003, Ryan *et al* 2004, McBride *et al* 2005).

The next question addressed the immunological markers of sepsis. Although there was an improvement in the nurses' knowledge it did not reach statistical significance. With PCT, however, and perhaps unsurprisingly given its significance in the study, there was a statistically significant improvement in awareness ($p = .001$) and of how to use it in practice ($p < .001$).

The final section of the questionnaire concentrated on the care of the patient once sepsis had been diagnosed. Answering who they would contact, there was a statistically significant difference between the two groups ($p = .008$) with Q2 nurses contacting more appropriate personnel including more contact with CCU. Lastly, nurses were asked whether they had ever had difficulty convincing others of a patient's deterioration. A higher percentage of nurses in Q2 answered yes to this

question (64.7% compared to 46.9%) but the difference was not statistically significant ($p=.139$).

The free text from the last question in Q1 is analysed together with the other qualitative data (see chapter six, section 6.6).

9.13 Nurse Questionnaires: Conclusion from the findings

In conclusion, 177 nurses working on days and nights across the trust received a dedicated teaching session on sepsis that was based on the latest evidence.

The analysis of the 85 pre and post questionnaires revealed five areas where there was a statistically significant improvement in knowledge:

1. The mortality rate for severe sepsis in previously healthy adults;
2. The mortality rate for severe sepsis in patients with cancer;
3. The nurse's knowledge of PCT and CRP;
4. How to use the PCT-Q; and
5. Which HCPs would be contacted if a patient was developing sepsis.

There were also a further four areas where an improvement was demonstrated but did not reach statistical significance:

7. Listing the different stages of the sepsis syndrome;
8. Tachypnoea as an early sign of sepsis;
9. Listing three indicators of sepsis; and
10. Recalling a time when a patient was deteriorating but it was difficult to convince others.

For the knowledge acquisition questions nine out of eleven thus showed an improvement with five reaching statistical significance. These included important practice improvement issues such as raising awareness of the dangers of sepsis in the cancer patient and recognising a raised respiratory rate as an important indicator of deterioration. Finally the questionnaires and teaching session prepared 177 nurses for using the PCT-Q during the patient part of the study.

An important contribution of this part of the study was reaching nurses right across the trust on all wards and on all shifts. The limitations were that in four questions only a small improvement was demonstrated and there was only a 58.6% return of the second questionnaire despite a reminder letter.

9.14 Sepsis admissions and deaths during the study period compared to the three preceding years: study limitations

During the study year, January 2005 to February 2006, there were 20 deaths due to sepsis. Most were on the CCU (18), with one on a general ward and one on the Step Up unit. This was compared to the archival data for the previous three years:

2002: 41 deaths due to sepsis and 695 admissions (6%)

2003: 36 deaths due to sepsis and 789 admissions (5%)

2004: 26 deaths due to sepsis and 710 admissions (4%)

2005: 20 deaths due to sepsis and 651 admissions* (3%)

*study period

There are however limitations to the interpretation of this data, for the following reasons:

1. The CCU electronic database had not been completed accurately; therefore information about cause of death from previous years may not be accurate. In an attempt to improve the integrity of the data the researcher and the nurse researcher for critical care nursing went through many of the death certificates, but these had limited details and often only details about the cancer.
2. The acuity and complexity of the surgical admissions to the CCU have changed markedly over the last four years. In 2004, the hospital became a major centre for hepato-biliary and upper GI surgery and there was therefore a major increase in level 3 surgical patients. The haemato-oncology population has however remained fairly stable.
3. A major change to the configuration of the critical care service took place in October 2004, which resulted in all critically ill patients being cared for together in one large unit. There are several advantages to this

reconfiguration and evidence that the survival figures generally have improved.

It is therefore not possible to conclude that the use of the PCT-Q alone has improved the outcome of cancer patients who develop sepsis. It is important to note, however, that, despite significantly more level 3 patients in the study year admitted to the CCU as an emergency due to sepsis 94 as opposed to 45, there were still fewer deaths overall from sepsis. Level 3 patients are those who require full intensive care support of at least one organ and often more, for example mechanical ventilation and renal replacement therapy. To put this into context, if the mortality rate for the haemato-oncology patients alone who developed sepsis is compared to the literature, then the survival figure of 66% is excellent (34% mortality) compared to published mortality rates of 65% to 85% (Groeger 1991, Chernecky and Berger 1998, Aisenberg *et al* 2004, Cone *et al* 2004, Scales *et al* 2008). Early diagnosis and treatment of sepsis is one of the key elements in survival for these patients and the data presented below demonstrates that the majority of patients who developed sepsis during the study were diagnosed at the early stage.

9.15 Patient Data: Use of the PCT-Q

The aim of the patient data part of the study was to investigate the use of the PCT-Q by ward and CCU nurses as a part of their assessment in the early recognition of sepsis. The validity, reliability, sensitivity and specificity of PCT as a diagnostic indicator for sepsis in the neutropenic and non-neutropenic adult and child has been demonstrated many times since its discovery in 1983 (Assicot *et al* 1993, Al-Nawas *et al* 1996, Rothenburger *et al* 1999, Delevaux *et al* 2003, Clec'h *et al* 2004, Mitaka *et al* 2005). Since its development in 1996, the validity and reliability of the rapid bedside test (the PCT-Q) has been established in two studies in children (Fenandez Lopes *et al* 2003, Casado-Flores *et al* 2006) and four in adults (Meisner *et al* 2000a,b, Pinkola *et al* 2001, Makay *et al* 2003, Olah *et al* 2005).

This study adds new work to the data on the PCT-Q: it is the first time it has been used by general ward nurses; with a large sample (416); and used exclusively with cancer patients. In common with previous studies, the PCT-Q was compared in this

study to the blood tests currently used in the host hospital to predict sepsis. The markers that were measured with the PCT-Q were CRP, WBC and lactate. The researcher had not originally intended to compare PCT with CRP as the superiority of PCT has been shown many times in robust studies (Delevaux *et al* 2003, Luzzani *et al* 2003, Clec'h *et al* 2004). On presenting the research protocol to the scientific peer review committee at the host hospital, medical consultants who were not familiar with the work on PCT were keen to continue to measure CRP. The researcher agreed to this as it constituted current practice and CRP is an indicator of a general deterioration.

An Excel spreadsheet was used to correlate the use of the PCT-Q with the individual patient data (see appendix 14). All relevant patient details such as gender, age, type of cancer and type of treatment were entered. Clinical details, especially those denoting the various stages of the sepsis syndrome (SIRS, sepsis, severe sepsis, septic shock definitions) were recorded, together with blood markers and the PCT-Q result. Other patient variables recorded were the microbiology and finally the patient episode outcome and the hospital outcome. From this database it was possible to extrapolate whether any PCT-Q tests had been done unnecessarily. It was also important to be able to assess whether there were any occasions when the PCT-Q was not done but should have been, or where the PCT-Q result was inaccurate. The general CCU and Step Up electronic database was used as the historical control to ascertain whether using the PCT-Q had brought forward the sepsis diagnosis.

9.15.1 Patient characteristics

There were 176 men and 141 women recruited into the study (n=317). In the complete sepsis episode data set that is used throughout this chapter (where some patients had more than one episode) there were 233 men and 183 women (n=416). The ages of the patients ranged from 18 to 86 with a mean of 54.5 years. Patients had a range of diagnoses including the common cancers breast, lung, gynaecological, urological and lower and upper gastrointestinal, and the rare cancers leukaemia, myeloma, lymphoma, neurological, head and neck, sarcoma and disseminated melanoma. As expected, of all cancers the haematological malignancies – the group most at risk from sepsis – were the most commonly recruited. Leukaemia represented the largest group with 96 patients (23.4%); lymphoma 78 patients

(18.8%); and myeloma 47 patients (11.3%). The haematological cancers therefore represent 222 patients (n=416) or 53.5% of the whole sample. Of the patients with solid tumours, the greatest number represented in the sample were those patients with upper gastrointestinal cancer (upper GI): 45 patients (10.8%). Patients with upper GI cancer tend to be older and to have comorbid conditions such as ischemic heart disease, chronic pulmonary disease and diabetes and are therefore also at greater risk of developing sepsis (DH 2001, Abunasra *et al* 2005).

There are several other factors that predispose patients to developing sepsis, for example age and the presence or absence of co morbid conditions (Mavrommatis *et al* 2001, Cariou *et al* 2002, Yamamoto *et al* 2002, Aird 2003, Knobl 2005). Treatment-related factors are also important: in this study the most common associated treatment was chemotherapy with 186 patients or 44.7% (n=416). Surprisingly, patients having surgery and those who had had a blood or marrow transplant were similarly sized groups: those who had surgery numbered 89 patients and those who had had a transplant numbered 90 patients. This may be explained by the fact that many of the patients who had had surgery were from the upper GI group as discussed above.

9.15.2 Use of the PCT-Q to improve the early recognition of sepsis in cancer patients

The 416 episodes were correlated with the stage of the sepsis syndrome when the nurse decided to use the PCT-Q. As described in the introduction there are four stages of the sepsis syndrome, with the first the early stage and the fourth septic shock and multi-organ failure requiring all critical care support:

1. Systemic Inflammatory Response Syndrome (SIRS);
2. Sepsis;
3. Severe sepsis; and
4. Septic shock and Multi Organ Dysfunction Syndrome (MODS) (Bone *et al* 1992).

An early diagnosis would mean that the PCT-Q was used when the patient had the characteristics of SIRS. The highest number of patients, 163 (39.2%, n=420), were recruited at the SIRS stage with 112 (26.9%) being recruited at the next stage

(sepsis). The only difference between SIRS and sepsis is that at the sepsis stage all other causes of inflammatory change have been discounted. Therefore 66.1% of patients were identified at an early stage before the onset of severe haemodynamic instability, acidosis and multi-organ failure. It was not possible to compare this result directly with archival results, as comparable data had not previously been collected. It is however important, when the early signs of sepsis are so subtle, that a majority of patients in this study were diagnosed at an early stage. The evidence from the literature on failure to rescue, problems with monitoring and recognising critical illness illustrate that this is a major patient care challenge (McQuillan *et al* 1998, McGloin *et al* 1999, Chellel *et al* 2002, DH 2003, Goldhill *et al* 2005).

9.15.3 The correlation of the PCT-Q with sepsis compared to the other inflammatory markers: WBC, CRP and lactate

Procalcitonin has been evaluated in many studies for validity, reliability, sensitivity and specificity, both on its own and in combination with other markers. No published study has compared the PCT-Q with CRP, lactate and WBC when diagnosing sepsis. It was important to include WBC as this is a reliable and easily-measured marker that ward and CCU nurses are equally familiar with monitoring. It is also important to monitor in the cancer population, as cancer patients may have an abnormally low WBC due to their disease or treatment. Lactate level is monitored in the critically ill, with raised levels >5 mmol/l being associated with impaired tissue oxygenation and a high mortality rate. Lactate levels are monitored using blood analysed from a venous or arterial blood gas test (Clec'h *et al* 2004, Fall and Szerlip 2005). As described earlier, CRP was the test most commonly used at the trust to indicate a general inflammatory response. PCT had not previously been used in the trust and neither had the PCT-Q – the bedside test.

The first analysis used was univariate ordinal logistic regression analysis of each variable:

1. WBC: Using the WBC as a categorical variable with the absolute value or banding it into three areas (low, normal or high), the WBC is a statistically significant predictor of late-stage sepsis when the WBC is low <1 or high >20.1 . Of these two levels, the lowest (WBC <1) is the

strongest predictor giving a six times greater odds of late-stage sepsis than a normal WBC count. The high WBC count (>20.1) gives two times the odds.

2. Lactate was also a statistically significant predictor of sepsis, with a high value >4 giving a four times greater risk of developing late-stage sepsis.
3. CRP does not reach statistical significance, $p=0.194$.
4. PCT is statistically significantly correlated with sepsis, with a high PCT reading of 10 or >10 giving a two times greater odds of developing late-sepsis. Therefore, of all the four indicators CRP was the only one that did not reach statistical significance. Of the other three, a low WBC indicates the highest odds (WBC <1 at six times the odds), a lactate level >4 gives four times the odds, PCT at a level of >10 gives two times the odds, and finally a high WBC > 20.1 gives twice the odds.

Finally, a multivariate logistic regression analysis was performed to compare the four indicators (including MAP) that were significant on univariate analysis with each other. At the final step of this analysis CRP was removed by the model although the four other indicators were retained.

9.15.4 Unnecessary tests

There were 11 ($n=420$) PCT-Q tests performed in patients who did not have and never developed sepsis. Therefore in 409 cases out of 420 nurses accurately identified the onset of sepsis, and in 66.6% of these they identified it at the early stage, when there would have been few obvious signs or symptoms. This is important as it suggests an extraordinary ability on the part of nurses to detect sepsis.

9.15.5 Patients who developed sepsis but no test was performed

There were 11 patients admitted either to the Step Up or CCU with sepsis who had not had a PCT-Q performed prior to admission. These numbers are an important part of the analysis as they indicate that the nurses were using the PCT-Q appropriately the majority of the time (398, $n=416$). This coupled with the previous comment about the 11 inappropriate tests suggests an extraordinary degree of precision or specificity, not only did nearly all the patients who were tested turn out to have been

tested appropriately, but nearly all those who were not tested were also not tested appropriately.

9.15.6 Inaccurate PCT-Q tests

There were three (n=416) PCT-Q tests that were high (>10 ngs/ml) and the patient never developed sepsis. This finding replicates the work by Clec'h and colleagues (2004) who had six patients (n=75) in their study with high PCT-Q values without sepsis.

This study has been able to demonstrate that the PCT-Q used for the first time by ward nurses was accurate in predicting sepsis at an early stage. The nurses also used the PCT-Q reliably for a majority of the time, with 11 tests done erroneously and 11 tests not performed before admission to CCU or Step Up (n=416).

