The Impact of Tele-advice on the Community Nurses’ Management of Leg Ulcers

J. Melanie Peters
The Impact of Tele-advice on the Community Nurses’ Management of Leg Ulcers

J. Melanie Peters

A thesis submitted in partial fulfilment of the requirements of the Council for National Academic Awards for the degree of Doctor of Philosophy

August 2003
University of Glamorgan
Declaration

This dissertation has not been, nor is being currently submitted for the award of any other degree or similar qualification.

Candidate

[Signature]

J. Melanie Peters

Director of Studies

[Signature]

J. Melanie Peters

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The copyright of this thesis is vested in the author.
Acknowledgements

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Finally, I have to thank Dave, Charlotte, Rachel and Robert. I now have no more excuses for providing boil-in-the-bag meals every night!
Abstract

This study attempted to investigate the impact of new technology, specifically tele-advice on community nurses’ care of leg ulcers. Firstly, a stratified randomised controlled study was designed to measure the impact of using this technology on their levels of wound knowledge and confidence. An individual self-test questionnaire and an attitudinal scale measured nurses’ knowledge and confidence respectively both pre and post-intervention. Secondly, a new visual wound assessment tool was designed to represent the state of the wound by a single numerical value; the State of the Wound Index (SWI). Thirdly, the impact of nurses’ knowledge, confidence and patient variables was explored to assess their impact on the state of the wound as represented by SWI.

The sample consisted of thirty-eight registered primary care nurses from two local NHS trusts in South Wales and their corresponding 38 patients with venous leg ulcers. Nurses were stratified according to their qualifications into experimental or control groups. Both groups were shown to have comparable levels of knowledge and confidence pre-intervention. Nurses in the experimental group received expert tele-advice by a Clinical Nurse Specialist (CNS) over a 12 week period regarding the care of their patient’s leg ulcer, whilst those in the control group continued to care for their leg ulcer patients in the traditional way.

In the experimental group, nurses’ level of knowledge increased significantly (p=0.02) whilst no improvement was observed for the control group. In terms of confidence, the experimental group reached near significance when extremely positive statements were excluded with no improvement observed for the control group. Results show that the intervention had a positively significant impact on nurses’ wound care knowledge and level of confidence.

A set of 18 tele-transmittable wound factors was identified by a panel of wound experts. These factors were ranked by another independent panel of leg ulcer experts and no significance could be established in their order of importance. These factors were then examined for their highest and lowest possible estimates for every wound in the sample both pre and post intervention using a Visual Analogue Scale (VAS). These estimated values formed the basis for 95% confidence interval estimates from which 100 virtual nurse assessed values were generated. These values were then used to generate SWI. This new index ranged from 0 (best possible state) to 100 (worse possible) and was seen to reliably increase when the wound deteriorated and decrease as the wound improved.

Linear regression models were built to establish the relationship between SWI, patient variables and nurses’ knowledge and confidence levels pre and post-intervention. These indicated that knowledge and confidence can have a positive impact on the healing process.

This study has shown that there is great potential for the use of tele-advice in community nurses’ care of leg ulcers. For this to succeed, it is recommended that further pre and post registration nurse training is provided to enhance their knowledge in wound care, especially in the areas of physiology and wound assessment.
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**Glossary and Abbreviations**

**ABPI**
Ankle Brachial Pressure Index. A handheld Doppler ultrasound test used to determine the presence and degree of peripheral arterial disease in patients with leg ulcers.

**AHCP**
Agency for Health Care Policy and Research.

**aetiology**
cause of disease.

**allergic reaction**
the body’s response to an allergic stimulus.

**AMWIS**
Alfred/Medseed Wound Imaging System (Santamaria & Clayton, 2000).

**anatomy**
the study of the structure of the body and the relationship between its parts.

**ankle flare**
distension of the small vessels which appear around the ankle and heel.

**atherosclerosis**
hardening of the artery caused through an accumulation of deposits in the tunica intima (inner lining).

**atrophie blanche**
small smooth ivory white areas with hyperpigmented borders and telangiectasis.

**autolysis**
spontaneous lysis (rupture) of cells produced by the release of enzymes.

**BMI**
body mass index.

**calibration**
determination of correct graduations.

**CAMs**
complimentary and alternative medical therapies.

**Cartesian co-ordinates**
rectilinear two-dimensional or three-dimensional co-ordinates (and therefore a special case of curvilinear co-ordinates) which are also called rectangular co-ordinates. The three axes of three-dimensional Cartesian co-ordinates, conventionally denoted the x-, y-, and z-axes are chosen to be linear and mutually perpendicular. In three dimensions, the co-ordinates x, y, and z may lie anywhere in the interval.

**CD**
compact disc.

**clinical governance**
a framework through which NHS organisations are accountable for continuously improving the quality of their services and safeguarding high standards of care by creating an environment in which excellence in clinical care will flourish (DoH, 1998).
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<td>community nurse</td>
<td>a registered nurse who has received post-basic training in order to provide skilled nursing care to all persons living in the community (DHSS, 1981).</td>
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<td>compression therapy</td>
<td>treatment of venous insufficiency, varicose veins or venous ulceration of the limbs using compressing bandages or stockings.</td>
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<td>confidence</td>
<td>self reliance (Oxford Medical Dictionary, 1930).</td>
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<td>concurrent validity</td>
<td>a type of criterion-related validity in which the independent criterion is measured at the same time as the instrument under study.</td>
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<td>content validity</td>
<td>the degree to which a measure covers the range of items included in that concept.</td>
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<td>CTRL</td>
<td>control group.</td>
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<td>decentralization</td>
<td>the dispersion or distribution of functions and powers; specifically: the delegation of power from a central authority to regional and local authorities (Merriam-Webster's Online Dictionary, 2003).</td>
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<td>diastolic</td>
<td>intracardiac pressure during diastolic relaxation of a cardiac chamber.</td>
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<td>diathesis</td>
<td>a constitutional predisposition toward a particular state or condition and especially one that is abnormal or diseased (Merriam-Webster's Online Dictionary, 2003).</td>
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<td>DoH</td>
<td>Department of Health.</td>
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<td>ENB</td>
<td>English National Board.</td>
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<td>epidemiology</td>
<td>branch of medicine concerned with epidemics.</td>
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<td>epithelialisation</td>
<td>stage of wound healing where epidermal cells migrate across the surface and of the wound from the wound margins and their remaining hair follicles.</td>
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<td>EPR</td>
<td>Electronic Patient Records.</td>
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<td>evidence-based practice</td>
<td>The conscientious, explicit and judicious use of current best evidence in decision making (Sackett et at. 1997).</td>
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<td>Term</td>
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<td>EXP</td>
<td>experimental group.</td>
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<td>exudate</td>
<td>material such as fluid, cells or cellular debris which has escaped from blood vessels and has been deposited in tissues or on tissue surfaces.</td>
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<td>face validity</td>
<td>the appearance of measuring the appropriate construct.</td>
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<td>gaiter area</td>
<td>Area of the lower leg from 2.5 cm below the malleoli to the point at which the calf muscles become prominent posteriorly (Callam et al. 1987).</td>
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<td>granulation</td>
<td>bright red tissue formed from new capillary loops.</td>
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<td>haemosiderin</td>
<td>a pigment containing iron.</td>
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<td>haemostat</td>
<td>device or chemical substance which stops blood flow.</td>
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<td>hematopoiesis</td>
<td>the formation and development of blood cells.</td>
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<td>hematopoietic</td>
<td>an agent that promotes hematopoiesis.</td>
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<td>heterogeneous</td>
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<td>holism</td>
<td>studying an organism as a whole rather than parts.</td>
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<td>homogeneous</td>
<td>the same.</td>
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<td>hypertension</td>
<td>persistently high arterial blood pressure.</td>
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<td>incidence</td>
<td>the number at risk of developing a disease during a specified time period.</td>
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<td>indolent</td>
<td>inactive.</td>
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<td>induration</td>
<td>an excessive hardening of any body site.</td>
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<tr>
<td>intra-rater reliability</td>
<td>a type of reliability assessment in which the same assessment is completed by the same rater on two or more occasions. These different ratings are then compared, generally by means of correlation.</td>
</tr>
<tr>
<td>inter-rater reliability</td>
<td>a type of reliability assessment in which a particular assessment is completed by two or more raters and these different ratings are then compared.</td>
</tr>
<tr>
<td>ischemia</td>
<td>obstruction of the arterial blood supply or inadequate arterial blood flow.</td>
</tr>
<tr>
<td>isotonic solution</td>
<td>a solution having the same tonicity as another solution with which it is compared.</td>
</tr>
</tbody>
</table>
knowledge a person’s range of information (Oxford Medical Dictionary, 1930).

lipodermatosclerosis skin changes seen in venous leg ulceration, characterised by induration, brown pigmentation, scaling, eczematous dermatitis and itching (Kushner, 1992).

LPN licensed practitioner nurse.

lymphoedema swelling of a region of the body.

malleoli ankle bone.

microbiology the study of organisms that are too small to be seen with the naked eye, such as bacteria, viruses and yeasts.

NA nursing auxiliary.

NACNS National Association of Clinical Nurse Specialists.

NAO National Audit Office.

necrosis local death of tissue.

neuropathy an impairment of the functioning of the nerves.

NHS National Health Service.

NHS CRD National Health Service Centre for Reviews and Dissemination.

NHSME National Health Service Management Executive.

NMC Nursing and Midwifery Council.

non-compliance failure to adhere to instructions.

oedema the presence of abnormally large amounts of fluid in the intercellular tissue spaces of the body.

pathogenesis the origination and development of a disease.

perforator vein vein connecting the deep and superficial veins.

pharmacology the medical science that deals with the discovery, chemistry, effects, uses and manufacture of drugs.
photo-plethysmography: a technique for assessing blood flow by placing a diode that emits infrared light, along with a sensor, on the surface of the skin over a blood vessel; the amount of light reflected back to the sensor is inversely proportional to the number of red blood cells flowing through the vessel. (Dorland's Illustrated Medical Dictionary, 2002).

physiology: the science of the functioning of living organisms.

pigmentation: abnormally increased colour due to melanin.

pilonidal sinus: fistula in the sacral region communicating with the exterior, containing hair.

post C: post-intervention confidence.

post WK: post-intervention wound knowledge.

pre C: pre-intervention confidence.

pre WK: pre-intervention wound knowledge.

pruritis: itching.


PWAT: photographic wound assessment tool (Houghton et al. 2000).

pyoderma gangrenosum: a chronic, non-infective eruption of spreading undermined ulcers showing central healing with diffuse dermal neutrophil infiltration (Stedman’s Online Medical Dictionary, 2003).

reflux: back flow.

reticular veins: veins which are abnormally dilated.

RN: registered nurse.

WHO: World Health Organisation.
Chapter One. Introduction

1.1 Introduction

It has been estimated that in the UK there are about 100,000 patients with active leg ulcers (Shami et al. 1997) and often these are not unique episodes. Chronic wounds, notably pressure ulcers and leg ulcers, are persistent problems. Many people receive nursing care in hospital and at home and the number of those choosing not to seek professional care has also been described as high (Nelzen et al. 1996). Whilst there is an increasing trend towards nursing patients in the home, the majority of patients with leg ulcers are found within primary care and comprise a major component of the community nurses’ workload (Cornwall et al. 1986, Callam et al. 1992). Leg ulcers are primarily caused through venous insufficiency, although arterial disease, rheumatoid arthritis, diabetes and other less common conditions may be contributory factors in their development. A general description of a leg ulcer is provided by Baker et al. (1991):

“a defect in the dermis at a site below the knee, persistent for 1 month or longer” (page 864).

However, consideration should be given to ulcers occurring on the foot which are invariably arterial or diabetic (Dale 1994). By definition, a chronic wound is one that does not achieve closure within 3 months or when no tendency for healing can be detected after 2 weeks (Wollina 2000).
Wide variations in recurrence reporting can be found throughout the literature from 69% (Monk & Sarkany 1982) to 26% (Franks et al. 1995), although the improvement seen in the latter study may be due to new technological developments in leg ulcer care seen over the past decade. Whilst both figures may be accurate for their time, recurrence is constant. Leg ulcers may also be active (or open) for extremely long periods of time. For example, Callam et al. (1987) reported an episode spanning over sixty years.

Chronic wound treatment is a major expense to the health service in both staff time and resources. Studies report district nurses spending between 10 to 50% of their time treating leg ulcers (Bosanquet 1992) at an estimated cost of £500 million per annum (Dodds 2002). The gradual shift in the balance from hospital to community care has resulted in increasing pressure on community services, as more people with more complex needs are cared for. Public expenditure on community-based care in England exceeded the hospital service (Audit Commission 1992) over a decade ago. At that time it was also proposed that the community nursing service used 60% of the annual wound care cost (Eagle 1992).

Previous studies have found that nursing practice is not evidence-based when deciding on the choice of dressing (Bale 1989, Vydelium 1990, O’Hare 1994, Stevens et al. 1997) and resulting in inadequate management of venous ulcers in the community (NHS CRD 1997).
Kerstein (2003) suggests that a true indication of ulcer costs includes nursing time, physician time, hospital stay, home health costs, risks, costs of complications and the frequency of dressing changes. In a situation of escalating costs where demand outstrips supply, there is a need to examine alternatives in making best use of limited resources (Luker & Kendrick 1995).

The impact of the ulcer on the patient’s lifestyle can be debilitating. Hyland et al. (1994) reported leg ulcer patients experiencing substantial functional limitations and avoidance strategies, such as impaired mobility, avoiding crowded places, and negative emotions such as depression. Price & Harding (1996) found patients with leg ulcers experiencing significantly more pain, less vitality and more restriction in terms of physical and social functioning when compared with age-matched norms. Typically leg ulcers are associated with the elderly. However, the onset of ulcer disease has been reported in early adult life (Callam et al. 1985, Neltzén et al. 1994) which have further financial implications for those below retirement age.

If best practice is to be achieved in wound management, nurses should possess a sound knowledge of the wound healing process and have confidence in their ability to identify the most appropriate treatment regimen. Knowledge and confidence are important attributes in any aspect of nursing practice and are necessary components of wound management, given the existence of an extensive range of wound products and treatment rationales. Knowledge has previously been defined as a “person’s range of information” and confidence as “self reliance” (Oxford Dictionary 1996).
However, research suggests that the nurse's decision in isolation is often inappropriate and may lead to a prolonged recovery for the patient (Dowsett 1997, Dealey 2001). Ulcer recurrence is also a major problem for patients and practitioners.

Collaborative approaches to the provision of leg ulcer aftercare are beginning to receive more attention (Flanagan et al. 2001). Patient education, good follow-up and specialist expert advice would greatly assist in reducing recurrence. However, these factors are often limited to areas with specialist clinics and practitioners. The diverse role of the Clinical Nurse Specialist (CNS) has been developed in response to social, technological and political changes in health care (Humprhis 1994). The National Association of Clinical Nurse Specialists (NACNS) describes the CNS as a clinical expert who bases nursing practice on research and theory in a particular area (NACNS 1998). The Tissue Viability Nurse (TVN) specialist acts as a catalyst to manage change and improve the quality of patient care (James 1994). Although the community nurse is largely responsible for leg ulcer care, their access to expert advice has been limited, often to other colleagues and the local hospital. Many areas may not have specialist nurses in post, or specialist services, such as leg ulcer clinics.

To assist the nurse in managing the wound effectively, a reliable method of recording and reporting the state of the wound should accompany a detailed assessment. However, recording of the progression of wound status is argued to be poor (McTaggart 1994, Harding 1995, Gorin et al. 1996).
CHAPTER ONE
INTRODUCTION

Many authors have attempted to use individual factors such as change in ulcer area measurement (Kantor & Margolis 1998) to determine wound status. However, wound healing is a complex process and cannot reliably be assessed using one factor. For example, a wound may increase in size as necrotic or sloughy tissue is debrided. Whilst the wound is actually improving, evaluating wound progress on area alone would be misleading. The development of an index, based on a combination of relevant factors that represent the state of the wound would provide a reliable method of assessing wound progress.

The rapid development of e-health (electronic health) and technology have created an opportunity to provide immediate expert advice for nurses providing patient care. Technology can be combined with expertise to overcome many of the inadequacies found in wound care, such as limited specialists and ineffective treatment regimes. In particular, telemedicine can be valuable for communities living in rural and remote areas (Yogesan et al. 2002). Samad et al. (2002) describe telemedicine as:

"the electronic exchange of medicinal information at a distance" (page 38).

There are two distinct classes of telemedicine interaction: those that are pre-recorded (store-and-forward) and those that occur in real-time (Loane & Wootton 2002). Store-and-forward techniques frequently use email or internet access to online care whilst real-time may employ telephone consultation or more complex videoconferencing. Telemedicine is an increasingly accepted method of providing care and is especially suited to specialities reliant on good quality visual information such as dermatology and wound care.
Digital photography has also become increasingly popular and is a useful medium for sending information to experts (Rajbhandari et al. 1999, Roth et al. 1999, Taylor 2000, Samad et al. 2002) and is particularly suited to telemedicine.

In the United States the use of telemedicine in the patient's home has increased primarily due to the need to provide high quality, cost effective care (Whitten et al. 1998, Dimmick et al. 2000). However, few UK studies have examined the provision of expert wound care advice in the patient's home. The UK government's move towards modernisation has adopted the strategy that all health improvement programmes will need to consider telemedicine and telehealth care options initially (Van den Bergh 2000). The World Health Organisation (WHO) has also recognised the need for telematics to become part of its Health For All strategy in the 21st century (WHO 1997).

The multi-faceted role of the CNS in tissue viability (CNSTV) including educator, clinician, researcher and change agent, present a well qualified medium to provide expert wound care advice for community nurses. Telemedicine can use the CNS efficiently and effectively, allowing expertise to be spread widely in both time and space. This is especially beneficial in areas with little or no access to specialist advice or services. There is also the potential to make considerable savings in staff time and resources using this technology. The provision of specialist tele-advice has the potential to enhance the community nurses' wound knowledge and confidence in addition to clinical practice. During consultations, nurses have the opportunity to discuss treatment options and best practice can be reinforced.
Specialist nurses are well qualified to facilitate the development of staff who lack detailed knowledge and experience to undertake some clinical functions (Newton 1999). Discussion of the benefits and limitations of treatment regimes with an expert will help the nurse to gain confidence in his/her practice. Telemedicine can assist specialist nurses to determine the state of the wound as many wound factors are transmittable, such as wound colour, wound tissue type and levels of exudate. High quality colour digital images will provide the specialist nurse with reliable information from which the state of the wound can be assessed. Based on a combination of such relevant visual factors, a single numerical index can be developed and used for monitoring improvement or deterioration in the state of the wound. Images can also provide a valuable teaching aid and allow colleagues to view the wound without the removal of dressings.

In the US, Ablaza & Fisher (1998), developed a physician led wound management system using telemedicine to monitor the care of patients at home. The system promoted a multidisciplinary team approach using enterostomal therapists, occupational therapists, physical therapists, podiatrists, dieticians and home health aides. Visiting nurses assessed the wounds and documented findings with digital images or video camera and audio recordings of clinical observations, which were then sent to each member of the team by email or overnight mail. However, ultimate approval of the treatment programme was the physicians' domain. Whilst this study claimed to reduce costs for wound care, the input from such a diverse range of healthcare professionals may have been impractical. In addition, nurses must be conversant with using digital and video cameras, making audio recordings then downloading and transmitting the images. Each member of the team also required access to a computer, email and the internet.
Finally, waiting for the accumulation of each member's treatment recommendation and overall physician approval, may prove to be time consuming and disadvantageous in using this approach.

Few UK studies have used telemedicine for wound care in the primary care setting. However, those that had were either physician led or required the patient to travel to a specialist clinic (Collins 2001, Macduff et al. 2001, Samad et al. 2002, Hayes & Dodds 2003). Many research studies have shown that community leg ulcer clinics can improve healing rates (Moffat et al. 1992, Moffat & Oldroyd 1994, Simon et al. 1996, Morrell et al. 1998, Carrington 1999, Rotchell 1999). However, transportation to and from these clinics remains problematic. Some areas have provided transport free of charge (Moffat & Oldroyd 1994, Morrell et al. 1998). Unfortunately most trusts cannot afford such facilities (Carrington 1999) or sustain them indefinitely. Other areas have relied on voluntary transport which is not always available (Stevens et al. 1997).

The introduction of e-health and telemedicine have created an opportunity to provide on-line and immediate access to wound care expertise in the patient's home. For frail, elderly and immobile patients as well as those in poor health or with transportation difficulties, telemedicine offers consultation within the security of their own home. Major benefits for the patient include not having the expense or inconvenience of travelling to hospital outpatient departments or waiting to be seen. In view of the community nurses' limited access to expert advice, a nurse-led telemedicine approach could provide a practical, simple and cost effective system of disseminating specialist wound management advice.
1.2 Study Aims

The research question of interest in this study asks whether tele-advice can be used efficiently to enhance the role of the community nurse in their care of venous leg ulcers. The purpose of this study is to investigate the provision of expert wound care tele-advice on the knowledge and confidence of community nurses’ caring for venous leg ulcers and whether it can make a significant impact on the state of the wound compared to traditional methods of care.

This study aims to:

- Develop reliable tools to quantify nurses’ knowledge and confidence in their wound care practice;
- Determine the impact of expert advice on nurses’ knowledge and confidence on the wound state;
- Develop a simple, efficient and cost-effective method of adapting telemedicine for wound care within the patient’s home.

The above stated aims can be presented through the following null hypotheses;

**Hypothesis 1:** *Expert tele-advice has no significant impact on nurses’ knowledge and confidence levels in the care of leg ulcers.*

**Hypothesis 2:** *Nurses’ knowledge and confidence levels do not play a significant role in the improvement of leg ulcers.*
Hypothesis 3: No significant relation between the state of the wound, patient factors and nurses' knowledge and confidence levels for the care of the wound could be established.

The study will use an experimental design in an attempt to disprove or reject each hypothesis.
1.3 The Conceptual Framework

The conceptual framework for this study is depicted in figure 1. The experimental pathway is shown in red whilst the control is in black. Each component within the framework is further discussed in the relevant numbered sections as annotated in each box.

Figure 1. Conceptual framework
Consultation, through telemedicine, between community nurses and an experienced CNS, will take the form of discussion and advice regarding the nurse's leg ulcer patient. It is expected that expert advice via telemedicine or tele-advice, will impact on nurses' existing wound care knowledge and confidence levels in managing wounds more effectively. The care of chronic wounds is often a lengthy, cyclical process of ulceration, healing and re-ulceration. Throughout the treatment of the wound, the nurse will constantly draw on their knowledge and confidence to evaluate and review the wound management regimes and record the progression of the wound at each visit. A change in knowledge and confidence levels will be reflected in the way nurses care for the wound and ultimately the progression of wound status.

In order to evaluate the impact of expert advice on knowledge and confidence, two groups of nurses and their corresponding patients with leg ulcers will be used. One group will adopt the newly proposed method of caring for leg ulcers using expert advice and the other will continue with the traditional treatment regimen. Traditional methods of care refer to the community nurse caring for the ulcer as previously determined. Advice may be sought from available sources such as the GP, local hospital or colleagues and may not necessarily be research-based.

In addition to nurses' existing knowledge and confidence levels at the start of the study, patient factors that are expected to influence the progression of the wound such as obesity, diabetes and previous ulceration will be considered.
1.4 Summary of Introduction

This chapter has described the chronic wound care problem, in terms of its impact on health care provision and the patient. The hypotheses have asserted that expert advice has a positive impact on nurses’ knowledge and confidence levels in wound care performance and ultimately the state of the wound. Therefore, it is important that community nurses possess sound knowledge and confidence, in order to provide efficient and evidence-based wound care. Lack of consensus in reporting wound status and current limited access to expert wound care advice was highlighted and a solution suggested by provision of a nurse-led technological approach.

In chapter two the relevant literature will be reviewed. This will include the nature of chronic wounds; who they affect and how they affect these patients. The role of the community nurse, current nurse management and treatment, application of research and the suitability of the CNS to provide expert advice in caring for these patients will be examined. Of particular interest is the examination of nursing knowledge and confidence. Existing tools that measure these concepts and also record the progression of the wound will be discussed. An overview of studies adapting technology for nursing care will be also be considered. Chapter three will discuss the methodological approach taken in this study as a result of reviewing the appropriate literature. The design of the study, recruitment of the sample and the actual intervention will be detailed. Justification will be made for the adopted approach and reasons for not pursuing others will be presented. The use of appropriate statistical tests will be outlined briefly.
In chapter four the findings will be presented and any significant associations highlighted based on the established hypotheses. Chapter five will discuss the findings of this study in relation to the literature. Chapter six will draw conclusions based on these findings. Finally, chapter seven addresses the limitations of this study and makes recommendations for future research and practice.
2.1 Introduction

This chapter is divided into five sections. In the first section, research on the nature of leg ulcers and their aetiological and physiological features are reviewed. In this context a comprehensive understanding of the condition and the type of the likely affected patient is provided thus aiding the design of the study. The prevalence and incidence of leg ulcers is then considered in order to establish the extent of the problem. The second section focuses on the role of community nursing in wound care and the community nurses’ application of research in wound care. The nursing management and treatment of leg ulcers are then reviewed in terms of their assessment and documentation. Consideration is given to the multifaceted role of the CNS and the way that it can be integrated with new technology in wound care. The third section establishes the role of tele-advice in wound care. Previous studies are sought to assess relevant, accurate and cost-effective approaches. Nurses’ knowledge and confidence in wound care are of particular interest throughout this study and the fourth section of the review examines measurement tools related to this issue. An overview of the decision making process is presented given that it is the nurse who decides on the choice of treatment. The final section focuses on methods of wound measurement and the wound assessment factors that may be tele-transmitable in the provision of tele-advice.
A literature search was conducted using a variety of sources including:


- **Grey sources:** unpublished theses, reports and trust audits.

- **Nursing and non-nursing textbooks.**

Key words included: venous leg ulcer, wound, knowledge, confidence, assessment, measurement, community nurses, CNS, wound dressings, telemedicine.

Key word combinations included: wound assessment, nurse knowledge, nurse confidence, wound measurement, wound area measurement, wound assessment.
2.2 The Venous Leg Ulcer Patient

It is important that the aetiology, physiology and course of the chronic wound are understood to identify new strategies of improving care. The impact of chronic wounds on quality of life has not been included in this work since these have already been extensively covered elsewhere in previous research and are not relevant to this study (Charles 1995, Walshe 1995, Price & Harding 1996, Franks & Moffat 1998, Anderson 2000, Teare & Barrett 2002, Wissing et al. 2002).

Leg ulcers are not a contemporary problem and have an extensive history. Approximately 1% of the population will suffer from this condition at some point in their lives (Dale et al., 1983, Callam et al. 1985, Shami et al. 1997). The treatment of chronic leg ulceration was first described by the physicians of ancient Egypt and its association with venous disease has been known at least since the time of Hippocrates (Sarkar & Ballantyne 2000). However, the condition remains widespread in current clinical practice. Regardless of a wealth of literature surrounding wound care, there is wide variation in practice and evidence of unnecessarily prolonged ulcer duration (NHS CRD 1997). The burden associated with leg ulcers has predominantly been reported in primary care. Leg ulcers are managed almost entirely by nurses in the community (Callam et al. 1985, Moffat et al. 1992) of which they spend up to 50% of their time (Bosanquet 1992).
Ulcers are painful and debilitating, affect the quality of life and are costly to treat. O'Brien et al. (2002) estimated the annual direct cost of dressing leg ulcers in Ireland to be €585,660 and a recent study using both UK and US patients estimated treatment costs for venous leg ulcers at $3 billion (McGuckian et al. 2002). The cost of venous disease in the UK has previously been estimated at 2% of the total health care expenditure with prescribing costs for venous disease at 0.26% of the total expenditure (Bosanquet & Franks 1996). Despite this cost, many patients continue to experience ulceration which is maintained rather than healed (Groake et al. 1996) and treatment has been criticised as being complex, expensive and not always effective (Dunn 1998).

In choosing the location in which to receive care, many people would prefer to stay at home (Warner et al. 2003). Therefore, new ways in which nurses can provide efficient quality wound care for patients in the home needs to be explored.

2.2.1 Ulcer Definition

As leg ulcers are central to this study, a clear definition is essential in helping to establish a strict inclusion/exclusion criteria and is necessary to assist in achieving a homogeneous sample. This prevents the inclusion of other erroneous dermatological conditions which could hinder reliable comparisons. However, some studies have failed to define leg ulceration (Hickie et al. 1998, Bello & Falabella 2002). In a study to establish content validation for a set of wound care algorithms, Beitz & van Rijswick (1999) acknowledged that the absence of reliable definitions is a hindrance.
Browse et al. (1988) defined a venous ulcer as a lesion caused by an abnormality of the veins draining the limb. However, other concurrent abnormalities may also be present.

Baker et al. (1992) suggested that the aetiology of foot and leg ulcers may differ. Ulceration of the foot is a common complication of diabetes and should be taken into consideration when determining venous aetiology. Baker et al. (1992) have therefore defined foot ulceration separately to leg ulceration as an isolated ulceration below the lower border of the gaiter area. However, difficulties may arise in determining the precise area. In this study, the following ulcer definition was adopted to provide clear inclusion criteria:

"an open sore below the knee anywhere on the leg or foot that takes more than 6 weeks to heal"

(Dale et al. 1983, page 311).

Whilst dated, this description was selected due to its simplicity and suggested wound duration. Reliable comparisons cannot be made between ‘acute’ or newly acquired ulcers and those that have become ‘chronic’ or failed to heal in the anticipated time. Dale et al. (1983) did not differentiate between leg and foot ulcers or make any assumption about their aetiology. The description was combined with clinical assessment, observation and a Doppler reading of $\geq 0.8$ (RCN 1998) to provide the inclusion criteria for venous leg ulcers. Careful consideration was given in ruling out other aetiologies such as diabetes and arthritis especially when the ulcer was located on the foot.
2.2.2 Prevalence and Incidence of Leg Ulcers

The occurrence of leg ulceration is generally expressed in rates of prevalence or incidence. Prevalence refers to the number in the ‘at risk’ population at the time of the study and includes old and new cases. This could be point prevalence (existing at a specified point of time) or period prevalence (existing at any time within a specified period of time) (Petrie 1978). However, it must be noted that point prevalence studies will underestimate the proportion of people who experience leg ulceration because of the recurrent nature of the disease. Incidence refers to the number of the defined population at risk of developing the disease during a specified time period and includes new cases only. Prevalence provides a ‘snapshot’ of ulceration and is useful in determining resources to manage existing ulcers whilst incidence can be used to monitor levels of care given and availability of resources (Bethell 2002). Examining the prevalence and incidence of leg ulcers will assist in identifying the magnitude of this condition.

Fowkes et al. (2001) estimated that open venous ulcers occur in approximately 0.3% of the adult population whilst in the US, venous leg ulceration has been estimated at 3.5% of the general patient population (Kerstein 2003). To the best of the author’s knowledge, the smallest identified leg ulcer prevalence, 0.6%, was found in an Australian study (Baker et al. 1991) and the largest being 3.6% (Maffei et al. 1986), followed by 1.5% (Henry 1986). Baker et al. (1991) suggested that the smaller finding (compared to British studies) was due to several factors; smaller percentage of elderly patients, ulcer duration at the start of the study and criteria to identify venous disease. The larger prevalence found by Maffei et al. (1986) could be attributed to a highly specified, non-representative sample.
The large prevalence found by Henry (1986) has been attributed to the use of non-medical interviewers with no indication of any formal training (Shami et al. 1997). Overestimation could have occurred from the omission of clinical examination to validate reported ulceration and therefore the inclusion of lesions other than ulcers and that respondents 'self diagnosed' their medical condition. However, as a simple random sample, those not seeking medical treatment were also included as respondents were identified from a door to door survey. Interestingly, if this was indicative of prevalence, the study would have implied that the majority of people were not receiving medical treatment and that over 50% of patients were self treating. Finally, parity has been attributed to risk factors for venous insufficiency (Cullum & Roe 1995) and two thirds of participants were female and 48% had had more than five pregnancies.

Callam et al. (1985) identified 0.15% leg ulcer prevalence in a study in which healthcare professionals in a variety of settings (GPs, district nurses, occupational nurses, residential and nursing home wardens, out-patient departments, physiotherapy departments, acute wards and long stay hospitals) were asked to identify patients undergoing current treatment for active ulceration or who had received treatment within the previous three months. Although the response rate was unusually high in this study for a postal survey (GPs n=94%, other groups n=100%), 6% (n=37) of GP's did not respond and their reasons for non-response were not indicated. The percentage of patients seen by these professionals is unknown, but was unlikely to have affected the overall prevalence rate.
Surprisingly, 5% of patients were reportedly treated by physiotherapists. Their specific role in the patient’s leg ulcer care was unclear and their suitability for treating this condition questionable. Some relevant professional groups such as chiropodists were absent from the study although part of their remit is in dealing with foot ulceration, in addition to community pharmacists.

However, Callam et al. (1985) acknowledged that the proportion of patients failing to seek medical treatment was unknown. As participants were asked to identify patients retrospectively, there was potential for under or overestimation. Furthermore, ulcer definition was unclear and the inclusion of lesions other than leg ulcers was possible. Despite its limitations, this study continues to be widely reported. Subsequent studies producing similar findings are also discussed in this section (Cornwall et al. 1986, Lees & Lambert 1992, Nelzen et al. 1996).

Cornwall et al. (1986) undertook a prevalence survey of leg ulceration in a defined health district and reported a prevalence of 0.18%. All G.Ps, hospital wards, residential and nursing homes for the elderly were investigated for leg ulcer patients. However, follow up was made only to GPs and community nurses. As community nurses do not undertake the care of patients in nursing homes, there was potential for underestimation. It remains that a clear definition of leg ulceration is yet to be established.
Lees & Lambert (1992) established the prevalence and incidence of lower limb ulceration from district nurse information within a community care setting and reported a rate of 0.19%. No clear definition of leg ulceration is provided and the accuracy of the nurses’ data is not tested. Nelzen et al. (1996) surveyed leg ulcer prevalence in people aged 50 to 89 years (n=12,000) and reported a point prevalence of 0.63%, more than double that expected. Forty-seven percent (n=143) of participants with reported open ulcers were followed up by clinical examination. Although the false-positive response rate was high at 43% (lesions reported as leg ulcers which were actually other conditions) they concluded that there was a high rate of self treatment and that the problem of leg ulceration had been underestimated.

2.2.3 Associated Features in The Development of Leg Ulcers

(i) Aetiology

Several large epidemiological studies carried out in Europe, Scandinavia and Australasia reported chronic ulceration of heterogeneous aetiology including venous disease, arterial disease, rheumatoid arthritis, diabetes and a combination of these aetiologies (Widmer 1978, Baker et al. 1992, Lindholm et al. 1992, Oien 2000). However, it has been suggested that venous disease is responsible for the majority of leg ulcers (de Araujo et al. 2003). Examples of studies reporting the percentage of ulcer patients with venous disease and their methods of assessment are presented in table 1.
Table 1. Examples of studies showing percentage of ulcer patients with venous disease.

<table>
<thead>
<tr>
<th>Study</th>
<th>% with venous disease</th>
<th>Comment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Baker et al. 1991</td>
<td>57 (n=138)</td>
<td>All ulcer types – photoplethysmography</td>
</tr>
<tr>
<td>Nelzen et al. 1991</td>
<td>72 (n=332)</td>
<td>All ulcer types – clinical assessment</td>
</tr>
<tr>
<td>Callam et al. 1987</td>
<td>76 (n=632)</td>
<td>All ulcer types – clinical assessment</td>
</tr>
<tr>
<td>Cornwall et al. 1986</td>
<td>22 (n=81)</td>
<td>No foot ulcers – ultrasound, photoplethysmography</td>
</tr>
</tbody>
</table>

Phillips (1994) noted an increase in the association of combined venous and arterial disease in leg ulcers. This could be attributed to factors such as improvements in diagnostic techniques like Doppler ultrasound and a growing ageing population where arterial disease is increasingly prevalent with longevity (Baker et al. 1992, Verhaeghe 1998).

Many clinicians use Doppler to measure the ABPI (ankle brachial pressure index) which assists in determining aetiology (see section 2.3.3). Classification of the presence of arterial disease varies ranging from an ABPI of 0.7 (Bjellerup 1997) to 0.92 (Sumner 1998). Classifying arterial involvement at the higher end of the scale, 0.9 will lead to higher rates of reported arterial ulcers.