9.16 The research journey, strengths and limitations to the study

The researcher has worked clinically for over 20 years in acute care, mainly in the field of critical care for adults, and for the last 15 years working with the critically ill person with cancer. The experience of the researcher, substantiated by the literature, is that the sickest patients to be admitted to a CCU are already in-patients (Hillman *et al* 2005, Sakr *et al* 2008). These patients are often admitted at a late stage of acute illness and the CCU staff, the patient and their family are then engaged in a desperate battle for their survival. It was this experience and a visit to Chicago to see the work of Dr Emmanuel Rivers, who had tried to link the emergency department and wards that was the inspiration to work with ward and CCU nurses to improve early recognition and then rescue. Having been involved in the start of CCU outreach teams in the UK, this was the next step. The researcher's clinical experience of many years talking with ward nurses was that they had often been worried about patients but had not had the confidence or "tools" to convince others. This study was therefore designed to try and improve this area of practice by raising awareness of sepsis, providing an extra tool to aid in nursing assessment (one that would be understood and meaningful to all disciplines) and exploring nurses'

experience and listening to their advice about the way they learnt and taught others. Table 9.1 (page 230) illustrates the achievements of the study in achieving the overall and subsidiary aims but also the limitations and therefore learning points for future research.

An experimental design was contemplated but rejected, as the researcher was keen to improve practice in all its complexity and muddle and not impose an artificial model that would not exist when the study had finished. The researcher was also concerned that a randomised controlled trial would pose major ethical challenges as the PCT-Q was already validated as the most useful predictive tool for sepsis. An historical reference was therefore chosen to evaluate the efficacy of the study: that of the mortality rate in the study year. The hypothesis was that early detection, coupled with generally raised awareness and a tool to help convince others, would translate into early rescue and therefore a lowered mortality rate. The mortality rate did improve over the study year, despite a greater number of critically ill patients, but one of the limitations to this study was that other variables could have contributed to this improvement. It would have been useful to compare stage of sepsis referral in the host hospital, but unfortunately detailed historical data was not available.

The other endpoints were to increase awareness and education regarding sepsis, and analysis of the 85 questionnaires did reveal an improvement in knowledge over the six to eight months. The PCT-Q behaved as expected from the literature as a reliable indicator of the stages of sepsis but, more meaningfully for the researcher, has remained as a core tool for nurses and doctors at the study hospital. The researcher was concerned that once the study had finished the PCT-Q would be forgotten, but it is now included in the assessment documentation of nurses and doctors and is used to follow the progress of sepsis in the CCU. Finally, the information gathered from the nurses in the interviews and qualitative section of the questionnaire has been used in formal education sessions and the mentorship of new practice educators in the host hospital.

The findings of the research have been discussed locally and presented at national and international cancer and intensive care conferences. This study has also led to ideas for further research which are discussed in Chapter Ten.

9.17 Conclusion

The experiences of 187 nurses in the qualitative part of the study illustrate the importance of the nurse's recognition of the early changes of deterioration due to sepsis. As described in chapter three the first signs of sepsis deterioration are very subtle and difficult to recognise thus the importance of intuition and preparedness in the theoretical framework for this study. From the many descriptions and models of intuition the researcher has chosen Croce's definition coupled with Dewey's description of "discomfort" as a stimulus to action (Croce 1866-1952, Dewey 1932).

Subtle changes in behaviour are particularly recognisable to the nurse when he or she has got to know the patient as a person. Continuity of nursing is therefore an important part of care provision if the nurse is to recognise subtle changes in the person she has come to know. These qualitative and less tangible signs can be used in further assessment and early mobilisation of the team. Linked to the importance of knowing the patient as a person is listening to the patient's own narrative of their experience. In both this study and those of Cioffi (2000a,b), the patient can reliably predict early changes and it is therefore essential that their narrative is encouraged and used. Both the nurses' and patients' oral testimonies are important indicators of early deterioration and can therefore be used as part of clinical assessment.

The questionnaire and the qualitative interviews demonstrated that nurses and doctors do not always share the same language. Nurses felt their language to be "less scientific" and that they needed to package their information in a particular way to gain the doctors' attention. Experienced nurses, however, were able to demonstrate that even using qualitative assessments of their patients they were able to convince doctors to see the patient and initiate effective treatment quickly. When nurses are not confident in their pathophysiological knowledge they are less able to provide a quantitative account of patient deterioration. The questionnaire survey found that the nurses' knowledge on sepsis was limited and that they recognised this and wanted to improve. In a contrary case in the interviews, a junior nurse recounted that she only had recourse to the patient's observations as she did not feel that she had the experience to notice anything qualitative. Where there is no continuity of expert nursing at the bedside or the nursing resource is inexperienced or unmatched to need,

then quantitative tools such as scoring systems can be useful tools. The PCT-Q has been shown in this study to be an easy-to-use, reliable and valid tool in highlighting the patient who is developing sepsis. This study was not designed to evaluate the use of the MEWS or the CCOT, but several nurses commented positively on using the MEWS and working with the CCOT.

When nurses discussed the way they learn in practice, intuition, experience and reflection were highlighted as the predominant methods, together with working with more senior nurses, formal education and even in one case writing an essay. The nurses' empirical knowledge of sepsis did improve throughout the study, but the study was not designed to measure whether this improved practice. It is encouraging, however, that nurses' recognition of when to use the PCT-Q was accurate in 394 (93%) of cases (n=416) and the teaching intervention may therefore have been useful.

As discussed earlier, the teaching session and the interviews provided opportunities for the nurse researcher to work with 187 nurses across the trust. This protected time led directly to the development of three unexpected clinical practice developments:

1. A new observation monitoring chart was developed by two of the outreach nurses in liaison with the ward nurses. The background of the chart is coloured on areas outside physiological norms as reflected in the MEWS chart. Thus a low or high respiratory rate is recorded against a red background, indicating to the nurse who uses it that the patient is scoring high on the MEWS and is at risk and to contact the outreach team.
2. The MEWS posters were reprinted and laminated to replace those that had been lost on some wards. Several wards elected to place a copy of the MEWS in each patient's bedside folder.
3. A session on the importance of the oral testimony of the bedside nurse is now included in the researcher's advanced life support teaching with the SHOs on their six-monthly induction to the hospital.

The researcher has also noted during her clinical experience that the doctors most involved with the study – those on the BMT unit and CCU – have found the PCT-Q useful and have now incorporated it into their daily blood test sheets. Lastly, the

outcome of cancer patients with sepsis during the study period improved, with only 20 deaths in one year. As noted earlier, other factors could have contributed to this, but the early recognition of sepsis has been shown to improve survival. In this study of 416 episodes of sepsis in 320 people with cancer, ward and CCU nurses identified the sepsis accurately in 93% of cases. Nurses also reflected that having a semi-quantitative tool to “back up” their early clinical assessments translated into improved communication with their colleagues and therefore more immediate intervention.

Table 9.1: Overview of theoretical framework, research aims, methods and key findings

Research Aims	Method	Key Findings
<p>Subsidiary aims: Research stage 1</p> <ol style="list-style-type: none"> 1. Experience of caring for cancer patients with sepsis 2. Experience of communicating with and mobilising the multi-professional team about a patient deteriorating with sepsis. 3. Introduction to a new bedside blood test –PCT-Q. 4. Experience of the patient deteriorating from sepsis. 5. The experience of using the PCT-Q in practice, 6. Nurses’ accounts of the optimal ways of learning and developing their practice, 7. How nurses think an effective multi-professional response with a deteriorating patient can be improved. 8. Nurses’ recommendations to improve the early detection and treatment of cancer patients. 	<p>18 pre and post qualitative interviews / Open question on questionnaire to 177 nurses.</p>	<ol style="list-style-type: none"> 1. Knowing the patient: the importance of nursing continuity: recognition of early changes either measurable or less tangible; 2. Making a diagnosis of sepsis: using vital signs, urine output, septic screen and the PCT-Q; 3. Contacting others to help: difficulty in persuading doctors at an early stage but senior nurses able to help, one example of a good coordinated response; 4. Asking the patient: they always know something is wrong and are often the first to raise the alarm; 5. Being aware of (the risk of) sepsis: even on wards that rarely see it, and that haematology patients are more at risk; 6. Nurses learning: develop confidence using reflection, experience and education and how they teach others; 7. Reflecting on failure: failure to get help early resulted in a patient’s death; 8. Improving practice: examples were provided about how to improve practice, which have led to practice developments.
<p>Research stage 2</p> <ol style="list-style-type: none"> 1. Raising awareness of sepsis. 2. Assessment of nurses’ knowledge 	<p>Pre and post-intervention questionnaires to 177 nurses across the hospital (pre) and 85</p>	<ol style="list-style-type: none"> 1. The questionnaire survey and educational intervention was delivered to 177 (53%) of the nurses across the Trust who worked on days and nights on the acute care wards (n=320).

Research Aims	Method	Key Findings
<p>of sepsis incidence, mortality risk, early diagnostic tests, procalcitonin and its role in the early diagnosis of sepsis.</p> <p>3. Introduction to a new bedside blood test –PCT-Q.</p> <p>4. Examples of patients deteriorating with sepsis and nurses finding it difficult to convince the team.</p> <p>5. Changes in nurses' awareness and knowledge regarding sepsis: incidence, mortality risk, early diagnostic tests, procalcitonin and its role in the early diagnosis of sepsis.</p> <p>6. The nurses' experience of using the PCT-Q in practice.</p> <p>7. The nurses experience of thinking that a patient was deteriorating but finding it difficult to convince other nurses/doctors or other health care professionals. Examples from practice.</p>	<p>(post) intervention.</p>	<p>2. The educational intervention contained the latest international evidence on sepsis, the risk for cancer patients, assessment and management.</p> <p>3. Nurses were taught about predictive markers and introduced to procalcitonin and to the PCT-Q for the first time.</p> <p>4. 75 nurses (n=177) took the opportunity to provide an example of a patient deteriorating and finding it difficult to convince the multi-professional team.</p> <p>The pre-intervention questionnaire demonstrated a lack of knowledge regarding acute deterioration due to sepsis. In comparing the two questionnaires answered by 85 nurses knowledge had improved. Five answers demonstrated an improvement that was statistically significant and four areas where an improvement was demonstrated but did not reach statistical significance.</p> <p>A limitation of this stage of the research was that only 85 nurses answered the post-intervention questionnaire, and that the questionnaire was only designed to test one type of knowledge acquisition.</p>
<p>Research stage 3 Intervention (a)</p> <p>1. Ward teaching sessions on the cancer patient and sepsis, associated risks and mortality rate, the evidence on early diagnosis and treatment, assessment tools and procalcitonin.</p>	<p>Provided to 177 nurses across the Trust following the pre-intervention questionnaire.</p>	

Research Aims	Method	Key Findings
<p>2. Introduction to the use of the PCT-Q bedside test.</p> <p>Research stage 3 Intervention (b)</p> <p>1. Introduction of the bedside PCT-Q test in the hospital for the first time. PCT-Q bedside blood test used on all patients that nurses assess as showing early signs of sepsis.</p> <p>2. Each patient recruited for the PCT-Q test to have all other infection markers mapped to be able to compare the efficacy of the PCT-Q test to those usually used in the hospital.</p> <p>3. All patients entered into the study to have episode and hospital outcomes mapped with the objective of comparing outcomes of those who had PCT-Q measured in the study year to outcomes in the three previous years when the PCT-Q was not available,</p> <p>Research stage 4</p> <p>1. Assess if the PCT-Q is used</p>	<p>1. 320 patients recruited and 416 episodes of sepsis assessed using the PCT-Q.</p> <p>2. PCT-Q results compared with Mean Arterial Pressure (MAP), White Blood Cell (WBC) count, lactate and C-reactive protein (CRP).</p> <p>3. Patient data set compared with the archival data for the three years prior to the study. Data used gathered from medical notes, nursing care plan, CCU and Step Up admission data and death certificates.</p> <p>PCT-Q patient survey with patients receiving acute care</p>	<p>1. In 398 out of 416 cases the PCT-Q was used appropriately.</p>

Research Aims	Method	Key Findings																																																					
<p>appropriately.</p> <p>2. Assess is using the PCT-Q in sepsis assessment means that sepsis is diagnosed earlier.</p> <p>3. The performance of the PCT-Q compared to the sepsis predictive markers already used by the hospital: WBC, CRP, lactate, MAP.</p> <p>4. The effect of introducing the two interventions: education and the PCT-Q on sepsis episodes and outcomes compared to the three previous years.</p>	<p>across the hospital.</p>	<p>2. In 409 cases out of 420 nurses accurately identified the onset of sepsis, and in 66.6% of these they identified it at the early stage, when there would have been few obvious signs or symptoms. This is important as it suggests an extraordinary ability on the part of nurses to detect sepsis. Higher than the relevant research literature.</p> <p>3. Performance of the PCT-Q: Multivariate Model PCT-Q performed well in comparison to the other sepsis predictive markers. CRP performed poorly as seen in relevant literature.</p> <table border="1"> <thead> <tr> <th>Parameter Estimates</th> <th>Odds ratio</th> <th>Sig.</th> <th>95% Confidence Interval</th> </tr> </thead> <tbody> <tr> <td rowspan="3">PCT</td> <td>Positive</td> <td>1.84</td> <td>0.007</td> <td>1.186</td> <td>2.864</td> </tr> <tr> <td>Negative</td> <td>1</td> <td></td> <td></td> <td></td> </tr> <tr> <td>Low<=4</td> <td>1</td> <td></td> <td></td> <td></td> </tr> <tr> <td rowspan="2">Lactate</td> <td>High>4</td> <td>2.97</td> <td>0.006</td> <td>1.356</td> <td>6.493</td> </tr> <tr> <td>Low</td> <td>5.39</td> <td>0.000</td> <td>3.050</td> <td>9.528</td> </tr> <tr> <td rowspan="2">WBC</td> <td>Normal</td> <td>1</td> <td></td> <td></td> <td></td> </tr> <tr> <td>High</td> <td>1.80</td> <td>0.066</td> <td>0.962</td> <td>3.378</td> </tr> <tr> <td rowspan="2">MAP</td> <td>Low</td> <td>2.17</td> <td>0.000</td> <td>1.406</td> <td>3.358</td> </tr> <tr> <td>High</td> <td>1</td> <td></td> <td></td> <td></td> </tr> </tbody> </table> <p>4. The comparison of sepsis episodes and outcomes against previous three years data was a limitation of the study in that the archival data was not complete and the delivery patterns had changed over 4 years.</p>	Parameter Estimates	Odds ratio	Sig.	95% Confidence Interval	PCT	Positive	1.84	0.007	1.186	2.864	Negative	1				Low<=4	1				Lactate	High>4	2.97	0.006	1.356	6.493	Low	5.39	0.000	3.050	9.528	WBC	Normal	1				High	1.80	0.066	0.962	3.378	MAP	Low	2.17	0.000	1.406	3.358	High	1			
Parameter Estimates	Odds ratio	Sig.	95% Confidence Interval																																																				
PCT	Positive	1.84	0.007	1.186	2.864																																																		
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Research Aims	Method	Key Findings
<p>Research stage 5 Overall Aim Investigate nurses' role in the early diagnosis of sepsis, to provide nurses with a new objective tool and dedicated education to improve early diagnosis and rescue.</p>	<p>Integration of the qualitative data and comparison with the quantitative data. 1. Pre and post – intervention qualitative interviews Interventions 2. Pre and post intervention questionnaires 3 Interventions 3(a) Dedicated teaching session on sepsis 3(b) Implementation of the PCT-Q bedside blood test. 4. PCT-Q patient stage</p>	<p>The mortality data for the study year was reduced despite increased admissions but this could have been due to several variables, Cancer nurses can and do recognise sepsis, consistently and accurately, and at an early stage. In 398 out of 416 cases (93%) the PCT-Q was used appropriately. In 66% cases patients were diagnosed at the early stages of sepsis which is high compared with the literature and clinical experience. Nurses reported that the PCT-Q helped giving them confidence and a vehicle with which to communicate effectively with the multi-professional team and achieve early rescue. The study has also led to other practice developments, such as a new physiological observation chart, improved documentation of deterioration on general wards and increased teaching for nurses and junior doctors on the need for collaboration in the early rescue of the cancer patient with sepsis. Nurses were also able to describe the way they learn most effectively, and these recommendations have been built into clinical supervision and postgraduate education programmes in the hospital's school of nursing.</p>