In addition to arterial and venous disease, other causative factors may be present concurrently such as active vasculitis associated with rheumatoid arthritis and neuropathies in diabetic ulcers. This can have implications for determining treatment and healing potential and should be considered in the design of future leg ulcer studies.
(ii) Age

Age frequencies vary but ulceration increases exponentially with age (Callam et al. 1987, Hansson 1988, Lindhom et al. 1992, Walker et al. 2002) increasing to around 2% at age 70+ (Salaman & Harding 1995). Evidence is growing which indicates that age is a key factor in delayed healing (Nelzen et al. 1991, Ashcroft et al. 1997, 1998) and it is anticipated that prevalence will increase due to the increasing longevity of the population (Phillips et al. 1994, Wissing et al. 1997, Hickie et al. 1998). The importance of age in skin ulceration can be attributed to the skin becoming thinner, more fragile, and more susceptible to injury (Boynton et al. 1999) and a deranged inflammatory response to acute injury (Ashcroft et al. 1998).

However, leg ulceration is not exclusive to the elderly population. In a study to determine the prevalence of leg ulceration below retirement age, Nelzen et al. (1996) found the median age to be 44 years and overall prevalence of ulcer history as 1.6%. The sample was a defined population of predominately male industrial workers and included foot ulceration thus making generalisations to leg ulceration difficult. However, the study by Nelzen et al. (1996) was effective in highlighting the existence of ulceration in the younger population.

(iii) Gender

Gender ratio varies between studies but with a predominance toward females (see table 2). One possible explanation could be the longevity of women compared to men resulting in a higher proportion of ulceration in older females.
Some studies adjust results to accommodate for this whilst others do not. An exception to this ratio was found by Widmer (1978) who reported that males with leg ulceration out-numbered females by 5:1. However, the study was conducted on a highly selective population of workers who were predominantly male. Callam et al. (1985) showed a slight increase in ulceration in males below the age of 45 years, although more females over 45 years were found to have ulcers, even when adjusted for the distribution of sexes.

Table 2. Examples of studies showing comparison of male:female ulcer ratio

<table>
<thead>
<tr>
<th>Study</th>
<th>Male to Female Ratio (M:F)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Callam et al. (1985)</td>
<td>1:2.8 M:F</td>
</tr>
<tr>
<td>Cornwall et al. (1986)</td>
<td>1:2.2 M:F</td>
</tr>
<tr>
<td>Nelzen et al. (1991)</td>
<td>1:1.4 M:F</td>
</tr>
<tr>
<td>Baker et al. (1992)</td>
<td>1:1.9 M:F</td>
</tr>
<tr>
<td>Lindholm (1992)</td>
<td>1:3 M:F</td>
</tr>
</tbody>
</table>

(iv) Mobility

Baker et al. (1991) categorised mobility into five grades: Grade 1: unrestricted, Grade 2: limited mobility, Grade 3: housebound, Grade 4: mobile with walking aid, Grade 5: chairbound. This classification facilitates comparisons between patient factors which may affect healing.
Moffat et al. (1992) suggested that approximately 50% of patients with leg ulceration experience restricted mobility and identified pain, oesteo-arthritis, rheumatoid arthritis, foot deformities, ill fitting footwear and reduced ankle mobility as factors which may affect mobility as well as obesity (Moffat 1998). Consideration should be given to the implications of reduced or restricted mobility as maintaining adequate mobility plays an important part in the success of the treatment regime.

Patients who are not sufficiently mobile enough to get in and out of bed at night, or rest horizontally during the day may choose to sleep in a chair. Therefore, the legs are continuously dependent without elevation to aid venous return. Sleeping in a chair may explain why the patient continues to have swollen oedematous legs even though the correct bandaging has been applied (Green 1997).

(v) Obesity

Obesity has been simply described as an imbalance between energy intake and energy consumption (Hamilton 2002). It is commonly defined in terms of the BMI (body mass index) which is calculated by dividing an individual's weight (kilogrammes) by their height squared (metres$^2$). A BMI above 30 is defined as obese (NAO 2001).

Studies have shown obesity to be significantly more common in selected groups with varicose veins, such as Maori men (Beaglehole et al. 1975), French policemen (Ducimetiere et al. 1981) and Sicilian villagers (Novo et al. 1988).
Padberg et al. (2003) found patients with morbid obesity (BMI >40) to have particularly unmanageable ulcers and suggested that obesity itself contributed to increasing limb symptoms. Other studies have shown no such association, Guberan et al. (1973), Hirai et al. (1990) and Komsuoglu et al. (1994). Obesity may also be a predisposing factor for venous disease in that the additional body mass hinders venous return or it may merely emphasise the development of any illness.

(vi) Duration

Chronic wounds are those failing to heal within an expected time scale (Hart 2002). Several causative factors may be present concurrently and each may delay healing e.g. rheumatoid arthritis, diabetes, inadequate nutrition. It is possible that the longest recorded non-healing ulcer is that reported by Callam et al. (1987) of an 85 year old lady experiencing a non-healing ulcer for 62 years.

Dorman et al. (1995) identified ulcer duration of more than six months in addition to decreased mobility and ulcer size (>10 cm²) as primary risk indicators of prolonged healing. Nelzen et al. (1994) found median duration of ulcer diathesis significantly longer in patients with venous ulcers (13.4 years) than those with non-venous lesions (2.5 years) ($p<0.0001$).

Chronic wounds such as leg ulcers, have been described as being of a long duration, slow to heal and likely to recur (Dealey 1999). As previously mentioned (see section 2.2.1) the stage of the leg ulcer, whether new or established, may have an impact on the healing potential.
(vii) **Previous Ulceration**

The refractory nature of venous ulcers affects the quality of life and work productivity of those afflicted (de Araujo *et al.* 2003). Chronic leg ulceration is a cyclical condition encompassing repeated episodes of ulceration followed by healing.

It has been suggested that from a pool of 400,000 ulcers in the UK, 100,000 will be open at some stage during their course (Callam *et al.* 1985). As previously discussed, re-ulceration rates have been estimated from 26% (Franks *et al.* 1995) to 69% (Monk & Sarkany 1982) and improvements in medicine and nursing care may explain the lower recurrence in the former study.

Callam *et al.* (1987) found that two-thirds of patients had experienced more than one episode of ulceration. Several reasons have been suggested for ulcer recurrence of which non-compliance by patients has frequently been cited (Muir Gray 1983). Another reason cited is that of incorrect application of dressings and products that could hinder the healing process. Interestingly, (Bassett 1991) suggested that nurses exhibit poor compliance with manufacturers' guidelines for products.

Flanagan *et al.* (2001) examined community nurses', home carers' and patients' perceptions of factors affecting recurrence rates. Key themes emerging from the study were that health promotion was perceived by community nurses and patients to be ineffective and aftercare services were fragmented.
Community nurses and home carers listed time constraints and limited resources as reasons for high recurrence rates. In addition, the community nurses in this study were keen to delegate preventive strategies and care of healed ulcers to home carers. The care of healed ulcers is equally as important as that of active ulceration and better patient education during the early stages of treatment may assist in reducing recurrence. Monthly visits, to check both the limb and patient compliance in following advice, would allow preventative practices to be instilled and alert the nurse to potential re-ulceration. Long term, this practice would also reduce nursing time spent on managing active ulcers.

(viii) Area Measurement

The majority of studies refer to area measurement (length x width) when reporting the size of an ulcer (Moffat et al. 1993, Nelzen et al. 1994, Dorman et al. 1995, Kantor & Margolis 2000). Chronic leg ulcers can vary in area from very small lesions to those extending around the entire circumference of the limb (see figure 2). Studies have reported wide ranges of venous ulcer area: from 0.1 cm$^2$ to 117 cm$^2$ (Moffat et al. 1992), 0.04 cm$^2$ to 550 cm$^2$ (Nelzen et al. 1994) and 1.1 cm$^2$ to 185.4 cm$^2$ (Kantor & Margolis 2000). The latter considering size to be an important indicator of wound status. Unsurprisingly, ulcers smaller in area have been found to heal significantly more quickly than large ones (Dorman et al. 1995, Thomson et al. 1996). Nelzen et al. (1994) and Dorman et al. (1995) classify small ulcers as <10 cm$^2$ and large ulcers as those >10 cm$^2$. 
(ix) Co-existing illnesses

Complications associated with diabetes include retinopathy, nephropathy, macro and microvascular disease and neuropathy (Springett 2000). The diminished blood supply and reduced sensation that may occur in patients with diabetes increase the risk of developing infections and ulceration, primarily to the foot.

Patients with rheumatoid arthritis have underlying connective tissue disorders and vasculitis that can lead to the occlusion of small vessels resulting in additional tissue breakdown (Collier 1996). Patients with other conditions such as hypertension, lymphoedema or who are immuno-suppressed, are also at risk of skin breakdown and ulceration.
In addition, medication for these conditions such as steroids, may have a negative effect on the wound healing process. One of the many side effects of steroids is that the patient’s skin becomes thin and fragile. The specific effect of other conditions such as chronic debilitating illnesses (i.e. hepatic, cardiovascular, auto-immune, carcinomas, renal, hematopoietic) on the state of the wound is unknown but considered to be detrimental to wound healing (Mandl 1972). Clark (2002) suggests that, in addition to the wound environment, deficiencies and co-morbidities of the patient influence wound healing. Therefore, any serious illness should be taken into consideration as a factor that may affect wound healing.

2.2.4 Aetiological and Physiological Features of Leg Ulcers

Defining the basic structure and underlying abnormality of the venous and arterial systems is necessary to correctly diagnose the aetiology of ulceration. It is essential that the type and cause of the ulcer is determined before treatment is given (Harding & Jones 1996).

(i) Venous Leg Ulceration

As previously stated, it has been accepted that the most common aetiology of leg ulceration is venous disease. However, current thinking is moving towards greater combined venous and arterial involvement as a cause of ulceration (Phillips 1994) with many patients having a degree of arterial involvement (Eagle 2001). Venous ulcers are predominantly caused by high pressure in the leg veins (venous hypertension) due to blockage or weakness of the valves in either the deep or superficial veins (Vowden & Vowden 1998).
In the lower limb, the venous system consists of both superficial and deep veins with veins known as perforators connecting the two (Collier 1999). The deep veins lie within the fascia, the superficial veins lie outside the fascia and the perforator (connecting) veins travel through the fascia linking the deep and superficial veins. Deep veins are under much higher pressure than the superficial ones.

Veins are similar in structure to arteries but unlike arteries, some veins possess valves. These valves allow blood to flow only in one direction towards the heart and prevent back flow or reflux. Incompetent or damaged valves result in venous reflux causing hypertension in the superficial veins. The valves beneath those which are damaged have to take greater pressures and may also fail in time. This high pressure continues to the capillaries giving rise to leakage of proteins and haemosiderin (an iron containing pigment) resulting in the typical brown staining of the surrounding skin.

The characteristic skin changes are referred to as 'lipodermatosclerosis', and are characterised by induration, brown pigmentation due to haemosiderin deposition, chronic scaling, eczematous dermatitis and intense pruritis (Kushner 1992). Eventually, the higher pressure blood leaks into the superficial veins which are not designed to take such high pressures and they become distended. Minor trauma to the limb will then result in ulcer formation. In a few cases, ulceration is due to an obstruction in the deep veins rather than valvular incompetence. A more detailed description of venous ulcer formation is given in appendix I.
In addition to impaired veins, valves and calf muscle pump (the action of the calf muscles 'pumping' the blood towards the heart during walking or exercise) other complex proposals have been made as to the pathogenesis of ulceration: fibrin cuff theory (Browse and Burnard 1982), white cell hypothesis (Coleridge Smith et al. 1988) and the trap hypothesis (Falanga & Eagelstein 1993) (see appendix II).

(ii) Classifying Venous Ulceration

Whilst tools have been designed to assess the risk of patients developing a pressure ulcer (Norton et al. 1962, Gosnell 1973, Knoll 1977, Waterlow 1985, Bergstrom et al. 1987) and stage the existing ulcer (Shea 1975, Torrance 1983, Lowthian 1987, NUAP 1989, Yarkony et al. 1990, Agency for Health Care Policy And Research (AHCPR) 1992), to the best of the author’s knowledge, no such tool exists to determine either factor for patients with leg ulceration. However, Shami et al. (1997) classify and grade chronic venous disease according to severity (see table 3).

With some adaptation, such as standardised and simplified international terminology, this classification could provide a useful future guide for nurses in evaluating 'at risk' and ulcerated limbs. The inclusion of high quality colour images to provide visual examples in addition to clear definitions will facilitate its use further.
Table 3. Clinical classification of chronic venous disease. (Shami et al. 1997).

<table>
<thead>
<tr>
<th>Clinical classification of chronic venous disease</th>
</tr>
</thead>
<tbody>
<tr>
<td>Class 0</td>
</tr>
<tr>
<td>Class 1</td>
</tr>
<tr>
<td>Class 2</td>
</tr>
<tr>
<td>Class 3</td>
</tr>
<tr>
<td>Class 4</td>
</tr>
<tr>
<td>Class 5</td>
</tr>
<tr>
<td>Class 6</td>
</tr>
</tbody>
</table>

(iii) Arterial Leg Ulceration

Arterial disease is less common than venous disease as a cause of leg ulcers, although as previously discussed, ulcers with a combination of aetiologies are becoming more widely reported. Whilst estimates may vary, Hafner et al. (2000) suggested that approximately 10% of ulcers are arterial in origin. Arterial ulcers develop as a result of reduced arterial blood supply, the most common cause being atherosclerosis (Cameron 1996) (see appendix III).

(iv) Differences between Venous and Arterial Leg Ulceration

Ulcers of purely venous or arterial aetiology would greatly simplify wound management. However, the ulcer is diverse in origin and unique to each individual patient. Whilst the underlying aetiology of venous and arterial ulcers differs greatly, to non-experts, they may sometimes be difficult to visually distinguish between (see figures 3, 3a).
It is essential that practitioners are able to differentiate between aetiologies to devise an effective and safe management plan. This is best achieved by clinical assessment and observation based on all the relevant factors and Doppler ultrasound. 

Multi-factorial or mixed aetiology is commonly associated with ulcers resulting from venous and arterial disease. However, many other factors may also be present such as active vasculitis associated with rheumatoid arthritis and neuropathy associated with diabetes making the ulcer more difficult to manage. At one extreme, incorrect diagnosis can produce ineffective treatment whilst at the other, inappropriate compression to an ischaemic leg could result in pressure necrosis, leading to amputation or even death (Callum et al. 1987). Vowden & Vowden (1998) provide guidance in distinguishing between venous and arterial ulceration (see table 4). They stress that these rough guides should not be used solely to form the basis of diagnosis as some classical aetiological features can be misleading if used in isolation. However, the inclusion of high quality colour images would, without doubt, enhance this guide.
Table 4. Differences between venous and arterial ulceration (Vowden & Vowden 1998)

The presence or absence of the following symptoms and signs that may help in the recognition of the aetiology of a leg ulcer, but in isolation should not form the basis of the diagnosis.

<table>
<thead>
<tr>
<th>Symptom/sign</th>
<th>Venous</th>
<th>Arterial</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ulcer Site</td>
<td>Gaiter area especially above medial malleolus, rarely on foot</td>
<td>Lower leg or foot especially over pressure points</td>
</tr>
<tr>
<td>Appearance</td>
<td>Rarely necrotic, frequently superficial, often heavily exuding, May be irregular and multi focal</td>
<td>Deep punched out, tendon or bone may be exposed, pale base, frequently black or necrotic base</td>
</tr>
<tr>
<td>Surrounding skin and nails</td>
<td>Itching</td>
<td>Pallor on elevation</td>
</tr>
<tr>
<td></td>
<td>Eczema</td>
<td>Dependent rubor (sunset foot)</td>
</tr>
<tr>
<td></td>
<td>Ankle flare</td>
<td>Thin, dry shiny</td>
</tr>
<tr>
<td></td>
<td>Pigmentation (brown staining)</td>
<td>Nail growth poor</td>
</tr>
<tr>
<td></td>
<td>Lipodermatosclerosis</td>
<td>Hairless (unreliable)</td>
</tr>
<tr>
<td></td>
<td>Atrophie blanche</td>
<td>Associated gangrene</td>
</tr>
<tr>
<td></td>
<td>Scars from previous ulcers</td>
<td></td>
</tr>
<tr>
<td>Vascular</td>
<td>Varicose veins</td>
<td>Poor capillary refilling</td>
</tr>
<tr>
<td></td>
<td>Normal pedal pulses</td>
<td>Pedal pulses absent or reduced</td>
</tr>
<tr>
<td>Limb</td>
<td>Oedema</td>
<td>Dependent oedema</td>
</tr>
<tr>
<td></td>
<td>Scarring giving inverted champagne deformity</td>
<td>Inappropriately cool</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Possible muscle and soft tissue wasting</td>
</tr>
<tr>
<td>Pain</td>
<td>Present, mild to severe eased by elevation or exercise, Bursting</td>
<td>Present, often very severe aggravated by elevation (rest pain) and exercise (claudication)</td>
</tr>
</tbody>
</table>

2.2.5 Summary

In order to propose new ways of caring for leg ulcers, the aetiological and physiological features have been reviewed. Despite extensive research in this area, leg ulceration continues to be problematic in nursing practice with an estimated 1% of people experiencing a leg ulcer during their lifetime and in terms of assessment and management clinical practice remains diverse.
From reviewing the literature it would appear that no contemporary prevalence surveys exist and dated studies such as Callam et al. (1985), Cornwall et al. (1986) and Lees & Lambert (1992) continue to guide leg ulcer prevalence. However, contemporary surveys should not exclude the younger population as their leg ulcer prevalence may have been underestimated as they are often self-caring.
2.3 The Role of Community Nursing

This section briefly reviews the development of community nursing and how it has evolved to its current status. The community nurse is the prime carer of leg ulcers and his/her role in wound care and issues surrounding the use of research to inform and update practice is examined. Optimal, cost-effective patient care requires the integration of research findings into practice (Kerstein et al. 1998, NMC 2002) and critical appraisal of relevant literature will identify barriers and facilitators in achieving this. Contemporary nursing care of leg ulcers is identified in order to determine best practice and the degree to which nurses adopt or reject optimal treatment regimens examined. As the nurse is often solely responsible for their patients’ treatment decisions, a brief overview of such processes is also presented. This gives an insight into nurses’ decision-making processes. Finally, the role of the CNS and how it can be integrated to promote and improve nursing practice through technology is considered.

2.3.1 The Evolution of Community Nursing

The essence of community nursing encompasses the provision of a range of skilled professional care for those members of the community who, temporarily or permanently, require nursing care and advice. William Rathbone, a wealthy Liverpool businessman, has been accredited with the birth of the district nursing service (Hardy 1981). In 1859, Rathbone’s appreciation for the work of Mary Robinson, a nurse who cared for his dying wife, prompted him to campaign for a service enabling the poor to receive similar care. Rathbone consulted with Florence Nightingale who also had an interest with the concept of home nursing (Jamieson et al. 1966).
As a result, Rathbone established the Liverpool Training School and Home for Nurses in 1862. From this basis, a community nursing system was implemented in Liverpool through the 1860s and spread throughout the country.

In 1997 the UK government indicated its wish to extend recent developments in the roles of acute and community nurses (DoH 1997) and in 1999, a strategic framework was published (national Assembly 1999). This strategy outlined the need to extend nursing roles to work more efficiently and make better use of knowledge and skills.

Community nursing has evolved to accommodate changes in healthcare delivery to improve patient care and new nursing roles such as the CNS, Clinical Nurse Consultant and Nurse Practitioner have been created for those who wish to practice at an advanced level. For example, in the community setting, venepuncture (previously a physician only task) is part of everyday practice and may be carried out by unregistered nursing auxiliaries. Consultant nurses perform many doctors’ tasks, such as prescribing drugs, venepuncture, intravenous infusions and requesting X-rays (Duffin 2003). This allows the patient to be seen quickly by an appropriately skilled clinician rather than waiting until a doctor is available. Contemporary nurse-led initiatives such as leg ulcer clinics, staffed and managed by nurses are popular in the community mainly because they are seen to be cost effective (Thambiaya 1996). However, the Audit Commission Report (1999) stated that the number of specialist practitioners, as a proportion of the district nursing service, is falling due to a reduction in entries to nurse training.
It is proposed that telemedicine could meet this deficit disseminating expertise regardless of distance. Using tele-advice, specialist consultations could be performed for a large number of patients over a substantial geographical distance using a single expert. In addition, the use of expert tele-advice in areas with few specialist nurses could have a beneficial impact on nursing knowledge and confidence.

2.3.2 The Community Nurses' Role in Wound Care and use of Research

In the UK, wound care has traditionally been accepted as the responsibility of the nurse (Watret & White 2001) and most leg ulcers are managed by district and community nurses. It is the nurse's responsibility to deliver care based on current evidence, best practice and validated research (NMC 2002). However, whilst research is continually producing increasing amounts of important new evidence for health care, Flanagan (1998) found that many people with compromised tissue viability were not benefiting from the implementation of evidence-based practice. Haynes et al. (1995) also suggested that research is not reflected in the care most patients receive and Luker & Kenrick (1992) reported that much practice was still predominantly based on experiential rather than research-based knowledge, particularly in community nursing.

In the early 1980s it was suggested that nowhere was the gap between research and clinical application more obvious than in the biology of wound healing (Peters et al. 1983). Subsequent studies suggest that this theory/practice gap remains. Parahoo (1998) found that approximately 10% of nurses never or seldom used research in their practical work and less than 40% had implemented new research findings in their work in the last two years.
Björkström & Hamrin (2001) found that even when nurses had a positive attitude towards research and development, there was poor application of it in daily work. This has implications for nursing skills and abilities and goes against the NMC guidelines for maintaining professional knowledge and competence (NMC 2002).

Lack of time has frequently been cited as a reason why nurses are not implementing research findings into clinical practice (Kajermo et al. 1998, Parahoo 2000, Retsas 2000, Clifford & Murray 2001, McCaughan et al. 2002, Oranta et al. 2002, Adamsen et al. 2003). Whether insufficient time can be interpreted as lack of interest remains debatable. Funk et al. (1991) indicated that nurses lacked confidence and skills to find and critically appraise research evidence. Parahoo (2000) listed the top 10 factors for nurses’ perceptions of barriers to research and those facilitators needed to overcome these barriers (see table 5). It must be noted that these have a different order of importance and therefore barriers are not directly associated with facilitators.

The obstacles for implementing research findings in clinical practice and their facilitating factors should be taken into consideration in the design of nursing studies in order to maximise participation and pose a challenge to traditional thinking. For example, the research question should be relevant to the nurses’ speciality.
Table 5. **Top ten obstacles and facilitators of research utilisation (Parahoo 2000)**

<table>
<thead>
<tr>
<th>Obstacle</th>
<th>Facilitator</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Lack of time</td>
<td>1. Manager’s support</td>
</tr>
<tr>
<td>2. Lack of funding</td>
<td>2. Time</td>
</tr>
<tr>
<td>3. Staff shortages</td>
<td>3. Support from colleagues</td>
</tr>
<tr>
<td>4. Lack of manager’s support</td>
<td>4. Motivated staff</td>
</tr>
<tr>
<td>5. Lack of education/training</td>
<td>5. Access to findings</td>
</tr>
<tr>
<td>7. Low morale</td>
<td>7. Opportunity for further study</td>
</tr>
<tr>
<td>8. Lack of resources</td>
<td>8. Research-aware staff</td>
</tr>
<tr>
<td>9. Senior staff set in their ways</td>
<td>9. Resources</td>
</tr>
<tr>
<td>10. Lack of support from nursing colleagues</td>
<td>10. Research seen as beneficial to patient care</td>
</tr>
</tbody>
</table>

2.3.3 **Nursing Management and Treatment of Leg Ulcers**

Wound management is complex and involves much more than choosing a dressing. For example, the patient should receive a holistic assessment to clarify any patient factors that may hinder healing such as allergies and the nurse should identify the aetiology of the wound before an appropriate treatment regimen can be determined. The care of chronic wounds is an integral part of the community nurses’ workload and it is important that current nursing practice of the chronic wound is understood in proposing new ways of adapting and improving care.

(i) Compression Therapy

Venous leg ulceration is the result of chronic venous hypertension of the lower leg and graduated compression therapy helps reverse this process (Eagle 2001) but does not reverse the cause. Little is known about the precise mode of action of compression therapy despite the recognition of its value as a treatment (Moffat & O’Hare 1995, Melhuish et al. 1996).

The sub-bandage pressure (the pressure exerted on the limb by the bandage) is calculated through the Laplace equation. This implies that the pressure on the limb will be greatest at the smallest radius of curvature, usually the ankle (Eagle 2001). In a normally shaped limb, the pressure should be 30 – 40 mmHg at the ankle graduating to 15 – 20 mmHg at the calf (Simon 1996). Compression therapy can be applied from a range of compression systems according to the type of material, method of application and degree of compression they produce at the ankle (see appendix IV).
Freak et al. (1995) suggested factors for nurses not using compression therapy which included:

- Inadequate training in leg ulcer assessment and management;
- Lack of Doppler ultrasound equipment to exclude arterial disease;
- Drug Tariff limitations on the supply of appropriate bandages to achieve compression;
- Cost shifting from community health services budget onto GPs to supply inappropriate dressings available on the Drug Tariff.

Perhaps the most important of these factors is insufficient training. If nurses cannot confidently and knowledgeably identify the underlying cause of ulceration through clinical assessment and observation, their management is likely to be ineffective and potentially dangerous. An awareness of the hazards of inappropriate use should ensure that the nurse is a safe practitioner (Bradley 2001). Nelson (1996) suggested that nurses’ bandaging techniques were generally poor and hazardous to the patient.

For example, failing to apply extra protective padding beneath the layers of compression bandaging for patients with thin legs, can lead to an increased risk of pressure damage. Most patients with chronic leg ulcers are managed by community nurses who may know that compression bandages are dangerous when applied to limbs with arterial insufficiency but who may not recognise its presence (Callam et al. 1987). Logan et al. (1992) found those who had been better trained or were more experienced in bandaging, obtained more consistent sub-bandage pressures.
However, studies have suggested training needs to be monitored and supervised if good practice is to be maintained (Nelson et al. 1995, Scanlon 1996). Therefore, training should be a regular on-going part of nursing activity.

Compression applied to patients with significant arterial disease can result in pressure necrosis, resulting in amputation (Callam et al. 1987, Finnie 2002). Table 6 outlines factors that should be considered in the application of compression therapy.

<table>
<thead>
<tr>
<th>Table 6. Factors involved in the application of compression therapy</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Factor</strong></td>
</tr>
<tr>
<td>▪ Ensuring the absence of arterial insufficiency</td>
</tr>
<tr>
<td>▪ Considering the size and shape of the limb</td>
</tr>
<tr>
<td>▪ Bandage class</td>
</tr>
<tr>
<td>▪ Bandaging technique</td>
</tr>
<tr>
<td>▪ Patient compliance</td>
</tr>
</tbody>
</table>
A minority of patients find compression therapy too uncomfortable and are unable to tolerate it. Once it has been established that the ulcer is venous in origin and that bandaging application is correct, if compression therapy remains painful, an alternative must be sought (see appendix V).

(ii) **Doppler Ultrasound**

Doppler ultrasound can detect velocity and blood flow in both veins and arteries through sound. Significant disease of the arterial lumen produces blood flow disturbances resulting in deviation from the normal Doppler ultrasound signal (Williams *et al.* 1993).

Nurses previously relied on detecting the absence of pedal pulses and clinical examination to signify arterial disease. However, the presence of oedema, ulceration or induration may make palpation difficult (Moffat 1993). In addition, pedal pulses are absent in approximately 0.5% of the population (Neale & Adams 1989). Early work with Doppler ultrasound established that a ‘normal’ ABPI (Ankle Brachial Pressure Index) was usually greater than or equal to 1 and an ABPI of <0.92 indicated the presence of arterial disease (Sumner 1998). Whilst no rationale has been given for the cut off figure being set at <0.8 for safely applying compression, this has become the accepted norm.

The use of the Doppler to measure systolic pressure and ABPI calculation is now considered a mandatory part of the assessment of leg ulcer patients (RCN 1998, SIGN 1998) and should be used in conjunction with clinical assessment and observation in ruling out arterial disease before compression therapy is administered.
It should be routinely carried out every three months to determine any change in patients’ vascular status and any subsequent action (RCN 1998, SIGN 1998).

It must be noted that Doppler assessment is not infallible and ABPI measurement has been shown to be unreliable when carried out by inexperienced operators (Ray et al. 1994). An incorrect ABPI measurement can lead to unnecessary mismanagement and discomfort for the patient (Davies 2001). Therefore, Doppler readings should not be regarded in isolation to determine patient suitability for compression therapy. Clinical assessment and observation should be combined with the ABPI to produce an informed decision. Carser (2001) suggests that the Doppler test is useful in identifying patients with a normal or very abnormal arterial tree but is less reliable for patients with mild or moderate arterial disease. Table 7 indicates the level of vascular status in accordance with the ABPI measurement which should be considered when treating patients with lower limb ulceration.

<table>
<thead>
<tr>
<th>Measurement</th>
<th>Indication</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 or &gt; 0.9</td>
<td>Normal arterial blood flow</td>
</tr>
<tr>
<td>0.9</td>
<td>A mild degree of arterial involvement</td>
</tr>
<tr>
<td>0.8</td>
<td>The patient is receiving 80 per cent arterial blood flow to the foot</td>
</tr>
<tr>
<td>0.7 or below</td>
<td>A level of arterial disease for which compression must not be used. A referral for vascular opinion should be sought.</td>
</tr>
<tr>
<td>0.6 or 0.5</td>
<td>Severe arterial impairment. An urgent referral for vascular opinion should be sought.</td>
</tr>
</tbody>
</table>
In addition to operator expertise, some clinical and environmental conditions can affect readings usually leading to an artificial reading and are listed below:

- Calcified arteries (usually found in diabetes);
- Arrhythmias;
- Hypertension;
- Rheumatoid arthritis;
- Oedema;
- Cuff repeatedly inflated or left inflated for long periods;
- Probe moved away from artery;
- Patient not rested;
- Cuff incorrectly placed;
- Incorrect cuff size used;
- Irregular pulse;
- Incorrect gel used.

The provision of expert advice would be especially beneficial for nurses who have received little experience or training in compression therapy. Compression is contra-indicated in arterial disease and incorrect application can have hazardous consequences. In the absence of a tissue viability nurse or equally qualified expert, tele-advice could ensure that the patient is suitable prior to the commencement of compression, assist in distinguishing appropriate treatment for complex cases and those where suitable alternatives are sought.
(iii) Wound Dressings

In addition to compression therapy, wound dressings are an important part of wound management. Wound dressings are increasingly sophisticated and nurses should be able to select and use them appropriately (Casey 2002). Turner (1982) described the criteria for the ideal dressing in:

- Removing excess exudate and toxic components;
- Maintaining a high humidity at the wound interface;
- Allowing gaseous exchange;
- Providing thermal insulation;
- Ensuring impermeability to micro-organisms;
- Ensuring removal without causing trauma;
- Protecting from particulate and toxic contaminant.

Furthermore, the following properties are also desirable by:

- Needing infrequent changing;
- Cost effectiveness;
- Carrying medicaments;
- Allowing wound monitoring without removal;
- Ensuring properties remain constant;
- Providing comfort.

Wound dressings can be categorised into five groups: alginates, film dressings, foams, hydrocolloids and hydrogels. The rationale for their use are described in appendix VI. With the magnitude of available products, the community nurse needs to have an understanding of their actions and the possible contra-indications.
Wounds require dressings to maintain their physiological integrity (Capasso & Munro 2003) therefore, the dressing must be appropriate for the individual wound. In addition, Courtenay (1998) suggests that the nurse needs an understanding of physiology to select a suitable wound dressing. However, as previously stated, nurses do not always have a justification for choosing dressings (Bale 1989, Vydelium 1990, O'Hare 1994, Stevens et al. 1997) and diversity of practice is apparent. For example, in a study to determine nurses’ knowledge regarding wound care products prior to the introduction of nurse prescribing, While & Rees (1993) found a high proportion of nurses who were able to identify the appropriate use of hydrocolloid and alginate dressings. Conversely, Bux & Malhi (1996) reported many instances of incorrect use of these dressing types. Sprecht et al. (1995) stated that in the case of pressure ulcers, inadequate knowledge led to nurses using products they had found to be effective or liked, with little regard to research evidence. This would suggest that knowledge of wound care, wound dressings and physiology are inter-linked. If the nurse does not possess a sound knowledge of the principles of wound care and physiology, then it is unlikely that an appropriate dressing will be chosen.

(iv) Wound Documentation

Sterling (1996) suggested that effective wound management relied on accurate wound assessment and precise documentation. In addition to written evidence of nursing practice, documentation also serves a professional and legal requirement. The nursing record is considered to be a display of professional competence (Hammersley & Atkinson 1991) and is often the most readily acceptable source of information at a trial (Gruber & Gruber 1990).
Records should be sufficiently clear and comprehensive to provide supporting evidence of the practitioners' action in light of a court hearing (Dimond 2003). Inadequate record keeping can lead to professional misconduct cases, ultimately resulting in nurses being removed from the professional register (NMC 2002). If a nurse does not clearly document his/her course of action, there is no evidence that it has been performed and Wardrope and Smith (1992) state that in a legal sense, not written equates to not done.

Previous studies have attributed poor documentation to nurses not having a fundamental understanding of the nursing process (Shea 1984) and the tendency to prioritise 'hands on' care over documentation (Meade and Kim 1982, Tapp 1990). In an audit study of new wound management guidelines (Briggs & Banks 1996) it was found that prior to their implementation, 16.4% of patients had no documentation, care plan or record of treatment but no suggestions were given as to why documentation was poor. Hopkins et al. (1998) reported inadequate documentation mainly due to the use of subjective statements and fragmented information. Kerr & Lewis (2000) found the main factor contributing to poor documentation in an acute CCU (coronary care unit) was the structure and format of the care plans. Nurses found them to be too rigid, encompassing a pre-determined framework and the magnitude of data in a small space left little room to document care appropriately and difficult to obtain information at a glance. Consideration of these studies provide a guideline in the future design of nursing documentation.
2.3.4 The Role of the Clinical Nurse Specialist (CNS)

The CNS guides nurses in the acquisition of clinical skills and knowledge, interprets nursing practice to nurses and non-nurses, develops innovative approaches to clinical practice, promotes interdisciplinary collaboration and advances the practice and the profession of nursing (Spross & Baggerley 1989).

Reiter (1973) defined the nurse clinician as a specialist with advanced knowledge and expertise in clinical practice, capable of demonstrating a high degree of judgement and competence for providing nursing care in a specialised area. The concept of the CNS is already well developed in North America and Canada but in Europe, recognition of their value has been slower (Miller 1995) occurring sporadically over the last decade (Flanagan 1996). Although the exact job descriptions of specialist tissue viability nurses may vary, they all share the common goal of dissemination of specialist knowledge in order to promote skin integrity (James 1994).

Humphris (1994) attributed the varied role of the CNS to a response to social, technological and political changes in the delivery of health care. Until the 1990s, the traditional career pathway for nurses was ward sister/charge nurse, then nursing management (Ibbotson 1999). In addition to providing flexibility and versatility in response to changing patient needs, the CNS role aimed to provide those nurses with advanced skills and knowledge with a new career pathway in direct patient care as opposed to management or academia. The components of the CNS role have been determined largely through the work of Hamric & Spross (1983).
Felder (1983) listed the subroles of the CNS as:

- Clinician;
- Educator;
- Researcher;
- Consultant;
- Manager;
- Patient advocate;
- Staff advocate;
- Liaison and change agent.

The CNS, with clinical and managerial experience, is helpful in assisting the effective allocation of a designated budget. Experience of the most appropriate treatment rationales, wound dressing products and equipment to achieve the best results, may not be the least expensive choice of less qualified colleagues, but may produce more cost-effective long term results. Ryan (1996) identified the role of the educator as the most influential part of the CNS work, whilst Harker (2001) stated that in challenging traditional practice, being a change agent was probably one of the most demanding roles of a tissue viability nurse.

Prior to the introduction of post-registration courses leading to formal qualifications, some nurses may have practised as tissue viability nurses without specialist training. Knowledge was gained through a trial and error basis, short courses such as the ENB course in leg ulcer care, study days and wound care conferences. This limited type of knowledge base is inadequate in meeting the demands of the CNS role.
According to the NMC (2001), nurses should meet the following criteria in order to register as a specialist practitioner:

- First level registration;
- Completed a period of sufficient length to have consolidated pre-registration outcomes;
- Provided evidence that the specialist practitioner qualification is necessary for higher order responsibility;
- Completed a programme of preparation that is:
  - no less than first degree
  - no less than an academic year (32 weeks full time)
  - made up of 50% theory and 50% practice.

Combining the expertise of the CNS with tele-advice is particularly advantageous for areas with limited access to expert wound care advice, as specialist knowledge can be disseminated over a large geographical area. Based on their relevant sub-roles, clinician, educator and change agent, the CNS can assist community nurses in the development of their wound care practice.