Chapter 10 Conclusion and implications for future research

10.1 Introduction

Nurses in an acute cancer setting are the healthcare professionals most in contact with the patient and are in a position to notice changes in the patient's condition and alert others. There are blocks to recognition, monitoring and then mobilisation of an effective and timely rescue for the patient. Nurses are working in increasingly pressured environments, with sicker patients on general wards and less resource to care for them. In the cancer centre where the research was undertaken, there are more junior nurses working in acute areas such as the bone marrow transplant unit that have less experience in acute cancer care. Junior doctors also have less clinical experience, with reduced practice hours in their training. There is evidence that there are serious delays to effective care in hospitals due to problems in communication both within and between disciplines, cultural problems with junior professionals unwilling to consult senior colleagues, and nurses and doctors not recognising the early signs of an acute deterioration (McQuillan *et al* 1998, McGloin *et al* 1999, Goldhill *et al* 1999 Chellel *et al* 2002, Clarke and Aiken 2003, DH 2003, Goldhill *et al* 2005). It was against the background of increasing incidence of sepsis, reduced resource on the wards, evidence of ineffective care and resultant increase in admissions to CCU that the present study was designed.

The research study described in this thesis has demonstrated that cancer nurses can and do recognise sepsis, consistently and accurately, at an early stage. In the period since the study was completed there has been evidence that the awareness of sepsis and the use of the PCT-Q have increased, as teaching on the sepsis syndrome and the use of the PCT-Q have been embedded in the practice of the hospital. It is essential that cancer nurses are encouraged and supported to use this information in an effective way to mobilise the multidisciplinary team to effect an early rescue for the cancer patient developing sepsis. The study has also led to other practice developments, such as a new physiological observation chart, improved documentation of deterioration on general wards and increased teaching for nurses and junior doctors on the need for collaboration in the early rescue of the cancer patient with sepsis. Nurses were also able to describe the way they learn most effectively, and these

recommendations have been built into clinical supervision and postgraduate education programmes in the hospital's school of nursing. A weakness of the design was its complexity but also the reliance on historical data, some of which was missing, for comparison of mortality data. The lack of robust archival data and some changes to the delivery of critical care during the study period means that it cannot safely be concluded that this research directly led to the decrease in mortality during the study year. The overall aim of the study however was to raise awareness of the dangers of sepsis and improve practice in the early detection and rescue of the person with cancer who develops sepsis and the evidence has been presented that this and the other subsidiary aims were achieved.

10.2 Implications for future research

10.2.1 Related sepsis studies

Having improved the early recognition of sepsis in the person with cancer, the imperative is now to implement an effective early intervention algorithm for the treatment of sepsis. There is robust evidence for such an algorithm and the next study is introducing an evidence-based treatment plan to be used by all clinical staff immediately the diagnosis of sepsis is made (Dellinger *et al* 2004, 2008, Robson and Daniels 2008).

This study is being instituted in two stages: first, across the host cancer centre and then, if successful, in a second stage across the six hospitals in the cancer network. In the network stage, relevant education and introduction of the PCT-Q and early intervention algorithm will be introduced to nurses working in accident and emergency departments and acute wards with cancer patients. There are good senior nursing links across the cancer network, but the complexities of working across institutions necessitate a larger research team and these studies will therefore be part of a programme bid submitted to the Department of Health under the Research for Patient Benefit programme.

10.2.2 Quality of nursing studies

This study has demonstrated that temporal continuity of nursing coupled with targeted education and the availability of a bedside test enables nurses to recognise subtle change early and accurately and to respond appropriately. However the study relates only to cancer nurses working in a specialised setting. An important question therefore is whether these

findings can be replicated in other clinical settings where early recognition of subtle change is essential for safe, effective care for example acute cardiology and acute postoperative care. Major questions to be asked in future research studies would include:

1. Do nurses in other clinical settings intuit change quickly and can this be incorporated into an effective early rescue plan?
2. Is it only trained nurses that can intuit this early change can the same practice be applied to non qualified support workers and assistant practitioners?
3. How can we improve nurses' confidence and multi-professional communication so that the nursing voice is heard more effectively in the acute setting?

These are of course large questions and would form the basis for a substantial programme of research. Reflections on the limitations to this study have also made the researcher more aware of the challenges described in the literature about evaluating complex interventions in practice and this learning will inform future work (Corner & Normand 2001).

Understanding and engagement with the patient as a person would seem to be essential if the nurse is to work alongside the patient nurturing and enabling them to achieve their personal goal for example recovery from major surgery, acute cardiac events. Even on the busiest ward during the most acute episodes a nurse that is fully engaged with the patient has two key advantages: the first is a therapeutic encounter that may be healing in itself, the second is that the nurse's knowledge of the patient can be used as another level of monitoring reducing the possibility of harm. Currently there is much concentration on tools used to enhance patient safety and reduce harm. These tools such as the Department of Health High Impact Interventions (2008) to reduce health care associated infections are important tools for the healthcare team. Several authors notably Linda Aiken have also demonstrated that well trained nurses and a good skill mix also improve care and outcomes (Aiken 2009). All of these are important but it seems that a vital question to answer is how nursing contributes to the well being of patients; whether the values held by nurses have importance in improving outcomes for patients.

In this study experienced well educated nurses were shown sometimes to be less safe than a junior nurse with little experience who had the motivation to engage and ensure a single

patient's safety whilst at the same time risking embarrassment in front of the team. Working with an acutely ill patient as they cope with ill health requires an acute concentration, observation and energy motivated by the wish to reduce harm and bring about a change for the better.

At a time when the nursing profession is criticised both by patients and the profession concentration on practice that is caring, based on intelligent reflection and the moral intent to do good is timely (Patients Association 2009, DH 2010). Research is needed to explore how these characteristics can be encouraged, nurtured and promoted across nursing. Nationally and internationally work has focused on reducing risk and improving the quality of patient care (IHI 2010, Patient Safety First 2010). Much of this work has been based on reducing systems and process errors, and using tools or algorithms to reduce risk (NPSA 2009). There remains a gap with research needed to explore the qualities of nursing that promote safe and effective care and ensure that the patient and family have a therapeutic experience. The work of Gallagher and colleagues (2008) has begun to address this need by replicating part of a study exploring patients' perceptions of the "good nurse" (Pang *et al* 2007). This small pilot included patients from the specialist cancer centre in the sepsis study and there were shared resonances: suggestions that "knowing the patient" and "personalised caring" were important to the patients interviewed. Another finding from the Gallagher pilot was the importance of the organisational culture and environment, with patients identifying a difference between the specialist centre and other NHS hospitals. The effect of the organisational culture on the behaviour of nurses was also identified in the sepsis study. Future research is therefore needed to explore the power of good nursing to positively affect outcomes and the experience of care, and how this might be encouraged, nurtured and replicated outside of the specialist cancer setting.

10.3 Conclusion

This practice development study has made a unique contribution to nursing and has identified that nurses who get to know the patient as a person, and receive a dedicated education session can effectively recognize the subtle changes of sepsis at an early stage. Sepsis is the major cause of death in people undergoing acute cancer care and its incidence is increasing. To treat sepsis successfully it has to be diagnosed early and this finding is therefore significant. The study has had a lasting effect on the way that ward and CCU nurses assess the person with

cancer who is deteriorating. Sepsis is now a major feature on all relevant undergraduate and postgraduate modules and is a part of the mandatory induction programme for all clinical disciplines. A new bedside blood test, the PCT-Q, has been successfully introduced into the hospital's core assessment of the deteriorating patient. Importantly, the ward nurses identify the translational value of this test and its numerical value in their ability to convince others to take action. The evidence from 187 nurses about the way they learn and their experience of trying to convince senior nurses and junior doctors is regularly used in coaching, mentoring and induction training. Finally, the effects of the study have been to raise the awareness of sepsis and its early diagnosis, to give confidence to nurses that their assessments are accurate, especially when they know the patient well and listen to them, and that "packaging" patient deterioration information to produce an effective and timely multidisciplinary response has a positive effect on patient survival.

Appendix 1: The epidemiology: incidence of sepsis

	Authors	Date	Methodology / Use of ACCP/SCCM sepsis definitions	Country / dates of sample / timeframe	Total number of patients admitted to hospital	Total number admitted to ITU	Number patients identified (ICU incidence per 100 ITU patients) stage of sepsis syndrome	Population incidence per 100,000 or 1000	ICU mortality	Hospital mortality
1	Vincent et al	2006	Prospective multi-centre, observational study. ACCP/SCCM	24 European countries May 1 to May 15 2002 (15 days)	N/A	3,147	37% Sepsis: 1,177 Severe sepsis: 930	N/A	313 (27%)	413 (36%)
2	Alberti et al	2005	Inception cohort study ACCP/SCCM	28 ICUs from Europe, Canada and Israel, 1997- 1998 (1 year)	N/A	14,364	10.6% Sepsis: 1,531 Severe sepsis: 795 Septic shock: 1,178	N/A	34%	41% 26% sepsis 42% severe sepsis 61% septic shock
3	Dombrovskiy et al	2005	Trend analysis ACCP/SCCM	New Jersey, United States, 1995-2002 (7 years)	7,364,550	Unavailable data	Sepsis: 233,432 Severe sepsis: 87,675	1995: 135.02 2002: 208.16 (severe)	Unavailable data	1995: 51.05% 2002: 44.96 N.B. per 100,000 population

	Authors	Date	Methodology / Use of ACCP/SCCM sepsis definitions	Country / dates of sample / timeframe	Total number of patients admitted to hospital	Total number admitted to ITU	Number patients identified (ICU incidence per 100 ITU patients) stage of sepsis syndrome	Population incidence per 100,000 or 1000	ICU mortality	Hospital mortality
4	Brun-Buisson et al	2004	Inception cohort study ACCP/SCCM	206 ICUs France, 2001 (2 weeks)	Unavailable e data	3,738	14.6% severe sepsis or shock 546	0.95% episodes per 1000 population sepsis)	Unavailable data	41.9%
5	Finfer et al	2004	Inception cohort study ACCP/SCCM	23 ICUs of 21 hospitals through Australia and New Zealand, 1999 (3 months)	Unavailable e data	5,878	11.75% severe sepsis: 691	0.77 patients with severe sepsis per 1000 population	Severe sepsis 183 (26.5%)	259 (37.5%)
6	Flaatten	2004	Retrospective analysis of a prospectively collected database	All Norwegian hospitals. 1999 (1 year).	700,107	Unavailable e data	Sepsis: 3517 Severe sepsis: 2121 Septic shock: 1562.	1.49 per 1000 population		Sepsis: 13.5% Severe sepsis: 27% Septic shock: 29.3%
7	Laupland et al	2004	Population based surveillance cohort	Calgary region of Canada 2000-2002 (2 years)	Calgary region population 958,610 people	9,226	3.68% 340 patients severe blood stream infections	15.7% per 100,000 population	111 (32.64%)	142 (42%)
8	Silva et al	2004	Multi-centre	5 ICUs from two		1688	24.58%			

	Authors	Date	Methodology / Use of ACCP/SCCM sepsis definitions	Country / dates of sample / timeframe	Total number of patients admitted to hospital	Total number admitted to ITU	Number patients identified (ICU incidence per 100 ITU patients) stage of sepsis syndrome	Population incidence per 100,000 or 1000	ICU mortality	Hospital mortality
			observational cohort study ACCP/SCCM	regions of Brazil 2001-2002 (8 months)			SIRS: 785 Sepsis: 415 Severe sepsis: 241 Septic shock: 203.			
9	van Gestel et al	2004	Point prevalence survey ACCP/SCCM	47 ICUs in the Netherlands, December 2001 (24 hours)	N/A	455	31.42% 143 sepsis 134 severe sepsis 53 septic shock	Unavailabl e data	N/A	N/A
10*	Williams et al	2004	Analysis of a prospective database ICD-9-CM	6 states in the US	6,754,638	220, 385	220, 385 severe sepsis 29, 795 with cancer	4.9% in cancer patients	N/A	37.8% in cancer patients / 24.9% in non cancer patients
11	Annane et al	2003	Analysis of a prospective database ACCP/SCCM	35 ICUs Paris, France, 1993-2000 (8 years)	Unavailabl e data	100,554	8.20% 8,251 septic shock	N/A	Septic shock 53.8%	N/A
12	Martin et al	2003	Nationally representative sample of all non-federal	United States, 1979-2000 (22 years)	750,000,00 0	Unavailabl e data	10,319,218 sepsis	82.7 per 100,000 population 1979 to	Unavailable data	27.8% in 1979 to 17.9% in 2000

Authors	Date	Methodology / Use of ACCP/SCCM sepsis definitions	Country / dates of sample / timeframe	Total number of patients admitted to hospital	Total number admitted to ITU	Number patients identified (ICU incidence per 100 ITU patients) stage of sepsis syndrome	Population incidence per 100,000 or 1000	ICU mortality	Hospital mortality
		acute care hospitals in the United States					240.4 per 100,000 2000		
13	2003	Observational cohort study retrospective analysis of prospectively collected data ACCP/SCCM	91 ICUs in England, Wales & Northern Ireland, 1995-2000 (5 years)	Unavailable data	56,673	27.10% 15,362 severe sepsis	51 per 100,000 population	Severe sepsis 5334 (35%)	7119 (47.3%)
14	2002	International Prospective cohort study ACCP/SCCM	28 ICUs in eight countries (Italy, France, Spain, Canada, Germany, Portugal, UK Israel). 1997- 1998 (1 year)	N/A	14,364	7.76% Sepsis: 1115 Severe sepsis 944 Septic shock: 1180	N/A	Sepsis 23.3% Severe sepsis 35.62% Septic shock 48.48 %	Sepsis: 32.16% Severe sepsis 43.36% Septic shock 56.16%
15	2001	Observational cohort study ACCP/SCCM	Seven US states, 1995 (1 year)	6,621,559	N/A	192,980 severe sepsis	3 per 1000 population	N/A	28.6%
16	1999	Data base review of prospectively	1 surgical ICU in Munich, Germany. 1991-1998 (7	48,136 received surgical	4,218	9.41% Severe sepsis/ septic shock:	Unavailable data	Severe sepsis /septic shock 260 (65.5%)	

	Authors	Date	Methodology / Use of ACCP/SCCM sepsis definitions	Country / dates of sample / timeframe	Total number of patients admitted to hospital	Total number admitted to ITU	Number patients identified (ICU incidence per 100 ITU patients) stage of sepsis syndrome	Population incidence per 100,000 or 1000	ICU mortality	Hospital mortality
			collected data ACCP/SCCM	years).	care in the hospital		397			
17	Rangel-Frausto et al	1995	Prospective cohort study ACCP/SCCM	3 ICUs and 3 wards United States,	N/A	3708	SIRS: 2527 Sepsis: 649, Severe sepsis: 467 septic shock: 110	N/A	SIRS 7% Sepsis 16% Severe sepsis 20% Septic shock 46%	Unavailable data
* 18	Danai et al	2006	Analysis of a nationally representative sample of non-federal acute-care hospitalisations	United States 1979 through 2001(23 years)	854,000,000 0 76,650,000 with malignancy	Not available	Sepsis: 1,781,445	1,465 cases per 100,000 cancer patients	Not available	1979: 44.7% 2001: 23.8%

* Cancer Patient studies.

Appendix 2: Table of sepsis early indicators

Abbreviation	Sepsis Early Indicator in full	Abbreviation	Sepsis Early Indicator – in full
PCT	Procalcitonin	APACHE II	Acute Physiology and Chronic Health Evaluation scoring system (Knaus et al 1985)
CRP	C-reactive protein	ESR	Erythrocyte sedimentation rate
WBC	White Blood Cell (count)	Ca (ion)	Ionized calcium
SOFA	Sequential Organ Failure Assessment (Vincent et al 1996)	AtIII	Antithrombin III
aPPT	Activated partial thromboplastin time	TT	Thromboplastin time
BPW	Partial thromboplastin biphasic waveform	AM	Adhesion molecules
TNFα	Tumour Necrosis Factor alpha	Thromb	Thrombomodulin
IL-1, 2, 6, 8, 10, 12	Interleukin 1, 2, 6, 8, 10, 12	vWF	von Willebrand Factor
vWF protein	Endocan – proteoglycan in vitro	HLA	Histocompatibility leukocyte antigen
L.	Lactate	PMNs	Polymorphonuclear cells
WBC diff	White blood cell differential	PRR	Peak respiratory rate
E.	Endotoxin	PHR	Peak heart rate
NT.	Neopterin	GCS	Glasgow Coma Scale
APOE	Apolipoprotein E genotypes	NGCS	Nadir Glasgow Coma Scale
PCT-Q	Procalcitonin Quick test	PBC	Peak blood creatinine
SAA	Serum amyloid A	C3a	Protein complement

Abbreviation	Sepsis Early Indicator in full	Abbreviation	Sepsis Early Indicator – in full
SLP	Silkworm larvae test	LE	Leukocyte elastase
T	Temperature	ICAM-1	Circulating intercellular adhesion molecule -1
HR	Heart rate	PECAM-1	Platelet endothelial cell adhesion molecule -1
RR	Respiratory rate	LHF	Leukaemia inhibitory factor
HSP	Heat Shock Protein	sTNF	Soluble Tumour Necrosis Factor receptors
SAA	Serum Amyloid A	MIF	Macrophage Migration Inhibitory Factor
sTREM-1	Soluble triggering receptor expressed on myeloid cells -1	suPAR	Soluble receptors urokinase –type plasminogen activator
MBL	Mannan-binding Lectin	ANP	Atrial natriuretic peptide
EAA	Endotoxin activity assay	LBP	Lipoprotein binding protein
mid pro-ANP	Mid pro-atrial natriuretic peptide	LAR	Leucocyte antisedimentation rate

Appendix 3: Nurse characteristics – participants in qualitative interviews

Respondent Number	Grade of Nurse	Length qualified	Ward area	Date of first interview	Date of post-intervention interview
01	G	9 years	Critical Care Outreach Sister	6.12.04	
02	E	4 years	Staff Nurse Haemato-oncology	7.12.04	
03	D	13 months	Staff Nurse General ward – upper GI & GU medical oncology and Neuro-oncology	7.12.04	
04	D	2 months	Staff Nurse Private patient unit – all cancer specialties	7.12.04	
05	F	4 years	Senior Staff Nurse Gynaecology ward	9.12.04	
06	E	2 years	Staff Nurse sarcoma, melanoma and chronic	13.12.04	

Respondent Number	Grade of Nurse	Length qualified	Ward area	Date of first interview	Date of post-intervention interview
			haematology ward		
07	F	6 years	Senior Staff Nurse breast cancer ward	13.12.04	
08	E	10 years	Staff Nurse Critical Care	15.12.04	
09	F	20	Senior Staff Nurse private patients OPD	17.12.04	
10	H	17 years	Senior Charge Nurse Critical Care	23.12.04	

Appendix 4: Nurse Information Sheet – qualitative interviews

The Royal Marsden NHS Foundation Trust

Sepsis Study: Protocol 2372

Nurse Information Sheet

The early identification of cancer patients who have the immunological precursors for severe sepsis: a tool to confirm nurses' intuition and experience

I would like to invite you to take part in a research study. Before you decide it is important for you to understand why the research is being done and what it will involve. Please take time to read the following information carefully. Ask us if there is anything that is not clear or if you would like more information. Take time to decide whether or not you wish to take part. Thank you for reading this.

What is the purpose of the study?

This study aims to improve the early diagnosis of sepsis and severe sepsis in patients who are receiving inpatient treatment at the Royal Marsden Hospital. As you will be aware Sepsis and Severe Sepsis are the cause of an increased morbidity and mortality in some cancer patients undergoing treatment. We know from experience and previous research that early diagnosis of this condition is important. This study aims to increase awareness and education about the sepsis syndrome, and also to provide the nurse working on the ward with a new tool that may help to diagnose sepsis in its early stages.

Why am I being invited to take part?

A cohort of 10 nurses who are permanently employed at the Royal Marsden NHS Trust and who work on the adult acute care wards are being invited to take part in this study. Because the study is about the early identification of sepsis it is very important that nurses caring for patients at risk are involved in the study.

Do I have to take part?

It is up to you to decide whether or not to take part. If you decide to take part you will be given this information sheet to keep and be asked to sign a consent form. If you decide to take part you are still free to change your mind or withdraw at any time and without giving a reason.

What will happen to me if I take part?

You will be asked to be interviewed on two occasions, once before the study intervention begins and one afterwards. The purpose of the qualitative interview is to ask you about your experience of caring for patients who develop sepsis. Following the introduction of the PCT-Q on all the wards a second interview will occur during which your experience of the study intervention will be sought. I am also interested in the way we learn as nurses and what you recommend for learning and teaching about sepsis in clinical practice. Your interview will be taped and then transcribed later. The transcripts will then be analysed using a constant comparative technique.

What is the drug or procedure that is being tested?

There is no drug being tested but we are testing a kit called PCT-Q which has been used previously in the detection of sepsis and severe sepsis. It is a kit that measures a substance in the blood called Procalcitonin. Procalcitonin levels can give us a clue as to whether a patient is developing sepsis. The PCT-Q has been used in several studies but these have been small and it has not been used in the hospital ward setting before. PCT was launched in 1996 as a diagnostic tool for identifying severe bacterial infections and indicating complications secondary to systemic inflammation. PCT levels increase in cases of sepsis, septic shock and in severe systemic inflammatory reactions. The main stimulus for PCT induction is the systemic effect of lipopolysaccharide from bacterial endotoxins, and systemic fungal infections. Viral diseases, autoimmune diseases and local and organ related infections do not induce PCT. PCT can therefore be used in the differential diagnosis of bacterial infections. PCT can also be used to monitor patients who are at risk of infection or sepsis for the early detection of infectious complications; this makes its application particularly important in high- risk surgical and immunosuppressed patients (Meisner 2000, Fleischhack et al 2000).

The PCT-Q is used by taking a sample of blood from the patient who is suspected of developing sepsis, spinning the blood down in a centrifuge and then adding a drop of the plasma to a test strip (a bit like a blood glucose test strip). After 30 minutes the PCT-Q gives a measure of the procalcitonin level and an indicator of the level of sepsis. The PCT-Q measures the different stages of sepsis from Systemic Inflammatory Response Syndrome (SIRS) right through the syndrome to Severe Sepsis. This semi-quantitative test can then be used in your communication with the multi-disciplinary team.

What are the possible disadvantages and risks of taking part?

The disadvantage of taking part in this study is having to be interviewed twice. Each interview will take about 45 minutes to one hour to complete.

What are the possible benefits of taking part?

We hope that the associated teaching sessions and the use of the new tool will augment your clinical practice. From clinical experience and the literature we know that there are many times when the clinical nurse knows that the patient is not as well but there are few clinical signs. It is hoped that this PCT-Q test will give nurses another tool that can be used in discussion with the MD team to ensure that patients with sepsis are diagnosed more quickly. The information we get from this study may help us to treat future patients with cancer who are at risk of developing sepsis. Your thoughts may also help to influence future nursing and future patient outcomes.

What if new information becomes available?

Sometimes during the course of a research project, new information becomes available about the treatment/drug that is being studied. If this happens, the research nurse will tell you about it and discuss with you whether you want to continue in the study. If you decide to withdraw your research nurse will make the necessary arrangements. If you decide to continue in the study you will be asked to sign an updated consent form.

Will my taking part in this study be kept confidential?

All interview transcripts will be coded so that only myself will know who has been interviewed. Any presentation or publication that results from this study will not therefore include the names of any nurses involved.

What will happen to the results of the research study?

The results of this study are likely to be available in December 2005, if you would like a summary of the results when available please let us know. The results will also be presented at conferences and as part of the education of cancer and critical care nurses, and in relevant cancer and critical care publications.

Who has reviewed the study?

This study has been reviewed by the Committee for Clinical Research and the Research Ethics Committee of the Royal Marsden NHS Trust.

Contact for the Further Information;

If you require any further information or if you have any questions about the study please contact any of the numbers listed below:

Shelley Dolan Nurse Consultant Cancer: Critical Care 0207 808 2351

Natalie Pattison Nurse Researcher: Critical Care Nursing 0207 811 8054

Sister Critical Care Outreach (Chelsea) 0207 808 2331

Sister Critical Care Outreach (Sutton) 0208 642 6011 ext: 1427/1038

Appendix 5: Nurse Information Sheet – pre-intervention questionnaire

The Royal Marsden NHS Foundation Trust

Sepsis Study: Protocol 2372

Nurse Information Sheet

The early identification of cancer patients who have the immunological precursors for severe sepsis: a tool to confirm nurses' intuition and experience

I would like to invite you to take part in a research study. Before you decide it is important for you to understand why the research is being done and what it will involve. Please take time to read the following information carefully. Ask us if there is anything that is not clear or if you would like more information. Take time to decide whether or not you wish to take part. Thank you for reading this.

What is the purpose of the study?

This study aims to improve the early diagnosis of sepsis and severe sepsis in patients who are receiving inpatient treatment at the Royal Marsden Hospital. As you will be aware Sepsis and Severe Sepsis are the cause of an increased morbidity and mortality in some cancer patients undergoing treatment. We know from experience and previous research that early diagnosis of this condition is important. This study aims to increase awareness and education about the sepsis syndrome, and also to provide the nurse working on the ward with a new tool that may help to diagnose sepsis in its early stages.

Why am I being invited to take part?

All nurses who are permanently employed at the Royal Marsden NHS Trust and who work on the adult acute care wards are being invited to take part in this study. Because the study is about the early identification of sepsis it is very important that all nurses caring for patients at risk are informed about the study.

Do I have to take part?

It is up to you to decide whether or not to take part. If you decide to take part you will be given this information sheet to keep and be asked to sign a consent form. If you decide to take part you are still free to change your mind or withdraw at any time and without giving a reason.

What will happen to me if I take part?

You will be asked to complete a short questionnaire exploring sepsis, its diagnosis and the early indicators of sepsis pre the introduction of the PCT-Q. Following the introduction of the PCT-Q on all the wards a second questionnaire which starts the same as the first but also includes a few questions on your experience of the use of the PCT-Q.

What is the drug or procedure that is being tested?