2.3.5 Summary

An overview of the role of community nursing and the application of research into clinical practice has been presented. Recent studies have suggested that nurses are still failing to implement evidence-based findings in clinical practice and a lack of time is often the reported reason (Kajermo et al. 1998, Parahoo 2000, Retsas 2000, Clifford & Murray 2001, McCaughan et al. 2002, Oranta et al. 2002, Adamsen et al. 2003) although the nurse has an obligation to deliver evidence-based care (NMC 2002).
Community nursing has developed in line with progress in healthcare and registered and unregistered staff may now take on physicians' tasks. Nurse-led initiatives are gaining popularity due to their assumed cost-effectiveness (Thambiaya 1996).


Clinical judgement in combination with Doppler readings are necessary to determine wound aetiology and the suitability of the patient for compression. An inadequate knowledge of wound dressings has been attributed to a lack of attention to research evidence and an emphasis on personal preference based on experience (Sprecht et al. 1995).

Through an educational advisory capacity, the CNS can assist the community nurse in the development of their wound care practice and provides an influential role to lead changes in nursing practice. Finally, findings from previous studies (Briggs & Banks 1996, Hopkins et al. 1998, Kerr & Lewis 2000) highlight the need for clear, concise and relevant documentation or written information, especially when it is considered a legal document (Gruber & Gruber 1990).
2.4 The Role of Telemedicine in the Advancement of Health Care

Inadequate access to wound care specialists in some areas, combined with the movement toward e-health, has led to the investigation of new ways of delivering expert advice. Technology, more specifically telemedicine, will become an indispensable tool for nurses to manage client health care (Milholland 2000). It provides health and education services to clients unhindered by space and time (Bashur 1997). Telemedicine combines medical or nursing expertise with communications technology and technological equipment ranging from a simple telephone consultation to complex tele-surgery. Previous studies using telemedicine are assessed in this section in order to prevent duplication of unproductive approaches and consideration of successful applications.

Much of the early work in telemedicine was developed in Scandinavia driven by the governments’ commitment to equal access to health care for all (Wootton 1998) and was reportedly the fastest growing area of health care provision with an annual estimated expenditure in excess of $27 billion in 1995 (Whitten and Collins 1998) and is becoming widespread in Europe (Ostbye & Hurlen 1997). Telemedicine has been developing in the UK since the early 1990s, but it is only in the past few years that nursing has adopted the technology (Dinsdale 2002).

Wootton (1998) described the expectation of telemedicine to improve the efficiency of a national health service by enhancing communication up and down the health care pyramid (see figure 4).
Widespread adoption of telemedicine would permit decentralisation: work previously conducted in the higher strata of the primary care sector could be carried out in the community; and work which had been the domain of the secondary care sector could be performed by those in primary care.

The World Health Organisation (WHO) recognised the need for telematics to become part of its ‘Health For All strategy for the 21st century’ in its 1997 press release. In 2000, Stuart, the then UK health minister reported that:

“telemedicine and telecare will play a vital part in modernisation...they will provide services for patients, when and where they need them... from 2001 all health improvement programmes and associated strategies will need to demonstrate that telemedicine and telecare options have been considered”.

(Van den Bergh 2000, page 7).
Telemedicine has previously been used successfully in a diverse range of specialties, including diabetology (Aldoui et al. 1999), dermatology (Bergmo 2000), home care (Dimmick et al. 2000, Tsuji et al. 2001), pathology (Bilalovic et al. 1998) and provides many potential advantages, including:

- Widespread access to expert advice;
- Consultation within the patient’s own home;
- Reduced costs such as consultant time and clinic overheads;
- Relatives or carers of patients who need to be accompanied on hospital visits do not have to take time off work.

An example of these benefits is highlighted by providing consultation in the home for those experiencing venous hypertension which are usually patients with venous leg ulceration. Lengthy journeys with legs dependent, such as those made by patients travelling considerable distances to receive specialist consultation, impedes venous return and may be detrimental to healing. This is especially true for those with venous hypertension who are advised to elevate the legs to aid healing (Bliss 1990). Telemedicine is particularly beneficial for patients in poor health with transportation difficulties and for those living in rural or medically under-served localities.
2.4.1 The Use of Telemedicine within Wound Care

Many factors have contributed to the necessity to rethink the traditional wound management paradigm, including:

- The shift of focus from secondary to primary care (Fawsey-Hewett 2000);
- Increasing numbers of patients being discharged earlier from hospital to community services due to cost containment (Wootton et al. 1998);
- Limited access to health care for many people living in rural locations (Macduff 2001);
- The need for specialist nurses;
- Increasing longevity resulting in higher potential for wound development;
- Improving poor wound care practice through clinical governance (Newton 1999), and;
- People preferring to receive care at home (Warner et al. 2003).

The resulting increase in patients being cared for in the community will produce the need for a wider range of services. Home health care in the US is one of the most rapidly growing segments of the health-care market (Warner 1997). The use of telemedicine in home care has increased due to this changing trend in health care. Primarily, the majority of previous applications have been US based possibly due to the demands created by a much greater rural population and an earlier introduction of telemedicine.

Ablaza & Fisher (1998) described the principle goals of contemporary wound management as providing effective care whilst containing costs, and developed a wound care plan using telemedicine for patients in the home (see figure 5). This study has been briefly discussed previously (see chapter 1, section 1.1).
A store-and-forward system was felt to be suitable due to the chronicity rather than acuteness of the wounds and the capacity for clinicians to review several wounds at a time. Visiting nurses assessed the wound and took digital images with either a camera or camcorder and also made audio recordings of clinical observations. Images were sent to a wound therapist via email or overnight mail, if taken by camcorder. The therapist then formulated a treatment plan which was transmitted to the other team members for consideration, promoting a multidisciplinary approach to wound care. Once the plan was finalised, it was presented to the attending physician for approval and then returned to the nurse for implementation.

Figure 5. Working relationship of WMS team members and some reported advantages of the system (Ablaza & Fisher 1998)
The authors reported the shortage of enterostomal therapy nurses and suggested that this system would allow these specialists to treat more than five times their usual number of patients. However, the diverse and specialised range of expert advice was subject to the physician's ultimate approval and a negative decision on application of the treatment plan would have resulted in wasted resources and time. Inclusion of multidisciplinary advice is a highly desirable but expensive option. The combination of several episodes of data transmission to different bodies awaiting approval and data 'batching', where several wounds are reviewed at the convenience of the wound care team could result in a delayed treatment decision, removing the essence of telemedicine – rapidity of consultation. It is surprising that the multidisciplinary body did not include hospital and community pharmacists. Pharmacists are able to recommend suitable alternatives when treatment is ineffective and advise on dressing usage (Barrett 1987).

In a system devised by physicians, Ablaza & Fisher (1998) suggest that only basic computing skills were necessary but nurses were required to send and receive email and email attachments, access the internet, use the wound management system (WMS) software, use a digital camera and camcorder and make audio recordings. It was assumed that nurses had access to computers and email accounts. This is indicative of the maturity of telemedicine in the US but reflective of its infancy in the UK.

Mathewson et al. (1999) undertook a pilot study in the use of telemedicine for pressure ulcer care. A single case study was reported of a patient who had previously undergone five surgical procedures for a pressure ulcer before enrolment into the study.
A simple store-and-forward method was used in the patient’s home to monitor and formulate weekly wound treatment for the patient’s pressure ulcer by an enterostomal nurse, from a hospital five hours drive away. Following four months of telemedicine, the ulcer had progressed to a stage where it did not limit the patient’s activities and after 6 months, the patient was self caring. The patient was relatively young (42 years) and potentially independent, unlike elderly patients experiencing similar wounds. He was also highly skilled in computer technology which could have aided the procedure. However, this method of care was clearly beneficial to the patient. He was able to remain in his own home and did not have to endure the discomfort or cost of the 10 hour round trip to and from the hospital. Whilst a cost-analysis was not undertaken in this study, it is feasible that considerable savings were made from this patient not requiring a lengthy hospital stay. As a single case study, it is not possible to generalise the findings but results suggested potential benefits (Mathewson et al. 1999).

Cornwall, a largely rural area, has enjoyed the successful use of telemedicine for several years (Newton et al. 2000). GPs routinely referred patients to a consultant dermatologist using a store-and-forward system. In this study, Newton et al. (2000) described a telemedicine system, initiated for CNS’s in tissue viability (CNSTV) to manage wound care, supported by advice from a consultant dermatologist. The two CNSTV involved benefited from readily available computer access and regularly used digital imaging in their practice. They had received additional training from a consultant dermatologist and GP, which is fairly uncommon in routine practice.
The two case studies which Newton describes (pyoderma gangrenosum and vasculitis), were both undertaken within the acute care setting, with the first being relatively unusual compared to the wounds seen regularly in community care. Routine use of a medical consultant, such as a consultant dermatologist, would incur high financial costs beyond the resources of this study.

Collins (2001) set up a telemedicine link for leg ulcer patients across the boundary between Ulster and the Irish Republic. Previous telemedicine links had already been established between the three hospitals involved, so much of the infrastructure was already in situ. However, the equipment had not been used, highlighting the necessity for adequate training, simplicity of equipment and ensuring sufficient need in the population before embarking on a project. Collins (2001) provided expert advice through telemedicine for nurses treating leg ulcer patients. In preparation for these consultations, nurses carried out procedures such as Doppler readings and essential blood tests. For more complicated cases, it was necessary to visit the patient at home.

Following initial training and encouragement, nurses involved in the scheme reported increased confidence in their care of leg ulcer patients. This was attributed to improved morale, the provision of evidence-based care and the achievement of best outcomes. Some nurses subsequently undertook courses in leg ulcer management. Improved healing rates were also reported but neither confidence or healing outcome was objectively measured.
Dinsdale (2002) reported district nurses’ use of telemedicine in delayed or deteriorated wound healing in older patients with long term venous insufficiency. Digital images were forwarded to a vascular surgeon at a near-by hospital. Suitable candidates for surgery received an initial teleconsultation through videoconferencing, in which the patient, nurse and consultant discussed the situation. Patients were enthusiastic and felt that they were referred more quickly. Whilst nurses visited patients in the home to take digital images and manage the wound, the consultation was undertaken at a health centre. Therefore, patients were required to travel to the health centre incurring the disadvantages of travelling. Trials to show improvement in wound outcome have not been published and it is not clear if the service will be extended to provide consultation for patients other than those undergoing surgery.

Samad et al. (2002) described an alternative technology based system for the care of leg ulcers. This paper builds on previous work aimed to compare methods of ulcer measurement (Samad et al. 2002) (see chapter 2, section 2.6.1). Community nurses undertook an initial holistic patient assessment and Doppler readings, which were transmitted with an accompanying digital wound image to a vascular clinic. Where or how the information was sent is not detailed and it is assumed that community nurses performed the task. Neither is it clear who reviewed the received information nor who made the decision for the patient to subsequently attend an ulcer assessment clinic. At these clinics, specialist investigations were undertaken to establish ulcer diagnosis and identify patients suitability for surgery.
A major benefit of the system was the use of shared Electronic Patient Records (EPR) which were accessible to hospital and community staff. The Department of Health (DoH 1998) envisaged that EPRs would be implemented across the NHS by 2005. Easy access to patients’ records reduced duplicated investigations, improved communication and enhanced decision-making through multidisciplinary support. Information, such as that received in the specialist clinic, could be added to the EPR. Assessment and progression of the ulcer could also be tracked as digital images could be added to the EPR. The system could be utilised fully by providing expert advice to the nurse in the patient’s home. Although reviewed by telemedicine, patients with poor healing rates or ulcer deterioration still received assessment and treatment at the hospital and community clinics (Samad et al. 2002).

The implementation of telemedicine has been shown to be driven by the necessity of providing cost-effective care (Dimmick et al. 2000). Store-and-forward has been considered be a more appropriate method of using telemedicine than real-time due to its ease of use, portability, reduced costs, accuracy of remote diagnosis and appropriate use of specialist time (Kvedar et al. 1997). However, the importance of the technology being warranted for the medical condition in question, is equally as important as addressing the financial element. Telemedicine should form the basis of a useful, much needed interaction rather than an exercise in managing technology.
2.4.2 The Use of Photography within Wound Care

The earliest reported clinical photograph is that of a woman with a goitre, circa 1847 (McFall 1997) giving medical photography a history of over 150 years. Whilst Melhuish et al. (1994) reported the use of simple, standardised photographs as a weekly clinical record was greatly undervalued almost a decade ago, wound photography has been slow to progress in many areas.

Pettarini & Jessop (2001) suggested that the lack of visual cues would be the biggest challenge in providing telephone advice. Whalberg et al. (2003) discussed such a drawback experienced by nurses who provided advice over the telephone (such as those employed by NHS Direct). Lack of visual contact e.g. 'not seeing the patient' became problematic.

However, technological advances have enabled affordable and high-quality clinical photography (Niamtu 2002). Digital photography can provide good quality images with minimal training and without the cost or inconvenience of film processing. Digital imaging technologies are increasing in use and diversity including pathology (Leong & Leong 2003), microscopy (Sonmez et al. 2003) and surgery (Wellmer et al. 2002).

The benefits and principle features of digital photography include:

- No need for photographic film or film processing.
  
  Images are stored either on the cameras memory or a special CompactFlash™ card (CF card) removing the need for films or sending the images away for processing.

- Rapid image viewing.
  
  Many digital cameras have an LCD display which allows images to be viewed instantaneously. If the image is considered poor, it can be deleted and retaken.
• Large image storage.
  CF cards of differing capacities, e.g. 4M, 8M, 15M, 30M, 48M, 128M are available. The larger the card's capacity the more images that can be stored, depending on the size of images. As an example, an 8M card can store up to 106 small images (640 x 480 pixels).

• Images can be stored on computer.
  Digital images can be downloaded on to computer, making a gallery of images. These can be useful in visually gauging wound progress and as a valuable teaching resource.

• Ease of use.
  Most digital cameras have automated functions, such as flash and focus, enabling the nurse to point and shoot. Most are relatively simple to use and some conventional cameras may be more difficult to use than their digital counterparts.

Particular advantages of the use of digital photography in wound care include the provision of a non-contact method of measurement and the ability for healthcare professionals to visually assess the wound and evaluate progress without repeatedly removing wound dressings. Continual wound exposure is not only potentially painful for the patient but may also increase the risk of developing a wound infection (Aycliffe et al. 1992).

Digital photography is undertaken in the same manner as conventional photography and many factors must be standardized in order to achieve a reliable and accurate comparison of images. Bellamy (1995) suggested that to obtain accurate clinical photographs as much control as possible should be given to variables that may influence results. Consideration must be given to:
  • Choice of equipment, materials and processing;
  • Control of subject, lighting and background.

Houghton et al. (2000) examined the validity and reliability of using wound photographs to accurately assess the status of pressure ulcers and leg ulcers.
Results from a photographic wound assessment tool (PWAT) were compared to results obtained from a bedside assessment tool, the pressure sore status tool (PSST). It was also shown to be sensitive to changes in the appearance of healing ulcers, but not non-healing ulcers. However, inconsistencies arose in the manner the photographs were taken. Two different camera systems were used and patients were photographed in a variety of settings including nursing homes and clinic offices, making the reliability of the findings questionable.

Houghton et al. (2000) concluded that the PWAT had good intra and inter-rater reliability and concurrent validity and could be used to form an accurate assessment in the event of a full bedside assessment not being possible. It is surprising that the PWAT is not advocated given that it was regarded as accurate and reliable. Alternatively, it could be adapted from the former tool, thus enhancing assessment procedures. However, the study by Houghton et al. (2000) does show the clinical usefulness and reliability of wound photography.

Despite its many advantages, photography is not without some limitations. These include the inability to assess wound volume and limited accuracy of wound measurement due to the camera angle (Addersley & Nelson 2000). However, a medical photograph can transfer more information to a health care professional than subjective descriptions, which are open to misinterpretation (Boardman et al. 1994, Melhuish et al. 1994). Given that adequate training is given and simple rules for standardisation are followed, photography can provide a valuable method of recording a wound. Russell (1999) describes wound photography as one of the best forms of documentation, providing a clear and meaningful record of the wound.
2.4.3 Summary

With developments in the delivery of healthcare, the use of telemedicine is timely. Telemedicine will become a useful method for nurses to manage care (Milholland 2000). Its advantages include rapid consultation and the provision of expert advice in the patient's home. This is especially beneficial due to the increasing trend to care for patients within primary care (Fawsey-Hewett 2000).

Digital photography, in conjunction with telemedicine, can provide an economical means of visual wound assessment. In particular, a good quality image allows the state of the wound to be evaluated without the inconvenience of continued dressing removal, which may be painful and potentially leave the patient prone to infection (Aycliffe et al. 1992).

Previous studies (Ablaza & Fisher 1998, Newton et al. 2000, Dinsdale 2002) have assumed nurses access to computers and computer literacy. In the design of future studies, levels of nurses' computer skills need to be assessed and basic training provided where necessary.
2.5 The Impact of Nurses' Knowledge and Confidence on Wound Care

Knowledge and confidence are important qualities in any aspect of nursing practice. A simple definition of knowledge and confidence have previously been outlined in chapter one. With the magnitude of wound products and their accompanying wound management protocols, the nurse should possess a sound knowledge of the basic principles of wound care and have confidence in his/her ability to apply them appropriately. Knowledge and confidence are difficult subjective concepts to measure. Prior studies assessing knowledge and confidence directly and indirectly are sought out to assist in the design of a tool to measure both concepts.

Some studies have referred to confidence and knowledge synonymously (Charles 1996, Quioc 2001). Whilst they may be inter-linked in many aspects of nursing care, they are two different phenomena. The knowledgeable practitioner has the power and the confidence to make decisions and to question accepted practice (Benner 1984, Emmott 1992). Therefore, knowledge can lead to confidence, enabling the practitioner to provide care based on research evidence while confidence in isolation cannot lead to knowledge. Nurses who are skilled and educated in wound care are likely to be confident in their practice, knowing the extent of their knowledge and what they do not know. Alternatively, nurses who do not possess the same attributes may not realise the extent of their lack of knowledge and confidently continue to provide sub-optimal wound care.
Lawton (1996) stated that some nurses lack basic wound management knowledge which promotes the continued use of ritualistic practice. Whilst wound care has developed rapidly over the past two decades, its format and inclusion in pre-registration courses is variable. Wound care education would appear to be contained within the biological sciences which Akinsanya (1987) considered to be: physiology, anatomy, pharmacology and microbiology. Pre-registration students have reported the taught biological sciences to be inadequate, failing to provide sufficient background knowledge to understand the physiological phenomena they encountered (Akinsanya 1987, Leonard & Jowett 1990, Courtenay 1991). Gould (1992) criticised pressure ulcer management teaching stating that it was inadequate, poorly taught and delivered at an inappropriate time in student training as they would be unable to apply it to clinical decision making. This would provide some insight into inconsistent knowledge within clinical practice, and it has been suggested that registered nurses may acquire their wound care knowledge through drug representatives or unnecessary and time consuming solitary trial and error (Brereton et al. 1998, Hickie et al. 1998, Hallet et al. 2000).

2.5.1 Measuring Nursing Knowledge in Wound Care

Continuing professional development is an essential component of nursing practice in ensuring that new and improved knowledge is gained (DoH 1998, An Bord Altranais 2000). However, despite comprising such an integral part of daily nursing practice, it has been suggested that knowledge in wound care is variable and often poor in some aspects (Bell 1994, Turner et al. 1994, Russell 1996, Pieper & Mattern 1997, Beitz et al. 1999, Naylor 2001, Kammerlander & Eberlein 2002).
Many studies focus on some aspects of nurse education in wound care, such as the role of education in the prevention and management of pressure ulcers and in the care of leg ulcers (Young 1996, Brereton & King 1998). However, knowledge has not been directly addressed.

<table>
<thead>
<tr>
<th>Study/Study aim</th>
<th>Measurement tool</th>
<th>Sample</th>
<th>Findings</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bell (1992) Examine nurses' knowledge of the physiology of wound healing</td>
<td>Interview schedule</td>
<td>n=18 hospital nurses</td>
<td>Deficits in knowledge and application of knowledge to practice. Lack of knowledge of stages of healing, cells involved in granulation tissue and minerals that assist healing.</td>
</tr>
<tr>
<td>Bostrom &amp; Kenneth (1992) Examine staff nurse knowledge and perceptions about prevention of pressure sores</td>
<td>Patient Skin Integrity Survey 12 item test</td>
<td>n=245 hospital and home-care nurses</td>
<td>Knowledge levels good. Nursing maintenance of skin integrity not considered high priority.</td>
</tr>
<tr>
<td>Hayes et al. (1994) Examine effectiveness of a teaching plan on nurses' knowledge of pressure ulcer risk, assessment and treatment</td>
<td>Pressure Ulcer Risks and Treatment Test 100 item test pre-post test</td>
<td>n=102 hospital nurses: registered nurses (RN's), licensed practitioner nurses (LPN's) and nursing auxiliaries (NA's)</td>
<td>Teaching intervention had significant effect on knowledge levels. Significant difference between experimental and control groups on overall knowledge of pressure ulcers. Significant difference on posttest scores between RN's and LPN's in knowledge of assessment and risk.</td>
</tr>
<tr>
<td>Pieper &amp; Mott (1995) Examine nurses' knowledge of pressure ulcer risk, prevention, staging and wound description</td>
<td>Pressure Ulcer Knowledge Test 47 item test</td>
<td>n=228 hospital nurses</td>
<td>Improved knowledge levels correlated with recency of relevant reading. Items with poor correct responses included knowledge of preventative methods, ulcer staging and wound description.</td>
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<tr>
<td>Study</td>
<td>Methodology</td>
<td>Sample Size</td>
<td>Participants</td>
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<tr>
<td>Russell (1996)</td>
<td>Questionnaire</td>
<td><em>n=30</em></td>
<td>Hospital nurses</td>
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<tr>
<td>Wilkes et al. (1996)</td>
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<td><em>n=34</em></td>
<td>Registered nurses</td>
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<tr>
<td>Pieper &amp; Mattern (1997)</td>
<td>Pressure ulcer knowledge test</td>
<td><em>n=75</em></td>
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<td>Adaptation of Patient Skin Integrity Survey (Bostrom &amp; Kenneth, 1992) pre-post test</td>
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<td>Registered nurses and nursing assistants</td>
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<tr>
<td>Authors</td>
<td>Study Title</td>
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<tr>
<td>Beitz <em>et al.</em> (1999)</td>
<td>Examine relationship between perceived need for further education in wound care issues and actual knowledge of pressure ulcer care</td>
<td>$n=74$</td>
<td>Registered nurses and nursing assistants</td>
</tr>
<tr>
<td>Mockridge &amp; Anthony (1999)</td>
<td>Examine nurses’ knowledge of pressure sore healing and treatments, comparison of knowledge of pressure sore healing and treatment, existence of any relationship between knowledge and experience (defined through time since qualifying and grade)</td>
<td>$n=56$</td>
<td>Hospital nurses</td>
</tr>
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* unless stated all nurses are registered
Bell (1994) studied nurses’ knowledge of the physiology of wound healing in venous leg ulceration in an attempt to identify the knowledge deficits and suggest ways of rectifying them. Data were collected using a 13 question interview schedule, five of which were pictures of venous ulcers to test participants on the stages of wound healing. Given the inclusion criteria of registered nurses with two years post-registration experience, working in a hospital outpatient department with leg ulcer clinics, and caring for at least one leg ulcer patient per week, this was a small study ($n=18$), focusing on knowledge amongst hospital nurses. The results suggested a number of deficits in knowledge and its application to practice and poor levels of understanding of physiology in wound healing.

In particular, nurses found difficulty in distinguishing from a photograph, a sloughy wound from an infected wound. However, Bell (1994) reported the misrepresentation of the colour of the surrounding skin in the wound picture, which may have led to respondents incorrectly identifying the tissue type in two wounds. This emphasises the importance of providing a true representation when using images to assess wounds. Consideration was given to the fact that some questions may have been too difficult and findings suggested a lack of knowledge in the physiology of wound healing. However, the participants were experienced qualified nurses who were caring continuously for patients with venous leg ulcers. These findings are supported by Emmott (1992) who also found nurses had difficulty in applying the principles of physiology to wound healing. If questions were regarded as simple, there would be little room for improvement and the extent of nurses’ knowledge could not be explored.
Hayes et al. (1994) and Provo et al. (1997) used a pre-post test method to measure the effects of a teaching plan on nursing knowledge and documentation patterns of nurses in the care and prevention of pressure ulcers. Both studies examined registered and unregistered nurses' knowledge (registered nurses (RN's), licensed practitioner nurses (LPN's) and nursing assistants (NA's)) using a teaching intervention. In the case of Hayes et al. (1994), the intervention was a 40 minute instructional session covering risks, assessment and current treatments for pressure ulcers. Content validity for the knowledge measurement tool, a 100 item true-false test, was assumed through generation of the tool from a thorough literature review by nurse experts.

Provo et al. (1997) provided a 20 minute educational session developed from the AHCPR guidelines and the findings of the pre-test survey. Hayes et al. (1994) found the teaching intervention improved post-test knowledge scores between RNs and LPNs. Provo et al. (1997) did not report registered and unregistered nurse knowledge scores separately and found no statistical difference in knowledge following intervention. This could be attributed to the fact that knowledge of pressure ulcers was high prior to the start of the study with staff answering at least 80% of the survey correctly pre-intervention, leaving little room for improvement post-intervention. The improvement in post-intervention scores reported by Hayes et al. (1994) may be explained by the timing of the post-test which was administered immediately. Provo et al. (1997) administered the post-test at three weeks following intervention. Follow up studies would assist in determining the long term retention of knowledge and any effect on pressure ulcer incidence.
Few studies have focused on measuring community nurses' knowledge in wound care as opposed to the hospital environment. This is understandable as the majority of studies have considered some aspect of pressure ulcer care rather than leg ulcers, which are found largely within primary care. Kennedy & Arundel (1998) examined the wound assessment practices of 20 district nurses in one national health trust using a questionnaire. The focus of the tool was to ascertain how district nurses gained wound care knowledge, current practices in wound assessment and perceptions of how wound care practice could be improved. However, the study gave no clear description of the contents of the questionnaire and little information is given about its development other than using open and closed questions and that it was tested for clarity.

The study suggested that gaps in knowledge were evident and that the majority of nurses reported that their knowledge was obtained through drug representatives or colleagues. The most commonly reported method of assessment was a combination of observation and experience, even though the latter did not necessarily correlate with knowledge. Nurses identified a need for regular wound care education and the majority felt that a standardised wound assessment chart would assist in improving practice although only one nurse reported using such a tool. This was a small study and had some methodological flaws. The five respondents forming the pilot group were also included in the main study which would have given them an unfair advantage. Kennedy & Arundel (1998) also suggested that as respondents were colleagues, this may have attributed to the high response rate. The study raised some concerns, chiefly that drug representatives may provide biased information and that few nurses use an assessment chart.
On a more positive note, these findings led the authors to establish a forum to improve clinical practice and to develop a research based assessment tool.

Most studies have included demographic questions such as: age, sex, nursing grade, years of experience, qualifications and educational and in-service training, but few have reported any significant findings. Exceptions were Russell (1996) and Mockridge & Anthony (1999). Russell (1996) found E grade nurses were more knowledgeable than other grades (C to G) on the grading of pressure ulcers but provided no justification for this. One explanation could be that the lower grades, C and D, performed more manual tasks such as essential nursing care, whilst the higher grades, F and G, were taking on more managerial duties. This would make the E grade the most likely nurse to deal with daily wound care and in possession of a better knowledge of the anatomy and physiology and treatment protocols for pressure ulcers than the lower grades. However, Mockridge & Anthony (1999) found a strong correlation between nursing grade and knowledge, as grades increased so too did knowledge, but years of experience were not significantly related to knowledge of pressure ulcer management. In this case, it could be argued that nurses of higher grades were more able to pursue educational courses and study days. Mockridge & Anthony (1999) concluded that the most competent nurses should take a proactive stance in managing care and supervising and educating junior staff.
2.5.2 Knowledge Measurement Tools


The majority of studies have used some form of questionnaire designed to test knowledge in pressure ulcer care and reliability varies in terms of design, development, degree of content, complexity and content validity. For example, Russell (1996) gave no information on design of the knowledge questionnaire, whether it was developed following a review of the literature or whether validation was sought from expert nurses. Conversely, Wilkes et al. (1996) described the concepts used following a review of the literature, input from expert clinicians and a pilot study of the tool to ensure clarity.

2.5.3 Measuring Nursing Confidence in Wound Care

Studies have considered nurse confidence in a variety of aspects: basic surgical skills, knowledge of their patients, competency, and specialist referrals. (McMahon et al. 1995, Radwin 1996, Bradshaw 1998, Newton 1999) but few attempt to quantify confidence levels in wound care (Cox & Bowman 2000, Graham et al. 2001). Therefore, in addition to nursing studies, other studies on measuring confidence were sought.

In a study evaluating educational requirements for community nurses, Cox & Bowman (2000) focused on nurses' confidence to treat or educate dermatological patients.
The sample comprised practice nurses, community nurses and health visitors. Approximately equal numbers of practice nurses and community nurses treated patients with leg ulceration. A questionnaire was used to measure confidence covering the type of dermatological conditions, level of expertise required for the conditions, amount of training provided and areas for future service development.

Only a few sample questions were demonstrated in the paper and no information was provided on piloting or validation of the tool. Based on these sample questions, wording may have provoked a positive response. For example, "Are you confident about your ability to:

- Perform four-layer bandaging?
- Educate patients/parents about topical steroids, lifestyle issues, diets, etc.?
- Distinguish the presence of infection as a cause of complication of dermatoses?"

The majority of nurses who treated leg ulcers, 85% (n=47), were confident in their ability to apply four layer bandaging. Respondents reported lower confidence for less frequently performed tasks, such as treating scalp scaling in psoriasis or applying a body suit to a child and may have felt inclined to appear competent in routine daily procedures such as applying bandaging. Health visitors rarely perform actual dressings but their limited numbers (n=2) should not have biased results. From the results shown, it would appear that measures of confidence were obtained on a yes/no format. This would not allow nurses to communicate their level of confidence, which may have provided more insight into their educational needs.
Kemper et al. (2002) undertook a randomised controlled crossover trial to assess the impact of an internet-based course on health professionals' knowledge, confidence and clinical practices related to complimentary and alternative medical therapies (CAM) in the United States. CAM's have become increasingly popular, but appropriate training is required for medicinal use. Kemper et al. (2002) suggested that clinicians may lack knowledge of the risks of using CAM's and the resources to answer patients' questions about them.

Participants included physicians, pharmacists, advanced practice nurses and dieticians (n=537). They were invited to take part by e-mail and completed a baseline questionnaire before being randomly assigned to either the intervention (the course), or a waiting list. The intervention group followed the course over 10 weeks, after which both groups completed the first follow up questionnaire, before crossing over groups and then completing a further follow up questionnaire. Questions were devised by a multidisciplinary group of clinicians and pilot tested, however, the profession or multidisciplinary nature of the pilot group is not stated.

Following the pilot study, questions were revised by an expert in survey development. Content validity was established by a satisfactory Cronbach's alpha of 0.83 (a test for internal consistency). The baseline and follow up questionnaires contained the same 10 attitude items in a Likert type format with five response choices, ranging from strongly agree to strongly disagree. In addition, 10 multiple-choice and 10 true-or-false questions relating to knowledge and four questions to practice were included.
Confidence scores were generated depending on response; strongly agree and agree responses were scored as confident, and neutral, disagree and strongly disagree were scored as not confident with a maximum score of 10. Results showed all respondents had similar scores in confidence, knowledge and practice at baseline and the intervention group improved significantly in all three areas at both follow-up questionnaires. The waiting list group improved but not significantly at the first follow-up and improved significantly in confidence and practice at the second.

It is likely that respondents had a keen interest and higher knowledge and confidence levels in the use of CAM's in this study despite the absence of any form of accreditation for completing the course. Over twice as many participants were included as initially anticipated (n=200) due to forwarding of the e-mail to interested parties. This method of recruiting and conducting a study allows large numbers over a widely diverse geographical area to be included. However, participants needed to have access to a personal computer and e-mail address.

Participants had up to two weeks to complete the questions and it is feasible that they could have discussed the content and reviewed relevant literature before returning the questionnaire. In addition, as respondents were self-reporting, the degree to which their answers mirrored their actual clinical practice is unknown. Furthermore, little attempt was made to determine participants’ level of confidence. Those who strongly agreed or agreed with an item received the same score, as did those who gave either a neutral response, disagreed, or strongly disagreed.
It is surprising that those who gave no opinion, a neutral response, received the same confidence ratings as those who strongly disagreed. A more suitable approach would have been to either discard neutral responses or create a third category and score.

Graham et al. (2001) conducted a needs assessment of community wound care before implementing changes in service delivery. All community nurses within three nursing agencies in a region of Canada received a hand delivered or postal survey package. In addition to demographic questions, the questionnaire contained three categories: patient assessment and treatment, nurses’ skills, knowledge and attitudes and the importance of sources of information. No information was given to describe how questions were developed and by whom, or if they were piloted.

Nurses’ perceptions of the skill and competencies within leg ulcer care, attitudes toward caring for leg ulcer patients and perceptions of barriers to ulcer healing were assessed by 17 Likert type questions possessing the same response format as Kemper et al. (2002). Of the 17 questions, three negative statements were allocated to measure attitude toward patients with ulcers:

- “Most physician specialists seem disinterested in the care of leg ulcers”
- “Caring for clients with leg ulcers is not rewarding”
- “If I had the option I would prefer not to care for leg ulcer patients”

Not surprisingly, the majority of nurses disagreed with the second and third statement, whilst the first provoked a neutral response. The five questions focusing on perceived skills and competencies of community nurses also appeared to provoke social desirability bias, reflected in participants’ responses:
• "I feel confident in my ability to treat leg ulcers"
• "I could benefit from ongoing education about leg ulcers"
• "I have learned most of what I know about leg ulcer treatment strategies from other nurses"
• "I do not have adequate knowledge of wound care products to use them effectively"
• "I can rely on physicians responsible for my clients to have up-to-date information on how to treat leg ulcers effectively"

The majority either strongly agreed or agreed with positive statements or disagreed or strongly disagreed with negative statements. The exception was question three, which most nurses agreed with. It is not known if ‘other nurses’ referred to expert or specialist wound care nurses or nurse colleagues. If the former were the case, this statement could be viewed as positive. Confidence seems to have been confused with attitudinal questions on perceived skills and competencies questions: "I feel confident in my ability to treat leg ulcers” and “I can rely on physicians responsible for my clients to have up-to-date information on how to treat leg ulcers effectively”.

Whilst nearly 60% of nurses reported confidence in their ability to treat leg ulcers, 41.5% had poor knowledge of the effectiveness of four layer compression, demonstrating that nurses can be confident without necessarily being knowledgeable. However, Graham et al. (2001) did acknowledge these deficits in knowledge and made recommendations to improve community wound care.
2.5.4 Nurses' Decision-making

In a study measuring nursing knowledge and confidence within a specific area of nursing practice, it is useful to explore aspects of clinical decision-making. It is anticipated that nurses' decision-making skills in wound management will be influenced by their knowledge and confidence levels. Decision making is a highly complex process because of the vast amounts of information to be processed and the uncertainty of outcomes (Hammond 1966).

In order to make an informed decision on treatment choice and the confidence to apply that treatment choice appropriately in practice, one would assume that the nurse requires a thorough knowledge of wound management. Using research evidence in practice is considered to be a key issue in providing best care (National Assembly 1999). However, as previously discussed, nurses do not seem to incorporate the results of research routinely into their clinical decision-making (Luker & Kenrick 1996) (see chapter 2, section 2.3.2). Initial studies have attempted to identify a generic reasoning process investigating the way in which clinicians make decisions. This could then explain expert decision making and be taught to the inexperienced novice (Parracino & Mitchell 1989). It is thought that experts have more highly developed categories of knowledge, containing richer information which links various categories together with many retrieval pathways (Benner 1984, Bordage 1984, Bordage & Zacks 1984). Theoretically, this allows experts to access information rapidly.

Nurses working in the community often face different decision-making challenges from those encountered by their hospital colleagues (Bryans & McIntosh 1996).
Luker & Kendrick (1992) investigated sources of influence on community nurses’ clinical decisions, arguing that they are influenced by three main sources of knowledge:

- Research and tested theories;
- Practice and arising out of nursing experiences;
- Common sense and that which is based on everyday life.

Not surprisingly, Luker & Kendrick (1992) also found that the largest influence on practice was ‘practice-based’ or experiential knowledge and that generally, community nurses were not positively predisposed to research-based knowledge. They argued that the difference between research-based and practice-based knowledge was an ‘illusion’, so that the former having diffused so thoroughly into professional culture had become ‘owned’ by practitioners.