There is no drug being tested but we are testing a kit called PCT-Q which has been used previously in the detection of sepsis and severe sepsis. It is a kit that measures a substance in the blood called Procalcitonin. Procalcitonin levels can give us a clue as to whether a patient is developing sepsis. The PCT-Q has been used in several studies but these have been small and it has not been used in the hospital ward setting before. PCT was launched in 1996 as a diagnostic tool for identifying severe bacterial infections and indicating complications secondary to systemic inflammation. PCT levels increase in cases of sepsis, septic shock and

in severe systemic inflammatory reactions. The main stimulus for PCT induction is the systemic effect of lipopolysaccharide from bacterial endotoxins, and systemic fungal infections. Viral diseases, autoimmune diseases and local and organ related infections do not induce PCT. PCT can therefore be used in the differential diagnosis of bacterial infections. PCT can also be used to monitor patients who are at risk of infection or sepsis for the early detection of infectious complications; this makes its application particularly important in high- risk surgical and immunosuppressed patients (Meisner 2000, Fleischhack et al 2000).

The PCT-Q is used by taking a sample of blood from the patient who is suspected of developing sepsis, spinning the blood down in a centrifuge and then adding a drop of the plasma to a test strip (a bit like a blood glucose test strip). After 30 minutes the PCT-Q gives a measure of the procalcitonin level and an indicator of the level of sepsis. The PCT-Q measures the different stages of sepsis from Systemic Inflammatory Response Syndrome (SIRS) right through the syndrome to Severe Sepsis. This semi-quantitative test can then be used in your communication with the multi-disciplinary team.

What are the possible disadvantages and risks of taking part?

The disadvantage of taking part in this study is having to complete 2 short questionnaires.

What are the possible benefits of taking part?

We hope that the associated teaching sessions and the use of the new tool will augment your clinical practice. From clinical experience and the literature we know that there are many times when the clinical nurse knows that the patient is not as well but there are few clinical signs. It is hoped that this PCT-Q test will give nurses another tool that can be used in discussion with the MD team to ensure that patients with sepsis are diagnosed more quickly.

The information we get from this study may help us to treat future patients with cancer who are at risk of developing sepsis.

What if new information becomes available?

Sometimes during the course of a research project, new information becomes available about the treatment/drug that is being studied. If this happens, the research nurse will tell you about it and discuss with you whether you want to continue in the study. If you decide to withdraw your research nurse will make the necessary arrangements. If you decide to continue in the study you will be asked to sign an updated consent form.

Will my taking part in this study be kept confidential?

All completed questionnaires will be coded so that only the staff nurses administering the questionnaires will know which wards and nurses have received a questionnaire. No questionnaire will have a nurse's name on it. Any presentation or publication that results from this study will not therefore include the names of any nurses involved.

What will happen to the results of the research study?

The results of this study are likely to be available in December 2005, if you would like a summary of the results when available please let us know. The results will also be presented at conferences and as part of the education of cancer and critical care nurses, and in relevant cancer and critical care publications.

Who has reviewed the study?

This study has been reviewed by the Committee for Clinical Research and the Research Ethics Committee of the Royal Marsden NHS Trust.

Contact for the Further Information;

If you require any further information or if you have any questions about the study please contact any of the numbers listed below:

Shelley Dolan Nurse Consultant Cancer: Critical Care 0207 808 2351

Natalie Pattison Nurse Researcher: Critical Care Nursing 0207 811 8054

Sister Critical Care Outreach (Chelsea) 0207 808 2331

Sister Critical Care Outreach (Sutton) 0208 642 6011 ext: 1427/1038

Appendix 6: Lesson plan for formal education session

Royal Marsden NHS Foundation Trust

Doctoral research – Shelley Dolan

The early identification of cancer patients who have the immunological precursors for severe sepsis: a tool to confirm nurses' intuition and experience.

Lesson Plan for nurses on general wards and CCUs

By the end of this ward based teaching session the nurse will have an understanding and be able to discuss the following:

1. The standard definition for the sepsis cascade
2. The mortality and morbidity of sepsis and severe sepsis
3. The increase in incidence across the UK and internationally
4. The increased morbidity and mortality in people with cancer
5. The early signs of sepsis
6. The immunological indicators of sepsis and severe sepsis including WBC, CRP and PCT
7. The evidence that the early identification of sepsis can reduce mortality and morbidity
8. How the PCT-Q works

9. How the PCT-Q can be used together with the nurse's intuition and experience to make an early diagnosis of sepsis
10. How to use the PCT-Q.
11. Key clinical colleagues to liaise with regarding the early recognition and optimisation of patients with sepsis and severe sepsis

References (for Lesson Plan)

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4. Young, J.D. Goldfrad, C., Padkin, A.J. Rowan, K. (2001) 'Hospital mortality for ICU admissions with severe sepsis in England, Wales and Northern Ireland'. *Intensive Care Medicine* 27 (suppl 2) S242 (Abstract 418).
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Appendix 7: Powerpoint presentation: Educational intervention

The early identification of sepsis in patients with cancer: Improving practice.

- Shelley Dolan
- Nurse Consultant Cancer: Critical Care

Sepsis: A Worldwide Health Care Challenge

Sepsis kills more than 1,400 people every day across the world.

Mortality rates from severe sepsis are on a similar scale to lung, breast and colon cancer and it is one of the leading causes of death in the intensive care unit (ICU)

The 28 day mortality rate in sepsis is similar to the 1960s 28 day mortality rate for Myocardial Infarction – much international work has reduced the mortality from AMI and now in some common cancers.

This is NOT the case for Sepsis.

The Mortality and Morbidity of Sepsis

- Mortality rates range from 40 - 85% depending on the previous performance status and co-morbidity of the patient, and the virulence / site of the organism.
- Mortality rates may be lower in patients who are previously fit and healthy than those with a chronic illness, malignancy or who are immune-compromised.

Overview of sepsis

- A major cause of morbidity and mortality
- The uncontrolled systemic response to infection
- Can rapidly escalate to severe sepsis causing acute organ dysfunction and ultimately death
- Affects healthy people or people with pre-existing illnesses at any age
- Worldwide mortality rates of 1,400 people a day.

In the Cancer Patient

Many reasons for risk of Sepsis:

- Disease
- Immunosuppression with prolonged neutropenia being an important risk
- Repeated Anti-microbial therapy
- Invasive therapy and catheters
- Malnutrition

Reasons for Sepsis in Cancer patient continued:

- Repeated blood and blood component transfusions
- Repeated hospitalisation
- Multi-modality therapy – i.e. Chemotherapy / surgery / radiotherapy –
- Cancer = a disease of the older person
- Older people may also have concomitant diseases such as diabetes or rheumatoid arthritis.

Causes of the growth in incidence of severe sepsis

- The ability to reverse life-threatening emergencies
- Older population
- Growing numbers of immune-compromised patients
- Increased nosocomial infections
- Increased microbiological resistance.

What is this thing called Sepsis ?

From our patient experience we know that sepsis is a complex syndrome that encompasses a range of clinical conditions.

The clinical signs that we encounter are:

Decreased mean arterial pressure, peripheral vasodilation, leaky capillaries, coagulopathy and fibrinolysis.

Definitions of Sepsis

The American College of Chest Physicians / Society of Critical Care Medicine Consensus Conference Committee 1992

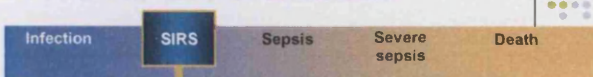
Defined the disease continuum of Sepsis > Organ Failure and Guidelines for Research into new therapeutic interventions.

Bone, Balk, Cerra et al 1992 Chest, 101 (6) 1644-55.

What is this thing called Sepsis ?

The most obvious starting point for us working with patients is that whilst there are many causes and presenting conditions there seems to be a final common clinical pathway recognisable by all ITU nurses - that of increasing metabolic derangement and organ failure requiring more and more support.

The disease continuum:



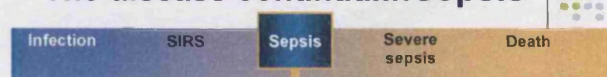
A non-specific clinical response including >2 of the following:

- Temperature >38°C or <36°C
- Heart rate >90 beats/min
- Respiratory rate >20/min
- White blood cell count >12,000/mm³ or <4,000/mm³ or >10% immature neutrophils

As well as infection, SIRS can also be caused by trauma, burns, pancreatitis and other insults

SIRS: systemic inflammatory response syndrome

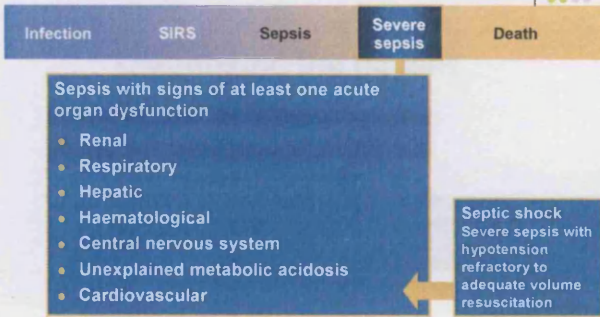
The disease continuum: Sepsis



SIRS with a presumed or confirmed infectious process

SIRS: systemic inflammatory response syndrome

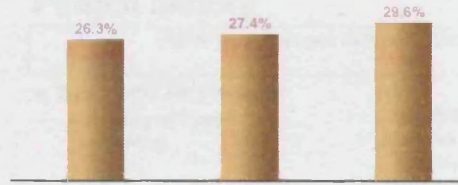
The disease continuum: severe sepsis



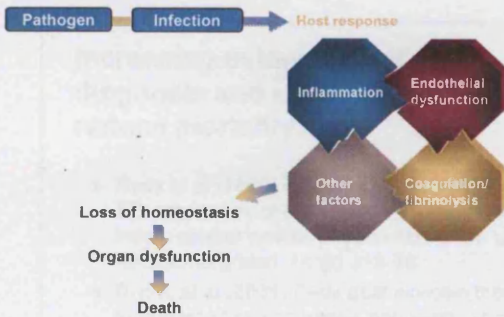
SIRS: systemic inflammatory response syndrome

Severe sepsis: a growing healthcare problem?

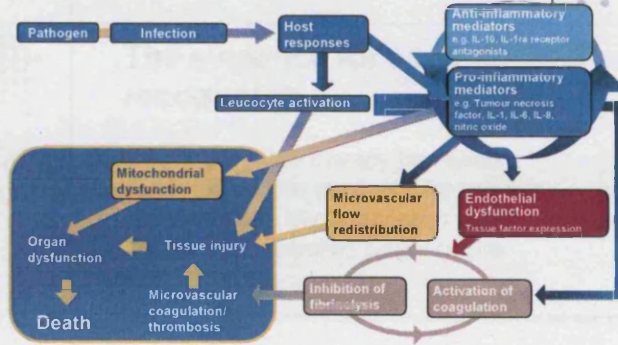
Proportion of admissions to ICU with severe sepsis in first 24 hours in ICU for three consecutive years in 26 ICUs



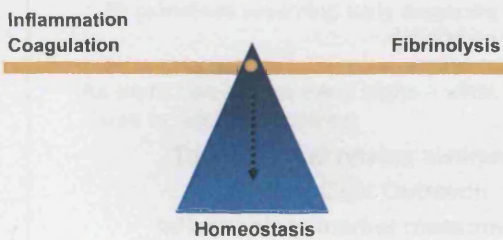
Host response to infection Progression to sepsis and severe sepsis



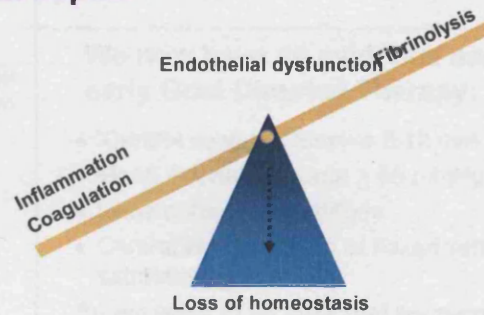
Pathogenesis of sepsis



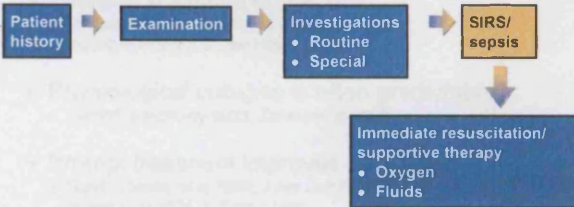
Homeostasis



Loss of homeostasis in sepsis



Diagnosing the patient with sepsis



Patient history

Prior and current medical history

- Symptoms may include:
 - 'Feeling hot/cold/shivering'
 - Rigors
 - Nausea/vomiting
 - Lethargy
 - Rash
 - Photophobia
 - Diarrhoea
 - Headache
 - Abdominal pain
 - Infective source

However N.B. there may be very few symptoms

Increasing evidence that early diagnosis and optimisation may reduce mortality

- Rady et al (1996) Resuscitation of the critically ill in the ED: responses of blood pressure, heart rate, shock index, central venous oxygen saturation and lactate, *Am.J.Emerg.Med*, 14 (2) 218-25.
- Rivers et al (2001) Early goal directed therapy in the treatment of severe sepsis and septic shock, *N.Engl.J.Med*, 345 (19) 1368-77.
- Vincent et al (2002) Reducing mortality in sepsis new directions, *Crit Care Suppl* 3:S1-18.

The evidence for early recognition

'Early goal directed therapy has been shown to improve survival...for patients presenting with septic shock in a randomised controlled single centre study'

Dellinger, R. et al 2004. Surviving Sepsis Campaign guidelines for management of severe sepsis and septic shock.

Critical Care Medicine, 32(3):858-873.

Critical Care Medicine
OFFICIAL JOURNAL OF THE SOCIETY OF CRITICAL CARE MEDICINE

All guidelines regarding early diagnosis and optimisation depend on early recognition

As there can be few early signs – what else can we use to raise awareness:

Teaching and raising awareness

Critical Care Outreach

Inflammatory marker measurement

Procalcitonin measurement on the ward

We now have an evidence base for early Goal Directed Therapy:

- 'Central venous Pressure 8-12 mm Hg
- Mean Arterial Pressure \geq 65 mmHg
- Urine output $>$ 0.5 ml/Kg/hr
- Central venous (SVC) or mixed venous oxygen saturation \geq 70%

So we need to be sure that we recognise it early

Dellinger et al (2004) Surviving Sepsis Guidelines for management of severe sepsis and septic shock, Crit Care Med, 32 (3), 858-873.



Outreach: Background evidence

- There **IS** a serious problem
 - McQuillan et al 1998, McGloin et al 1999
 - Young et al 2003, J Gen Intern Med.
- Physiological collapse is often predictable
 - Goldhill & McNarry 2003, Schein et al 1990
- Prompt treatment improves outcomes
 - Gusto, Newby et al 1996, J Am Coll Cardiol.
 - Rivers et al 2001, N Engl J Med.

McGloin et al 1999, J R Coll Physicians London

Avoidable deaths & ICU admissions: our 'best' hospital

- Hospital deaths over 6 months
- 2 unexpected, potentially avoidable deaths a month
- Clear signs of prior deterioration over hours / days:
untreated BP < 80 for > 24 hours, ↓ K⁺, ↓ O₂, ↓ BM

Vincent et al 2001, BMJ

Adverse events

10.8% patients experience adverse event:
half are preventable

1/3 of adverse events lead to disability / death

McQuillan et al 1998, BMJ

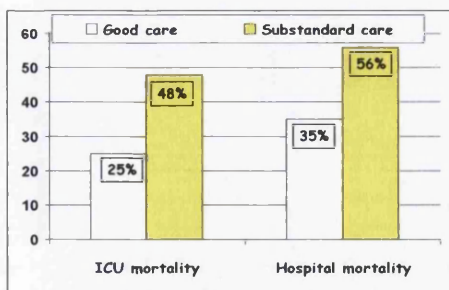
Suboptimal care on wards

*100 non-elective ICU admissions from wards:
20 well-managed*

- Process issues (organisation & supervision)
- Cultural issues (experience, advice-seeking)
- Education issues (knowledge, urgency)

McQuillan et al (1998)

- Effects of sub-optimal care



poor management of:

Airway
Breathing
Circulation
Oxygen therapy
Monitoring

Also: failures of communication & teamwork

McQuillan et al 1998, BMJ

Critical Care throughout the patient journey

Pre-hospital

⇒ Emergency Room

⇒ ICU / HDU / Ward

⇒ Operating Room

⇒ Recovery / ICU / HDU

⇒ Ward

⇒ Home

critical care is a need, not a place

Early Warning Scoring System

THE ROYAL MARSDEN NHS TRUST

CRITICAL CARE UNIT

EARLY WARNING SCORING SYSTEM

A score of 3 or more should alert the ward nursing staff that the patient is at risk of **RAPID** deterioration.
Seek **IMMEDIATE** review by outreach team / medical team / on call team.
OUTREACH SERVICE AVAILABLE ON 2301 OR 2321

Score	3	2	1	0	1	2	3
Pulse	>100	66-100	41-60		101-110	66-100	>120
Systolic BP	<70	71-90	91-100			>130	
Respiratory Rate	>18				16-20	11-15	>30
Temperature	<36		36.1-36		36.1-36.5	36.6	
Urine Output	<10ml/hr	<50ml/hr					
Neurological Response	No Response	To Painful Stimuli	To Verbal Stimuli		Confused/Agitated		
GCS (Glasgow Coma) Scale					14	10-13	8-9

N.B. The outreach team can be contacted for any patient you are seriously worried about or who has unexpectedly deteriorated even if they do not fit the above criteria.

Inflammatory Markers in sepsis

Indicator of inflammation or infection	Action	Authors & Dates of research studies
C-reactive protein	Acute phase reactant biochemical marker of inflammation & infection	Engel et al 1998, Meisner et al 1999, Fleischhack et al 2000
Tumour Necrosis Factor (TNF α)	Macrophage / monocyte derived cytokine mediates an acute phase reaction	Suffredini et al 1999, Fleischhack et al 2000
Interleukin 6 (IL6) Interleukin 8 (IL8)	Macrophage / monocyte derived cytokines mediates an acute phase reaction	Lotz 1995, de Werra et al 1997, Engel et al 1998
PMN Elastase	Proteolytic enzyme – biochemical marker for granulocyte stimulation	Peters et al 1991, Ishikawa et al 1998
White Blood Cell Count (WBC)	Normal 5-10	

Inflammatory marker in sepsis – Procalcitonin (PCT)

Of all markers studied over the last 10 years PCT has demonstrated the greatest specificity & reliability in the detection, differentiation and prediction of the development of infection, sepsis and severe sepsis.

PCT has been studied since 1996 in the neutropenic and non neutropaenic patient.

Carsin et al 1997, de Werra et al 1997, Chiesa et al 1998, Mimoz et al 1998, Meisner 1999, Oberhoffer 1999, Fleischhack et al 2000, Kuse et al 2000, Rau et al 2000.

What is Procalcitonin (PCT)?

PCT is a 116 amino acid with a sequence identical to that of the prohormone of calcitonin. In the normal healthy person under normal metabolic conditions hormonally active calcitonin is produced and secreted in the C-cells of the thyroid gland following specific intracellular proteolytic interaction of the prohormone PCT.

In severe infections intact PCT is found in the blood.

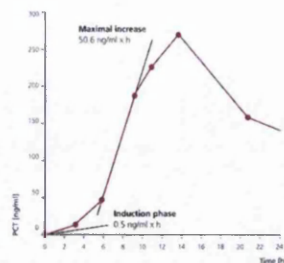
PCT

- In health plasma PCT levels are usually below the detection limit.
- PCT concentrations above 0.5ng/ml indicate an acute infection + a systemic inflammatory reaction
- High PCT concentrations from 10ng/ml - > 1000 ng/ml are found in patients with sepsis and severe sepsis.

Importantly PCT levels rise quickly following infection and stay high for 24-48



- PCT level increases after 2-3 hrs post infection
- Levels then rise rapidly achieving a peak at 6-12 hrs
- PCT levels then remain at a plateau for 24-48 hrs
- Then start to fall.



Thus PCT levels can be used:

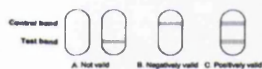


- To aid early diagnosis of infection
- BUT also to monitor the course of sepsis – especially important in the person with cancer – a peripheral blood test much less invasive than returning to theatre, even journeying to a CT scan or having repeated bronchealveolar lavage.

The rapid test PCT-Q



The PCT-Q is a semi-quantitative test that provides a PCT concentration but also groups the results according to the sepsis syndrome banding.



During this study



PCT-Q used by ward based nurses, critical care outreach team and nurses in critical care.

Each nurse on the above areas also receives a teaching session with pre and post test to raise their knowledge and awareness of the importance of recognising the signs of sepsis early.

Study to enroll 400 patients and 200 nurses

Data Collection:



- PCT finding – collated with other important markers of sepsis e.g. CRP, lactate, BP etc. & importantly nurse's intuition.
- Nurse's teaching sessions and pre and post test results
- 20 qualitative interviews with nurses re their experience of the use of the PCT -Q to aid their decision making and interventions.

Study end points:



- To increase numbers of patients with severe sepsis identified early – compare with historical data (problematic ?)
- To increase numbers of patients – receiving early goal directed therapy
- To increase nurses –satisfaction with decision making and communication with MD team.
- To decrease mortality from severe sepsis
- ??To raise awareness of sepsis and the early signs of sepsis at an early stage.

Conclusion

The sepsis syndrome is a complicated immunological syndrome that affects homeostasis and causes multi-organ failure. The incidence is rising and the mortality rates in people with cancer are still too high.

It may be that use of the PCT-Q coupled with increased awareness and teaching may improve rapid access to acute care and optimisation.



A request:



Internationally to raise the awareness of the Surviving Sepsis Campaign –supported by:

American Association Critical Care Nurses, American College Chest Physicians, American College of Emergency Physicians, American Thoracic Society, Australian & New Zealand Intensive Care society, European Society of Clinical Microbiology and Infectious Diseases, European Society of Intensive Care Medicine, European Respiratory Society, International Sepsis Forum, Society of Critical Care Medicine, Surgical Infection Society.

Click onto:
www.survivingsepsis.com

Appendix 8: Summary guide for PCT-Q testing kits

The sample can be taken in either a red top (for serum) or green top/EDTA (for plasma). Ideally the sample should be centrifuged within one hour of being taken. Please note time it was taken and write the hospital number onto the test.

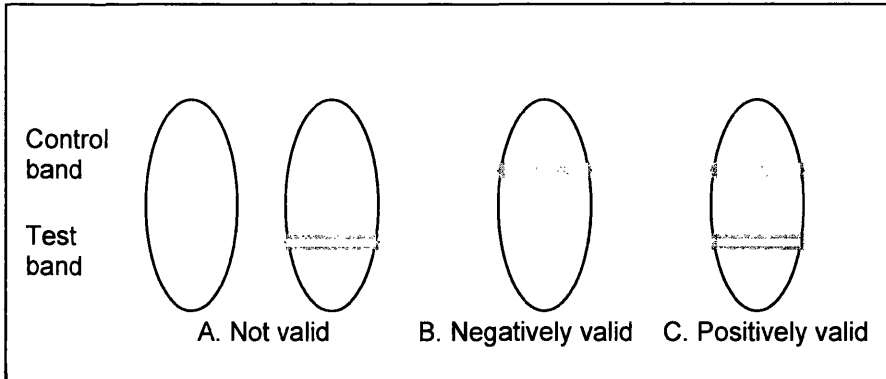
- Place sample in centrifuge, counter the weight of the sample on the opposite spindle with a same-sized tube filled with water/saline to the same amount as sample.

- Set temp on centrifuge to 25°C. (At Sutton, you may need to spin it empty for a few minutes to warm up machine, as they are often set at 4°C.) Centrifuge at 5000 rpm (max machines will do in Sutton is 4000) for 15 mins.

- Pipette 6 drops onto PCT-Q test in the bottom hole. Pipette should be filled to line, without bubbles. Tilt slightly when pipetting.

- Leave for 30 mins (max. 45) at room temperature.

- Read test results in conjunction with reference card.



- Test A is invalid
- Test B negatively valid (procalcitonin < 0.5 ng/ml)
- Test C positively valid

Check intensity of band colour with colour blocks on reference card. A positive should be followed up 12-24 hourly and clinical measures taken.

N.B.

A follow-up comparing one test with one from the day before is not valid. The colour may change within a few hours (red to violet). It may also happen that a test which is negative after 30 mins may turn slightly in colour after a few hours, the result after 30 mins is valid in this case.

Hb <5g/dl affects accuracy.

Any queries please call Natalie Pattison, Nurse Researcher: Critical Care

Nursing on ext: 8054, or Shelley Dolan, Nurse Consultant Cancer: Critical

Care ext: 2351

Appendix 9a: Nurse Consent form: Qualitative Interviews

CONSENT FORM

Early identification of sepsis in patient with cancer (Nurse consent)

Protocol Number: 2372

Please initial box

I confirm that I have read and understand the information sheet for the above study and have had the opportunity to ask questions.

I understand that my participation is voluntary and that I am free to withdraw at any time without giving any reason, without my employment or legal rights being affected

I agree to take part in the above study.

Name of Patient

Date

Signature

Name of Person taking consent
(if different from researcher)

Date

Signature

Researcher

Date

Signature

Appendix: 9b Nurse Consent form: Questionnaires

CONSENT FORM

Early identification of sepsis in patient with cancer (Nurse consent)

Protocol Number: 2372

Please initial box

I confirm that I have read and understand the information sheet for the
above study and have had the opportunity to ask questions.

I understand that my participation is voluntary and that I am free to
withdraw at any time without giving any reason, without my
employment or legal rights being affected

I agree to take part in the above study.

Name of Patient

Date

Signature

Name of Person taking consent

Date

Signature

(if different from researcher)

Researcher

Date

Signature

Appendix 10: Pre-intervention questionnaire

Ward Nurse No. Date

Royal Marsden NHS Foundation Trust

Doctoral research – Shelley Dolan

The early identification of cancer patients who have the immunological precursors for severe sepsis: a tool to confirm nurses' intuition and experience.

Questionnaire for Nurses

Pre-test questionnaire

1. **How long have you worked with cancer patients?** *(please circle answer)*

Less than 1 year 2-4 years 5-10 years more than 10 years

2. **Have you undertaken any post-registration education in cancer nursing?** *(please circle answer)*

ENB 237 type course Diploma in cancer

BSc in cancer

MSc Cancer

Other – please give details...

.....

3. Do you feel your knowledge is up to date regarding the sepsis syndrome? (please circle answer)

No Yes Could be improved

4. Please describe the standard definitions for the different parts of the sepsis cascade

5. What is the mortality rate for severe sepsis in previously healthy adults?

.....

6. What is the mortality rate for severe sepsis in people with cancer?

.....

7. Please describe the early signs of sepsis developing

.....
.....
.....
.....
.....
.....
.....
.....

8. Please list three immunological / blood indicators of sepsis and severe sepsis

.....
.....
.....
.....
.....
.....
.....
.....

9. Do you think that identifying sepsis at an early stage makes any difference to morbidity and mortality rates? (please circle answer)

Yes No Not sure

10. Have you heard of CRP and Procalcitonin blood tests? (please circle answer)

Yes No

11. Do you know how to use the PCT-Q? (please circle answer)

No Yes

12. If one of your patients was developing the early signs of severe sepsis who would you contact? (please list personnel below)

.....
.....
.....
.....
.....
.....
.....
.....

13. Have you nursed a person with cancer who has developed severe sepsis? (please circle answer)

Yes No Not sure

14. Have you ever had the experience of thinking that a patient was deteriorating but finding it difficult to convince other nurses /doctor or other health care professionals?

No Yes

15. If you have had any such experience please could you give an example below:

Thank you very much for completing this questionnaire

Appendix 11: Post-intervention questionnaire

Royal Marsden NHS Foundation Trust

Doctoral research – Shelley Dolan

The early identification of cancer patients who have the immunological precursors for severe sepsis: a tool to confirm nurses' intuition and experience.

Questionnaire for Nurses

Post-test questionnaire

1. How long have you worked with cancer patients? *(please circle answer)*

Less than 1 year 2-4 years 5-10 years more than 10 years

2. Have you undertaken any post-registration education in cancer nursing? *(please circle answer)*

ENB 237 type course Diploma in cancer BSc in cancer

MSc Cancer Other – please give details...