In a study examining clinical reasoning amongst expert and novice orthopaedic nursing practitioners, Greenwood & King (1995) used verbal protocols and protocol analyses (thinking aloud and providing a verbal report). Greenwood & King (1995) reported that their findings differed from other studies such as Benner et al. (1992). The differences observed were that although experts possessed more basic and subordinate concepts than their novice peers, the complexity of their concepts appeared to be the same. Furthermore, the concepts identified in the reasoning of both expert and novice were almost exclusively physically orientated. The authors acknowledged that thinking aloud is an alien practice in everyday clinical activities and may have reduced nurses’ capacity to focus on their clinical reasoning. Future studies using this method would require subjects to practice thinking aloud before their verbal report is recorded.
Lamond et al. (1996) also used this ‘thinking aloud’ technique to identify information strategies used in nursing clinical decisions in acute medical and surgical wards. Their results suggested that experts used more forward reasoning (working forwards from the information given to find a problem solution) and novices more backward reasoning (working backwards from a goal to find a solution). This was not mutually exclusive however, and subjects used a combination of the two forms of reasoning.

Lamond and Farnell (1998) also compared decision making between ‘expert’ and ‘novice’ nurses concerning appropriate treatment for pressure ulcers. Their findings supported the hypothesis that the expert would make a more accurate decision. Results indicated that the novice focused on non-specific information whilst the expert appeared to focus on the more salient types of information and making more informed decisions. These results could be attributed to the expert nurses in this study using their knowledge in a more efficient way. Koh (1993) suggested that knowledge does not necessarily come from experience. Nurses who had been qualified for more than five years were less likely to update their knowledge than those qualified for a shorter time. Possibly, these nurses had become complacent. However, each nurse’s career path is unique and generalisations cannot be made from one such study.

Boxer & Maynard (1999) sought to determine how registered nurses make decisions regarding chronic wound management. Following a pilot study, a Likert type questionnaire and open-ended questions were administered to nurses in hospital and community services in a region of New South Wales.
The tool aimed to explore aspects of chronic wound management including: the role of the nurse, sources of knowledge, influences on decision-making and demographic questions. The majority of nurses, 86% ($n=120$), indicated that they were responsible for regularly managing wound treatment with just under half, (49%), stating that they had adequate autonomy in their wound care practices and 62% expressing confidence in choosing wound products. The most commonly used sources of knowledge were the nurses' own experience and that of their colleagues, whereas the least cited source was research articles. It must be noted that nurses are personally accountable for keeping their knowledge and skills up-to-date throughout their working lives and delivering care based on current evidence, best practice and research findings (NMC 2002).

Boxer & Maynard (1999) found no statistically significant relationship between levels of autonomy and confidence in choosing wound care products with area of practice and level of qualification. Nurses in this study ($n=140$) relied on their own experience and that of their colleagues more than research articles and protocols. This type of decision making is not based on a clear rationale and can lead to a series of incorrect and inappropriate treatment choices. In addition, doctors were the third most commonly used sources of reference for decision making although nurses expressed the opinion that doctors had an inadequate knowledge base in wound care.
Boxer & Maynard (1999) found that in some cases open ended questions were not completed. Multiple choice, single best answer format has been used successfully to assess the educational experiences of clinicians on the subject of pressure ulcers (Odierna & Zeleznik 2003) and would have produced a better response.

Boxer & Maynard (1999) concluded that comprehensive wound care education is necessary for both nursing and medical students to produce practitioners capable of making informed treatment choices based on relevant material. However, nurses that are already qualified also need an established in-service training programme. Providing a multidisciplinary wound management course could lead to a better understanding of the boundaries of each other's role and reduce conflict in this area.

2.5.5 Summary

Previous studies to measure nurse knowledge show methodological flaws. Both Hayes et al. (1994) and Provo et al. (1997) used a pre-post test. However, Hayes et al. (1994) assessed knowledge through a true-false test which is more likely to evaluate nurse recall rather than understanding and is an inappropriate tool. Bell (1994) found some ambiguity in responses potentially due to a defect in the images used and suggested that questions may have been too difficult for nurses. Kennedy & Arundel (1998) included several participants used in both the pilot and actual study which could have lead to these nurses already knowing the answers and therefore biasing results.
Confidence has been assumed on the basis of yes/no responses (Cox & Bowman 2000) which does not allow the degree of attitudes to be explored. From reviewing the literature, attitudinal scales are considered to be appropriate methods of measuring confidence, as they allow levels of confidence to be explored such as extremely low levels of confidence to extremely high levels. In addition, direct questioning of nurse confidence as demonstrated in studies by Cox & Bowman, (2000) and Graham et al. (2001) would appear to provoke a positive response and future studies would be improved by less obvious questioning.

In any test it is not known whether responses are true reflections of actual practice. However, nurse knowledge and confidence are likely to have an impact on nursing wound care practice performance and therefore, the state of the wound. If nurses are not adhering to best practice, despite indicating they are, and patient factors are not detrimental, a deterioration may be observed in the wound.

Nursing today requires clinicians who are autonomous decision-makers (Boney & Baker 1997). Nursing is changing and nurses should be familiar with new strategies that call for reflective practitioners and clinical governance as a means to provide quality assurance and clinical supervision as a source of learning (DoH 1999). The provision of best care should be made through informed decisions based on sound knowledge of relevant and recent research, guidelines, protocols and confidence in the ability to apply them to an effective treatment strategy.
2.6 Factors affecting Tele-advice

In this section, wound assessment and accompanying factors are considered to determine those which are suitable for transmitting tele-advice. In particular, due to the emphasis placed on area measurement as a means of evaluating the state of the wound (Bulstrode et al. 1986, McTaggart 1994, Vowden 1995, Kantor & Margolis 1998, Langemo et al. 1998, Lucas et al. 2002, Öien et al. 2002), methods of wound area measurement are reviewed in order to establish an appropriate and reliable method.

Previous criticisms have highlighted areas for concern in wound measurement. Lawton (1995) suggested that wound measurement was inconsistent, infrequent and possibly only recorded once whilst Plassmann (1995) described methods of wound measurement as crude with a considerable margin for error. Wound area measurement has been viewed as an important indicator of the healing status as researchers have used it in isolation as the sole determinant of wound progress (Bulstrode et al. 1986, McTaggart 1994, Vowden 1995, Kantor & Margolis 1998, Langemo et al. 1998, Lucas et al. 2002, Öien et al. 2002). In community nursing practice, wound area measurement has been used predominantly to evaluate the progression of healing status (Baines 1997).

Wound healing is a complex, multi-dimensional process. Basing the progression of wound status on either a single quantifiable factor or a limited number of factors could be misleading. For example, a change in wound area measurement from 10 mm\(^2\) to 25mm\(^2\) in a 12 week period would suggest a deterioration in wound status.
However, following debridement, wound size generally increases in spite of the fact that the wound environment has improved (Thorman 1997). The evaluation of the wound solely on the basis of area may therefore result in erroneous conclusions.

Wound area is commonly calculated by simple linear measurement using a ruler. Dimensions are recorded for the length and width of the wound. However, this method has been criticised for its imprecision (Bryant 1992, Makeske 1992, Morison 1992, Dealey 1994). Yet, in the absence of superior methods, linear measurement has been used with the aim of providing a basis for evaluating wound progress. The perimeter of a wound is detailed and rarely straight and linear measurement of a contoured edge is likely to underestimate the actual area.

2.6.1 Wound Area Measurement Methods

A review of wound area measurement techniques follows.

(i) Computer-based Planimetry

Computer-based planimetry is a method of measuring wound area from tracing the wound and using specifically designed computer software and hardware to calculate the area within the trace (Kantor & Margolis 2000). The area may also be computed in this way using digital photographs. ‘Mouseyes’ is a computer-based planimetry program designed to measure image area and perimeter length (but not depth), using the computer mouse as the digitizer (Taylor 1997). Digitising an area is achieved by tracing the outline with the mouse.
The computer draws a line following the movement of the mouse cursor. In this way the user marks the outline or edge of the wound. Based on this graphical information the computer can perform calculations on the image area inside the wound. Taylor (1997) recruited five volunteers to digitise 12 shapes of known dimensions. The image to be digitised is traced onto acetate which was then secured onto the computer screen. Using the computer mouse, the image could be manually traced by either a continuous tracing outline or a series of points which were joined on completion of tracing. This method gave rise to two possibilities for error; through inaccurate tracing and digitization.

The program allowed users to calculate wound area and the distance between features of interest within a wound, such as islands of epithelium (although the number of sub-areas of interest the program could record were vague). This allowed the difference between the derived and actual image measurements to be compared. However, the accuracy of calculated areas was within an error of 1.3% and accuracy and reproducibility increased as the area increased. Taylor (1997) pointed out that circular shapes appeared as polygons in point mode, thus under-estimating actual measurement and distance between points had to be kept small (1-2 pixels) to provide accuracy. Problems arose when images were too large to fit on the screen or too small to be accurately traced. Therefore, they were reduced or enlarged on a photocopier which could have led to errors in calibration. Accuracy in calibration was critical and mistakes would have led to erroneous calculations.
Taylor (2002) subsequently up-graded the program to include a built-in help file and the capacity to save screen calibration factors and wound outlines from digital images. Digital images were saved as bitmap files (BMP). However, BMP files are large and take up considerable computer memory. JPEG files (joint photographic experts group) lose a small amount of image quality by compressing the image but are much smaller in size and would be more appropriate when storing large numbers of images. Taylor (2002) compared the original method of tracing the image whilst fixed to the screen with tracing a digital photograph downloaded to computer and a digital photograph of a shape adhered to a volunteer’s leg in an attempt to reproduce a realistic clinical situation, which was also transferred to the computer.

The accuracy of calculated areas was within 0.8% and there was no statistically significant difference between the derived and actual areas for all the shapes digitised. It is anticipated that a reduction in accuracy would be observed when calculating actual wounds rather than artifacts. The range of errors from tracing digital images was larger than tracing images adhered to the screen, however, the co-efficient of variation was smaller for digital images. Although two of the three calculations obtained from photographs attached to the volunteers leg had high levels of agreement with the actual area, the third calculation was in error by 3.5%. Taylor (2002) attributed the large range of error to the surface of the image not being parallel to the camera’s image plane, leading to ‘foreshortening’. This effect is described as foreground objects appearing larger than identically-sized background objects. This could be avoided by ensuring that the image is captured at a perpendicular angle, that is, the camera is pointing directly downwards onto the wound.
Santamaria & Clayton (2000) developed a similar digital wound imaging system, AMWIS (Alfred/Medseed Wound Imaging System). This system comprised a software package that quantitatively analysed digital wound photographs. In addition to wound measurement, it contained a method of storing and transmitting wound information. Rather than providing length, width or depth measurements, AMWIS calculated surface area and sub-areas of interest, expressed in mm$^2$ as this was believed to be a more useful and accurate measure of complex wounds. The outline of the wound was traced with the computer mouse and images were calibrated by aligning the cursor over a known length marker.

Santamaria & Clayton (2000) reported that this system took approximately five minutes to enter, per complex wound. However, the timing is dependent on the smooth running of the equipment and the expertise of the operator. Further work was envisaged to refine its functions and determine effects on wound healing and as yet no comparisons have been made to establish its reliability in wound area measurement. A randomised controlled trial is currently being undertaken to establish the effectiveness of AMWIS in remote consultation for Aboriginal communities, and results are yet to be published (Santamaria 2003).

Samad et al. (2002) compared the accuracy and reproducibility of leg ulcer measurements from digital image tracing and conventional tracing. Four volunteers used both methods to measure 11 elliptical shapes of known area measurement. Following this, 25 patients had their venous leg ulcers measured by a nurse using both methods. Area measurement was calculated by computer program for digital images.
Conventional tracing was carried out on a semi-opaque sheet with a pre-printed grid of squares. Area measurement was calculated by counting the number of complete squares (16 squares per cm\(^2\)) within the wound tracing and estimating the number of partially completed squares. Although accuracy for both methods was considered good (mean error <5%), conventional tracing significantly underestimated the area of the shapes by 3.9%. Variation between observers for digital measurement of leg ulcers was greater than for the shapes. This was attributed to error in camera technique. Samad et al. (2002) found digital image tracing to be less time consuming than conventional tracing and also provided a means of visual assessment. Samad et al. (2002) acknowledged the advantages of digital photography over tracing in that it provided information on the nature and site of the ulcer, was more convenient to store and could be easily transferred. However, Samad et al. (2002) gave little consideration to nurse training and suggested that any poor quality images arising from poor technique could be avoided with a few minutes of operator training.

Tracer\(^\circ\) is a simple planimetry computer program designed at the University of Glamorgan (Plassmann & Jones 1990) and calculates area measurement from digital wound images. From reviewing the literature, it was concluded that this method provided a simple, practical and inexpensive technique to form one of the components with which a reliable wound measurement tool could be established. The program provides an area measurement and is similar in design to other computer planimetry programs (Taylor 1997, Santamaria & Clayton 2000) but has been modified and improved in line with advances in technology specifically for measuring leg ulcers.
The operator uses the mouse to plot a series of points outlining the wound perimeter which the program then calculates. The program allows the epithelium and four areas of interest to be measured. For example, the amount of sloughy, necrotic tissue and other factors may be required to measure progress in addition to the wound area. Tracer® stores images as smaller JPG files.

**Tracing**

One of the first documented methods of non-invasive measurement was by Lecomte du Noüy (1937) who measured open wounds on soldiers during the first world war by tracing the wound outline on cellophane sheets. This method is still commonly used in current practice as it is simple and inexpensive. However, there are reliability issues with this technique. Firstly, the precision of the tracing is dependant on the user’s skill and the reliability of the technique depends on consistent and precise location of the wound edge (Goldman & Salcido 2002). Secondly, inter-rater and intra-rater reliability is questionable as it is unlikely that one nurse would achieve the same results on subsequent tracings or achieve the same results as another nurse. Finally, as with many measurement tools, in order to obtain consistent and reliable measurements, the wound must be measured under standard conditions, for example, placing the patient in the same position.

A variation of the tracing method encompasses placing the tracing on metric graph paper and counting the number of square centimetres within the tracing and some modern acetates have pre-printed squares. This is a time consuming task for a large wound.
Alternatively, the tracing can be cut out and weighed. The precision with which the tracing is cut out and the sensitivity of the weighing scales will determine the accuracy of the measurement.

(iii) Wound Gauge

Kundin (1989) developed a measurement tool using mathematical (Cartesian) co-ordinates to measure length, depth and breadth to calculate surface area and volume - the "wound gauge". Using this tool, wound surface area was calculated from adapting the mathematical formulae for the area of an ellipse. While smaller wounds approximate the shape of an ellipse, larger wounds may be more irregular in shape and less amenable to simple wound measurements (Kantor & Margolis 2000).

Kundin (1989) reported that the gauge correlated with standard methods of measurement and with an 'acceptable' inter-rater reliability (which was not stated) although no clinical trials have been published. It must be noted that this tool has been criticised for consistently underestimating the size of larger and irregular-shaped wounds (Thomas & Wysocki 1990). In addition, this technique calls for the operator to establish the perimeter of the wound, based on a subjective determination of multi-operator variability.

(iv) Wound Moulds

Wound moulds measure wound volume in two ways, either by pouring a substance such as alginate into the wound or injecting a solution into the wound cavity. In the former method, the substance forms a mould on removal.
The mould is then placed into a cylinder of water and the amount of water displaced represents the wound volume. In the latter method, a transparent film is placed over the wound and surrounding skin and an isotonic solution is injected into the cavity. The amount of solution needed to fill the cavity is assumed to represent the wound volume. Errors could arise through the subjective nature of the alginate being ‘levelled off’ to follow the former skin and determining when the isotonic solution had filled the cavity. It is also possible that the wound would absorb some of the solution. Both of these methods require physical contact with the wound potentially causing pain, damage and infection. They are also messy, time consuming and impractical for the community setting.

Other methods include stereophotogrammetry (Bulstrode et al. 1986), computerized image analysis (Frantz & Johnson 1992), structured light (Plassmann & Jones 1995), and digital videometry (Wunderlich et al. 2000). These methods are infrequently adopted in daily clinical practice mainly due to the cost of the equipment, the size of some equipment, the skill required to operate specialist equipment and the specific environment it may need to be housed in.

All measurement techniques share potential flaws. Some are specific, others universal, such as subjectivity in determining the wound edge and frequently encountered issues deal mainly with accuracy and precision. However, the reliability and validity of wound assessment and measurement based on still digital images has been found to be comparable to traditional methods (Brown Etris et al. 1994, Wirthlin et al. 1998, Rajhandari et al. 1999, Lucas et al. 2002).
2.6.2 Wound Assessment and Relevant Factors

Detailed and reliable assessments are the basis of good wound care (Waitret & White 2001) and adequate patient assessment is the most important element of chronic wound management (Davies 2001). Effective leg ulcer treatment begins with a comprehensive assessment of the patient’s condition (Roe et al. 1994, Cullum et al. 1997) and before applying compression, it is imperative that a holistic assessment is undertaken (Eagle 2001).

However, evidence suggests that treatment is often based on inadequate assessment that fails to take account of the underlying condition (Audit Commission 1996). Flanagan (1996) suggested that wound assessment has tended to rely on anecdotal evidence, failing to provide reliable information.

Many wound assessment tools have been developed to facilitate this process (Sutton 1989, Flanagan 1994, Maylor 1995, Miller & Powell 1995, Briggs & Banks 1996) (see appendix VII). In many cases, their validity and reliability have not been established. Factors to include in assessment are numerous and differ according to which assessment tool is used. They can be broadly categorised into three domains:

1. Factors relating to the patient’s general condition;
   *e.g. weight, level of mobility, nutritional status*

2. Factors relating to the limb;
   *e.g. oedema, temperature, colour*

3. Factors relating to the wound;
   *e.g. exudate, size, odour*
Examples of wound assessment factors potentially suitable for tele-transmission are briefly discussed:

(i) **Colour**

Cuzzell (1988) has been credited with introducing colour to describe the appearance of a wound. This was considered to be a simple, easily communicable method using three colours: red, yellow and black. Red relates to granulation and epithelialisation within the wound and this delicate tissue should be protected until the wound has healed. The colour yellow refers to slough. Both necrotic tissue and slough are comprised of devitalised tissue (Cutting 1999), the main difference being that necrotic tissue is dehydrated and therefore hardened, whilst slough is liquified. In the case of slough, the management aim is to cleanse the wound to free it of the non-viable tissue. Black refers to hardened necrotic tissue and the main management aim is to debride the tissue. The colour green has also been used in addition to red, yellow and black to represent wound infection (Lomas 1988). However, using wound colour in isolation can misrepresent the state of the wound. Some necrotic wounds appear as dark yellow or brown and infected wounds are not necessarily green in colour (Pudner 1997).

(ii) **Tissue type within the wound**

The tissue type within the wound gives an indication of the state of the wound as well as suggesting appropriate treatment, as discussed in wound colour. Flanagan (1997) combined tissue type with wound colour to produce a more reliable assessment, adding the colour pink, as new epithelial tissue may have a pinky-white appearance.
(iii) **Inflammation, exudate and oedema**

Inflammation is part of the body's normal response to injury where there is an increased blood flow to the area and an accumulation of fluid in the soft tissues (Flanagan 1997). Exudate is also produced during this stage of healing to bathe the wound with nutrients and actively cleanse the wound surface (Flanagan 1997).

Oedema has been described as an abnormal accumulation of interstitial fluid (Tortora & Anagnostakos 1990). Hofman (1998) considered the effective control of oedema to be vital in the management of venous ulcers.

(iv) **Ulcer edge**

Wound edges are a composite of characteristics that include distinctness, degree of attachment to the wound base, colour and thickness (Stotts 1993). Different types of wounds exhibit different wound edge characteristics (Bates-Jensen 1999) therefore providing useful clinical information. According to Bates-Jensen (1999) venous ulcer edges are often irregular and indistinct whilst arterial ulcer have regular distinct wound edges with a punched out appearance.

In addition to wound area, current evaluation of wound status may be determined by single factors such as those previously discussed or a combination of several factors including wound colour and degree of tissue type in wound (Flanagan 1997) and wound size, shape and margin (Russell 1999).
Similarly, other studies advocating the use of several factors assess each factor in isolation. The inaccuracy of this approach has been previously discussed, as wound healing is a complex, multidimensional process.

From reviewing wound assessment tools, the researcher considered many to have flaws such as being unduly lengthy and time consuming (Flanagan 1994), complex (Thomas et al. 1994), requiring unnecessary repetition of information at subsequent assessments (Briggs & Banks 1996) and not producing enough relevant information to evaluate the wound (Sutton 1989). Many factors should be covered at the initial assessment such as medication, mobility and nutritional status. Subsequent assessment would only be necessary when changes occurred, for example, if medication was altered or the patient experienced a decrease in their mobility.

Thomas et al. (1994) introduced a wound assessment tool as part of a larger wound assessment/audit system which also aimed to provide a single numerical value measuring the state of the wound based on collective factors. Although the title would lead the reader to assume the assessment tool was aimed at chronic wounds, ‘Assessment of patients with chronic wounds’, provision was made to include all wound types. The assessment tool comprised eight headings, subdivided into a total of 56 factors. Numerical values between 0 (best wound state) and 20 (worst wound state) were allocated to factors according to their severity. However, clinicians needed to be skilful to complete some sections. For example, the wound type heading gave responses such as: ‘partial thickness wound or burn’, and ‘devitalised ischaemic tissue’.
The wound condition section gave choices such as: 'epithelialising from margin only', 'forming new granulation tissue' and 'base has indolent anaemic appearance'. It is questionable therefore whether community nurses would have the expertise to recognise these wound states. A single overall score was calculated from adding the figures from each factor. The single measure introduced by Thomas et al. (1994) allocated equal weights to the factors contributing to the final measure.

2.6.3 Use of the Visual Analogue Scale (VAS) in Wound Assessment

The VAS has been a widely used and reliable assessment tool since 1970 (Banos 1998, DeLoach 1998, Coll 2001). Combined with a good quality image, this could provide an objective method of assessing wound factors. The horizontal VAS is simple to use, rapid to complete and has the ability to allow the rater to make fine discriminations. Conventionally, the VAS is a 100mm straight line that is either vertically or horizontally anchored at both poles with word descriptors representing extreme limits of the factor being measured. For example, the amount of exudate observed in a wound (see figure 6).

What is the amount of exudate in this wound?

![Image of VAS for exudate]

Figure 6. Use of VAS to measure exudate
2.6.4 Summary

It has been identified that wound healing is an intricate process and cannot be reliably evaluated by single wound factors. Previous studies have evaluated wound progress through such a single factor, area measurement (Bulstrode et al. 1986, McTaggart 1994, Vowden 1995, Kantor & Margolis 1998, Langemo et al. 1998, Lucas et al. 2002, Öien et al. 2002) and the potential for error has been demonstrated.

A thorough assessment is necessary in order to establish an effective treatment regimen (Roe et al. 1994, Cullum et al. 1997). In addition to area measurement, many other factors must be taken into consideration in assessing the state of the wound. These include wound factors such as colour, exudate and oedema and as previously discussed, patient factors such as obesity and gender (see chapter 2, section 2.2.3).

A tool that produces a value to represent the state of the wound based on relevant wound and patient factors would provide an objective method to evaluate wound progress.
2.7 Summary of Literature Review

In summary, the following factors have emerged from reviewing the literature and should be considered in the design of future wound care studies:

• Clear ulcer definition and inclusion criteria;

• Thorough general and wound assessment for ulcer patients, to include Doppler assessment to achieve a definitive ulcer diagnosis;

• Training in wound assessment, Doppler ultrasound and bandaging technique;

• Thorough wound documentation practices;

• Wound treatment to be based on research findings;

• Objective measurement of nurses’ knowledge and confidence in their wound care practice;

• Wound measurement techniques to be carried out accurately and at pre-determined intervals according to the nature of the wound;

• A simple, visual assessment tool to evaluate wound status;

• Determining nurses’ level of competency and access to computers and other technologies, with basic training provided where necessary;

Previous studies have omitted a clear definition of leg ulceration (Hickie et al. 1998, Bello & Falabella 2002) which have been found to be problematic (Beitz & van Rijswick 1999). As a result of these findings this study will adopt the simple description provided by Dale et al. (1983) in addition to clinical judgement and an ABPI of ≥0.8 (RCN 1998). In addition to determining the underlying cause, patient factors should also be considered as many may affect the progression of the wound. These include: age, gender, mobility, obesity, ulcer duration, area measurement and co-existing illness.
In order to propose new ways of caring for leg ulcers, the aetiology and associated features have been reviewed. Venous disease is the most common cause of leg ulcers, although 'mixed' ulcer aetiology is becoming more common (Phillips 1994). The majority of patients with leg ulcers are cared for in the community and managed by community nurses. Although a profusion of literature surrounding the treatment of leg ulcers exists, diversity is apparent in clinical practice and treatment has been criticised as being inefficient (Groake et al. 1996, Dunn 1998). The cost of treating leg ulcers is vast and in order to be cost-effective, it is important that the individual patient receives the most appropriate treatment.

No contemporary prevalence surveys could be found in the literature and dated studies such as Callam et al. (1985), Cornwall et al. (1986) and Lees & Lambert (1992) continue to guide leg ulcer prevalence estimates. These estimate that approximately 100,000 people at some point during their lifetime will develop an ulcer and that the risk of ulceration increases with longevity. However, contemporary surveys should not exclude the younger population as their leg ulcer prevalence may have been underestimated as they are often self-caring.

This study will aim to objectively evaluate community nurses’ knowledge and confidence in their wound care practice. For the purposes of this study, a Likert type attitudinal scale will be designed to measure levels of confidence. Multiple choice question format has been demonstrated to successfully test clinicians knowledge (Odierna & Zelenik 2003) and will be used to measure knowledge in this study.
Consideration will be given in the design of these tools to avoid the previously mentioned methodological flaws such as including participants in the pilot and main study (Kennedy & Arundel 1998) and direct questioning of nurse confidence (Cox & Bowman 2000, Graham et al. 2001) (see chapter 2, sections 2.5.1, 2.5.3).

Evaluation of wound status has been shown to be complex and inaccurate. Progress in evaluating wound healing is indicated in many ways, such as tissue type, colour and exudate levels and the inaccuracy of determining wound status on individual factors has been discussed. Therefore, development of a single numerical index to evaluate wound status is one of the main new contributions in this work. In the current study the index will be based on a combination of measured intensity of different visual wound assessment factors that are more amenable to telemedicine. The relative importance of each factor will be established through a panel of experts.

Dimond (2003) pointed out that the practitioner has a duty to ensure instructions given over the phone are understood and that they are followed up in writing. Consultations in this study will be carried out over a distance and nurses will receive advice by telephone. Therefore, the expert will ensure that any treatment instructions are fully understood and the consultation will be clarified with written documentation summarising important factors, to provide a clear record of the consultation. This will guide the nurse in their decision to accept or reject treatment advice based on their clinical judgement.
Nurses play a major role in assessment and documentation practices in wound care. If they are to be accountable for their actions, they must base their delivery of care on informed and rational decisions (Flanagan 1996). Dimond (2003) considered record keeping and standards of documentation to be in the best interest of the patient, rather than as an exercise to protect against increasing litigation.

It has been suggested that much practice, particularly in the community, is based on experiential learning rather than evidence-based practice (Luker & Kendrick 1992, Boxer & Maynard 1999). The gap between research and practice needs to be closed if the developments made in modern medicine, patient care and clinical practice are to be recognised and implemented. Similarly, the application of any technology must be based on research findings, patient centred and relevant to patient care to avoid the accumulation of little used expensive equipment.

Parahoo (2000) found a lack of motivation to be an obstacle preventing nurses using research in practice. In this study, the research question is pertinent to the community nurses’ daily practice and it is anticipated that the relevance of the research will provoke interest. In addition, involving nurses in a research study from the beginning could lead to a sense of ‘ownership’ and increase enthusiasm.

Referring good quality ulcer images to specialist practitioners can also facilitate diagnosis and provide expert treatment advice.
Warner et al. (2003) pointed out that many patients would choose to receive care in their own home and new studies should attempt to accommodate keeping the patient at home. In this study, the provision of specialist advice to patients at home is proposed through tele-advice.

The methods used in this study are discussed in the next chapter.
Chapter 3  Methods

3.1  Introduction

This study was designed to examine the impact of tele-advice on nurses management of leg ulcers. This was performed in two stages. Stage one concentrated on two central themes: measuring the impact of the provision of tele-advice on nurses knowledge and confidence, whilst stage two examined the impact of nurses knowledge and confidence on the state of the wound.

A stratified randomised controlled trial was designed to investigate the impact of tele-advice on nurses knowledge and confidence. In addition, a visual wound assessment tool was designed to represent the state of the wound by a numerical value – State of the Wound Index (SWI). This was followed by examining the link between knowledge and confidence and the state of the wound. Figure 7 combines the three central themes in this study: knowledge, confidence and wound assessment and figure 8 provides a diagrammatic representation of the study design.

As already stated in the introduction, the research question in this study asked whether tele-advice can be used efficiently to enhance the role of the community nurse in their care of venous leg ulcers.
This can be represented in the following null hypotheses:

**Hypothesis 1:**  *Expert tele-advice has no significant impact on nurses' knowledge and confidence levels in the care of leg ulcers.*

**Hypothesis 2:**  *Nurses' knowledge and confidence levels do not play a significant role in the improvement of leg ulcers.*

**Hypothesis 3:**  *No significant relation between the state of the leg ulcer wound, patient factors and nurses' knowledge and confidence levels for the care for the wound could be established.*

The impact of tele-advice on nurses' knowledge and confidence was explored through a self-assessment multiple-choice questionnaire and attitudinal scale administered pre and post intervention respectively.

The self-assessment knowledge questionnaire consisted of 40 questions which aimed to cover wound care through three broad themes: wound aetiology/physiology, wound dressings and wound management. Questions were also categorised according to their level of difficulty: easy, medium and difficult. Bloom (1956) identified six levels within the cognitive domain, from simple recall at the lowest level to evaluation, which is considered the highest level (see appendix VIII). In accordance with Bloom’s taxonomy, easy questions were categorised as being of the first two levels: knowledge and comprehension, medium questions of the third and fourth levels: application and analysis and difficult questions of the fifth and sixth levels: synthesis and evaluation. The marking strategy was devised to provide an overall mark within thematic grouping and a weighted average of marks according to the level of difficulty. This provided insight into which areas improved or deteriorated and therefore, implications for nurse training.
A Likert type attitude scale was designed through the generation of a large number of statements relating to confidence to determine individual nurse's confidence levels. Through a process of review by strict criteria from a pilot group and expert panel rating according to the degree statements reflected high or low confidence, a final 10 item scale was produced. This was given to the nurses to record agreement or disagreement with the statements. A marking scheme was devised to score their responses accordingly, from 0 to 100. The higher the level of confidence represented by the statement, the higher the score.

In addition, a visual wound assessment index - state of the wound index (SWI), was designed to provide a single numerical value representing the state of the wound for each leg ulcer within the study. Visual wound factors were established (n=18) and ranked by experts in order of importance.

Throughout the study, a series of expert panels were used in rating exercises. For the purpose of clarity, each expert panel has been given an individual name and details are given in appendix IX.

A set of Virtual Nurse Response (VNR) replies were created to produce the SWI. A small expert panel, (panel A), provided minimum and maximum ranges for each wound factor to represent 95% confidence intervals, used to generate a set of 100 VNR responses. In parallel, experienced wound care nurses, (panel B), rated each wound factor for a selection of images (15 pairs of pre and post-intervention images) on computer screen using a visual analogue scale (VAS).
From the image bank, pre and post images ($n=74$) for each wound were placed on a CD and a computer program designed to randomly select the fifteen pairs of pre-post wound images. Randomisation of images would provide a more representative selection and ensure that the same 15 pairs were not duplicated. This rating produced a corresponding value for each factor between 0 (best state) and 100 (worst state). The mean value for each factor and the area measurement were combined and weighted according to the experts’ ranking to produce the SWI. In the same way, the closer to 0, the better the state of the wound, and the larger the number, the worse the state of the wound.

The importance of knowledge, confidence and an objective assessment tool have been previously discussed in chapter two, sections 2.5.1, 2.5.3, 2.6.2. However, there has been negligible previous work undertaken to investigate the effect the combination of these factors may have on wound outcome (see figure 7).
Figure 7. Combining the three central themes: knowledge, confidence and wound assessment
Analysis of these three themes: knowledge, confidence and wound assessment, considered the association between each individual theme and a combination on wound outcome. In addition, the responses created by the VNR and the actual nurses completing the wound assessment factors were investigated.
AIMS:
- Evaluate aspects of nursing practice: knowledge, confidence following expert advice through the use of new technology
- Development of simple visual wound assessment tool
- Provision of expert advice to underserved areas

SUBJECTS:
Community nurses caring for patients with venous leg ulcers

LOCATION:
Two local trusts

To evaluate the impact of expert wound care advice through telemedicine on nursing management in the care of venous leg ulcers.

MEASURE 1
Nurses Knowledge
Adaptation of self-assessment wound care test

MEASURE 2
Nurses Confidence
Development of attitude scale

MEASURE 3
Wound Status
Development of simple visual wound assessment tool

OUTCOME

Figure 8. Flow diagram of study design
3.2 Recruiting Participants

The population to be studied were registered nurses working in the community within two local trusts (see figure 9). At the time of this study, there was a combined total of 174 community nurses. The two trusts in this study were chosen because the areas provided a range of semi-rural and rural locations and neither trust at that time employed a CNS in wound care or a tissue viability nurse. New technology used in this study aimed to provide expert wound care consultation to those patients who up to the time of the study, had no access to such services. Telemedicine has the potential to assist in providing health services to those patients whose access to care is limited for geographic or other reasons (Balas et al. 1997). Therefore it is especially suited to remote and rural areas, such as those areas in the South Wales valleys.

Contact with both study centres was made initially through a written introduction. Following this, a series of separate informal meetings was arranged with the two nurse managers at their trust headquarters. An open invitation was also given to any other management or healthcare personnel such as locality nurse managers and senior community nurses.

In the first of these meetings, the project and nurse involvement in it was detailed in a PowerPoint© presentation as well as a short written report provided for each member. The presentation was followed by a question and answer session where any reservations or queries regarding the project could be discussed.
CHAPTER THREE

METHODS

Figure 9. Stages in the sampling process
The main issues arising were to ensure that ethical approval had been obtained prior to data collection as well as maintaining patient confidentiality. Subsequent meetings were intended to keep managers informed of progress and to address any other issues or queries that arose.

Complete and current registers and demographic data of community nurses in each trust were obtained from the nurse managers. Each nurse was sent an introductory letter briefly outlining the project (see appendix X). As nurses are already required to complete a substantial amount of paperwork, the decision was taken to keep information as short and concise as possible and increased the likelihood of it being read. Nurses were invited to ask for further information if required. The letter covered key points of the project such as:

- Why the project was being carried out;
- Who was involved;
- Criteria for inclusion of leg ulcer patients;
- The nurse would be required to identify suitable patients but would be responsible for one patient in the study;
- Administrative procedures followed;
- Expected nature and level of their participation;
- When the researcher would make contact.

**Ethical Approval**

The Local Research Ethics Committee (LREC) had requested that the community nurse approached patients initially rather than the researcher (see appendix XI).
The committee felt that this would allow the patient to discuss their concerns more easily with a known, named, health care professional. Nurses were asked to identify any leg ulcer patient they thought would be suitable for the study and asked the patient if they would provisionally consider being involved.

Nurses were provided with several copies of simple written patient information and preliminary patient consent forms, approved by the ethics committee, to read to the patient with stamped addressed envelopes for the patients in which to return the form (see appendix XII). Nurses were instructed to complete patients' names as well as their own on the introductory patient letter, as appropriate. The written information briefly explained why the patient had been approached, who would be carrying out the study and the study objectives. It also stated that patients would not necessarily see any improvement in their leg ulcer from taking part in the study. The preliminary consent form granted the researcher permission to visit patients in their home to discuss the project further and did not confirm recruitment to the study until the patient was willing to sign the consent form.

Nurses were informed that the researcher would contact them by phone within two weeks to discuss the project and then take details of any suitable patients. This provided the nurses with time to read the information and prepare any queries they had. As the community nurses were responsible for providing patient care, it was important that they had the opportunity to raise any concerns and act as the patient's advocate.
During the follow up phone calls, nurses provided information on potentially suitable patients for the study. Nurses were also invited to attend an informal half study-day set up on three different dates to maximise attendance. Nurses were asked to book a place on the most convenient date for them. The purpose of these sessions was to present and discuss the project and introduce the digital cameras to the nurses. However, subsequent attendance was disappointing as several nurses had not read the information, some had misplaced it and some reported not to have received it.

In each case, a suitable time was arranged to re-contact them to enquire about appropriate patients for the study and where appropriate, the information was re-sent. Patient information obtained included name, address, brief ulcer history (such as duration of current ulcer, location of ulcer, cause of ulcer) and Doppler readings. Ninety patients in total were identified for inclusion to the study.