.....

3. Do you feel your knowledge is up to date regarding the sepsis syndrome? (please circle answer)

No Yes Could be improved

4. Please describe the standard definitions for the different parts of the sepsis cascade

5. What is the mortality rate for severe sepsis in previously healthy adults?

.....

6. What is the mortality rate for severe sepsis in people with cancer?

.....

7. Please describe the early signs of sepsis developing

.....

.....

.....

.....

.....

.....

.....

8. Please list three immunological / blood indicators of sepsis and severe sepsis

.....

.....

.....

.....

.....

.....

.....

9. Do you think that identifying sepsis at an early stage makes any difference to morbidity and mortality rates? (please circle answer)

Yes No Not sure

10. **Have you heard of CRP and Procalcitonin blood tests?** *(please circle answer)*

Yes No

11. **Do you know how to use the PCT-Q?** *(please circle answer)*

No Yes

12. **If one of your patients was developing the early signs of severe sepsis who would you contact?** *(please list personnel below)*

.....
.....
.....
.....
.....

13. **Have you nursed a person with cancer who has developed severe sepsis?** *(please circle answer)*

Yes No Not sure

14. Have you ever had the experience of thinking that a patient was deteriorating but finding it difficult to convince other nurses /doctor or other health care professionals?

No

Yes

Thank you very much for completing this questionnaire

Appendix 12 :Patient Information Sheet (PIS)

THE ROYAL MARSDEN FOUNDATION NHS TRUST

Sepsis Study: Protocol Number 2372

PATIENT INFORMATION SHEET

The early identification of sepsis and severe sepsis in patients with cancer

I would like to invite you to take part in a research study. Before you decide it is important for you to understand why the research is being done and what it will involve. Please take time to read the following information carefully and discuss it with friends, relatives and your GP if you wish. Ask us if there is anything that is not clear or if you would like more information. Take time to decide whether or not you wish to take part. Thank you for reading this.

What is the purpose of the study?

This study aims to improve the diagnosis of sepsis and severe sepsis in patients who are receiving inpatient treatment at the Royal Marsden Hospital. Sepsis and Severe Sepsis are conditions where an infection starting somewhere in the body starts to have an effect on the rest of the body causing trouble for the lungs, heart, kidneys or other areas. You may have heard this condition called Septicaemia or Septic Shock. We know from experience and previous research that early diagnosis of this condition is important. This study is hoping to

help nurses on your ward to recognise this condition earlier and therefore hope to improve patient care.

Why am I being invited to take part?

You are due to be admitted to the Royal Marsden for treatment of your cancer or are already receiving treatment on a ward at the Royal Marsden Hospital. Your doctors and nurses in the clinic will have explained that cancer and its treatment: chemotherapy, radiotherapy and surgery can make your body temporarily more susceptible to an infection. The aim of this study is to ask all patients, who because of their cancer or its treatment may be more likely to develop an infection, and then sepsis, to allow a sample of their blood to be tested.

Do I have to take part?

It is up to you to decide whether or not to take part. If you decide to take part you will be given this information sheet to keep and be asked to sign a consent form. If you decide to take part you are still free to change your mind or withdraw at any time and without giving a reason. This will not affect the standard of treatment or care you receive.

What will happen to me if I take part?

During your stay in the ward if you develop a temperature or any of the other early signs of sepsis: faster pulse, lower blood pressure, faster breathing or lowered urine output, we would like to take an extra blood test from you. One of the nurses will take the blood from you either from your central line your Hickman line or your arterial line, or directly from your vein. We will need about 10 mls of your blood about 2 teaspoonful. You will probably need blood taken for other reasons and we will take this blood at the same time. Depending on

your condition we might ask to do this blood test once, twice or three times during your stay in hospital.

What do I have to do?

Agree to have a blood test if you display any of the early signs of sepsis.

What is the drug or procedure that is being tested?

There is no drug being tested but we are testing a kit called PCT-Q which has been used previously in the detection of sepsis and severe sepsis. It is a kit that measures a substance in the blood called Procalcitonin. Procalcitonin levels can give us a clue as to whether a patient is developing sepsis. The PCT-Q has been used in several studies but these have been small and it has not been used in the hospital ward setting before.

What are the possible disadvantages and risks of taking part?

The disadvantage of taking part in this study is having the extra blood tests taken.

What are the possible benefits of taking part?

We hope that the PCT-Q and the information gained will help you. However, this cannot be guaranteed. The information we get from this study may help us to treat future patients with cancer who are at risk of developing sepsis.

What if new information becomes available?

Sometimes during the course of a research project, new information becomes available about the treatment/drug that is being studied. If this happens, your research nurse will tell you about it and discuss with you whether you want to continue in the study. If you decide to

withdraw your research nurse will make arrangements for your care to continue. If you decide to continue in the study you will be asked to sign an updated consent form.

Also, on receiving new information your research nurse might consider it to be in your best interests to withdraw you from the study. He/she will explain the reasons and arrange for your care to continue.

Will my taking part in this study be kept confidential?

All information which is collected about you during the course of the research will be kept strictly confidential. Any information about you which leaves the hospital will have your name and address removed. Any presentation or publication that results from this study will have your name and address removed. Your GP with your agreement will also be informed of your participation in this study.

What will happen to the results of the research study?

The results of this study are likely to be available in December 2005, if you would like a summary of the results when available please let us know. The results will also be presented at conferences and as part of the education of cancer nurses, and in relevant cancer publications.

Who has reviewed the study?

This study has been reviewed by the Committee for Clinical Research and the Research Ethics Committee of the Royal Marsden NHS Trust.

Contact for the Further Information;

If you require any further information or if you have any questions about the study please contact any of the numbers listed below:

Natalie Pattison Nurse Researcher: Critical Care Nursing 0207 811 8054

Shelley Dolan Nurse Consultant 0207 808 2351

Sister Critical Care Outreach (Chelsea) 0207 808 2331

Sister Critical Care Outreach (Sutton) 0208 642 6011 ext: 1427/1038

Date given to patient: _____

Appendix 13: Patient consent form

CONSENT FORM

Early identification of sepsis in patient with cancer (Patient consent)

Protocol Number: 2372

Please initial box

I confirm that I have read and understand the information sheet for the above study and have had the opportunity to ask questions.

I understand that my participation is voluntary and that I am free to withdraw at any time without giving any reason, without my medical care or legal rights being affected

I understand that information from my medical notes may be reviewed by the study team. I give my permission for this team to look at my clinical notes.

I agree to take part in the above study.

Name of Patient Date Signature

Name of Person taking consent Date Signature
(if different from researcher)

Researcher Date Signature

Appendix 15: Transcript from the post-intervention qualitative interviews

THE ROYAL MARSDEN NHS TRUST

Sepsis Study

Study Protocol Number:

Interviewees: 10

Post-intervention interviews

Date: 14/12/05

— the patient usually is one to know something wrong
— Nurse response

patient not right

effective communication
= MD team

Nurses learn by examples
my support 2000s
example of deterioration

— Use of ACT-Q

(packaging info)

SD: ... finally I should have said its all confidential, you are given a number and the tapes are destroyed after they've been transcribed. OK.

10: Yes

SD: Thank you very much for this. Erm first of all I just want to ask since, since you've been working on the unit, probably since you came back, have you had the experience of looking after somebody erm... who you've thought are, they're going to develop sepsis? Or anybody who you know, kind of was alright, and then is going off and then you think that could be sepsis.

10: Not since I've come back.

SD: Right. So right it would be reflecting back erm, is there anyone you can think of when you reflect back and, I don't know, it could be anyone on the unit or on a ward or whatever, who was going along alright and then maybe developed some changes?

10: Um, probably a patient who came back and who was with us for a few days after having an oesophagogastrectomy.

SD: Right

10: Whose name I can't remember.

SD: And you shouldn't say anyway so that's alright! (laughing)

10: And he was toodling along okay, chest drains were coming out and um, up to sit and then he became sort of generally unwell, clammy, Respiratory-wise he was going off. There was nothing palpable you could put your finger on initially, you just sensed there was something not quite right with him. He just looked a little bit more distressed even though he was comfortable he was just a little bit slow to respond when you spoke to him...

SD: Right, right

10: ...those kind of initial things where you look at the patient and you see that there's not, something's ... something's not right.

SD: Yeah. Brilliant, thank you. Erm, have you had a chance to use the PCT-Q?

10: I haven't, no.

SD: No, that's fine. Erm and the reason... and er why do you think you haven't used it?

10: I think because it's because I've been off sick for quite a long period of time.

SD: That's fine, that's fine. I don't want to put any words in your mouth but I presumed that was why. Erm, do you think you understand what it is or why we would be using it?

10: I understand it's an indicator, an early sign of sepsis, but as for the actual mechanics of it I'm not totally ...

SD: Okay. That's fine. Do you...erm, it's probably a slightly unfair question because you've been back such a short time. But have you heard people talking about the measurement of it in the unit when they've been talking about in the unit when they've been talking about patients?

10: I haven't, no.

SD: No, that's fine. Erm, final question about the PCT-Q. Do you remember which level of PCT-Q is a kind of worrisome level?

[pause]

SD: It's absol...

10: No (laughs)

SD: Absolutely. That's fine 10. 'Cause the other questions are not about the PCT-Q ...

10: Right

SD: ...and it's completely understandable 'cause you've not been around. Erm, okay, I'm now going to leave the PCT-Q questions and I've just got one, two, three, four, five questions ...

10: Okay

②

SD: ...erm about the early recognition of sepsis generally. Obviously, in your role you're a lot about coaching and teaching junior staff.

10: Yes

SD: If you were coaching or teaching a junior staff member about how to recognise the early signs of sepsis. Thinking about the early stages - SIRS sort of stage, what would you say to them...you know, would, should make them think about it?

10: When they're doing their checks of the patient you know...

SD: Yes

10: ...observe the patients colour, how the patient is breathing, how the patient responding. If they are in pain, if they are not in pain 'cause that might be a sign of sepsis, 'cause they've actually got a...especially if they are surgical patients 'cause they've got a wound...

SD: Yes, yes

10: Erm, once they've done the drip, the erm the assessment of the patients to look at the patient's vital signs, their blood pressure, heart rate erm their temperature if there's an underlying, a sort of slow rise in temperature.

SD: Yes, yes

10: Erm...if they're clammy, if their fluid requirements are going up. If their urine output's varying at all, if it's going down.

SD: Yes, yes.

10: Erm, I think that's all...

SD: Yes, that's great. Thankyou. It's a sort of leadership question, but erm, if you were talking to, teaching the same nurse who might either be on a unit or on the ward...

10: Mmhmm

SD: And you were trying to tell her how to mobilise help around. So, you know, you know how to effect help around. I don't mean in an arrest situation, more in the early stage... how do you, how would you tell the nurse (laughing), to talk to, say, doctors or senior nurses to get them to pay attention to you.

10: I think it's very important to have, maybe prior to this I would make sure that nurses knew they were empowered within this hospital and within this trust

SD: Yeah

(3)

10: That they, that their voice will be heard.

SD: Yes

10: And that should be done maybe at induction when they come to work here.

SD: Yes yes

10: That they are not just a number but that their view and their perception of what is happening with the patient is very important.

SD: Yes

10: So we should still empower those working here.

SD: Yes

10: And erm, again if they have concerns about the patient, that those are real concerns and that they should be able to act on them so it's being able to assess the patient and being able to get accurate information to the other nurses on duty. Maybe the F grade who is on in-charge. When they go to get in touch with the doctor to have the accurate bullet points of what has happened with the patients. So they're able to liaise with the doctors or with the other members of the multi-disciplinary team.

SD: Yes

10: When they're getting in touch with the outreach to be able to have all the information on the patient there ready to give us.

SD: Yes

10: So that they get a quick response to what is happening with the patient.

SD: Yeah, brilliant. Thank you. Erm, (laughs) Erm, no that's brilliant. Erm I suppose I just want to push you one more bit on that because you are very experienced nurse.

10: Mmhmm

SD: You've got all that information together and all that kind of stuff. How do you actually, say its doctors, how do you talk to them, you know, what's the kind of way you do it to make it work?

10: You would talk to the doctors erm I concerned about this patient. They look like this.

SD: Yep.

④

10: ... You know, and you would give a description of how the patient physically looked and say that there's been slight but marked changes in the patient's condition.

SD: Yes, yes

10: And overall the ... with the temperature, with the blood pressure with the urine output, with the fluid requirements or whatever. Because this isn't normal for the patient. There's been an actual change with them ... with the patients brewing, or going along and improving and then all of a sudden this is started to happen...

SD: Yes

10: So there's been a marked [pause]

SD: deterioration?

10: Deterioration (both laugh) Although not a dramatic one maybe initially there has been a deterioration in the condition, to have all that information together not to just go to the doctor: "I think that this is happening..."

SD: Absolutely, absolutely

10: To be a professional to have it all with them when they do go there.

SD: Fantastic, erm... is it ... when you're speaking to somebody about sepsis the nurse or whatever ... is there, do you think the patient ever knows ... that there's something wrong? Do you think, in your experience, has the patient ever had any inkling?

10: The patient's usually maybe the first one that actually indicates that there's something wrong

SD: Right, right.

10: They may not verbalise it, but initially they will probably, eventually say if you start to show concern, people might say "Actually I don't feel ... I feel sick..."

SD: Right, yes

10: And it's usually a feeling of just unwellness...

SD: Yes

10: ... that they feel a change has happened. They feel cold and shivery.

SD: Yes

5

10: You know, they might want to put another bed jacket on...

SD: Yes, yes

10: Or something, another blanket 'cause they're feeling unwell, they feel a general malaise.

SD: Right, brilliant. Thank you 10. In a cancer hospital is there anything er that you think we could do to improve the early diagnosis of sepsis? Is there anything else that we could do, do you think?

(pause)

10: Erm, I think that nurse education is important and nurses knowing how to present their patients that if they are concerned about a patient, that those concerns are relevant to the patient's care.

SD: Yes

10: And that should not just, they should be empowered to be able to sort of say to people that I'm this is important and you maybe need to have some form of indicators, either a flow chart, or an early warning chart.

SD: Yeah, yeah

10: That says if this happens, this happens then you should contact... and I think with the outreach... (whispers) what's it called?

SD: Outreach team, Oh erm the early warning system

10: The early warning system, the nurses know that they should get in touch but it just gives them a little bit more...

SD: Yeah

10: ... they feel encouraged by because it's actually there and they can actually quote numbers and say that this is needed.

SD: Yeah, brilliant. Thankyou very much. Penultimate question.

10: Penultimate

SD: Erm, yeah how have you (both laugh)...in , if you think back on your career, how have you learnt what you have learnt, do you think? What's you know if I'm looking at how nurses, how best to help nurses learn? How have you learnt what you've learnt?

10: By example (both laugh). Erm, both by example and by actually working with patients by being exposed to those situations with support erm

6

and also obviously through more structured learning and more structured learning environments.

SD: Yes

10: I think in the critical care unit it is a more structured learning environment and it is both formal and informal. And in those environments there should always be an opportunity for junior nurses to be able to be exposed to a patient who is undergoing this dreadful situation. Erm, the nurses should be supported and it should be used, wherever possible, as a teaching tool as well.

SD: Yes, yes.

10: ...which is a dreadful way to talk about a patient...

SD: No, but... yeah

10: ...the nurses... these situations should be utilised wherever possible. So that nurses can be taught.

SD: Yes, yes. Yeah. Thank you. Finally is there anything else you'd like to add about the early diagnosis of sepsis?

10: Well just that I'm sorry that I missed out on the...

SD: PCT-Q?

10: PCT. Erm, but I'm very interested to hear. I'll be very interested to hear the results of the study. (both laugh)

SD: Thank you so much.

10: Thank you so much for involving me.

SD: Thank you very much for being part of it.

END

⑦

Glossary

Acquired immunity – immunity acquired by infection or vaccination.

Acute Graft versus Host Disease (AGvHD) – a complication of allogenic blood or marrow transplant that occurs in the first 100 days following transplant, when transplanted cells mount an immunological attack on the host.

Adenocarcinoma – cancer that originates from epithelial or glandular tissue.

Allogeneic Transplant – blood or marrow transplant from another person.

Anastomotic leak – is a serious complication of a leak at the site of a surgical join or anastomosis. In Gastro-intestinal surgery this leak can be associated with sepsis and a critical illness.

Antibody – or immunoglobulin (Ig) is a protein in the blood that is used by the immune system to identify and neutralize foreign organisms such as bacteria or viruses.

Antigen – a substance that prompts generation of antibodies and an immune response.

Anti-inflammatory mediators – substances released to control the process of inflammation.

Antimicrobial proteins – are important components of the innate immune system.

Autologous Transplant – blood or marrow transplant from the self.

Apoptosis – the process of programmed cell death involving a series of biochemical events.

B cell – lymphocyte that has a major role in the humoral immune response making antibodies against antigens.

Basophil – the least common of the white blood cell involved in the immune system and in allergic reactions.

Blasts – immature blood cells that in large numbers can be an indicator of disease such as leukaemia.

Calcitonin – a 32- amino acid linear polypeptide hormone produced primarily by the parafollicular cells of the thyroid.

Cancer – a class of diseases where cells grow in an uncontrolled way, invade and destroy other tissues and can metastasise locally or to distant sites.

Carcinogenesis – the process by which normal cells are transformed into cancer cells.

Cell cycle or cell division cycle – the process that takes place in a cell that leads to its division and replication.

Central-venous Access Device (CVAD) – small flexible plastic tubes inserted into large veins for the delivery of fluids and medicines.

Chemokine – small cytokine or protein secreted by cells. Some chemokines are pro-inflammatory and are used to direct cells of the immune system to the site of an infection.

Chemotactic (chemotaxis) – the phenomenon by which cells and bacteria direct their movements according to chemicals in their environment.

Chemotherapy – chemical treatment of disease in this study cancer.

Cluster Designation system (CD) – a system of defining the cell surface molecule on an immune cell.

Co-morbid – the presence of one or more diseases in addition to the primary disease.

Complement system – the biochemical system that helps to clear pathogens from the host. It is part of the innate immune system.

C-reactive protein (CRP) – is a protein produced by the liver and fat cells and is found in the blood as a response to inflammation (an acute phase protein).

Critical Care Unit (CCU) – a specialised unit in a hospital that provides intensive care.

Critical Care Outreach Team (CCOT) – a multi-professional or nursing team taking critical care skills onto the wards external to critical care.

Cytokine – is a signalling molecule that is used extensively in cellular communication. Cytokines are critical to the development and functioning of the immune system.

Deoxyribonucleic acid (DNA) – a nucleic acid that contains all the genetic instructions used in the development and functioning of all living organisms.

Electrocardiogram (ECG) – the recording of the electrical activity of the heart over time using skin electrodes.

Empirical – data or information produced by experiment, experience or observation.

Endothelium – the thin layer of cells that line the interior surface of the blood vessels.

Endotoxin – a toxin associated with certain bacteria. Endotoxin forms a structural component of the bacteria and is released when the bacteria is lysed.

Eosinophil – a white blood cell that is responsible for combating infection and parasites in the immune system.

Epidemiology – the study of factors that affect the health and illness of populations.

Epiphyses – the rounded end of a long bone that is filled with red bone marrow.

Epistemology – the theory of knowledge, how we know what we know.

Epithelial cells – line the cavities and surfaces of structures throughout the body. Epithelial cells express adhesion molecules such as immunoglobulins which are essential in the immune system.

Erythrocytes – red blood cells the most common blood cell. They contain haemoglobin which has an affinity for oxygen.

Failure to Rescue – failure of health care professionals to respond in a timely or effective manner to acute patient deterioration.

Gel filtration chromatography – a process that separates molecules of different size such as proteins, peptides and oligonucleotides.

Glycoprotein – a protein that contains oligosaccharide chains that are important in cell cell interactions.

Granulocyte colony-stimulating factor (G-CSF) – is a growth factor to produce granulocytes and stem cells.

Haematological cancer – a cancer that affects the cells of the blood or lymphatic system.

Haematopoiesis – the formation of blood cell components.

Hemostatic balance – the complex process that causes the blood to clot, includes primary and secondary hemostasis.

Hepa filtration – removes 99% of airborne particles measuring 0.3 micrometers in diameter. Hepafilters are used in bone marrow transplant units to protect transplant recipients.

Heuristics – an adjective for methods that help with problem solving which lead to learning and discovery. These methods typically use experimentation or trial and error, heuristic methods are “rules of thumb” or educated guesses, intuition.

Human Immunodeficiency Virus (HIV) – a retrovirus that can lead to Acquired Immunodeficiency Syndrome (AIDS) that causes the immune system to fail.

Immunochromatic – a rapid dipstick type test to test the presence of a chemical substance for example procalcitonin in the PCT-Q.

Immunology – the physiological functioning of the immune system in health and illness.

Immunoneutralisation - the neutralisation of various aspects of the immune system in an effort to moderate or prevent severe sepsis.

Immunosuppression – reduction of the activation or efficacy of the immune system as a result of cancer or the treatment of cancer.

Immune System – processes that protect the host from disease by identifying and killing pathogens and cancer cells.

Infection – the detrimental colonisation of a host by a foreign organism.

Inflammation – the complex biological response of vascular tissues to harmful stimuli such as pathogens, infection, damaged cells or irritants.

Innate immunity – the cells and mechanisms that protect the host from infection in a generic way.

Intuitive- humanist – a type of decision making that is based on intuition and is more likely to be used by the expert than the novice.

Lactate – lactic acid which is constantly produced from pyruvate by the action of the enzyme lactate dehydrogenase (LDH) during metabolism and exercise.

Lactate Dehydrogenase (LDH) – an enzyme that converts pyruvate to lactic acid in low oxygen states. LDH is abundant in red blood cells and a high level can indicate haemolysis but also the breakdown of other cells.

Leukaemia – cancer of the blood or bone marrow.

Leukocyte – another term for the family of white blood cells.

Logistic regression analysis – a statistical process used to predict the probability of the occurrence of an event by fitting data to a logistic curve.

Lymphocytes – a type of white blood cell important in the immune system.

Macromolecules – a large molecule usually in the field of biochemistry.

Macrophage – white blood cells within the tissues which are involved in phagocytosis and therefore an important part of the immune system.

Mean Arterial Pressure (MAP) – at normal resting heart rates the MAP is twice the diastolic Pressure + systolic pressure then the total divided by three. At high heart rates the MAP is closer to the arithmetic mean of the systolic and diastolic pressures. In Critical Care Units cardiac monitors display the MAP continuously.

Megakaryocyte – a blood marrow cell responsible for the production of platelets which are involved in the clotting of the blood.

Meningitis – inflammation of the three meninges which form the protective membrane covering the brain and spinal cord. This can be caused by infection, disease and some drugs.

Modified Early Warning Score (MEWS) – a simple physiological scoring system to be used at the bedside to detect deterioration.

Monoclonal antibody – monospecific antibodies that are identical because they are produced by one type of immune cells.

Morbidity – disease or sickness due to any cause, often used as a measure of incidence of disease in contrast to mortality.

Multi-Organ Dysfunction Syndrome (MODS) – altered organ function in a patient which requires medical intervention.

Myeloid cell line – is one of two groups of stem cells produced in the bone marrow that differentiates into several types of blood cells including: megakaryocytes, erythrocytes, macrophages, neutrophils, eosinophils, basophils.

Myelosuppression – the bone marrow is suppressed as a result of cancer or treatment for cancer and results in less red and white blood cells and platelets being produced.

Natural Killer Cells (NK) – a type of cytotoxic lymphocyte that play an important role in the rejection of tumours and cells infected by viruses. NK cells are an important part of the innate immune system.

Neuroendocrine cells – cells that receive neuronal input and then release hormones to the blood.

Neutrophil – the most abundant white blood cell which has a very important role in the immune system.

Non-Hodgkins Lymphoma – a cancer that starts in the lymphatic system and affects B cell or T cell lymphocytes but most commonly B cell.

Null model – null model or null hypothesis is a statistical method or computer simulation used to test a hypothesis. The null hypothesis (H_0) specifies the value of the parameter to be tested the null hypothesis will then be contrasted by another hypothesis.

Oesophagogastrectomy – large surgical procedure to remove the lower oesophagus and proximal stomach for the treatment of cancer.

Pancreatitis – inflammation of the pancreas which in its acute form can cause a critical illness.

Pancytopenia – a condition where the red and white blood cells and platelets are reduced due to disease such as cancer or treatment for the disease.

Paradigm – a philosophical or theoretical framework.

Parafollicular cells – also called C cells are in the thyroid and produce and secrete Calcitonin.

Pathogen – an infectious agent that causes disease or illness of the host.

Patient At Risk Team (PART) – a multi-professional or nursing team taking critical care skills onto the wards external to critical care.

PCT-Q – rapid bedside test for measuring serum procalcitonin.

Perineum – the surface region in males and females between the symphysis pubis and the coccyx.

Periodontium – the layer of connective tissue around the teeth.

Phagocytosis – a cellular process used to engulf and remove dead cells and bacteria from the host.

Platelet – or thrombocytes are small anuclear cells which play a fundamental role in hemostasis and are a source of growth factors.

Pluripotent stem cell – a stem cell that has the potential to differentiate into any of the three germ layers (endoderm, mesoderm or ectoderm).

Pneumonitis – inflammation of the lung tissue which can be caused by many irritants such as infection or chemotherapy or radiotherapy.

Polymorphonuclear cells – these are granulocytes which are white blood cells characterised by the granules in their cytoplasm. There are three types Neutrophils, Basophils and Eosinophils with neutrophils being the most abundant.

Praxis – the process by which a skill, theory or lesson is enacted or practiced.

Procalcitonin (PCT) - is a 116 amino acid protein which is a predictor of sepsis.

Procoagulant – the precursor of any of the substances needed for coagulation (clotting) of the blood or an agent that promotes coagulation.

Pro-inflammatory mediators – When harmful bacteria or other irritants attack the host pro-inflammatory mediators are released to initiate the inflammatory process.

Radiotherapy – the use of ionising radiation for the treatment of cancer.

Reflexivity – a subjective process of self-consciousness inquiry used in qualitative research methods.

Ribonucleic acid – a single strand of nucleotide units. RNA is central to the synthesis of proteins.

Septic screen – specimens of skin flora, blood, urine, faecal or wound drainage collected and sent for microbiological culture to assess the cause of an infection and sepsis.

Septic Shock – critical medical condition resulting from reduced tissue perfusion and oxygen delivery as the result of sepsis and infection.

Serum lactate – high lactate levels are present in the blood in septic shock and severe sepsis probably as a result of anaerobic metabolism due to hypoperfusion. Serum lactate is typically measured in a blood gas analyser in a Critical Care Unit.

Squamous cell – a cell of the squamous epithelium that is characterised by its flat scale like cells.

Staphylococcal Toxic Shock Syndrome – a rare critical illness caused by a bacterial toxin.

Systemic Inflammatory Response Syndrome (SIRS) - is an inflammatory state of the whole body with no proven infection.

Systematic Positivism – a philosophy developed from Comte by Herbert Spencer (1820-1903) that all knowledge is attainable by scientific inquiry.

T cell – belong to the group of white blood cells called lymphocytes. Tcells play a major role in cell- mediated immunity.

Tachypnoea – rapid breathing may be caused by the need to excrete carbon dioxide or another gas such as carbon monoxide.

Targeted Therapies – cancer therapy that targets drugs against specific targeted molecules which govern carcinogenesis and tumour growth.

Teratoma – a tumour which is histologically based on the germ cell most often found in the ovary or testis.

Tertiary referral centre – a hospital that receives referrals for specialist treatment from general hospitals or General Practitioners.

Total body irradiation – irradiation of the whole body (shielding the lungs) in preparation for a blood or marrow transplant for haematological cancer.

Vasomotor tone – the constant level of nervous stimulation to the muscles in the walls of blood vessels.

Veno-Occlusive Disease (VOD) – a disease following high dose induction chemotherapy prior to blood or marrow transplantation where the small veins in the liver are blocked.

Vital signs – measures of physiological statistics monitored by health care professionals to assess body functions, for example, heart rate, respiratory rate, temperature and blood pressure.

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