Nurses who reported not having any leg ulcer patients were also invited to the sessions and subsequently contacted regularly in the event that a leg ulcer patient had been added to their caseload. All potential patients’ GPs were sent an introductory letter briefly explaining the project and assuring them that ethical approval had been obtained. In addition, a relevant paper studying GPs perceptions of store-and-forward dermatology was also included (see appendix XIII) to demonstrate the use of telemedicine. Several GPs expressed an interest and offered to provide advice on any medical aspect if required. Consequently, meetings were held and issues discussed included approaches to store-and-forward methods and choice of equipment.
Consideration was given to making the study days as convenient and interesting as possible for the community nurses, with the anticipation that producing a topical, relevant session would encourage nurses to attend. Considerations included:

- Scheduling them for afternoons to accommodate shift patterns and workload, as most patient calls are made in the morning;
- Locating suitable venues within central sites within each trust to reduce nurses' travelling time;
- Enlisting several well-known external speakers to deliver short talks on aspects of assessing and delivering wound care;
- Approaching a pharmaceutical company to provide refreshments and a wound product display stand to raise the profile of the study days;
- Designing certificates to show attendance, which would be printed on the day and could also be used in nurse's professional portfolios.

However, few nurses made contact to book places. Therefore, the researcher contacted each nurse in an attempt to ensure each study day was fully attended. The majority of nurses felt that they would be unable to attend on any given date due to poor staffing levels. Some community nurses worked part-time hours, usually during 8am to 12 noon. This meant that those attending afternoon sessions would need time back in lieu. This would be time taken in a subsequent morning, leaving smaller nursing teams of 3 to 4 nurses short staffed. As a result, this logistical exercise proved to be challenging with staffing levels, time constraints and motivation to attend as the main contributory factors.
Nurses were unwilling to attend in their own time. This unwillingness could be attributed to a variety of reasons including prior commitments, family obligations and lack of interest in the subject. In anticipation of poor attendance for the above reasons, a different approach was followed to liaise with nurses to inform them about the project. Following further discussions with nurse managers and community nurse colleagues, the researcher arranged to visit nurse clinic bases. Surprisingly, visiting them during their lunch hour proved to be the most convenient time. Direct meetings with the nurses allowed provision of the required information, avoiding inadvertent withholdings or misplacement.

Several practices cancelled meetings at short notice, which were successively re-scheduled. Thirty nurse bases in total were visited over a three-month period in an endeavour to reach every nurse within each trust. Nurses who reported not having any current leg ulcer patients were also visited in anticipation of new patients being referred.

At these lunchtime meetings the project was outlined briefly. The decision was taken to keep the talks relaxed and informal. Therefore, combined with the impracticality of transporting and setting up the necessary equipment in primary care settings, PowerPoint© presentations were not given at these sessions. Nurses were informed that they would be required to: identify appropriate leg ulcer patients but would only be responsible for one actual patient in the study, would complete a multiple choice questionnaire and attitude scale immediately before intervention and at the end of the study, not to discuss the questions with each other so that a true reflection of knowledge and confidence scores could be obtained.
Nurses were reassured that their scores would remain confidential and would not be seen by anyone other than the researcher and project supervisors. Following completion of data collection, their individual scores were made available on request. Nurses were given the opportunity to use the digital cameras and practised by photographing each other. The researcher then downloaded their images onto a portable laptop computer for the nurses to view.

Nurses were encouraged to discuss any concerns that arose regarding the study. These included:

- **Length of time data collection would take**
  
  *how much time would it add to their patient visit*

- **Study approval**
  
  *were their managers fully informed of the project*  
  *had ethical and trust approval been gained*

Most of these issues had been addressed in the introductory letter that was originally sent out and nurses were reassured that the correct procedures had been adopted. Nurses were again asked to recommend suitable patients for inclusion to the study. On completion of visits to nurse bases, 44 potential patients had been identified (see table 10) all of which had returned completed preliminary consent forms. Further meetings were arranged over the following four weeks to visit patients in their home to discuss the project with the patient’s community nurse present. Nurses had already outlined the project to the patient and this was repeated in more detail by the researcher. It was important that patients fully understood their involvement in order to achieve informed consent.
Patients were highly positive about the study and hoped that the findings would be instrumental in healing leg ulcers in the future. Their only concern was that participation meant that they may have to go into hospital. Patients were reassured that the study would be carried out in their own home, that the researcher had no authority to request their hospitalisation and that their care remained the responsibility of the community nurse.

Patients were reminded that they may be placed in one of two groups: experimental or control, so that the intervention could be compared with their usual treatment. They were also reassured that pictures of their leg ulcers may be used to teach nurses about leg ulcer care and that they could not be recognised from the images. Digital cameras were also taken for the patient to handle and assist in dispelling any reservations about unknown technology and equipment.

Patients were left with a consent form which the community nurse would collect one week later and post back to the researcher. Most patients were willing to sign the form immediately but were asked to wait until the following nurse visit. This would allow time to discuss the project with their family and carers and make an informed decision. Contact numbers for the researcher were also provided in case patients had a further query. (One patient rang to inform the researcher that his ulcer had now healed, which was confirmed by his community nurse. A further four patients ulcers healed and two patients died prior to data collection.) Thirty eight patients with venous leg ulcers and 38 community nurses having the responsibility of caring for these wounds were finally recruited to this study. The stages in recruiting nurses and patients are represented in figure 10.
From the original 90 patients identified for this study, 52 were not included in the actual study. The reasons for exclusion are presented in table 9.

<table>
<thead>
<tr>
<th>Reason</th>
<th>Count</th>
</tr>
</thead>
<tbody>
<tr>
<td>Further investigations found ulcer was not venous in origin</td>
<td>11</td>
</tr>
<tr>
<td>Patient referred to new leg ulcer clinic</td>
<td>10</td>
</tr>
<tr>
<td>Ulcer currently healed</td>
<td>9</td>
</tr>
<tr>
<td>Patient referred to wound healing research unit</td>
<td>8</td>
</tr>
<tr>
<td>Patient currently hospitalised</td>
<td>5</td>
</tr>
<tr>
<td>Patient currently involved in other wound trial</td>
<td>3</td>
</tr>
<tr>
<td>Patient deceased</td>
<td>3</td>
</tr>
<tr>
<td>Patient refused following initial consent</td>
<td>2</td>
</tr>
<tr>
<td>Nurse considered patient too confused to take part in study</td>
<td>1</td>
</tr>
</tbody>
</table>

It was not possible to match or stratify patients for variables, such as age, gender, obesity or co-existing illness due to a small sample size limitations. Therefore, differences may have occurred between experimental and control groups.
RESEARCHER LIAISES WITH NURSE MANAGERS IN BOTH TRUSTS:
- SERIES OF MEETINGS SET UP
- REGISTER OF COMMUNITY NURSES
- 174 COMMUNITY NURSES

PROJECT INFORMATION SENT TO EACH COMMUNITY NURSE:
- POTENTIAL PATIENTS APPROACHED BY NURSES

FOLLOW UP CALLS:
- 90 PATIENTS SELECTED

PATIENTS GPS INFORMED:
- CONSENT OBTAINED

COMMUNITY NURSES VISITED AT CLINIC BASES:
- 30 VISITS
- 44 PATIENTS SUGGESTED

PATIENTS VISITED IN OWN HOMES:
- 44 VISITS
- PATIENT CONSENT SOUGHT
- COMMUNITY NURSE ACCOMPANIES RESEARCHER

FINAL SAMPLE OBTAINED:
- 38 PATIENTS WITH VENOUS LEG ULCER
- 38 COMMUNITY NURSES

Figure 10. Stages in recruitment.
3.3 Sampling Technique

The two trusts included in the study had small populations and the sample size was dictated by the number of patients with a venous leg ulcer. For the purposes of this study, the simple leg ulcer description provided by Dale et al. (1983) (see chapter 2, section 2.2.1), in conjunction with an ABPI of $\geq 0.8$ (RCN, 1998) provided the criteria for the inclusion of venous leg ulcers:

- Nursing and non-nursing qualifications;
- Post-registration wound care courses;
- Experience within the community setting;

Consequently, nurses recruited to the study were selected and divided into two groups based on their nursing qualifications, wound care courses studied and years of experience within the community setting. These elements were felt to be key factors in contributing to wound care knowledge and confidence.

In terms of qualifications, thirty nurses held a post-registration qualification in addition to their registered general nursing registration (RGN). By contrast, eight nurses had their nurse registration only. Therefore, as part of a randomised controlled trial to investigate the impact of providing expert advice through telemedicine on nurses' knowledge, the sample was divided into two equal groups. It was assumed that there was a difference in the level of knowledge between the two groups given the differences in observed qualifications.
In this case, a direct randomised sample could have led to an imbalanced grouping, therefore introducing bias. For example, it was possible that the eight nurses without further qualifications could be placed into the same experimental or control group so representation of both levels of qualification required stratification. This would ensure that appropriate numbers of elements were drawn from homogenous subsets of the population. Therefore, a stratified randomised control design was adopted. This ensured that nurses within both experimental and control groups had similar qualification levels, providing a balance between groups and minimising bias.

For a stratified random partitioning of the sample, 15 of the 30 nurses with further qualifications were drawn successively to make two equal groups. The same process was adopted for the remaining eight nurses to place them into two subsequent groups of four. At this stage, a coin was tossed to decide which group of four would be amalgamated with which group of 15 making two equally balanced groups of 19 nurses. The groups were then randomly selected to determine whether they were experimental or control (see figure 11).
Following the design, the other characteristics which could have an indirect impact on knowledge and confidence were also examined (see tables 10 and 11). As previously stated, post-registration wound care courses and years of experience within the community setting were factors potentially affecting the community nurses wound care knowledge and confidence.
Table 10. Distribution between experimental and control groups of nurses holding post-registration courses

<table>
<thead>
<tr>
<th></th>
<th>Experimental Group (n=19)</th>
<th>Control Group (n=19)</th>
</tr>
</thead>
<tbody>
<tr>
<td>POST-REGISTRATION WOUND CARE COURSES</td>
<td>6</td>
<td>7</td>
</tr>
<tr>
<td>NO POST REGISTRATION WOUND CARE COURSES</td>
<td>13</td>
<td>12</td>
</tr>
<tr>
<td>TOTAL</td>
<td>19</td>
<td>19</td>
</tr>
</tbody>
</table>

Table 11. Distribution between experimental and control groups of nurses years of experience in the community

<table>
<thead>
<tr>
<th></th>
<th>Experimental Group (n=19)</th>
<th>Control Group (n=19)</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt;5 YEARS EXPERIENCE IN COMMUNITY SETTING</td>
<td>1</td>
<td>3</td>
</tr>
<tr>
<td>&gt;5 YEARS EXPERIENCE IN COMMUNITY SETTING</td>
<td>17</td>
<td>15</td>
</tr>
<tr>
<td>YEARS EXPERIENCE IN COMMUNITY SETTING NOT KNOWN</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>TOTAL</td>
<td>19</td>
<td>19</td>
</tr>
</tbody>
</table>

The distribution of these characteristics was compared for the two new groups, experimental and control. A column of Chi-squared $p$ values for table 10 (0.78, 0.84) showed no significant difference for those who held post-registration wound courses compared to those who did not.
No significant difference was observed ($p=0.72$) for nurses with more than five years experience of working in the community setting (see table 11) compared to those who had less than five years experience. Observations for nurses with less than five years experience and for those nurses who did not indicate their length of experience working in the community are small for tests to be conducted but have reasonably comparable numbers.

The power calculation was based on community nurses' knowledge prior to the start of the experiment. Given that the commonly used university pass mark is 40% and these are trained nurses dealing with leg ulcers on a daily basis, it is anticipated that 90% of them will have a pass mark between 30% and 90%. Translating this into a normal distribution would give a mean ($\mu$) of 60% with an approximate standard deviation of 15. With this information and based on the given sample, a 20% improvement in nurses' knowledge of leg ulcer care can be verified with 83% power.
3.4 The Intervention

3.4.1 Nurse Training

As the clinical images were to be taken by community nurses, thorough training in the use of the cameras was essential. Nurses' experiences of using cameras were limited and none had previously used a digital camera. Following discussion with medical photographers and technical experts, the camera selected for this study was the Canon Powershot A50. In addition to possessing the beneficial features previously outlined (see chapter 2, section 2.4.2) the camera was chosen due to its high resolution and competitive price at the time of the experiment.

A comprehensive training manual was designed with advice from a wound care educationalist from a local wound healing research unit and a medical photographer from the media department of a local university hospital. Their input guided the researcher in the layout, content and technological aspects of the manual (see appendix XIV). The medical photographer also gave advice in obtaining good quality wound images, lighting, camera angle and camera distance to wound. The manual comprised eleven sections covering:

- Rules for standardising images;
- Taking, viewing and deleting images;
- Camera parts and functions;
- Using the flash card;
- Recharging the camera battery;
- Do's and dont's;
- Safety aspects.
The thoroughness of the instruction manual was an attempt to enable nurses to deal with basic camera problems on their own, removing the researcher’s participation in their role in the study. The commercial instruction manuals provided with the cameras covered in-depth and obscure information and advanced features unnecessary for the nurses’ purpose. For example, some functions such as deleting images could be performed in two ways, a standard procedure and a short cut. From previous experience of providing the nurses with literature and because of time restrictions it was unlikely that they would refer to detailed, complex instructions. Therefore, a manual was designed specifically for the nurses’ role. The researcher aimed to cover each section as concisely as possible and to avoid duplicating information, only standard methods for performing functions were covered. The manual was laid out in independent sections so the nurse could move on to the required section without having to read the entire manual. Contact telephone numbers for the researcher were also included in the manual. If nurses were interested in further details regarding the camera, a copy of the manufacturer’s handbook was made available.

The manual was piloted on a small group of nurse and non-nurse colleagues, (panel C), in a 30 minute training session to assess the appropriateness of the material. Two registered nurses and two non-nurses employed in a higher education establishment as research assistants comprised the panel. Both nurses were qualified to first degree level and one was registered for a doctorate whilst the other was nearing completion of their masters degree. Both non-nurses were nearing completion of their doctorate.
Each member of this pilot group was involved in several research projects and considered to be suitably qualified to provide an objective and informed opinion regarding the appropriateness of the manual. In one section, a description of a camera function was considered ambiguous. Therefore, it was reworded and an accompanying picture inserted to clarify the function. Following a further presentation to the pilot group, the manual was found to be clear and concise.

Given the earlier logistical problems of organising the half day training sessions for groups of community nurses in which nurses would work through the training manual with support from the researcher, arrangements were made to train individual nurses to use the digital cameras during short training sessions at the nurses clinic base immediately prior to data collection. Arrangements were made to train individual nurses to use the digital cameras. The timing of the training, immediately prior to visiting the patients, would be more beneficial in preventing nurses from forgetting how to use the camera as opposed to completing training several days beforehand. In this case only the necessary sections of the manual were covered: using the flash card, identifying camera parts and taking, viewing and deleting images. Technical training aimed to enable the nurse to use the camera independently. Although the researcher was present during each intervention episode, her role was as a non-participant observer. Only in the event of a camera malfunction would the researcher provide support but nurses were encouraged not to ask for assistance or rely on the researcher for image capture.
3.4.2 Project Equipment

The laptop computer used in this study was an RM GT7000 Pentium III with 64 MB. Images were downloaded from the digital camera to the laptop computer which was then transferred to the expert, approximately ninety five miles away at a district general hospital using an image editing software program Ulead PhotoImpact. However, images were not edited in any way other than resizing for printing.

A software program, Laplink® was used to transfer files directly from the researcher’s laptop computer to the expert’s computer via dial up networking communication using a modem. The program was installed on both computers prior to the start of data collection. This software was used to ensure security of image transfer avoiding any potential erroneous transfer via the internet and e-mail. Images were then processed in adherence to the eight principles of the Data Protection Act, 1984 (see appendix XV).

Three Canon PowerShot A50 cameras and 3 CompactFlash™ (CF) cards were used in this study. This camera was chosen because it combined key features previously discussed in the literature review (see chapter 2, section 2.4.2), had high resolution, was straightforward to use and competitively priced. Images were captured on a CF card, a piece of software in the form of a small square card that slots into an adapter which then fits into the side of the camera.
The benefits of digital photography have been previously discussed in detail (see chapter 2, section 2.4.2) but principle features included:

- Provision of an objective wound image;
- Photographic film or film processing were unnecessary;
- Images could be viewed immediately;
- Large numbers of images could be taken and stored on a CF card.

The camera manufacturers were contacted and an agreement set up that, in the event of camera malfunction, a replacement would be made available if necessary. A similar agreement was established for the laptop computer.

Pale green paper hand towels were considered a suitable, cost-effective background which would not detract from the wound being the focus of the image and would avoid specular reflection. Polarising filters were also necessary to reduce specular reflections (see appendix XVI). As the camera had a retractable zoom lens, it was not possible to purchase an attachable ready made filter. Therefore, one was made from cardboard tubing and a sheet of plastic polarising filter which was attached around the periphery of the camera’s lens. A piece of polarising filter was also attached over the camera’s flash. Further technological developments since the data collection phase of this study have now produced a filter for the camera. Prior to the intervention, practice images were taken from three distances: 5 inches (18cms), 10 inches (25.5cms) and 15 inches (38cms).
The closest distance, 5 inches, repeatedly produced the best results. In order to provide an approximate, simple, quick and straightforward rule for nurses to take images from the same distance, a length of string with a coloured mark at 5 inches was attached to the camera. The importance of avoiding cross-infection, through not allowing the string to touch the wound was emphasised. A paper ruler was placed at the bottom of the image for calibration. This allowed measurements to be standardised regardless of the distance they were taken from. To provide a constant light source for each image, all images were taken with the camera flash on. As images were taken at close distances the macro mode was used to prevent the picture becoming blurred. Whenever possible, images were taken at a perpendicular angle. In the patient’s home, curtains or blinds were drawn and any additional light sources avoided. Images were clearly identified with a unique numerical code to avoid confusing the images. This preparatory work was undertaken to achieve reliably comparable images taken in a standardised method and formulated seven simple rules for nurses to check when capturing images:

- All pictures are taken from the same pre-determined distances;
- All pictures are taken at the same angle;
- The lighting is the same for each picture;
- The background is the same for each picture;
- Each picture is clearly identified with a unique numerical code;
- The macro mode is set to on;
- A filter is placed on the camera lens and flash.
On the day of data collection, patients were given a further opportunity to discuss any concerns they had regarding the study. Signed consent forms were confirmed and spare forms were made available should the patient have misplaced them.

Patients were positioned as comfortably as possible with the affected limb held at 90° allowing images to be taken at a perpendicular angle. In some cases, this angle was not obtainable and an alternative position was necessary. These cases included: patient morbidity, such as contracted limbs due to rheumatoid arthritis, ulceration located on the posterior aspect of the limb and extensive ulceration surrounding the entire limb. These positions needed to be replicated at post intervention and were carefully documented with simple diagrams by the researcher. After completing the preparatory checklist for taking images, the nurse took a test picture to ensure that patient positioning and lighting were satisfactory. In six cases or approximately 16%, patient positioning had to be corrected.

In the experimental group, nurses completed a pre-printed proforma assisting nurses in outlining relevant and specific information for the wound expert (see appendix XVII) which included:

- Patient medication;
- Results of Doppler readings;
- Any relevant hospital or community tests.
3.4.3 The Consultation

Nurses in the experimental group received consultation providing expert wound care advice from an experienced CNS for their patient's leg ulcer. The CNS had over 20 years experience of wound care, had published extensively in nursing journals, had run several projects of a similar nature and had also recently been awarded a PhD for their work in wound care.

The consultation took the form of a telephone discussion where the community nurse presented a brief history of the patient, previous wound care treatments, relevant wound factors and any specific problems with wound management, enabling the expert to probe for further details where necessary. The duration of consultations varied due to many factors including: the complexity of the wound, the level of nurses' knowledge, confidence and experience, the type of treatment advice given, and ranged between approximately 5 and 30 minutes.

The expert had previously received a digital image of the wound. On the basis of reviewing the image together with the nurse's information, the expert could then provide appropriate treatment advice. Throughout the intervention, nurses could contact the expert for advice regarding their patients' wound care. In the control group, nurses continued to provide their usual protocol of wound care treatment. In both groups, patients were seen in their own home by their designated community nurse.
Patients in the experimental and control groups had their ulcer photographed by the researcher at the beginning and end of the intervention lasting 12 weeks. In each case, two identical digital images of the same wound were produced. One was used by the researcher and one by the nurses. The researcher used the image to establish the size of the wound pre and post intervention using Tracer, a simple computer program (see chapter 2, section 2.6.1) and was separate from the nurses' assessment or treatment of patients' wounds. As images were taken by one individual, the researcher, this process of obtaining images and area measurement was standardised.

In addition to the researcher's image, nurses took images of their patient's in both experimental and control groups. These images were used to supplement nursing notes and in the case of the experimental group, assist in their assessment and management of the ulcer with support from a remote expert. Expert advice was provided using a "store-and-forward" consultation. In this method, the image is downloaded and advice provided at a later time. "Real-time" consultation was also considered, where images are transferred directly and the expert provides immediate advice. However, it was not implemented as leg ulceration is a chronic condition, and did not warrant the necessary immediate advice of an acute condition.

Nurses completed a pro-forma outlining basic information as previously discussed, which accompanied the digital image sent to the expert. This information and the images were then viewed on the expert's computer. For the purposes of this study, advice was received within forty-eight hours.
Nurses received feedback and treatment advice at a pre-arranged time directly from the expert by telephone to their clinic base and also received a written report detailing the consultation.
3.5 Measurement Tools

Knowledge was measured using a self-assessment test in questionnaire format and confidence through an attitude scale. Subjects completed the wound knowledge test and confidence scale both before and after the intervention to evaluate any change in their knowledge and confidence as a result of the intervention and to examine the effect they had on the state of the wound.

3.5.1 Measuring Knowledge

A self-assessment multiple choice test designed and used by a specialist wound healing research unit (WHRU) in Cardiff was adapted for this project. Although validity and reliability had not previously been established for this tool face validity was confirmed through a pilot group. The original questionnaire was revised several times. For example, it consisted of 80 questions which would have been too lengthy for nurses to complete and questions relating to some practices, such as staging of pressure ulcer severity, differed according to which tool was used. Questions were reviewed to ensure the wording was unambiguous, relevant, of an appropriate language level, concise and would not bias the respondents answer. In order to encourage a high level of response, an opt-out clause, such as ‘don’t know’, was not included in the multiple choice responses. A brief explanation instructing respondents to place a mark next to their chosen answer was included at the start of the questionnaire. Initially, photographs of chronic wounds were included for nurses to review. These images would have to be printed on high quality paper with superior colour standards for analysis. This increased costs but did not guarantee a high response rate. Therefore, they were not included and questions were structured accordingly in the absence of images.
The test was piloted on 10 registered nurse colleagues and three non-nurse colleagues for face validity, (panel D). All participants were employed by higher education establishments and involved in other research projects. All nurses had been registered for a minimum of six years and were qualified to at least, first degree level. Four were highly experienced in wound care and regularly taught pre and post-registration nursing students and the remaining six had an interest in this area. Whilst non-nurses may be unable to answer medically orientated questions, they were able to bring expertise from other domains, also providing a valuable viewpoint on structure, layout and grammatical correctness.

All pilot respondents were in agreement that the test was relevant to wound care. One question was found to be unclear by several pilot respondents, which was subsequently reworded and rechecked for clarity with all pilot respondents. In addition, low scores reflected difficulties found in the test, specifically with regard to aetiological/physiological questions. If the test had been determined as simple by nurses unfamiliar in this area, experienced community nurses would have had little scope for improvement post-test. The test comprised forty multiple-choice questions (see appendix XVIII). Table 12 provides example questions.
Table 12. Example questions from the wound knowledge tool

The use of a Doppler ultrasound is useful in the assessment of:
(a) pressure ulcers
(b) pilonidal sinus
(c) arterial disease
(d) weight control

Autolysis can be described as:
(a) the natural formation of new blood vessels
(b) the migration of epithelial cells to resurface a wound
(c) the natural degradation of devitalised tissue
(d) the automatic release of leukocytes into damaged tissue

The questions encompassed three broad themes: wound aetiology/physiology, wound dressings and wound management and was designed to cover the range of phenomena found in wound care (see table 13). Questions were further grouped into three other categories based on their level of difficulty: easy, medium and difficult (see table 14).

Table 13. Knowledge question and corresponding thematic category

<table>
<thead>
<tr>
<th>QUESTION</th>
<th>THEME</th>
</tr>
</thead>
<tbody>
<tr>
<td>Q4, Q14, Q27, Q32, Q36, Q38, Q39, Q40</td>
<td>WOUND DRESSING</td>
</tr>
<tr>
<td>Q1, Q2, Q3, Q6, Q8, Q12, Q13, Q17, Q18, Q20, Q21, Q23, Q25, Q26, Q29, Q33, Q35</td>
<td>WOUND MANAGEMENT</td>
</tr>
<tr>
<td>Q5, Q7, Q9, Q10, Q11, Q15, Q16, Q19, Q22, Q24, Q28, Q30, Q31, Q34, Q37</td>
<td>PHYSIOLOGY</td>
</tr>
<tr>
<td>QUESTION</td>
<td>LEVEL OF DIFFICULTY</td>
</tr>
<tr>
<td>---------------------</td>
<td>---------------------</td>
</tr>
<tr>
<td>Q1, Q5, Q6, Q8, Q12, Q15, Q18, Q20, Q24, Q26, Q39</td>
<td>EASY</td>
</tr>
<tr>
<td>Q2, Q3, Q4, Q7, Q10, Q11, Q13, Q19, Q21, Q23, Q27, Q29, Q31, Q33, Q35, Q36, Q38, Q40</td>
<td>MEDIUM</td>
</tr>
<tr>
<td>Q9, Q14, Q16, Q17, Q22, Q25, Q28, Q30, Q32, Q34, Q37</td>
<td>DIFFICULT</td>
</tr>
</tbody>
</table>

For marking purposes, in addition to an overall average mark presented within thematic grouping, for both of the experimental and control groups pre and post intervention, a weighted average of marks was established in order to reconcile the level of difficulty with the obtained responses. Medium level questions were counted as double the difficulty of easy questions whilst the difficult questions were counted as triple the difficulty of the easy questions, thus establishing a weighting of 1/6, 2/6 and 3/6 for the easy, medium and difficult levels respectively. Questions were determined as easy, medium and difficult by an expert nurse. Nurses' responses pre-intervention were also taken into consideration.

For example, all nurses answered Q1 correctly pre and post intervention which was categorised as easy, half of the nurses answered Q3 correctly pre and post intervention which was categorised as medium, and Q22 was answered correctly by less than a quarter of nurses pre intervention and even fewer post intervention which was categorised as difficult. Classification based on the content of the questions matched up closely with the classification achieved based on nurse responses.
In order to determine which themes (aetiology/physiology, dressings and management) improved or deteriorated, which could have implications for future practice, it was necessary to identify them within the test. Questions were randomly placed throughout the questionnaire so that questions with the same themes were not all together. Respondents could not be influenced on their choice of response for a question from the previous response.

At the end of the questionnaire and as part of the pre-test questionnaire, nurses were asked about their qualifications, wound care courses undertaken, length of time since qualifying, length of experience in the community and age. In the post-test nurses were asked for details of any additional qualifications or wound care courses gained since completion of the first questionnaire. No further training was observed to cause bias within the agreed stratification.

Following completion of both pre and post knowledge questionnaires, all nurses were sent a copy of the questionnaire with the correct responses marked, a copy of a recent effective health care bulletin concerning venous leg ulceration (NHS CRD 1997) and an open invitation to discuss any issues with the researcher. One nurse requested further information on a specific wound care product and another requested information on handheld Dopplers, which was sent. No formal requests were made for questionnaire scores although some nurses had expressed an interest in previous meetings.
3.5.2 Measuring Confidence

A Likert type scale was developed and implemented to determine individual nurse’s level of confidence in their wound care practice pre and post intervention (see appendix XIX). The scale was used in order to produce a meaningful single number that described the individual nurse’s confidence towards their wound care practice. This scale was chosen because it compared expert judges’ opinions with that of community nurses. This comparison provided a meaningful numerical score reflecting individual nurses’ confidence, was quick and simple to complete and provided respondents with confidentiality and anonymity.

The Likert type scale has integrated a wide range of anchor points. Examples of its diversity range from 4 points (Froelicher et al. 2002, Glacken 2002) to 10 (Blaivas et al. 2002, Reischman & Yarandi 2002). For example, a scale may ask for a dichotomous response to a series of questions such as yes/no or agree/disagree, whilst a scale focusing on peoples’ attitudes towards their perception of personal health may have a set of statements with a range of responses such as strongly agree, agree, disagree and strongly disagree (Douglas & Brown 2002) similar to the original five point Likert scale. In this scale, a seven-point item was used to capture the range of responses from extremely low confidence to extremely high confidence (see figure 12). The number and type of response format varies in scales and depends on the concept under examination (Polit & Hungler 1995). In practice, a scale with more options would require a larger sample and may be difficult for respondents to objectively decide on the most appropriate option. Alternatively, reducing options reduces choice and forces the respondent to chose a category which is inappropriate for their opinion.
In the construction of Likert type scales, Polit & Hungler (1995) advise against including neutral statements or statements that are so extreme that virtually all respondents would agree or disagree. However, for the purposes of this study, the range of attitudes from extreme low confidence to extreme high confidence including neutral were considered.

A total of 254 statements were generated that were meaningful to the concept of confidence in nursing wound care practice. Direct questioning of any desirable attribute relevant to nursing, such as confidence was likely to provoke a positive response. Therefore, questions such as ‘are you confident in leg ulcer management’ were avoided in favour of less obvious questioning. Statements were as exhaustive as possible to cover all the attributes of confidence. Furthermore, as the final scale would select the most appropriate statements from this group, it was necessary to generate as many statements as possible.

The rule for formulating these items was to generate statements describing attitudes which nurses may have towards their wound care practice. Approximately equal numbers of positive and negative statements were included to avoid biasing response. The statements were formulated through reviewing relevant literature, discussion, brainstorming sessions with experienced practitioners and personal experience.
The areas of wound care identified to reflect nurses' confidence levels included dressings, decision making in treatment choice, experience and use of new technologies. The statements were presented in a random order so as not to follow any pattern, theme or order of subject.

A pilot study was conducted to review the 254 statements generated under strict exclusion criteria. Five registered nurse tutors with substantial clinical experience formed the pilot group, (panel E). Teaching fields were varied, but included backgrounds of sociology, psychology and research methods. Statements were discarded if they were:

- Vague;
- Indistinct;
- Unduly long;
- Ambiguous;
- Difficult to understand;
- Irrelevant to determining confidence levels;
- Duplicated with other statements.

The pilot group edited the remaining statements keeping them short and succinct, worded similarly and not differing in grammar or structure. For example, each item was a statement and not a question. Each item also had to be worded in a way that would lead to only two mutually exclusive responses, agree or disagree. Subsequently, 126 statements were identified by the pilot group.
In order to verify the pilot group's findings, a panel of three experienced health care researchers reviewed the statements, (panel A). Two researchers were post-doctoral fellows and well qualified in supervising health care research studies, one having also developed an attitudinal scale for their own doctoral thesis. Both researchers had provided expert guidance for several large scale studies which encompassed elements of wound care. The third researcher was a nurse consultant with over 20 years experience in wound care and nurse education at both bachelor and masters degree level. In addition, this researcher had also recently submitted her own doctoral thesis, in which nurses' attitudes toward wound care were part of the focus. The panel rejected a further 29 statements under the inclusion criteria. The panel then categorised each of the 97 remaining statements into seven groups according to the degree of negative or positive confidence they reflected. Only the two end points and the mid-point were anchored with word descriptions. It was perceived that statements within each rating category represented similar levels of nursing confidence.

The 97 statements were sent to expert judges to be categorised under the same criteria, for confirmation. The 13 judges were registered nurses experienced in wound care (panel F). These nurses were identified as suitable as each nurse was considered skilled and experienced in wound care by an experienced educational director of a local wound healing research unit. All nurses carried their own caseload for which they were responsible for making daily decisions regarding treatment. A comparison was made between the judges' grouping (panel F) and that of the panels' (panel A).
Grouping was achieved by rating statements from extremely low confidence to extremely high confidence, using ‘mode’ as a measure of central tendency calculated from the frequency of responses obtained. Apart from some minor variability, consensus was reached confirming a high degree of consistency (see table 15).

Table 15. Grouping of statements according to representative degree of confidence and examples of statements

<table>
<thead>
<tr>
<th>Groups</th>
<th>Level of Confidence</th>
<th>Example of Statement</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Extremely Low</td>
<td>“I am afraid of using new technology”</td>
</tr>
<tr>
<td>2</td>
<td>Fairly Low</td>
<td>“If an ulcer heals with a specific dressing I will use that on all ulcer patients”</td>
</tr>
<tr>
<td>3</td>
<td>Mildly Low</td>
<td>“All venous ulcers should be referred to a vascular surgeon”</td>
</tr>
<tr>
<td>4</td>
<td>Neutral</td>
<td>“I would bathe a leg ulcer in tap water rather than an antiseptic”</td>
</tr>
<tr>
<td>5</td>
<td>Mildly High</td>
<td>“I rarely consult the GP when selecting treatment”</td>
</tr>
<tr>
<td>6</td>
<td>Fairly High</td>
<td>“I think I would be good at teaching leg ulcer care”</td>
</tr>
<tr>
<td>7</td>
<td>Extremely High</td>
<td>“I think nurses can provide just as good leg ulcer care as doctors”</td>
</tr>
</tbody>
</table>

Careful consideration was given to the choice of statements for inclusion in the final scale. Representative statements were taken from each group as it would have been impractical for nurses to respond to all 97 statements. Representative statements were selected based on relevance to the areas of wound care reflecting nurses’ confidence levels. Equal numbers of positive and negative statements were included to avoid biasing nurse response.
Those statements that were placed into the mid-point group four, were regarded as unrepresentative of either positive or negative nursing confidence and therefore discarded. Inclusion of those statements would force respondents to agree or disagree with a statement that was considered to be neutral, introducing bias and therefore no representative statements from this group were included in the final scale. The final distribution and actual statements used in each group are presented in the following table 16.
### Table 16. Ten statements used in the attitudinal scale

<table>
<thead>
<tr>
<th>Negative Confidence Levels</th>
<th>Positive Confidence Levels</th>
</tr>
</thead>
<tbody>
<tr>
<td>Extremely Low Confidence</td>
<td>Mildly High Confidence</td>
</tr>
<tr>
<td>Fairly Low Confidence</td>
<td>Fairly High Confidence</td>
</tr>
<tr>
<td>Mildly Low Confidence</td>
<td>Extremely High Confidence</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Statement</th>
<th>Confidence Level</th>
</tr>
</thead>
<tbody>
<tr>
<td>A leg ulcer will never heal no matter treatment I give.</td>
<td>1</td>
</tr>
<tr>
<td>The GP always decides on my patients leg ulcer treatment.</td>
<td>2</td>
</tr>
<tr>
<td>Telemedicine is too complex to be relevant in wound care.</td>
<td>2</td>
</tr>
<tr>
<td>My patients leg ulcers are slow to heal because I am short-staffed.</td>
<td>2</td>
</tr>
<tr>
<td>If a colleague disagrees with my treatment choice I will change it straightaway.</td>
<td>2</td>
</tr>
<tr>
<td>I always refer patients to the leg ulcer clinic when necessary.</td>
<td>1</td>
</tr>
<tr>
<td>I think community nurses are competent in carrying out leg ulcer care.</td>
<td></td>
</tr>
<tr>
<td>I will sometimes question a colleagues treatment rationale if I can improve on it.</td>
<td></td>
</tr>
<tr>
<td>My confidence in dealing with wounds has improved since I was first registered.</td>
<td></td>
</tr>
<tr>
<td>I would need to be fully informed about a wound before making a treatment decision.</td>
<td></td>
</tr>
</tbody>
</table>

TOTAL: 5 NEGATIVE STATEMENTS  
TOTAL: 5 POSITIVE STATEMENTS  

The scale was then administered to each nurse pre and post-intervention. Nurses were asked to simply tick if they agreed with each of the 10 statements. A file of responses indicating either 0 (disagrees) or 1 (agrees) was created in SPSS for analysis.
CHAPTER THREE

Nurses received a score of 100 if they agreed with a positive statement or disagreed with a negative one. Conversely if they disagreed with a positive statement or agreed with a negative one, they were given 0.

In an attempt to reduce social desirability response set bias, where respondents misrepresent their attitudes by giving responses they feel consistent with general social views, statements were both positively and negatively worded and anonymity and confidentiality reassured. Acquiescence response set bias, in which respondents either agree or disagree with all statements regardless of their content (Polit & Hungler 1995), was considered highly unlikely amongst the community nurses, as statements were reflective of their practice.

As knowledge, confidence and wound states pre and post-intervention are continuous variables represented by average figures, the use of parametric t-test was appropriate. Normality was established through normal probability plots for all average marks and no anomalies were found (see appendix XX for examples of relevant Q-Q plots). The t test is able to identify significant differences between the population means using the calculated sample means and standard deviation and the assumed established distribution of the measure of location (Clegg 1990).

The chi square test was also used to examine the association between thematic distribution of knowledge questions and levels of difficulty (see chapter 4, section 4.3.1). Figure 13 outlines the stages in the development of the scale.
Regression can be expressed as the quantitative formula that intends to express a variable usually called 'dependent' in terms of a set of 'independent' or 'explanatory' variables. As both knowledge and confidence scores are known, linear regression was relevant and used to predict their relationship with the state of the wound.
CHAPTER THREE

METHODS

254 STATEMENTS GENERATED

PILOT STUDY REVIEW
STATEMENTS USING STRICT
INCLUSION CRITERIA
126 DISCARDED

PANEL RATE 97
STATEMENTS INTO 7
GROUPS BASED ON
REPRESENTATION OF
DEGREE OF
CONFIDENCE

97 STATEMENTS SENT TO 13
JUDGES FOR RATING

JUDGES RATING
COMPAED
WITH PANELS

REPRESENTATIVE
STATEMENTS
SELECTED
NEUTRAL
STATEMENTS
DISCARDED

10
STATEMENTS
CHosen

PANEL CONFIRM PILOT
GROUPS RECOMMENDATIONS
FURTHER 29
STATEMENTS REJECTED

Figure 13. Diagrammatic representation of development of scale
3.5.3 Visual Wound Assessment Tool

The misrepresentation that can arise from the evaluation of wound status based on single factors, such as wound area, has been previously discussed (see chapter 2, section 2.6.2). A simple tool to communicate progression of the wound by a numerical value yet accommodating the complexity of relevant factors would be a desirable wound management asset.

In this study, a venous leg ulcer measurement tool incorporating the combination of a range of important wound assessment factors was devised based on the measured intensity of different visual wound factors. In addition to wound factors, relevant patient factors were also included in the tool. These included: age, gender, mobility, obesity, duration, previous ulceration, size and co-existing illnesses. Each factor could have implications for treatment and healing potential and were considered in combination with wound factors. The classification for mobility used by Baker et al. (1991) (see chapter 2, section 2.2.3) was simplified for ease of use in this study: Grade 0: poor mobility (chairbound or very limited mobility), Grade 1: ambulant (mobile with aids), Grade 2: mobile (unrestricted mobility). Patients in this study were defined as obese according to their BMI (see chapter 2, section 2.2.3). With regard to area measurement, ulcers <10cm² were classified as small and those >10cm² large (Nelzen et al. 1994, Dorman et al. 1995) (see chapter 2, section 2.2.3).

To enhance a reliable reflection of wound progress, the tool was designed for venous leg ulcers in primary care but possessed the potential to be adapted for use with other wound types, such as pressure ulcers and other care settings, such as hospitals and nursing homes.
In the design of the assessment tool, wound factors were rated using a horizontal VAS (visual analogue scale) (see figure 14). The end anchors of the scale were labelled as the extreme limits of the factor being measured.

From reviewing the literature on existing wound assessment tools and discussion with experienced nurse colleagues, a large number of wound assessment factors ($n=108$) (see appendix XXI) were identified. Due to their combined expertise, the same expert panel (panel A) who verified the pilot groups findings in the development of the confidence scale were also used to initially determine wound factors that could be assessed visually, under the following strict exclusion criteria.
CHAPTER THREE

Factors were discarded if they:

- Could not be assessed visually;
- Were irrelevant to venous leg ulcers;
- Were duplicated.

Using this method, additional tools for other wounds could be designed by reviewing factors specific to the wound type.

Twenty visual wound assessment factors were identified:

- Exuding;
- Oedematous;
- Inflamed;
- Undermining;
- Induration;
- Red;
- Yellow;
- Black;
- Green;
- Pink;
- Necrotic;
- Epithelialising;
- Granulating;
- Sloughy;
- Punched out;
- Sloping;
- Rolled;
- Scaly/flaky;
- Eczematous;
- Haemosiderin staining.
Thirty wound care experts, (panel G), including CNSs, tissue viability nurses and physicians, were invited to rank the 20 wound assessment factors from 1 (most important) to 20 (least important) in expressing the state of the wound. These experts were identified through reviewing the literature for good quality, peer reviewed publications which had addressed wound assessment and 24 experts responded.

In order to gain individual judge’s rankings on these factors, not relating to a specific wound, a digital wound image was not included. Two judges marked the factors incorrectly and these responses were excluded. Four judges commented that they had found this a difficult task as they regarded all the factors as important. Judges were also instructed to include any additional factors they felt necessary and highlighted any irrelevant factors.

One judge felt that the history and duration of the wound should be included. However, these were non-visual factors which would be covered at initial assessment and were not subsequently included in the scale. Several judges felt that undermining of the wound and induration would require further clinical assessment in addition to a visual assessment. Whilst some episodes of induration are clearly apparent, many could be mistaken for other dermatological conditions such as eczema and were therefore discarded. As the factors selected were initially considered to all be highly relevant and important indicators of the state of the wound, a consensus by the experts on their ranking was not expected.
Therefore, the aim was to ascertain if an unequal rather than an equal weighting of the selected factors would generate a more realistic representation of the state of the wound. The remaining 18 factors were combined with wound area to make eight new groups:

- Exuding;
- Oedematous;
- Inflamed;
- Colour of tissues in wound:
  - Red;
  - Yellow;
  - Black;
  - Green;
  - Pink;
- Tissue type in wound:
  - Necrotic;
  - Epithelialising;
  - Granulating;
  - Sloughy;
- Condition of ulcer edge:
  - Punched out;
  - Sloping;
  - Rolled;
- Condition of skin surrounding wound:
  - Scaly/flaky;
  - Eczematous;
  - Haemosiderin staining.

Initially, 228 digital images of venous leg ulcers were generated in this study. Assessing each wound image for all 18 factors would have produced 4104 (228 x 18) assessment factors in total. Ideally, the community nurse would perform the assessments. However, the magnitude of the task would have been impractical and time consuming and would be difficult for the nurse to complete in addition to his/her caseload. It was also unlikely that the nurse could maintain a constant level of concentration from start to finish, thus making assessment unreliable.
At this stage, rather than requesting the wound expert panel (panel A) that had determined the 20 tele-transmittable factors to estimate scores for individual wound factors, it was thought more realistic to provide the best possible range to represent the likely score for each factor. This range was then considered to form the 95% confidence interval for the corresponding wound parameter score.

Given that the:

\[
\text{upper band} = b \\
\text{lower band} = a
\]

assuming a normal distribution for the relevant score, the 95% confidence interval \((a, b)\) for the mean \(\mu\), will lead to the following equations:

\[
\mu + 1.96 \sigma = b \\
\mu - 1.96 \sigma = a
\]

Solving these two equations:

\[
\text{the mean } \mu = \frac{a + b}{2}
\]

and \(\sigma = \frac{b - a}{2 \times 1.96}\)

standard deviation

These two values, \(\mu\) and \(\sigma\), are used to simulate 100 values from a normal distribution with the given mean and standard deviation within SPSS. These values can be assumed as if they have been specified by nurses. In this study these responses are termed as virtual nurse responses (VNR).
The mean for the completed 18 factors and area measurement were then combined to provide a numerical value for each factor. These numerical values were averaged with the eight new groupings to provide an overall numerical score between 0 and 100 to represent the state of the wound both pre and post-intervention. Zero indicated a healed wound whilst 100 indicated the wound in its worst state.

In addition, the post index was subtracted from the pre index to provide an overall difference in the score for the state of the wound. Therefore, a positive value represented wound deterioration and a negative value, improvement. This virtual data was used to examine the validity of the developed tool and to measure the state of the wound.

Given that $f_i$ is the numerical mean of the $i^{th}$ factor, $i=1,\ldots,18$, the overall index ($I$) representing the state of the wound is expressed as:

$$I = \frac{1}{18} \sum f_i$$

From the above formula, possible values of the index, I will be between zero and 100.

In parallel to the VNR the tool was tested on actual community nurses as it was necessary to examine nurse responses. As it would have been impractical for nurses to respond to all 228 images and costly to reproduce high quality paper copies, in the second stage of the design of the visual assessment tool a CD was prepared with the same representative sample used by the expert panel.
3.5.4 ‘WoundView’®

‘WoundView’®, a computer program was developed to assess the status of wound images on a computer screen (see appendix XXII, see figure 15). The program was written in the C++ programming language using the Borland C++ Builder programming environment by a computer programmer. The program requirements were desktop or laptop computer with at least 600x800 pixel screen resolution in 16 bits per pixel or more, mouse, CD drive and floppy disc drive.

![Figure 15. ‘WoundView’® showing wound assessment factors](image)

1. The segmented red bars at the top of the screen indicate which picture it is being viewed. Once all the factors for a picture have been rated it will turn green.

2. The sliding scales allow the severity of a factor to be indicated (for each wound 0 [none] to 100 [maximum]).

3. It is NOT possible to move on to the next picture until ALL the factors have been rated for the one currently on display.

4. It is, however, possible to go back to the previous picture(s) to change ratings at any time. (Unless, of course, you are viewing the very first one...)

5. To rate a factor as zero (say, no oedema) you still have to move the slider and then return it to 0.

6. It is possible to interrupt the program at any point and save missing ratings to floppy disk. The data saved on disk will automatically restart the program at the point where you stopped. No pictures need to be re-rated.
The program and images were all located on a single CD ROM which started automatically when inserted into a computer and all rated images were recorded on a floppy disc. There were no installation or de-installation procedures, therefore providing a simple and rapid tool for nurses to use. After starting the exercise, the program randomly selected 30 images (15 pairs of pre and post image) from those stored on the CD (n=76). The clinician could then assess the range of 18 wound factors from 0 (best possible scenario) to 100 (worst scenario). For example, in assessing the amount of slough present in a wound, 0 would represent none, and 50 would represent half the wound being covered in sloughy tissue, whilst 100 would represent a wound completely covered.

‘WoundView’® was administered to a panel of 11 experienced wound care nurses from neighbouring trusts for judgement, (panel B). These nurses were identified by the educational director of Cardiff WHRU due to their experience in wound management and qualifications prior to the nurse completing the CD. The researcher visited each nurse at their clinic base to demonstrate, explain the task and provide simple written instructions. In addition, simple guidelines were also included as an information screen on the CD program that could be accessed at any time during image rating. For practical purposes, the program could be interrupted at any point during image rating, and existing data saved to floppy disc through selecting the ‘quit’ option. The program was designed to restart at the last rated factor so that no images required re-rating on continuation of the program. A dialogue box also prompted nurses if any image had not been completed.
Five main headings with sub-headings encompassing the 18 factors accompanied each image with a 10cm VAS rated from 0 to 100 in the form of a sliding scale to assess and grade each image. Nurses moved the scale to the appropriate point to assess each factor. If the nurse wanted to rate an image as 0, the scale still required moving away from the 0 point but was then returned. As each factor was rated, the corresponding red bullet point turned to green. In this way, it was not possible to miss factors. Unfortunately, one set of nurse response data was spoilt and therefore discarded. This was potentially due to the nurse removing the floppy disc before selecting the option to ‘quit’.

From the rating exercise, little consensus was achieved. Some image factors were rated at both extremes: 0 and 100, and few were consistently rated. Diversity is apparent in many aspects of wound care practice, including venous ulcer assessment (Bell 1997), wound cleansing (Watret & Armitage 2002) and grading pressure ulcers (Bethell 2003). This disparity suggests that further training is necessary irrespective of nurse experience. The two wound status results were compared and conclusions drawn based on their validity. In addition, the link between knowledge, confidence and the state of the wound index including demographic patient factors were examined using statistical tools; correlation and linear regression. However, in the regression analysis, care had to be taken not to include too many explanatory variables, especially patient demographics in order to avoid overparameterization which affects the reliability of the results.

The stages in the development of the tool are presented in figure 16.
CHAPTER THREE

METHODS

LITERATURE SEARCHED FOR WOUND ASSESSMENT TOOLS

REVIEW TOOLS
LIST ASSESSMENT FACTORS
DISCARD NON-VISUAL FACTORS
20 FACTORS ESTABLISHED

EXPERT JUDGES RANK FACTORS IN ORDER OF IMPORTANCE
TWO FACTORS DISCARDED
FACTORS SCORED ACCORDING TO IMPORTANCE

FACTORs SENT TO FURTHER EXPERT JUDGES FOR VISUAL ANALOGUE RATING IN IMAGES

MEAN FOR EACH FACTOR COMBINED WITH IMPORTANCE SCORE TO PROVIDE NUMERICAL VALUE FOR EACH FACTOR

RESULTS COMPARED CONCLUSIONS DRAWN

VIRTUAL DATA SET GENERATED

Figure 16. Diagrammatic representation of development of visual wound assessment tool
3.5.5 Establishing the link between Knowledge, Confidence and the State of the Wound

To establish the potential impact of the nurses’ levels of knowledge and confidence on the state of the wound, linear regression models were built. It was anticipated that nurses with higher knowledge and confidence levels would manage the wound more effectively, therefore the wound would improve more so and the corresponding wound index would be lower. In addition, it was possible that nurses in the control group had similar or higher levels of knowledge and confidence compared with those in the experimental group. Therefore, both scores for both experimental and control groups were combined to obtain a single sample. The larger combined sample also enabled more reliable the findings.

Using both nurses’ weighted and un-weighted knowledge scores based on level of question difficulty as the explanatory variable, two models were built pre and post-intervention and included nurses’ confidence scores and all available patient factors which were considered to play a role in wound status: age, gender, mobility, obesity, previous ulceration, diabetes and arthritis.

In an attempt to prevent over-parameterisation and increase reliability, a further set of pre and post-intervention models were also built excluding those factors whose signs remained inconsistent and illogical.
3.6 Consideration of Other Methods

Other methods to measure both knowledge and confidence were considered. These included face-to-face interviews, telephone interviews, focus groups and video conferencing.

(i) Interviews

Both face-to-face and telephone interviews possess similar advantages and disadvantages. Interviews provide an opportunity to build a rapport with subjects and may obtain more in-depth and relevant information not included in structured questionnaires (DePoy & Gitlin 1994). Subsequently, issues such as ambiguous questions can be clarified immediately. The addition of visual aids such as wound images could be implemented in this method and were considered. However, the cost of reproducing high quality colour images was a deciding factor in determining the design of the study. Furthermore, nurses may focus on the given image and respond specifically to that wound rather than relating to wounds in general. Interviews have the flexibility to explore unanticipated issues, but for the purpose of this study, structured questionnaires allowed the phenomenon in question to be adequately measured and was appropriate to obtain factual responses without needing to explore issues further.

Telephone interviews are relatively cheap to conduct and would allow the researcher to access a geographically wide area (Belson 1986, Thomas & Purdon 1994).
Telephone interviewing has the advantage of the researcher being able to use technology and enter responses directly into a computer, speeding up the transfer of data from interviewers’ records to a statistical package and analysis. However, this method does not allow respondents to study difficult questions or revise their given answers. Telephone interviews also needed to be conducted at a prescribed time. Unexpected circumstances, such as a patient falling, a colleague calling in sick or a patient’s dressing taking longer than usual may arise, disrupting the community nurse’s routine and preventing the nurse from being able to commit herself to the specified time of the interview.

It would have been difficult to inform nurses on how long the interview would take. The duration of the interview would have depended on the respondents’ ability to answer questions and could have been time consuming. A suitable environment in which to conduct the interviews was also a concern. Many of the nurses’ clinic bases are housed in small, shared rooms with a single telephone and it was unlikely that interviews could have been performed in an appropriate quiet and private manner. In addition, difficulty in completing wound knowledge questions may also have caused embarrassment in the presence of their colleagues. Telephone interviews were considered unsuitable for these reasons and could have also prevented patients from being able to contact the nurse during the interview.
A criticism of the interview in scientific research is that ‘the questioner takes the lead’ (Rice 1931). Data obtained from an interview are likely to represent the preconceived ideas of the interviewer as well as the attitudes of the interviewee. In order to prevent such biases, the interview must be conducted in a neutral manner and questions standardised with a common and clear meaning. Each question should be read exactly following the language set in the questionnaire with the same intonation and emphasis to avoid bias.

The interviewer must be familiar with the topic in order to deal with queries in a standardised way. Standardising questions would reduce the researcher’s role to a minimum, so variation in meaning between respondents would be entirely due to the respondents themselves and not the researcher. However, due to the volume of interviews to be performed, it was unlikely that the researcher could have delivered each set of questions in an identical manner.

Interviews were therefore not an appropriate method for this study given that they would be too time consuming. If an interview approach had been chosen, thirty-eight interviews would have needed to be conducted both pre and post intervention. However, from prior experience discussed earlier, problems encountered from attempting to organise a date and time convenient for nurses to attend the study day led the researcher to seek an alternative method.
Polit & Hungler (1997) state that complicated or detailed schedules are not well suited to telephone interviewing and Bechhofer & Paterson (2000) support the use of surveys for structured written questionnaires. Furthermore, Russell (1996) and Wilkes et al. (1996) found a questionnaire approach an effective technique to assess nurses' knowledge.

The wound knowledge questionnaire was intended to be completed in approximately 30 minutes but contained several complex questions for which some nurses may have required some time to think about the answers. It was also not known in which order nurses answered the questions. In addition to allowing nurses to complete questions in the order they wished, questionnaires offered respondents anonymity and confidentiality, as they were marked only by unique identification number. Immediately prior to visiting the patient to collect data, nurses completed the questionnaire and attitudinal scale at their clinic base whilst the researcher waited in another room. Nurses were provided with an envelope in which to place the completed questionnaire and attitudinal scale which were handed to the researcher. These envelopes were not opened until the researcher returned to the university. As a questionnaire was the chosen tool to measure knowledge, a second questionnaire to measure confidence would have been tedious for nurses to complete. Therefore, a quicker method involving an attitudinal scale was considered more appropriate.
(ii) Focus groups

The use of focus groups has become increasingly popular in nursing research and is an established research method within the social sciences (Merton 1987, Halloran & Grimes 1995, Winstanley et al. 2003).

Examples of utilisation of this method include focus groups as a method for evaluating quality of care (Quantock & Beynon 1997), in the assessment of the competency of midwife assessment (Worth-Butler et al. 1996) and teenage sexual health promotion (Thomas 1996). Kitzinger & Barbour (1999) define them as 'group discussions exploring a specific set of issues' using groups consisting of between five to eight participants (Robinson 1999).

Smaller numbers may inhibit an in-depth discussion due to the lack of input gained through a larger group whilst more than eight participants may produce too much discussion to be meaningful to the specific issue and could result in sub-group discussions within the main group (Krueger 1994, Kitzinger 1995). The interviews are often tape-recorded for transcription. The key feature of focus groups is the active interaction amongst an homogenous group (in this case community nurses) and the focus is the collective activity of discussing a particular topic. It is not necessary for the group to reach a consensus of opinion, the prime objective is to obtain accurate data on a limited range of specific issues (McHugh & Thoms 2001).
A particular advantage of this method is the way that group members can stimulate each other to explore reactions to a common theme, thus exploring the topic in detail and generating a wide variety of ideas. This can produce rich amounts of qualitative data in the respondent’s own words. However, generalisation of findings may be limited from focus groups, as samples are likely to be small and content generally specific (Jackson 1998). Group interaction provides a social environment and comments must be interpreted within that context.

Care is needed to avoid lifting comments out of context and out of sequence or coming to premature conclusions (Krueger 1994). Focus groups are quicker and less expensive to perform than individual interviews as several respondents are interviewed at once. However, they do not provide a suitable environment for testing or assessing either individual knowledge or confidence levels as they aim to provoke group responses.

Problems can arise if the topic is highly controversial as participants may not feel comfortable about sharing their views or if conflict arises in the group (Morgan 1988). Results can be biased by dominant or opinionated members, resulting in some members feeling unable to voice their own viewpoint (Curtis 2001) particularly in the presence of their team leader or manager. Members may feel obliged to express what they consider to be the ‘correct’ viewpoint. For example, in a discussion regarding ‘clean’ wound dressing technique versus ‘aseptic’ technique, members may feel that the former is a valid method of wound care but may express their support of the opposing view as this is the traditional method.
Individual confidentiality and anonymity cannot be maintained due to the nature of the method and this may impact on what members feel able to express. The researcher is less in control in this method compared to face-to-face interviewing and the technique may be used inappropriately (Jackson 1998). For example, as the focus group allows members to interact with each other, the group may influence the course of the discussion, resulting in deviation from the intended topic. In another example, Seals et al. (1995) found that unless instructed otherwise, group discussions emphasised negative experiences more so than positive ones.

The researcher must keep the group focussed on the topic which may be problematic with dominant members. This highlights the need for a skilled interviewer to guide the focus group interviews. The appropriate use of open ended questioning, techniques such as pauses and probes and knowing when and how to progress to a new topic were necessary skills of which the researcher had limited knowledge.

It would be advantageous to have two researchers managing the process, one facilitating the discussion whilst another making notes and tape-recording the event. The employment of another researcher for this exercise was beyond the financial and time constraints of this study. The focus group requires members to take time to liase at a designated place at a prescribed time to share their views with others. Due to the widely spread, semi-rural location of many practices, nurses' shift patterns and previous problems encountered from attempting to synchronise groups of nurses, a more appropriate method was sought.
(iii) **Video conferencing**

Video conferencing has the ability to reach a wide audience over large geographical distances (Regnard 2000). Technology allows ‘real time’ interactive videoconferencing where participants can engage in discussions. It has been used for many purposes including providing a link for children with cystic fibrosis and their families with other families (Sigmon & Grady 2002) delivering courses, such as HIV/AIDS education (Dinotshe Tlou 2001) and disseminating research activities (Montgomery *et al.* 2001).

At the author’s university base, video conferencing has been used successfully for seminars, lectures and individual interviews in locations such as Australia. Consideration was given to conducting a conference in each trust in an attempt to target the population in one session. However, it required a skilled operator to set up the equipment and neither trust had the personnel or the equipment available. Furthermore, attempting to measure individual knowledge and confidence in this way shared similar problems to that of focus groups interviews: potentially dominant members (Henderson 1995) and acquiescence of those less confident to the majority view (Carey & Smith 1994). In addition, the nature of this method has the added problems of organising large groups of nurses and lacks confidentiality.

Table 17 summarises the methods considered in this study.
Table 16. Factors involved in consideration of methods.

<table>
<thead>
<tr>
<th>FACTOR</th>
<th>STRUCTURED QUESTIONNAIRE</th>
<th>FACE-TO-FACE INTERVIEW</th>
<th>FOCUS GROUP INTERVIEW</th>
<th>TELEPHONE INTERVIEW</th>
<th>VIDEO CONFERENCING</th>
</tr>
</thead>
<tbody>
<tr>
<td>PROVIDES ANONYMITY</td>
<td>YES</td>
<td>YES</td>
<td>NO</td>
<td>YES</td>
<td>NO</td>
</tr>
<tr>
<td>PROVIDES CONFIDENTIALITY</td>
<td>YES</td>
<td>YES</td>
<td>NO</td>
<td>YES</td>
<td>NO</td>
</tr>
<tr>
<td>REDUCES INTERVIEWER ERROR</td>
<td>YES</td>
<td>NO</td>
<td>NO</td>
<td>NO</td>
<td>NO</td>
</tr>
<tr>
<td>CAN INCLUDE VISUAL AIDS, SUCH AS WOUND IMAGES</td>
<td>NO</td>
<td>YES</td>
<td>YES</td>
<td>NO</td>
<td>YES</td>
</tr>
<tr>
<td>INCREASES LIKELIHOOD OF RESPONDENT REPORTING OWN OPINIONS</td>
<td>YES</td>
<td>NO</td>
<td>NO</td>
<td>YES</td>
<td>NO</td>
</tr>
<tr>
<td>CONTROLS FOR DOMINANT MEMBERS</td>
<td>YES</td>
<td>YES</td>
<td>NO</td>
<td>YES</td>
<td>NO</td>
</tr>
<tr>
<td>CAN COVER GEOGRAPHICALLY LARGE AREA</td>
<td>YES</td>
<td>NO</td>
<td>NO</td>
<td>YES</td>
<td>YES</td>
</tr>
<tr>
<td>CAN ACCESS LARGE NUMBERS</td>
<td>YES</td>
<td>NO</td>
<td>NO</td>
<td>YES</td>
<td>YES</td>
</tr>
<tr>
<td>CHEAP TO PERFORM</td>
<td>YES</td>
<td>NO</td>
<td>YES</td>
<td>YES</td>
<td>NO</td>
</tr>
<tr>
<td>SIMPLE TO STATISTICALLY ANALYSE</td>
<td>YES</td>
<td>NO</td>
<td>NO</td>
<td>YES</td>
<td>NO</td>
</tr>
<tr>
<td>ALLOWS CLARIFICATION OF AMBIGUOUS CONCEPTS OR QUESTIONS</td>
<td>NO</td>
<td>YES</td>
<td>YES</td>
<td>YES</td>
<td>YES</td>
</tr>
<tr>
<td>SIMPLE TO CARRY OUT - DOES NOT REQUIRE SPECIALIST TECHNOLOGICAL SKILLS</td>
<td>YES</td>
<td>YES</td>
<td>YES</td>
<td>YES</td>
<td>NO</td>
</tr>
<tr>
<td>CAN BE COMPLETED AT RESPONDENTS PAGE</td>
<td>YES</td>
<td>NO</td>
<td>NO</td>
<td>NO</td>
<td>NO</td>
</tr>
<tr>
<td>DOES NOT REQUIRE PREDETERMINED VENUE OR TIME</td>
<td>YES</td>
<td>NO</td>
<td>NO</td>
<td>NO</td>
<td>NO</td>
</tr>
</tbody>
</table>
3.6.1 Researcher as Non-participant

Nurses completed the knowledge and confidence tools immediately prior to and post intervention and the visual assessment tool in their own time. During each intervention episode (telemedicine) the researcher was present. That presence was merely to provide the equipment and to collect the digital images in a non-participant observer role. Nurses were instructed not to ask for routine technical support or to seek advice regarding wound care. Whilst minimal interaction may minimise ‘observer effects’, it was considered that the presence of a non-interacting observer would be disruptive and cause anxiety for both the patient and the nurse.

Therefore, an attempt was made to put the patient and nurse at ease through a more ‘natural’ role, engaging in occasional conversation but adopting a detached ‘pure observer’ approach regarding any aspect of wound treatment (Robson 1993). Textbooks advising the researcher’s appearance as a way of maximising response, advocate dressing in a similar manner to that of the participating groups (Weisburg & Bowen 1977, Babbie 1990). Whilst this is a minor factor, it was important to reinforce a non-participant role. Although the researcher was known to the nurses in a research capacity, an attempt was made to underplay academic status, emphasising clinical experience and nurse status. However, adopting nursing uniform would have appeared false and may have encouraged nurses to ask for a colleague’s advice. Several nurses sought assurance in their choice of wound care in the pre-intervention episode and were subsequently reminded that advice was not within the researcher’s remit and could not be provided.
3.7 Summary of Methods

A randomised controlled trial was designed to test the following null hypotheses:

Hypothesis 1: *Expert tele-advice has no significant impact on nurses' knowledge and confidence levels in the care of leg ulcers.*

Hypothesis 2: *Nurses' knowledge and confidence levels do not play a significant role in the improvement of leg ulcers.*

Hypothesis 3: *No significant relation between the state of the wound, patient factors and nurses' knowledge and confidence levels for the care of the wound could be established.*

Thirty-eight community nurses from two areas and 38 leg ulcer patients in their care comprised the sample. Nurses were stratified into experimental and control groups based on their nursing qualifications. The intervention was the process of providing expert advice via telemedicine. Community nurses and the researcher took digital images of patients' leg ulcers prior to and after the intervention. In conjunction with brief patient and wound history, these images were used to provide the expert with objective information.

An established questionnaire encompassing important aspects of wound care practice was adapted to assess the community nurses’ levels of knowledge and a new attitudinal scale was designed to measure confidence pre and post-intervention. A new wound assessment tool, SWI, using tele-transmittable wound factors, was also designed to provide a single numerical value, the index, to represent the state of the wound. Wound area measurement was carried out via a simple computer program ‘Tracer’. The area measurement of three identical wound images was taken by the researcher and the mean area calculated. Tracer is a component of an already validated and commercially available tool.
Linear regression models were built in order to examine the relationship between the three central themes of the study: knowledge, confidence and the state of the wound.

In the following chapter, the results will be presented and discussed for each of the three themes and in combination to establish the link between them. Firstly, the relevant patient factors will be addressed. Following this the impact of tele-advice on knowledge and confidence on the nurses’ leg ulcer care will be examined individually and the findings from introducing the state of the wound index tool. Finally, the relationship between knowledge and confidence and their impact on the state of the wound will be explored.
Chapter Four Results

4.1 Introduction

This study aimed to investigate the impact of tele-advice on nurses' management of leg ulcers and consists of four main components of nurses’ knowledge and confidence, the state of the wound and relevant patient factors anticipated to be significant in measuring and assessing the process. This was examined by firstly investigating relevant patient factors followed by the impact of the provision of tele-advice on nurses’ knowledge and confidence and their subsequent influence on the care of leg ulcers. A self assessment test was adapted to measure nurses’ knowledge of leg ulcer care whilst a Likert type attitudinal scale determined individual nurse’s level of confidence in their wound care practice. The assessment of the state of the leg ulcer was performed using a newly developed tool based on factors reflecting the state of the wound and that are tele-transmittable.

A stratified randomised controlled trial was designed to measure community nurses’ knowledge and confidence pre and post provision of expert tele-advice for the experimental group. Thirty eight nurses and their corresponding 38 patients with venous leg ulcers comprised the sample.
4.2 Relevant Patient Factors

Patients were placed into experimental or control groups according to how the community nurse caring for their wound was grouped (see chapter three, section 3.3). As each patient in the study was cared for by a community nurse practising at the patient’s GP practice, it was neither practically feasible nor ethical to randomly allocate patients to nurses. Furthermore, the size of the sample and the practicalities mentioned earlier (see chapter 3, section 3.2) did not allow for the confounding patient variables and the diversity (for example, more female patients within the control group) to be accounted for in the analysis. Therefore, these possible in-homogeneities within the two groups could have influenced the findings. However, many relevant patients’ variables were comparable between experimental and control groups: age, mobility levels, obesity, ulcer area and duration and co-existing illnesses (diabetes/rheumatoid arthritis). The discrepancies between experimental and control groups for gender, patients experiencing their first ulcer and those experiencing severe concurrent illnesses, were small and therefore unlikely to have affected findings. It must be noted that the major focus of the study was on the impact of tele-advice on nurses’ knowledge and confidence and it was possible that the intervention may not exert a major effect on actual wound healing. However, as observed in the following section, overall, ulcers did decrease in area.

Table 18 displays key patient variables distributed between experimental and control groups, which may have attributed to wound healing potential.
Table 18. Distribution of patient variables for the experimental and control groups

<table>
<thead>
<tr>
<th>Patient variable</th>
<th>Experimental Group</th>
<th>Control Group</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age &lt;65 years</td>
<td>2</td>
<td>4</td>
</tr>
<tr>
<td>&gt;75 years</td>
<td>10</td>
<td>10</td>
</tr>
<tr>
<td>Gender M</td>
<td>9</td>
<td>6</td>
</tr>
<tr>
<td>F</td>
<td>10</td>
<td>13</td>
</tr>
<tr>
<td>Reduced level of mobility</td>
<td>11</td>
<td>9</td>
</tr>
<tr>
<td>Obesity</td>
<td>7</td>
<td>8</td>
</tr>
<tr>
<td>Very large ulcer at start of study &gt;50cm²</td>
<td>3</td>
<td>1</td>
</tr>
<tr>
<td>Small ulcer at start of study &lt;10cm²</td>
<td>12</td>
<td>12</td>
</tr>
<tr>
<td>First ulcer</td>
<td>3</td>
<td>6</td>
</tr>
<tr>
<td>Ulceration duration &lt;12 months</td>
<td>7</td>
<td>9</td>
</tr>
<tr>
<td>Diabetes/Rheumatoid arthritis</td>
<td>10</td>
<td>9</td>
</tr>
<tr>
<td>Significant co-existing illness e.g. malignant disease, Parkinsons</td>
<td>5</td>
<td>1</td>
</tr>
</tbody>
</table>

(i) Age

Patients' ages ranged between 41 and 92 years, with the median being 74 years. The experimental group had fewer younger patients (<65 years) than the control group, however, the modal age distribution was 75 years for both groups. As age has been indicated as a key factor in delayed healing (Nelzen et al. 1991, Ashcroft et al. 1998, 1999) and age correlates positively with ulcer occurrence (Walker et al. 2002) significant improvement in the state of the ulcers for the sample considered in this research would require more time.
(ii) **Gender**

In the experimental group, comparable numbers of male and female patients were observed, whilst there were more than twice as many females as males in the control group. Previous studies have suggested predominance towards females (Nelzen et al. 1992, Baker et al. 1992, Lindhom 1992) which may be explained by the longevity of women compared to men.

(iii) **Mobility**

Mobility was classified from a simplified adaptation of grades used by Baker et al. (1991) including patients with unrestricted mobility, those who were mobile with a walking aid and those who were chairbound (chapter 3 section 3.5.3). Twenty patients had impaired mobility, including equal number ($n=5$) of patients in both experimental and control groups who were chairbound. Similarly, obese patients were equally distributed between the two groups. There are conflicting reports regarding the implications of obesity on venous leg ulcer patients (Ducimetiere et al. 1998, Komsuoglu, et al. 1994).
(iv) **Size**

The asymmetry of Table 19 shows the distribution of overall pre and post-intervention ulcer area in cm². This is further demonstrated in a boxplot (see figure 17).

**Table 19.** *Range of pre and post-intervention ulcer area in cm²*

<table>
<thead>
<tr>
<th>Ulcer area cm²</th>
<th>Pre-intervention Frequency</th>
<th>Post-intervention Frequency</th>
</tr>
</thead>
<tbody>
<tr>
<td>0cm² - 10cm²</td>
<td>25</td>
<td>24</td>
</tr>
<tr>
<td>11cm² - 20cm²</td>
<td>4</td>
<td>4</td>
</tr>
<tr>
<td>21cm² - 40cm²</td>
<td>3</td>
<td>8</td>
</tr>
<tr>
<td>41cm² - 60cm²</td>
<td>3</td>
<td>1</td>
</tr>
<tr>
<td>61cm² - 80cm²</td>
<td>2</td>
<td>0</td>
</tr>
<tr>
<td>&gt;200cm²</td>
<td>1</td>
<td>1</td>
</tr>
</tbody>
</table>
There was a wide variation in pre-intervention ulcer area and ulcers ranged from 0.19cm² to 214.76cm² with a mean area of 19.69cm² and a median of 5.8 cm². However, as the frequency distribution is left skewed, the mode provides a more representative measure of location and meaningful information than the arithmetic mean or median (Fowler et al. 2002). The majority of ulcers \((n=25)\) were small, less than 10cm², at the start of the study and the pre-intervention mode was 0.56cm². Post-intervention, ulcers ranged from 0.07cm² to 228.91cm² and the mode was 0.32cm². This showed an improvement of 0.24cm² in the mode. Therefore, ulcers decreased by 25% post-intervention. The overall difference between pre and post-intervention ulcers are shown in figure 18.
For the experimental group, the difference between pre and post-intervention ulcer area ranged from -30.48 cm$^2$ to 14.24 cm$^2$ with a mean of -4.77 cm$^2$. The control group had a larger range -33.04 cm$^2$ to 39.44 cm$^2$ with a mean of -1.65 cm$^2$. As the post-intervention area is deducted from the pre-intervention area a negative difference denotes an improvement in area.

(v) Previous Ulceration

The majority of patients had previously experienced leg ulcers ($n=29$). Approximately 25% ($n=9$) of patients were experiencing their first leg ulcer, twice as many patients in the control group ($n=6$) as opposed to the experimental group ($n=3$).
These findings are slightly lower than those of Callam et al. (1987) who reported that two-thirds of patients had experienced more than one episode of ulceration. However, consideration must be given to the fact that this was a small sample.

(vi) Duration

In a study focusing on venous leg ulcers, it is not surprising that the ulcers were chronic. Figure 19 shows the overall ulcer duration in months.

![Figure 19. Overall duration of ulcer in months at start of study.](image)

Ulcers of similar duration would allow directly comparable results, as they would be at equivalent stages in the trajectory of the ulcer. However, due to sample limitations, this was not possible.
At commencement of the study, ulcer duration ranged from two months to 11 years (132 months). In three cases, the patient and the nurse were unsure about the age of the ulcer since it had become active, but indicated that it had been over 12 months. Over half of ulcers with known duration (58%, \( n=22 \)) had been present for more than 12 months and the majority had been established for a minimum of eight months. The overall mean of duration was 20 months. The ulcer with the longest duration, 132 months, was an outlier and results were skewed. Therefore, when it was excluded, the mean was 18 months, 19 months for the experimental group and 16 months for the control group. Results are right skewed, therefore the mode provides more meaningful information than the arithmetic mean or median, and is 10 months. With regard to ulcer area and duration, ulcers in the experimental group improved more than the control group although the overall mean for these patients' ulcers indicated that patients in this group had had their ulcers for longer.

(vii) Co-existing illness

Comparable number of patients in both experimental and control groups experienced either diabetes and/or rheumatoid arthritis, \( (n=10) \) and \( (n=9) \) respectively. Both disease processes affect the micro-vascular supply (Collier, 1996, Springett, 2000), potentially leaving these patients at increased risks of ulceration. More patients in the experimental group had serious co-existing illnesses \( (n=5) \) including malignant diseases (ovarian cancer, chronic lymphatic leukemia), Parkinson's disease and cardiac disease than the control group \( (n=1) \). As with diabetes and arthritis, the disease process may place these patients at greater risk of developing ulceration and with an increased susceptibility to infection.
In addition, medication such as steroids, may hinder the healing process (Wicke et al. 2000). However, numbers remained small and are therefore unlikely to have affected the results.
4.3 Impact of Tele-advice on Nurses' Knowledge of Leg Ulcer Care

4.3.1 Introduction

Nurses were stratified into experimental or control groups based on their nursing qualifications. Wound care courses undertaken and years of experience were also examined as these were felt to be important factors in the development of nurses' knowledge and confidence in wound care practice. This exercise ensured that nurses possessed similar relevant attributes and that the sampling was unbiased.

The knowledge questionnaire included three themes: wound dressings, management and physiology. The scores and marking were performed out of 100 and averaged to obtain an overall mark for each nurse. In addition, the questionnaire was also categorised by level of difficulty namely; easy, medium and difficult. The weighting strategy introduced in chapter 3 (section 3.5.1) was used to provide marks for nurse knowledge accounting for each question's level of difficulty.

To examine the independency of the thematic distribution of the questions with different levels of difficulty, a cross-tabulation and Chi-square test of independence was performed for the two groupings (see table 20). This also ensured that the knowledge questions were evenly distributed between the three themes and levels of difficulty.
Table 20. Distribution of question groupings

<table>
<thead>
<tr>
<th></th>
<th>Easy</th>
<th>Medium</th>
<th>Difficult</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dressing</td>
<td>1</td>
<td>5</td>
<td>2</td>
<td>8</td>
</tr>
<tr>
<td>Management</td>
<td>7</td>
<td>8</td>
<td>2</td>
<td>17</td>
</tr>
<tr>
<td>Physiology</td>
<td>3</td>
<td>5</td>
<td>7</td>
<td>15</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>11</strong></td>
<td><strong>18</strong></td>
<td><strong>11</strong></td>
<td><strong>40</strong></td>
</tr>
</tbody>
</table>

\[ \chi^2 \] \text{ (4) } = 6.68 \text{ } p = 0.154

The above table indicates that for the thematic distribution of questions, those relating to wound management had a larger number (n=17), while, with regard to level of difficulty, the question group with a medium level were the largest (n=18). In both cases, although this may be seen to be advantageous to the nurses’ practical role, the chi-squared test carried out, did not support any significant dependence between the two categories (p=0.154). This confirms that no clear imbalance exists between the distribution of different levels of difficulty and themes.

4.3.2 Number of Correct Nurse Responses to Knowledge Questions

The number of correct responses for experimental and control groups pre and post-intervention, categorised by theme and level of difficulty are shown in appendix XXIII. Unsurprisingly, the questions that nurses consistently responded correctly to both pre and post-intervention, related to five wound management questions of easy and medium difficulty (see table 21).
Table 21. Wound management questions answered correctly by all nurses pre and post-intervention

<table>
<thead>
<tr>
<th>QUESTION NUMBER</th>
<th>LEVEL OF DIFFICULTY</th>
</tr>
</thead>
<tbody>
<tr>
<td>Q1 'The use of a Doppler ultrasound is useful in the assessment of?'</td>
<td>EASY</td>
</tr>
<tr>
<td>Q2 'What percentage of leg ulcers are due to venous disease?'</td>
<td>MEDIUM</td>
</tr>
<tr>
<td>Q18 'Wound infection is not caused by'...</td>
<td>EASY</td>
</tr>
<tr>
<td>Q26 'Compression is a major factor in the successful management of which of the following types of leg ulcers?'</td>
<td>EASY</td>
</tr>
<tr>
<td>Q35 'The most important factor in healing of venous leg ulcers is'...</td>
<td>MEDIUM</td>
</tr>
</tbody>
</table>

The issues addressed in these questions were commonplace in the community nurses' daily practice and most likely to be covered in any wound care study day. Conversely, the question with the largest decrease in correct post-intervention responses: Q25 'What is the estimated cost of leg ulcer treatment to the NHS?' was a wound management question, categorised as difficult. This question reduced from 16 correct responses pre-intervention to 9 post-intervention.

Estimates of annual leg ulcer treatment vary (Shami et al. 1997, Dodds, 2002, O'Brien et al. 2002) and it is possible that nurses referred to old literature they had previously reviewed to respond to this question. For the remaining 10 of the 17 management questions, six improved by between one and six correct responses post-intervention and four decreased by one response, indicating that gaps existed in nurses' knowledge of this area.

Four questions had poor numbers of correct overall responses pre and post-intervention and less than 25% of those answered Q10, Q22 and Q25 correctly post-intervention (see table 22).
Table 22. Questions with overall fewest correct responses pre and post-intervention

<table>
<thead>
<tr>
<th>QUESTION NUMBER</th>
<th>THEME</th>
<th>LEVEL OF DIFFICULTY</th>
<th>OVERALL SCORE PRE</th>
<th>OVERALL SCORE POST</th>
</tr>
</thead>
<tbody>
<tr>
<td>Q10</td>
<td>WOUND PHYSIOLOGY</td>
<td>Medium</td>
<td>7</td>
<td>3</td>
</tr>
<tr>
<td>Q22</td>
<td>WOUND PHYSIOLOGY</td>
<td>Difficult</td>
<td>10</td>
<td>6</td>
</tr>
<tr>
<td>Q25</td>
<td>WOUND MANAGEMENT</td>
<td>Difficult</td>
<td>16</td>
<td>9</td>
</tr>
<tr>
<td>Q37</td>
<td>WOUND PHYSIOLOGY</td>
<td>Difficult</td>
<td>14</td>
<td>13</td>
</tr>
</tbody>
</table>

The implications of Q25 have already been discussed. Q10 asked 'Secondary healing of a cavity wound requires mainly the process of... ', Q22 'Platelets and macrophages release important growth factors including...' and Q37 'Monocytes are attracted to the wound site by chemical signals given off by bacteria. This process is known as... '. Unsurprisingly, these questions are related to wound physiology, two being categorised as difficult. This would indicate that nurses' knowledge of wound physiology was poor.

Studies have reported nurses' difficulty in applying physiology to wound healing (Emmott, 1992, Bell, 1994) and the inclusion of biological science in pre-registration nursing courses has reportedly been poor for over a decade (Akinsanya, 1987, Leonard & Jowett, 1990, Courtenay, 1991). Findings suggest that this area still needs to be addressed in current pre-registration nurse training. However, Q7 and Q19, both physiology questions of medium difficulty, had the first and third largest increases in correct responses post-intervention, from 6 correct responses to 15 for Q7 and 15 to 22 correct responses for Q19.
This may have potentially been due to nurses having a particular interest in obtaining the correct answers for these questions, leading them to refer to the literature. Despite a large increase, correct post-intervention responses were poor, with less than 40% \((n=15)\) of nurses correctly answering Q7 and just over half, 58% \((n=22)\), correctly answering Q19. For the wound dressing theme of the questionnaire, equal numbers of questions increased as well as decreased (see table 23).

<table>
<thead>
<tr>
<th>QUESTION NUMBER</th>
<th>LEVEL OF DIFFICULTY</th>
<th>OVERALL NO OF CORRECT RESPONSES PRE</th>
<th>OVERALL NO OF CORRECT RESPONSES POST</th>
</tr>
</thead>
<tbody>
<tr>
<td>Q4</td>
<td>MEDIUM</td>
<td>32</td>
<td>36</td>
</tr>
<tr>
<td>Q14</td>
<td>DIFFICULT</td>
<td>12</td>
<td>18</td>
</tr>
<tr>
<td>Q27</td>
<td>MEDIUM</td>
<td>22</td>
<td>30</td>
</tr>
<tr>
<td>Q32</td>
<td>DIFFICULT</td>
<td>34</td>
<td>36</td>
</tr>
<tr>
<td>Q36</td>
<td>MEDIUM</td>
<td>37</td>
<td>36</td>
</tr>
<tr>
<td>Q38</td>
<td>MEDIUM</td>
<td>37</td>
<td>36</td>
</tr>
<tr>
<td>Q39</td>
<td>EASY</td>
<td>38</td>
<td>37</td>
</tr>
<tr>
<td>Q40</td>
<td>MEDIUM</td>
<td>34</td>
<td>31</td>
</tr>
</tbody>
</table>

Nurses improved in the number of correct responses for the three questions categorised as difficult and also for Q27 ‘What would be the preferred dressing choice for an infected, heavily exuding leg ulcer?’, which had the second largest increase in overall correct responses post-intervention, from 22 to 30 responses.
Q36, Q38 and Q39 decreased by one and Q40 by three overall correct post-intervention responses. It has been reported that nurses may obtain their wound care knowledge through pharmaceutical representatives (Brereton et al. 1998, Hickie et al. 1998, Hallet et al. 2000) and from peers (Boxer & Maynard, 1999), both of which may be biased towards their own products or prior successful experiences with specific dressings. This may explain the variation in nurses' knowledge of wound dressings found in this study.

The mean number of overall correct responses post-intervention were the same for wound management and dressing questions, 32.5, whilst unsurprisingly that of physiology was lower, 22, indicating a deficit in nurses' knowledge of physiology compared to that of wound management and dressings.

4.3.3 Nurse Responses Relating to Knowledge Question Theme

The following table, table 24, examines the significance of differences between levels of knowledge prior to the start of the intervention between the two groups of experimental and control using independent t-tests. The test confirms that no significant difference could be established either for any of the themes or for the overall marks. These results support the randomised controlled trial's initial consideration that both the control and experimental groups were at a comparable level of knowledge prior to the intervention.
Table 24. Independent t-test showing significance of differences between knowledge themes for experimental and control groups prior to the intervention

<table>
<thead>
<tr>
<th>Levene’s Test for Equality of Variance</th>
<th>t-test for Equality of Means</th>
<th>95% Confidence Interval of the Difference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Equal variances assumed</td>
<td>Equal variances not assumed</td>
<td></td>
</tr>
<tr>
<td>Pre knowledge wound dressing marks</td>
<td>.903</td>
<td>.348</td>
</tr>
<tr>
<td>Pre knowledge physiology marks</td>
<td>.070</td>
<td>.792</td>
</tr>
<tr>
<td>Pre knowledge wound management marks</td>
<td>.455</td>
<td>.504</td>
</tr>
<tr>
<td>Pre knowledge themes total marks</td>
<td>.116</td>
<td>.736</td>
</tr>
</tbody>
</table>

Although all the mean differences were positive, none of the t-values were close to any of the 95% confidence limits. Furthermore, the smallest p-value was 0.37 which indicated a significance level of only 63%.

Summary statistics for the scores for each of the themes including an overall mark pre and post-intervention for experimental and control groups, together with their corresponding standard deviations, are presented in table 25.

Table 25. Mean and standard deviations for marks pre and post-intervention

<table>
<thead>
<tr>
<th>Marks (%)</th>
<th>Prior to Intervention</th>
<th>Post Intervention</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Dress</td>
<td>Man</td>
</tr>
<tr>
<td>Experimental</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mean</td>
<td>79.6</td>
<td>83.59</td>
</tr>
<tr>
<td>Std. Dev.</td>
<td>2.38</td>
<td>1.93</td>
</tr>
<tr>
<td>Control</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mean</td>
<td>82.23</td>
<td>84.83</td>
</tr>
<tr>
<td>Std. Dev.</td>
<td>2.91</td>
<td>2.17</td>
</tr>
</tbody>
</table>
In addition to an increase in each theme and overall average mark for the experimental group, the corresponding standard error for the average mark decreased, apart from that of wound management which increased minimally, indicating narrower distributions around post intervention average marks. The largest decrease, in standard error of 1.27, was seen for questions relating to physiology. In the control group, the only improvement observed for average marks was for wound dressings, but as with the other themes and overall average mark, the standard error increased making the improvement less reliable.

The increase in all the average post-intervention marks for the experimental group indicated an improvement in the general level of knowledge of 4.84% (see table 26).

<table>
<thead>
<tr>
<th>Pre-Post average marks (%)</th>
<th>Mean</th>
<th>Std. Deviation</th>
<th>Std. Err Mean</th>
<th>95% Confidence Interval of the Difference</th>
<th>t</th>
<th>Sig. (2-tailed)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Experimental</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Management</td>
<td>-3.7168</td>
<td>7.8977</td>
<td>1.8119</td>
<td>-7.5234 – 0.089</td>
<td>-2.051</td>
<td>.055</td>
</tr>
<tr>
<td>All</td>
<td>-4.8368</td>
<td>8.3780</td>
<td>1.9220</td>
<td>-8.8749 – -7.988</td>
<td>-2.517</td>
<td>.022</td>
</tr>
<tr>
<td><strong>Control</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dressing</td>
<td>-0.6579</td>
<td>14.1137</td>
<td>3.2379</td>
<td>-7.46 – 6.14</td>
<td>-2.03</td>
<td>.041</td>
</tr>
<tr>
<td>Management</td>
<td>0.6189</td>
<td>11.5831</td>
<td>2.6574</td>
<td>-4.96 – 6.20</td>
<td>-2.33</td>
<td>.188</td>
</tr>
<tr>
<td>Physiology</td>
<td>0.7026</td>
<td>12.5496</td>
<td>2.8791</td>
<td>-5.34 – 6.75</td>
<td>-2.44</td>
<td>.210</td>
</tr>
<tr>
<td>All</td>
<td>0.2200</td>
<td>6.5690</td>
<td>1.5070</td>
<td>-2.94 – 3.38</td>
<td>-1.46</td>
<td>.146</td>
</tr>
</tbody>
</table>

The largest of these increases was seen in the wound dressing category by 6.58%, followed by 4.21% for physiology and 3.72% with respect to wound management.
However, for the control group, the overall average mark declined post intervention by 0.22%, as well as those for wound management, 0.61% and physiology, 0.7% (see table 26). These changes have been statistically validated using paired t-tests (see table 26). The improvement of 4.8% in the overall average mark for the experimental group is significant with a p-value of 0.022 (see table 26). Furthermore, for both wound dressing and wound management, the improvements in the levels of significance are near the normally accepted value of 0.05. However, for questions relating to physiology, the increase was not found to be significant, \( p=0.23 \). This is not surprising as an improvement in the level of knowledge relating to this area is less likely to be influenced by the nature of this short-term intervention. It is assumed that an improvement in nurses' knowledge of wound dressings and wound management could be achieved through expert advice and discussion, as provided through the intervention in this study. Results relating to the control group indicate no significant differences in the level of knowledge in any of the themes. With the exception of wound dressings in which the mean is -0.65%, the remaining average marks have decreased, although the decrease in the overall average mark is not significant (\( p=0.886 \)).

### 4.3.4 Nurse Responses relating to Knowledge Question Difficulty

In addition to themes, the questionnaire was further grouped into three different categories based on level of difficulty: easy, medium and difficult. The overall average mark was presented within the thematic grouping for both of the experimental and control groups prior and post intervention, and a weighted average of marks calculated in order to take the level of difficulty into account in the obtained responses.
For this purpose, every medium levelled question was counted as double the difficulty of the easy questions whilst the difficult questions were counted as triple the difficulty of the easy questions. This established a weighting of 1/6, 2/6 and 3/6 for the easy, medium and difficult levels respectively. Table 27 provides average marks, both weighted and un-weighted, with their corresponding standard deviations prior to, and after the intervention for both the control and experimental groups.

<table>
<thead>
<tr>
<th>Mark (%)</th>
<th>Prior to Intervention</th>
<th>Post Intervention</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Easy</td>
<td>Med</td>
</tr>
<tr>
<td>Experimental</td>
<td>Mean</td>
<td>91.86</td>
</tr>
<tr>
<td></td>
<td>Std. Dev.</td>
<td>1.82</td>
</tr>
<tr>
<td>Control</td>
<td>Mean</td>
<td>89.47</td>
</tr>
<tr>
<td></td>
<td>Std. Dev.</td>
<td>1.99</td>
</tr>
</tbody>
</table>

Given that the responses for easy questions were at a high level prior to the intervention, any significant improvement as a result of the intervention would be more observable in the medium and difficult questions. With the exception of questions categorised as easy, scores for the experimental group were either the same or better than those for the control group. Weighting scores provided a more balanced indication of knowledge gained, due to the high number of nurses answering the easy questions. The largest improvement seen in the experimental group was in the medium questions, 5.85%, followed by an overall improvement in marks of 4.47%, 4.37% for difficult questions and 1.91% for easy questions.

It is interesting to note that while the average marks have shown an increase in all cases for the experimental group, uniformity is not present in the results for the control group.
Overall weighted scores and those for the difficult questions decreased by 0.14% and 7.45% respectively. The largest increase was observed for medium questions, 3.75% whilst the easy questions improved by 1.44%. Furthermore, post-intervention, the standard deviations were smaller for the experimental group indicating a higher level of clustering around the calculated averages. Whilst for the control group, with the exception of the medium and weighted questions which remained the same, the standard error has increased displaying a wider variation in responses (see table 27).

Independent t-tests were performed for differences between the experimental and control groups initial level of knowledge based on each questions’ level of difficulty for different groups of questions as well as the overall weighted and un-weighted total marks. The results are shown in table 28 below.

Table 28. Independent t-test showing significance of differences between levels of question difficulty for experimental and control groups

<table>
<thead>
<tr>
<th>Knowledge by marks</th>
<th>t-test for Equality of Means</th>
<th>95% Confidence Interval of the Difference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Equal variances assumed</td>
<td>F</td>
<td>Sig</td>
</tr>
<tr>
<td>Equal variances not assumed</td>
<td>.001</td>
<td>.978</td>
</tr>
<tr>
<td>Equal variances assumed</td>
<td>1.359</td>
<td>.251</td>
</tr>
<tr>
<td>Equal variances not assumed</td>
<td>1.294</td>
<td>.263</td>
</tr>
<tr>
<td>Equal variances assumed</td>
<td>.000</td>
<td>.993</td>
</tr>
</tbody>
</table>

205
Similar to the independent t-test based on the thematic distribution, no significant differences could be observed between the two groups based on levels of difficulty prior to the start of the intervention. Paired t-tests were carried out to validate the significance of these changes for both groups of nurses and questionnaire categories. The results are shown in table 29.

Table 29. Paired samples t-test of difference between pre and post average marks based on level of difficulty for the experimental and control group (df = 18)

<table>
<thead>
<tr>
<th>Pre-Post average marks (%)</th>
<th>Paired differences</th>
<th>95% Confidence Interval of the Difference</th>
<th>t</th>
<th>Sig. (2-tailed)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean</td>
<td>Std. Deviation</td>
<td>Std. Error Mean</td>
<td>Lower</td>
</tr>
<tr>
<td>Experimental</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Easy</td>
<td>-1.91</td>
<td>8.34</td>
<td>1.91</td>
<td>-5.93</td>
</tr>
<tr>
<td>Medium</td>
<td>-5.85</td>
<td>10.55</td>
<td>2.42</td>
<td>-10.9</td>
</tr>
<tr>
<td>Difficult</td>
<td>-4.38</td>
<td>13.42</td>
<td>3.1</td>
<td>-10.86</td>
</tr>
<tr>
<td>Overall average</td>
<td>-4.11</td>
<td>7.78</td>
<td>1.78</td>
<td>-7.86</td>
</tr>
<tr>
<td>Weighted average</td>
<td>-4.46</td>
<td>9.32</td>
<td>2.13</td>
<td>-8.95</td>
</tr>
<tr>
<td>Control</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Easy</td>
<td>-1.44</td>
<td>8.16</td>
<td>1.87</td>
<td>-5.37</td>
</tr>
<tr>
<td>Medium</td>
<td>-3.22</td>
<td>10.69</td>
<td>2.45</td>
<td>-8.37</td>
</tr>
<tr>
<td>Difficult</td>
<td>7.46</td>
<td>10.35</td>
<td>2.37</td>
<td>2.46</td>
</tr>
<tr>
<td>Overall average</td>
<td>0.89</td>
<td>5.31</td>
<td>1.22</td>
<td>-1.76</td>
</tr>
<tr>
<td>Weighted average</td>
<td>2.42</td>
<td>5.68</td>
<td>1.3</td>
<td>-0.32</td>
</tr>
</tbody>
</table>

It can be seen from table 29 (as the pre score was deducted from the post score), that all the mean differences for the experimental group have a negative sign indicating improvement. The change in the average marks relating to the easy questions was insignificant as they all had high marks initially, leaving little room for improvement. However, for the difficult questions, given their nature and the time period that the consultation and the experiment had taken place, it is unsurprising that the improvement in marks was not significant.
It is possible that more time and input from the expert was required for more positive results to be established at this deeper level of knowledge.

Both the medium group and overall average marks improved significantly ($p=0.027$ and 0.033 respectively) while the weighted average mark that could be seen as more representative, improved with a significance level of 0.052.

It is worth noting that the control group did not show significant improvement in any of the question categories. Small increases were observed for the easy and medium questions but they were insignificant. The significant $p$-values corresponding to each of the difficult and weighted average grouping are not improvement indicators as their corresponding mean differences are positive with the average mark prior to the intervention being greater than that after the intervention. The overall change in average mark for the control group is also insignificant. The changes in both experimental and control knowledge marks are further demonstrated in the following boxplots (figures 20 and 21).
Figure 20. Boxplot showing pre and post-intervention knowledge marks for nurses in the experimental group.
Figure 21. Boxplot showing pre and post-intervention knowledge marks for nurses in the control group.
4.4 Impact of Tele-advice on Nurses’ Confidence in Leg Ulcer Care

4.4.1 Introduction

The development of the attitudinal scale to measure confidence is presented in chapter three (section 3.6.2). From an initial large number of statements representing nurse confidence in wound care and through a process of expert panels (panels E, F and G), a 10 item Likert type scale was designed to measure individual nurse’s level of confidence in leg ulcer care. The scale was used in order to produce a meaningful single number that described individual nurse’s confidence towards their wound care practice.

4.4.2 Expert Rating for the Confidence Statements

Table 29 shows the distribution of expert rating (panel F) using the mode and level of nurse agreement in the experimental and control groups, for the 10 statements. The expert ratings (panel F) were determined prior to the intervention and therefore remains the same throughout the study. The actual ratings used in the study were defined according to the experts’ mode.

By default, the number of nurses disagreeing with the statements can be calculated by deducting the total number of nurses agreeing with each statement from the total number of nurses (38) in the sample (see table 30). For example in statement 2, 14 nurses in the experimental group and 15 in the control group agreed with the statement. This implies that 9 nurses disagreed with the statement.
It can be observed that there was diversity even within expert rating and this scenario was repeated within the wound assessment factors (see chapter 3, section 3.5.3). Expert rating is still subject to human error and subjective individual opinion. The experiences and qualifications obtained by experts in their accumulation of knowledge will vary according to many variables such as where and when they were obtained and will ultimately influence their individual judgement. For example, expert rating for statement 3, 'The GP always decides on my patients’ leg ulcer treatment' varied between reflecting extremely negative (-3) and mildly positive (1) levels of confidence. During the course of their career these expert nurses may have enjoyed a mutually good working relationship with their patients’ GP whilst others may have found the GP to be lacking in wound knowledge.
Similarly for statement 4 'I always refer patients to the leg ulcer clinic when necessary' ratings varied between representing mildly negative (-1) and extremely positive (+3) levels of confidence. Leg ulcer clinics are relatively new in some areas and the expert nurses may have encountered problems with newly formed clinics and inexperienced staff whilst others may have been instrumental in establishing a long running efficient and effective service.

Statement 7 'Telemedicine is too complex to be relevant in leg ulcer care' also varied widely between extremely negative (-3) to fairly positive (+2) levels of confidence. Expert nurses may have experienced prior successful use of this technology. Alternatively, they may have been employed in an area which did not advocate such technological advances or had limited financial resources encouraging a negative opinion of unfamiliar concepts. It is surprising that two experts rated statement 5 'A leg ulcer will never heal' as mildly positive whilst the remaining 11 experts rated it between reflecting extremely negative (-3) and fairly negative (-2) levels of confidence. However, for the two who indicated fairly positive it is possible that the two experts had experienced a large percentage of ulcer recurrence.

4.4.3 Nurse Responses Relating to Confidence Statements

It is not surprising therefore, that the non-expert nurses in this study did not reach a consensus for each statement in the attitudinal scale. The depth of experience and level of qualifications possessed by community nurses' is likely to be varied from poor to highly skilled, but it is unlikely that many will share the expertise of the CNS.
In some cases, the nurse may have drawn on limited experience or knowledge with regard to individual statements which may have varied during the 12 week intervention period. Hence, nurses may have given a different answer post-intervention to pre-intervention.

Nurses were awarded 100 marks for every statement for which their responses agreed with those of the experts (agreeing with positive statements and disagreeing with negative statements) and 0 if their response conflicted with the experts (see table 31).

<table>
<thead>
<tr>
<th>Negative statements</th>
<th>Positive statements</th>
</tr>
</thead>
<tbody>
<tr>
<td>(-3, -2, -1)</td>
<td>(+1, +2, +3)</td>
</tr>
<tr>
<td>Agree</td>
<td>Agree</td>
</tr>
<tr>
<td>Disagree</td>
<td>Disagree</td>
</tr>
<tr>
<td>0</td>
<td>100</td>
</tr>
<tr>
<td>100</td>
<td>0</td>
</tr>
</tbody>
</table>

Statement 5 'A leg ulcer will never heal no matter what treatment I give' was the only one to be consistently marked amongst both experimental and control groups pre and post-intervention, with no nurse agreeing with it. All 19 nurses in the control group agreed with statement 6 'My confidence in dealing with wounds now has improved since I was first registered' both pre and post-intervention, whilst in the experimental group all nurses agreed with this statement pre-intervention and one nurse disagreed with it post-intervention. Given the nature of both statements, responses are unremarkable for community nurses.
Community nurses’ responses closely matched the experts’ ratings (as determined by the mode) for statements reflecting extremely negative (-3) and fairly positive (+2) levels of confidence. Summary statistics for the marks obtained by respondents for each of the confidence categories provided by the 10 statements pre and post-intervention are presented in table 32.

<table>
<thead>
<tr>
<th>Marks (%)</th>
<th>PRE INTERVENTION</th>
<th>POST INTERVENTION</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>NEGATIVE CONFIDENCE LEVELS</td>
<td>POSITIVE CONFIDENCE LEVELS</td>
</tr>
<tr>
<td></td>
<td>-3</td>
<td>-2</td>
</tr>
<tr>
<td>EXP</td>
<td>Mean</td>
<td>100</td>
</tr>
<tr>
<td></td>
<td>St. Err</td>
<td>0</td>
</tr>
<tr>
<td>CTRL</td>
<td>Mean</td>
<td>100</td>
</tr>
<tr>
<td></td>
<td>St. Err</td>
<td>0</td>
</tr>
</tbody>
</table>

It is possible that the decrease in higher levels of confidence (+2, +3) for the experimental group could have been attributed to nurses questioning their own confidence levels following discussions with the wound care expert. The corresponding standard errors for the calculated average mark are presented in table 33. These were consistent with improvement and deterioration in the marks, making them more reliable. These changes have been statistically validated using paired t-tests (see table 33).
Table 33. *Paired samples t-test of difference between pre and post-intervention average marks based on confidence levels for the experimental and control groups*

<table>
<thead>
<tr>
<th>Pre-Post average marks (%)</th>
<th>Paired differences</th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean</td>
<td>Std. Dev</td>
<td>Std. Err</td>
<td>95% CI Lower</td>
<td>95% CI Upper</td>
<td>t</td>
</tr>
<tr>
<td>EXP</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>-3* extremely negative confidence</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>-2 fairly negative confidence</td>
<td>-7.89</td>
<td>18.73</td>
<td>4.3</td>
<td>-16.9231</td>
<td>1.1337</td>
<td>-1.837</td>
</tr>
<tr>
<td>-1 mildly negative confidence</td>
<td>-2.63</td>
<td>20.23</td>
<td>4.64</td>
<td>-12.3834</td>
<td>7.1202</td>
<td>-0.567</td>
</tr>
<tr>
<td>2 fairly positive confidence</td>
<td>5.26</td>
<td>22.94</td>
<td>5.26</td>
<td>-5.7943</td>
<td>16.3206</td>
<td>1.000</td>
</tr>
<tr>
<td>3 extremely positive confidence</td>
<td>5.26</td>
<td>22.94</td>
<td>5.26</td>
<td>-5.7943</td>
<td>16.3206</td>
<td>1.000</td>
</tr>
<tr>
<td>CTRL</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>-3* extremely negative confidence</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>-2 fairly negative confidence</td>
<td>7.89</td>
<td>18.73</td>
<td>4.3</td>
<td>-1.1337</td>
<td>16.9231</td>
<td>1.837</td>
</tr>
<tr>
<td>-1* mildly negative confidence</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1 mildly positive confidence</td>
<td>5.26</td>
<td>22.94</td>
<td>5.26</td>
<td>-16.3206</td>
<td>5.7943</td>
<td>-1.000</td>
</tr>
<tr>
<td>2 fairly positive confidence</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3 extremely positive confidence</td>
<td>-10.53</td>
<td>31.53</td>
<td>7.23</td>
<td>-25.7234</td>
<td>4.6707</td>
<td>-1.455</td>
</tr>
</tbody>
</table>

* The correlation and t cannot be computed because the standard error of the difference is 0.

It should be noted that a negative mean value indicates an improvement as post scores are deducted from pre scores. The increase of 13.16% for mildly positive statements for the experimental group is significant with a value of 0.02 and the increase of 7.89% for fairly negative statements is near the normally accepted value of 0.05. In the control group, the decrease of 7.89% for fairly negative statements is also near the normally accepted value of 0.05 whilst the improvement of 10.53% in the extremely positive statement is not significant. Table 34 shows the average mean difference in scores pre and post intervention. Results for the statements were examined and had potential for improvement.
### Table 34. Summary statistics for pre and post-intervention average confidence marks

<table>
<thead>
<tr>
<th>Marks (%)</th>
<th>PRE-INTERVENTION</th>
<th>POST-INTERVENTION</th>
<th>AVERAGE MARK PRE-POST 10 STS</th>
</tr>
</thead>
<tbody>
<tr>
<td>pre-pst</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>-3</td>
<td>100 89.47</td>
<td>100 100 97.37</td>
<td>100 97.37</td>
</tr>
<tr>
<td>-2</td>
<td>100 94.74</td>
<td>100 100 97.37</td>
<td>100 100 97.37</td>
</tr>
<tr>
<td>-1</td>
<td>100 73.68</td>
<td>100 100 97.37</td>
<td>100 100 97.37</td>
</tr>
<tr>
<td>0</td>
<td>100 89.47</td>
<td>0 0</td>
<td>0 0</td>
</tr>
<tr>
<td>1</td>
<td>0 0</td>
<td>0 0</td>
<td>0 0</td>
</tr>
<tr>
<td>2</td>
<td>0 0</td>
<td>0 0</td>
<td>0 0</td>
</tr>
<tr>
<td>3</td>
<td>0 0</td>
<td>0 0</td>
<td>0 0</td>
</tr>
<tr>
<td>sig</td>
<td>* 0.83 0.58</td>
<td>0.33 0.33</td>
<td>0.11</td>
</tr>
</tbody>
</table>
| * sig cannot be computed because the standard deviation of both groups are 0.
It can be seen from table 34 that the average difference between pre and post scores is not significant for either experimental or control groups ($p=0.11, 0.54$ respectively). For fairly negative statements (-2), the control group significantly deteriorated in post scores, $p=0.08$. As the pre-intervention score is deducted from the post-intervention score, a minus sign denotes an improvement. A large increase in confidence was not anticipated, as confidence is a behaviour that can accumulate over time, such as a nurses career and also with experience and cannot be easily increased in a short time span.
4.5 Measuring Wound Area

Tracer®, a simple planimetry computer program which calculates area measurement from digital wound images was used to obtain reliable wound measurements in this study (see chapter 2, section 2.6.1).

In this research, it has been established that wound area alone, at least the way that it has been calculated, has little to contribute to measures of the state of the wound. As a short-term measurement tool, the wound area is less relevant while on a long-term basis this may differ and requires further investigation. Therefore, this study combined area measurement with additional relevant wound factors such as the percentage of tissue colour and type in the wound, levels of oedema, levels of exudate and inflammation to provide a reliable method tool to represent the state of the wound.

In order to reduce inter-operator variability, the researcher was responsible for measuring each wound. Each pre and post-intervention image was measured three times and the mean calculated to provide the pre and post wound area (see figures 22a to 22f).
Figure 22a
Example 1.
Pre-intervention area: 5.96cm²
Pre mean: 5.83cm²

Figure 22b
Example 2.
Pre-intervention area: 5.58cm²

Figure 22c
Example 3.
Pre-intervention area: 5.95cm²

Figure 22d
Example 1.
Post-intervention area: 1.78cm²
Post mean: 1.56cm²

Figure 22e
Example 2.
Post-intervention area: 1.42cm²

Figure 22f
Example 3.
Post-intervention area: 1.50cm²
In extreme cases, leg ulcers can cover the lower limb and extend around the entire circumference. Therefore, a figure of 800 mm$^2$ was assumed to be the maximum potential area of an ulcer. The actual area of each ulcer determined from using the planimetry program was then calculated as a percentage of that area.

For example:

Pre weighted mean: $214.76\, \text{cm}^2 \times \frac{100}{800} = 26.85$

Post weighted mean: $14.75\, \text{cm}^2 \times \frac{100}{800} = 1.84$

This was performed to standardise different wound areas in a way that makes them comparable with the VAS measuring of wound factors.
4.6 Wound Assessment Tool Results

4.6.1 Introduction

Published research in the area of wound care highlighted a large number of wound factors \((n=108)\) that have been used to describe various aspects of the state of the wound under investigation. A complete list of these factors was produced and presented to a wound expert panel (panel A) to identify those factors that could be considered good visual wound status indicators and which were tele-transmittable. This resulted in the selection of 20 factors which were subsequently categorised into seven groups and a postal survey of respected wound care experts ranked them according to their individual order of importance.

4.6.2 Expert Ranking for Wound Factors

The experts' rankings for the 20 factors are presented in table 35 and it can be observed that all the factors received similar mean rankings with no evidence to support any significant difference between their order of importance. A Kruskal-Wallis test confirmed an insignificant difference between experts' ranking of factors \((p=0.472)\). Following this exercise a further two factors (induration and undermining) were withdrawn from the list due to potential ambiguity during tele-transmission \((n=18)\) (see chapter 3, section 3.5.3).
Table 35. Summary statistics for experts’ rankings for wound factors

<table>
<thead>
<tr>
<th>FACTOR</th>
<th>EXPERT RANKING (MEAN)</th>
<th>STANDARD DEVIATION</th>
<th>LOWER 95% CONFIDENCE LIMIT</th>
<th>UPPER 95% CONFIDENCE LIMIT</th>
</tr>
</thead>
<tbody>
<tr>
<td>EXUDATE</td>
<td>8.36</td>
<td>2.38</td>
<td>3.7</td>
<td>13.02</td>
</tr>
<tr>
<td>OEDEMA</td>
<td>7.86</td>
<td>1.32</td>
<td>5.27</td>
<td>10.45</td>
</tr>
<tr>
<td>INFLAMMATION</td>
<td>7.41</td>
<td>1.00</td>
<td>5.45</td>
<td>9.37</td>
</tr>
<tr>
<td>INDURATION</td>
<td>9.82</td>
<td>3.66</td>
<td>2.65</td>
<td>16.99</td>
</tr>
<tr>
<td>COLOUR OF TISSUES IN WOUND: RED, YELLOW, BLACK, GREEN, PINK</td>
<td>6.55</td>
<td>3.21</td>
<td>0.26</td>
<td>12.84</td>
</tr>
<tr>
<td>TISSUE TYPE IN WOUND: NECROTIC, EPITHELIALISING, GRANULATING, SLOUGHY</td>
<td>6.95</td>
<td>0.74</td>
<td>5.50</td>
<td>8.40</td>
</tr>
<tr>
<td>ULCER EDGE: PUNCHED OUT, SLOPING, ROLLED</td>
<td>7.77</td>
<td>3.37</td>
<td>1.16</td>
<td>14.38</td>
</tr>
<tr>
<td>CONDITION OF SKIN SURROUNDING WOUND: SCALY/FLAKY, ECZEMATOUS, HAEMOSIDERIN STAINING, UNDERMINING</td>
<td>7.41</td>
<td>2.41</td>
<td>2.69</td>
<td>12.13</td>
</tr>
</tbody>
</table>

Based on the pre-selected wound images, the same expert panel who identified the visual and tele-transmittable wound factors (panel A) provided estimates for each of the wound factors pre and post-intervention. These estimates were based on the provision of a range of values (minimum and maximum within the VAS range of 0 to 100). That is, for each wound factor, the expert group provided two values that they believed the ‘true’ value for that factor should lie within. This is further depicted below:

\[
\begin{array}{cccc}
\text{Factor} & 0 & a & b & 100 \\
\hline
a = \min & b = \max
\end{array}
\]
The identified range between the two values of $a = \min$ and $b = \max$ were then assumed to provide the 95% confidence interval for the true value for the wound factor under consideration. Assuming normality for the distribution of the factor, these two values were then used to estimate the mean and standard deviation of the normal distribution representing the factor.

That is,

\[
\text{The mean factor} = \frac{a + b}{2} \quad \text{and}
\]

\[
\text{The standard deviation} = \frac{b - a}{2 \times 1.96}
\]

For example, given the two values ($a = 60$ and $b = 80$) provided by the experts to represent the most likely range for 'exudate' using VAS,

\[
\text{The mean Exudate} = \frac{a + b}{2} = \frac{60 + 80}{2} = 70, \quad \text{and}
\]

\[
\text{The standard deviation for Exudate}
\]

\[
= \frac{b - a}{2 \times 1.96}
\]

\[
= \frac{80 - 60}{3.92} = \frac{20}{3.92} = 5.1
\]
Determining a minimum and maximum range was considered to provide a more reliable estimation process than requesting experts to specify a single exact value. This argument will further be confirmed when the process is applied using a wider panel of wound care experts. The same principle was followed for all the factors of each wound prior and post-intervention.

Figures 23 and 23a represent a sample of wound images together with their corresponding wound factors and the minimum and maximum estimates as provided by the expert panel with their corresponding mean and standard deviations.

<table>
<thead>
<tr>
<th>FACTOR</th>
<th>MIN</th>
<th>MAX</th>
<th>MEAN</th>
<th>STD. DEV</th>
</tr>
</thead>
<tbody>
<tr>
<td>EXUDATE</td>
<td>60</td>
<td>80</td>
<td>70</td>
<td>5.10</td>
</tr>
<tr>
<td>OEDEMA</td>
<td>50</td>
<td>70</td>
<td>60</td>
<td>5.10</td>
</tr>
<tr>
<td>INFLM.</td>
<td>60</td>
<td>80</td>
<td>70</td>
<td>5.10</td>
</tr>
<tr>
<td>RED</td>
<td>35</td>
<td>45</td>
<td>40</td>
<td>2.55</td>
</tr>
<tr>
<td>YELL.</td>
<td>55</td>
<td>60</td>
<td>57.5</td>
<td>1.28</td>
</tr>
<tr>
<td>BLACK</td>
<td>0</td>
<td>10</td>
<td>5</td>
<td>2.55</td>
</tr>
<tr>
<td>GREEN</td>
<td>0</td>
<td>5</td>
<td>2.5</td>
<td>1.28</td>
</tr>
<tr>
<td>PINK</td>
<td>20</td>
<td>30</td>
<td>25</td>
<td>2.55</td>
</tr>
<tr>
<td>NECR.</td>
<td>0</td>
<td>10</td>
<td>5</td>
<td>2.55</td>
</tr>
<tr>
<td>EPI.</td>
<td>0</td>
<td>5</td>
<td>2.5</td>
<td>1.28</td>
</tr>
<tr>
<td>GRAN.</td>
<td>80</td>
<td>85</td>
<td>82.5</td>
<td>1.28</td>
</tr>
<tr>
<td>SLOUGH</td>
<td>15</td>
<td>20</td>
<td>17.5</td>
<td>1.28</td>
</tr>
<tr>
<td>PUNCH.</td>
<td>0</td>
<td>1</td>
<td>0.5</td>
<td>0.26</td>
</tr>
<tr>
<td>SLOPE</td>
<td>70</td>
<td>80</td>
<td>75</td>
<td>2.55</td>
</tr>
<tr>
<td>ROLLED</td>
<td>0</td>
<td>1</td>
<td>0.5</td>
<td>0.26</td>
</tr>
<tr>
<td>SCAL/FLK</td>
<td>0</td>
<td>10</td>
<td>5</td>
<td>2.55</td>
</tr>
<tr>
<td>ECZEMA</td>
<td>0</td>
<td>10</td>
<td>5</td>
<td>2.55</td>
</tr>
<tr>
<td>HAEMSID.</td>
<td>0</td>
<td>1</td>
<td>0.5</td>
<td>0.26</td>
</tr>
</tbody>
</table>

Figure 23. Pre-intervention wound with corresponding VAS factor values
In some cases the expert panel were less able to give more precise range of values for certain factors, mainly due to the complexity of the wound. This resulted in wider ranges being specified and therefore larger standard deviations. Figures 24 and 25 provide examples of two different wounds where factors (oedema, rolled edge, scaly/flaky skin) are less clear.
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<table>
<thead>
<tr>
<th>IMAGE NO 10</th>
<th>FACTOR</th>
<th>MIN</th>
<th>MAX</th>
<th>MEAN</th>
<th>STD.DEV</th>
</tr>
</thead>
<tbody>
<tr>
<td>OEDEMA</td>
<td>30</td>
<td>55</td>
<td>42.5</td>
<td>6.38</td>
<td></td>
</tr>
</tbody>
</table>

Figure 24.  Example 1
Wound image with wide range of values for wound factors

<table>
<thead>
<tr>
<th>IMAGE NO 8</th>
<th>FACTOR</th>
<th>MIN</th>
<th>MAX</th>
<th>MEAN</th>
<th>STD.DEV</th>
</tr>
</thead>
<tbody>
<tr>
<td>ROLLED</td>
<td>30</td>
<td>60</td>
<td>45</td>
<td>7.65</td>
<td></td>
</tr>
<tr>
<td>SCAL/FLK</td>
<td>30</td>
<td>60</td>
<td>45</td>
<td>7.65</td>
<td></td>
</tr>
</tbody>
</table>

Figure 25.  Example 2.
Wound image with wide range of values for wound factors.

Alternatively, in some cases wound factors were very clear and the experts were able to specify more precise values on them. Figures 26 and 27 display different wound images, each having some wound factors with a narrow range of values.
### Chapter Four: Results

#### Table: IMAGE NO 6

<table>
<thead>
<tr>
<th>FACTOR</th>
<th>MIN</th>
<th>MAX</th>
<th>MEAN</th>
<th>STD.DEV</th>
</tr>
</thead>
<tbody>
<tr>
<td>BLACK</td>
<td>0</td>
<td>1</td>
<td>0.5</td>
<td>0.26</td>
</tr>
<tr>
<td>GREEN</td>
<td>0</td>
<td>1</td>
<td>0.5</td>
<td>0.26</td>
</tr>
<tr>
<td>NECR.</td>
<td>0</td>
<td>1</td>
<td>0.5</td>
<td>0.26</td>
</tr>
<tr>
<td>ROLLED</td>
<td>0</td>
<td>1</td>
<td>0.5</td>
<td>0.26</td>
</tr>
</tbody>
</table>

*Figure 26. Example 1  
Wound factors with small range of values*

#### Table: IMAGE NO 12

<table>
<thead>
<tr>
<th>FACTOR</th>
<th>MIN</th>
<th>MAX</th>
<th>MEAN</th>
<th>STD.DEV</th>
</tr>
</thead>
<tbody>
<tr>
<td>INFLM.</td>
<td>0</td>
<td>1</td>
<td>0.5</td>
<td>0.26</td>
</tr>
<tr>
<td>RED</td>
<td>0</td>
<td>1</td>
<td>0.5</td>
<td>0.26</td>
</tr>
<tr>
<td>YELL</td>
<td>0</td>
<td>1</td>
<td>0.5</td>
<td>0.26</td>
</tr>
<tr>
<td>BLACK</td>
<td>99</td>
<td>100</td>
<td>99.5</td>
<td>0.26</td>
</tr>
<tr>
<td>GREEN</td>
<td>0</td>
<td>1</td>
<td>0.5</td>
<td>0.26</td>
</tr>
<tr>
<td>NECR.</td>
<td>99</td>
<td>100</td>
<td>99.5</td>
<td>0.26</td>
</tr>
<tr>
<td>PINK</td>
<td>0</td>
<td>1</td>
<td>0.5</td>
<td>0.26</td>
</tr>
<tr>
<td>EPI.</td>
<td>0</td>
<td>1</td>
<td>0.5</td>
<td>0.26</td>
</tr>
<tr>
<td>GRAN.</td>
<td>0</td>
<td>1</td>
<td>0.5</td>
<td>0.26</td>
</tr>
<tr>
<td>SLOUGH</td>
<td>0</td>
<td>1</td>
<td>0.5</td>
<td>0.26</td>
</tr>
<tr>
<td>PUNCH.</td>
<td>0</td>
<td>1</td>
<td>0.5</td>
<td>0.26</td>
</tr>
<tr>
<td>ROLLED</td>
<td>0</td>
<td>1</td>
<td>0.5</td>
<td>0.26</td>
</tr>
</tbody>
</table>

*Figure 27. Example 2  
Wound factors with small range of values*
Due to the total volume of wound assessment factors generated from reviewing each wound pre and post-intervention \( (n=38 \times 18 \times 2 = 1368) \), it would have been impractical to ask community nurses to also complete this task in order to obtain an index to represent the overall state of the wound. In addition to time restrictions it was unlikely that the nurse would have been able to maintain equal levels of concentration for the duration of the exercise. For the above reasons, it was considered that the generation of 100 virtual nurse responses (VNR) as a population, based on the values create by the expert panel, would provide a more homogeneous and reliable sample to generate pre and post-intervention indices for each wound. The generated VNR responses established a mean for each of the 18 factors which were combined with area measurement and calculated to obtain an overall numerical index for each factor. As no significant difference between the importance of these factors could be established, a direct averaging process suitably provided overall indices for each wound prior and post-intervention.

Figures 28 – 30a show examples of wounds with their pre and post-intervention indices and the sub-components of the overall index. The increase in the post index observed in example 2 denotes a deterioration in the state of the wound. This is mainly due to an increase in oedema, inflammation, colour and tissue type in the wound due to a reported potential allergic reaction to the initial wound dressings reflected in the generated index.
EXUDATE | 79.46
OEDEMA  | 50.16
INFLM.  | 17.78
COLOUR  | 50.23
TISSUE  | 40.63
EDGE    | 85.09
SKIN    | 37.60
AREA    | 0.71

**PRE INDEX** | 45.2

---

Figure 28. Example 1
Wound pre index

---

EXUDATE | 69.7
OEDEMA  | 20.3
INFLM.  | 7
COLOUR  | 22.2
TISSUE  | 7.8
EDGE    | 32.1
SKIN    | 6
AREA    | 0.9

**POST INDEX** | 20.8

---

Figure 28a. Example 1
Wound post index
Figure 29. Example 2
Wound pre index

<table>
<thead>
<tr>
<th>Metric</th>
<th>Pre Index</th>
</tr>
</thead>
<tbody>
<tr>
<td>Exudate</td>
<td>34.8</td>
</tr>
<tr>
<td>Oedema</td>
<td>0.5</td>
</tr>
<tr>
<td>Inflammation</td>
<td>0.5</td>
</tr>
<tr>
<td>Colour</td>
<td>20.1</td>
</tr>
<tr>
<td>Tissue</td>
<td>13</td>
</tr>
<tr>
<td>Edge</td>
<td>33.5</td>
</tr>
<tr>
<td>Skin</td>
<td>0.5</td>
</tr>
<tr>
<td>Area</td>
<td>0.6</td>
</tr>
</tbody>
</table>

Figure 29a. Example 2
Wound post index

<table>
<thead>
<tr>
<th>Metric</th>
<th>Post Index</th>
</tr>
</thead>
<tbody>
<tr>
<td>Exudate</td>
<td>30.2</td>
</tr>
<tr>
<td>Oedema</td>
<td>12.7</td>
</tr>
<tr>
<td>Inflammation</td>
<td>7.7</td>
</tr>
<tr>
<td>Colour</td>
<td>36.7</td>
</tr>
<tr>
<td>Tissue</td>
<td>27</td>
</tr>
<tr>
<td>Edge</td>
<td>33.5</td>
</tr>
<tr>
<td>Skin</td>
<td>2.8</td>
</tr>
<tr>
<td>Area</td>
<td>0.3</td>
</tr>
</tbody>
</table>

*Post Index 12.9

*Post Index 18.9

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CHAPTER FOUR.
RESULTS

<table>
<thead>
<tr>
<th>EXUDATE</th>
<th>39.3</th>
</tr>
</thead>
<tbody>
<tr>
<td>OEDEMA</td>
<td>65.5</td>
</tr>
<tr>
<td>INFLM.</td>
<td>44.7</td>
</tr>
<tr>
<td>COLOUR</td>
<td>34.7</td>
</tr>
<tr>
<td>TISSUE</td>
<td>26.3</td>
</tr>
<tr>
<td>EDGE</td>
<td>8.6</td>
</tr>
<tr>
<td>SKIN</td>
<td>6.9</td>
</tr>
<tr>
<td>AREA</td>
<td>1</td>
</tr>
<tr>
<td>PRE INDEX</td>
<td>46.9</td>
</tr>
</tbody>
</table>

**Figure 30.** Example 3
*Wound pre index*

<table>
<thead>
<tr>
<th>EXUDATE</th>
<th>49.8</th>
</tr>
</thead>
<tbody>
<tr>
<td>OEDEMA</td>
<td>57</td>
</tr>
<tr>
<td>INFLM.</td>
<td>8.2</td>
</tr>
<tr>
<td>COLOUR</td>
<td>52.1</td>
</tr>
<tr>
<td>TISSUE</td>
<td>37.5</td>
</tr>
<tr>
<td>EDGE</td>
<td>30.3</td>
</tr>
<tr>
<td>SKIN</td>
<td>11.1</td>
</tr>
<tr>
<td>AREA</td>
<td>0.14</td>
</tr>
<tr>
<td>POST INDEX</td>
<td>36.5</td>
</tr>
</tbody>
</table>

**Figure 30a.** Example 3
*Wound post index*
The pre and post-intervention indices for each wound are presented in table 36. Note that a positive value in the change column denotes deterioration as the larger the index, or the further away from 0, the worse the state of the wound.

<table>
<thead>
<tr>
<th>IMAGE NO:</th>
<th>PRE INDEX</th>
<th>POST INDEX</th>
<th>CHANGE</th>
<th>IMAGE NO:</th>
<th>PRE INDEX</th>
<th>POST INDEX</th>
<th>CHANGE</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>20.8</td>
<td>21.7</td>
<td>0.8</td>
<td>2</td>
<td>29</td>
<td>30.1</td>
<td>1.1</td>
</tr>
<tr>
<td>4</td>
<td>29.7</td>
<td>26.3</td>
<td>-3.5</td>
<td>3</td>
<td>38.2</td>
<td>28.2</td>
<td>-10</td>
</tr>
<tr>
<td>6</td>
<td>51.7</td>
<td>14.3</td>
<td>-37.4</td>
<td>5</td>
<td>35.3</td>
<td>9.4</td>
<td>-25.9</td>
</tr>
<tr>
<td>8</td>
<td>56.8</td>
<td>36.8</td>
<td>-20</td>
<td>7</td>
<td>31.2</td>
<td>15.7</td>
<td>-15.5</td>
</tr>
<tr>
<td>9</td>
<td>24</td>
<td>12.2</td>
<td>-11.8</td>
<td>10</td>
<td>33.2</td>
<td>18.3</td>
<td>-14.8</td>
</tr>
<tr>
<td>11</td>
<td>16.2</td>
<td>16.2</td>
<td>0</td>
<td>13</td>
<td>39.2</td>
<td>31</td>
<td>-8.3</td>
</tr>
<tr>
<td>12</td>
<td>32.4</td>
<td>17.7</td>
<td>-14.7</td>
<td>15</td>
<td>23.2</td>
<td>7.9</td>
<td>-15.3</td>
</tr>
<tr>
<td>14</td>
<td>46.9</td>
<td>36.5</td>
<td>-10.5</td>
<td>19</td>
<td>26.5</td>
<td>22.4</td>
<td>-4</td>
</tr>
<tr>
<td>16</td>
<td>28.4</td>
<td>32.1</td>
<td>3.7</td>
<td>21</td>
<td>40.5</td>
<td>41.2</td>
<td>0.7</td>
</tr>
<tr>
<td>17</td>
<td>24.3</td>
<td>10.3</td>
<td>-14</td>
<td>22</td>
<td>38</td>
<td>20.4</td>
<td>-17.7</td>
</tr>
<tr>
<td>18</td>
<td>27</td>
<td>21.1</td>
<td>-5.9</td>
<td>23</td>
<td>20.2</td>
<td>15.1</td>
<td>-5.1</td>
</tr>
<tr>
<td>20</td>
<td>31.8</td>
<td>14.4</td>
<td>-17.4</td>
<td>25</td>
<td>48.1</td>
<td>34.3</td>
<td>-13.8</td>
</tr>
<tr>
<td>24</td>
<td>18.7</td>
<td>10</td>
<td>-8.6</td>
<td>26</td>
<td>15.2</td>
<td>9.1</td>
<td>-6.1</td>
</tr>
<tr>
<td>28</td>
<td>12.9</td>
<td>8.4</td>
<td>-4.4</td>
<td>27</td>
<td>39.6</td>
<td>9.6</td>
<td>-30.1</td>
</tr>
<tr>
<td>29</td>
<td>26.4</td>
<td>17.4</td>
<td>-9</td>
<td>30</td>
<td>17.5</td>
<td>16.6</td>
<td>-1</td>
</tr>
<tr>
<td>31</td>
<td>32.7</td>
<td>21.5</td>
<td>-11.2</td>
<td>32</td>
<td>28.8</td>
<td>16.6</td>
<td>-12.2</td>
</tr>
<tr>
<td>36</td>
<td>29.4</td>
<td>21.5</td>
<td>-7.9</td>
<td>33</td>
<td>29.4</td>
<td>18.9</td>
<td>-10.4</td>
</tr>
<tr>
<td>37</td>
<td>25.6</td>
<td>18.9</td>
<td>-6.7</td>
<td>34</td>
<td>16.7</td>
<td>15.2</td>
<td>-1.5</td>
</tr>
<tr>
<td>38</td>
<td></td>
<td></td>
<td></td>
<td>35</td>
<td>21.7</td>
<td>10.1</td>
<td>-11.6</td>
</tr>
</tbody>
</table>
The overall indices ranged between 12.9 to 56.8 pre-intervention and 7.9 to 41.2 post-intervention and are summarised in table 37. Indices for the experimental group had a greater range pre-intervention, 12.9 to 56.8, than the control group which may have been indicative of greater variation in the state of patients’ wounds prior to the start of the study. This is also suggested by both the largest improvement and deterioration being observed for wounds in the experimental group (see table 37). The larger range of indices observed for the control group post-intervention compared to the experimental group, can be attributed to the positive benefits of the intervention.

Table 37. Summary of changes in overall wound indices

<table>
<thead>
<tr>
<th></th>
<th>PRE INDEX</th>
<th>POST INDEX</th>
<th>LARGEST IMPROVEMENT</th>
<th>LARGEST DETERIORATION</th>
</tr>
</thead>
<tbody>
<tr>
<td>EXP</td>
<td>12.9 – 56.8</td>
<td>8.4 – 36.8</td>
<td>37.4</td>
<td>3.7</td>
</tr>
<tr>
<td>CTRL</td>
<td>15.2 – 48.1</td>
<td>7.9 – 41.2</td>
<td>30.1</td>
<td>1.1</td>
</tr>
<tr>
<td>OVERALL</td>
<td>12.9 – 56.8</td>
<td>7.9 – 41.2</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Although the majority of patient factors were comparable between groups (see section 4.2), a disparity was observed in others which could not be controlled due to sample limitations. Therefore, it is possible that existing, new or latent patient factors may have had an effect on the indices. For example, if a patient’s condition deteriorated, or a new illness occurred during the intervention period, they may have needed longer to heal or their healing potential may have become further compromised.
In total, four wound indices deteriorated (increased), two in the control and two in the experimental group. Table 38 shows the pre and post-intervention indices and possible explanations for the deterioration.

<table>
<thead>
<tr>
<th>GROUP</th>
<th>IMAGE NO</th>
<th>PRE INDEX</th>
<th>POST INDEX</th>
<th>CHANGE</th>
<th>RATIONALE</th>
</tr>
</thead>
<tbody>
<tr>
<td>EXP</td>
<td>1</td>
<td>20.8</td>
<td>21.7</td>
<td>0.8</td>
<td>ALLERGIC REACTION TO COMPONENT IN REGIMEN</td>
</tr>
<tr>
<td>CTRL</td>
<td>2</td>
<td>29</td>
<td>30.1</td>
<td>1.1</td>
<td>PATIENT CONSIDERED NON-COMPLIANT WITH REGIMEN</td>
</tr>
<tr>
<td>EXP</td>
<td>16</td>
<td>28.4</td>
<td>32.1</td>
<td>3.7</td>
<td>NEW CONDITION DIAGNOSED</td>
</tr>
<tr>
<td>CTRL</td>
<td>21</td>
<td>40.5</td>
<td>41.2</td>
<td>0.7</td>
<td>PATIENT CONSIDERED NON-COMPLIANT WITH REGIMEN</td>
</tr>
</tbody>
</table>

4.6.3 Wound Care Nurses’ Responses for ‘WoundView’©

As the tool was designed to aid community nurses in their assessment of wounds, it was important to investigate their use of it. Community nurses involved in the study were unable to allocate specific time within their working day to complete the task and may have been unintentionally biased towards reporting wound factors favourably. Therefore, in addition to the VNR, 11 experienced wound care nurses (panel B) working within the primary care setting also rated the 18 factors for each wound pre and post-intervention. Due to their involvement in wound care, these nurses were able to dedicate time within their workload to complete the task. Nurses rated the images using ‘WoundView’©, a computer program which allowed the images to be stored on CD-ROM and assessed on a computer screen (see chapter 3, section 3.5.4). Nurses used VAS to rate each factor between 0 (best possible state) and 100 (worst possible state).
Surprisingly, little consensus was achieved amongst the wound care nurses, which has repeatedly been shown throughout nurse rating exercises in this study. In some cases, factors for the same image were rated at both extremes: 0 and 100. Table 39 provides an example of comparison of VNR and wound care nurses ratings for wound factors for one wound. It must be noted that the range of wound care nurse ratings are taken from all 11 nurses and are not indicative of one individual’s responses. For example, for wound image 11, one nurse rated oedema at 2 whilst another rated it at 89 and the expert panel (panel A) rated oedema between 15 and 25.
Table 39. Examples of comparisons between expert panel and wound care nurses’ wound factor ratings for wound image 11

<table>
<thead>
<tr>
<th>IMAGE NO: 11</th>
<th>ACTUAL NURSE RESPONSES POINT ESTIMATES</th>
<th>VIRTUAL RANGE (95% CONFIDENCE INTERVAL)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>SMALLER VALUE</td>
<td>HIGHER VALUE</td>
</tr>
<tr>
<td></td>
<td>(found amongst 11 nurses)</td>
<td></td>
</tr>
<tr>
<td>FACTOR</td>
<td></td>
<td></td>
</tr>
<tr>
<td>EXUDATE</td>
<td>1</td>
<td>34</td>
</tr>
<tr>
<td>OEDEMA</td>
<td>2</td>
<td>89</td>
</tr>
<tr>
<td>INFLAMMATION</td>
<td>0</td>
<td>25</td>
</tr>
<tr>
<td>COLOUR:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>RED</td>
<td>0</td>
<td>100</td>
</tr>
<tr>
<td>YELLOW</td>
<td>0</td>
<td>48</td>
</tr>
<tr>
<td>BLACK</td>
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<td>13</td>
</tr>
<tr>
<td>GREEN</td>
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<td>4</td>
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<tr>
<td>PINK</td>
<td>0</td>
<td>91</td>
</tr>
<tr>
<td>TISSUE TYPE:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>NECROTIC</td>
<td>0</td>
<td>31</td>
</tr>
<tr>
<td>EPITHELIALISING</td>
<td>0</td>
<td>73</td>
</tr>
<tr>
<td>GRANULATING</td>
<td>0</td>
<td>81</td>
</tr>
<tr>
<td>SLOUGHY</td>
<td>0</td>
<td>48</td>
</tr>
<tr>
<td>ULCER EDGE:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>PUNCHED OUT</td>
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<td>100</td>
</tr>
<tr>
<td>SLOPING</td>
<td>0</td>
<td>61</td>
</tr>
<tr>
<td>ROLLED</td>
<td>0</td>
<td>90</td>
</tr>
<tr>
<td>SURROUNDING SKIN:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>SCALY/FLAKY</td>
<td>43</td>
<td>100</td>
</tr>
<tr>
<td>ECZEMATOUS</td>
<td>0</td>
<td>92</td>
</tr>
<tr>
<td>HAEMOSIDERIN</td>
<td>0</td>
<td>55</td>
</tr>
</tbody>
</table>

Table 40 compares the pre and post-intervention indices calculated from the wound factor ratings for two of the wound care nurses in panel B chosen at random, with that of the expert panel for three wounds.
Table 4.0. Examples of comparisons between two wound care nurses in panel B and experts’ calculated indices

<table>
<thead>
<tr>
<th>Wound Image No: 6</th>
<th>Wound Image No: 11</th>
<th>Wound Image No: 21</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pre Index</td>
<td>Post Index</td>
<td>Pre Index</td>
</tr>
<tr>
<td>Nurse 3</td>
<td>11.5</td>
<td>0.6</td>
</tr>
<tr>
<td>Nurse 7</td>
<td>20.5</td>
<td>10.1</td>
</tr>
<tr>
<td>Expert panel</td>
<td>51.7</td>
<td>14.3</td>
</tr>
</tbody>
</table>

Both nurses’ indices underestimated the severity of the state of the wound as determined by the expert panel. The only indices showing change in the same direction as the expert panel post-intervention were observed for wound image 6, where there was an improvement. According to both nurses’ indices, wound image 11 deteriorated, although the expert panel considered it to have remained the same and wound image 21 improved whilst the expert panel indicated that it had deteriorated. The wide diversity amongst experienced nurses’ responses emphasises the need for further training in wound assessment in order to prepare reliable information to receive tele-advice.

4.6.4 Linking Wound Assessment with Knowledge and Confidence

The study also aimed to investigate the relationship between nurses’ knowledge and confidence and the state of the wound. It was anticipated that the higher the nurse’s levels of knowledge and confidence, the lower the resulting wound index would be. That is, the more knowledgeable and confident the nurse, the more efficient their wound management and hence the bigger the improvement in the state of the wound.
In the process of attempting to examine this hypothesis, it is important to point out the possibility of nurses in the control group having comparable levels of knowledge and confidence to those of the experimental group. That is, as this process does not include interventions specifically to measure the degree of such a relation, results of both control and experimental groups could equally be combined and used as a complete sample. This would also add credibility to the findings as compared to that obtained if the sample is split between the control and experimental groups for separate investigation.

The impact of the intervention on nurses' knowledge and confidence for those in the experimental group has previously been reported (see sections 4.3, 4.4). It was therefore important to examine the impact of nurses' knowledge and confidence on their performance with regard to their care of leg ulcer patients. One way of examining this was through establishing a relationship between the state of the patient's wound and the nurses' level of knowledge and confidence. In addition to knowledge and confidence, many other patient factors such as obesity could have played a part in determining the state of the wound.

In this study, some of these factors were included despite the sample size limitations and are reported below. However, it should be noted that the relationship between the state of the wound and the explanatory variables mentioned earlier was not expected to be linear. That is to say changes in knowledge and confidence at different stages of the wound's progression are not expected to have the same proportional impact on the state of the wound.
An examination of this issue requires a much larger data set and more technical efforts. However, it is important to point out that a linear approximation of such a relationship, despite its incompleteness, would be of value. In this relationship, an attempt has been made to keep the number of the explanatory variables as small as possible in order to avoid over-parameterisation and produce unreliable results.

As noted earlier, two sets of weighted and un-weighted marks were generated to represent nurses’ knowledge based on the level of difficulty of the questions asked. On that basis, two linear regression models were built at the start of the experiment before the intervention and another two after the intervention including all the available patient factors in each case (model 1: tables 41 - 44). The resulting models are summarised in the following tables.

<table>
<thead>
<tr>
<th>Table 41.</th>
<th>Pre-intervention model 1 with un-weighted knowledge as an explanatory variable</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dependent variable</td>
<td>Wound index</td>
</tr>
<tr>
<td>Constant</td>
<td>44.134</td>
</tr>
<tr>
<td>Knowledge mark</td>
<td>-0.225</td>
</tr>
<tr>
<td>Confidence mark</td>
<td>-0.006</td>
</tr>
<tr>
<td>Age</td>
<td>0.008</td>
</tr>
<tr>
<td>Gender</td>
<td>-4.0</td>
</tr>
<tr>
<td>Mobility</td>
<td>0.86</td>
</tr>
<tr>
<td>Obesity</td>
<td>9.013</td>
</tr>
<tr>
<td>Previous ulceration</td>
<td>-0.676</td>
</tr>
<tr>
<td>Diabetes</td>
<td>6.372</td>
</tr>
<tr>
<td>Arthritis</td>
<td>-1.021</td>
</tr>
<tr>
<td>R (Regression factor)</td>
<td>0.414</td>
</tr>
<tr>
<td>Significance (ANOVA)</td>
<td>0.805</td>
</tr>
</tbody>
</table>

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CHAPTER FOUR.

RESULTS

Table 42. Pre-intervention model 1 with weighted knowledge as an explanatory variable

<table>
<thead>
<tr>
<th>Dependent variable</th>
<th>Wound index</th>
<th>Coefficients</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Constant</td>
<td></td>
<td>50.825</td>
<td>0.101</td>
</tr>
<tr>
<td>Weighted Knowledge mark</td>
<td></td>
<td>-0.328</td>
<td>0.112</td>
</tr>
<tr>
<td>Confidence mark</td>
<td></td>
<td>-0.004</td>
<td>0.986</td>
</tr>
<tr>
<td>Age</td>
<td></td>
<td>-0.006</td>
<td>0.747</td>
</tr>
<tr>
<td>Gender</td>
<td></td>
<td>-2.5</td>
<td>0.53</td>
</tr>
<tr>
<td>Mobility</td>
<td></td>
<td>-1.661</td>
<td>0.454</td>
</tr>
<tr>
<td>Obesity</td>
<td></td>
<td>2.72</td>
<td>0.533</td>
</tr>
<tr>
<td>Previous ulceration</td>
<td></td>
<td>-0.015</td>
<td>0.998</td>
</tr>
<tr>
<td>Diabetes</td>
<td></td>
<td>-1.99</td>
<td>0.786</td>
</tr>
<tr>
<td>Arthritis</td>
<td></td>
<td>0.315</td>
<td>0.925</td>
</tr>
<tr>
<td>R (Regression factor)</td>
<td></td>
<td>0.468</td>
<td></td>
</tr>
<tr>
<td>Significance (ANOVA)</td>
<td></td>
<td>0.637</td>
<td></td>
</tr>
</tbody>
</table>

For the results reported in tables 41 and 42 to have a strong degree of credibility, the value of R (Regression factor) should be close to 1 and the ANOVA significance should be less than or equal to 0.05. In addition to those conditions, the explanatory variable’s p-value should be less than or equal to 0.05 to indicate 95% confidence. Whilst the R factor does not reach 1, the explanatory variable becomes significant in one model ($p=0.036$) (see table 48).

In addition to the possible reasons discussed regarding the unreliability of such a model and the over parameterisation, it is interesting to note that each of the factors of knowledge, confidence, gender and obesity have their signs persistently logical in both models. That is to say, for example, the coefficient of knowledge is negative but not significant, indicating that as knowledge increases the wound index decreases, confirming a negative relation between knowledge and the state of the wound. In this, it must be remembered that the higher the wound index, the worse the state of the wound.
Furthermore, for knowledge, the significance is in one case, 0.295 (table 41) and in the other is 0.112 (table 42), which are consistently lower than the significance of the patient factors excluding obesity in one of the models. The following tables include the model summaries for post-intervention.

**Table 43. Post-intervention model 1 with un-weighted knowledge as an explanatory variable**

<table>
<thead>
<tr>
<th>Dependent variable</th>
<th>Wound index</th>
<th>Coefficients</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Constant</td>
<td>39.56</td>
<td>0.211</td>
<td></td>
</tr>
<tr>
<td>Knowledge mark</td>
<td>-0.189</td>
<td>0.289</td>
<td></td>
</tr>
<tr>
<td>Confidence mark</td>
<td>-0.004</td>
<td>0.88</td>
<td></td>
</tr>
<tr>
<td>Age</td>
<td>0.006</td>
<td>0.743</td>
<td></td>
</tr>
<tr>
<td>Gender</td>
<td>-3.82</td>
<td>0.434</td>
<td></td>
</tr>
<tr>
<td>Mobility</td>
<td>0.238</td>
<td>0.927</td>
<td></td>
</tr>
<tr>
<td>Obesity</td>
<td>8.69</td>
<td>0.083</td>
<td></td>
</tr>
<tr>
<td>Previous ulceration</td>
<td>-0.64</td>
<td>0.907</td>
<td></td>
</tr>
<tr>
<td>Diabetes</td>
<td>6.265</td>
<td>0.471</td>
<td></td>
</tr>
<tr>
<td>Arthritis</td>
<td>-1.016</td>
<td>0.801</td>
<td></td>
</tr>
<tr>
<td>R (Regression factor)</td>
<td>0.414</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Significance (ANOVA)</td>
<td>0.805</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Table 44. Post-intervention model 1 with weighted knowledge as an explanatory variable**

<table>
<thead>
<tr>
<th>Dependent variable</th>
<th>Wound index</th>
<th>Coefficients</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Constant</td>
<td>48.79</td>
<td>0.08</td>
<td></td>
</tr>
<tr>
<td>Weighted Knowledge mark</td>
<td>-0.329</td>
<td>0.054</td>
<td></td>
</tr>
<tr>
<td>Confidence mark</td>
<td>-0.007</td>
<td>0.972</td>
<td></td>
</tr>
<tr>
<td>Age</td>
<td>-0.007</td>
<td>0.697</td>
<td></td>
</tr>
<tr>
<td>Gender</td>
<td>-2.379</td>
<td>0.54</td>
<td></td>
</tr>
<tr>
<td>Mobility</td>
<td>-2.051</td>
<td>0.351</td>
<td></td>
</tr>
<tr>
<td>Obesity</td>
<td>2.096</td>
<td>0.623</td>
<td></td>
</tr>
<tr>
<td>Previous ulceration</td>
<td>0.557</td>
<td>0.909</td>
<td></td>
</tr>
<tr>
<td>Diabetes</td>
<td>-1.686</td>
<td>0.812</td>
<td></td>
</tr>
<tr>
<td>Arthritis</td>
<td>0.241</td>
<td>0.941</td>
<td></td>
</tr>
<tr>
<td>R (Regression factor)</td>
<td>0.506</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Significance (ANOVA)</td>
<td>0.496</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
In addition to their insignificance in the relation, some of the factors signs alternated between different models. In an attempt to increase the reliability of the developed models, the insignificant factors that displayed inconsistencies in the relationships between models were excluded. Therefore, knowledge, confidence, gender and obesity remained as explanatory variables. This was performed using the SPSS 'Enter' mode for regression in order to keep the parameters that were insignificant at 95% while their coefficient remained consistently within logic. That is, their relation with the SWI can logically be explained. Their respective $p$-values indicate that the alpha-level for a forward or backward regression model, would keep them within the selected model parameters. For example, the corresponding $p$-value for knowledge is $p=0.254$. This indicated that if an alpha value of 0.255 was selected, a forward regression model would select knowledge as one of its explanatory variables. A further four models (model 2: tables 45 - 48) were built to replace the four models developed previously. These are summarised below:

<table>
<thead>
<tr>
<th>Dependent variable</th>
<th>Wound index</th>
<th>Coefficients</th>
<th>$p$-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Constant</td>
<td>47.07</td>
<td></td>
<td>0.034</td>
</tr>
<tr>
<td>Knowledge mark</td>
<td>-0.216</td>
<td>0.254</td>
<td></td>
</tr>
<tr>
<td>Confidence mark</td>
<td>-0.0024</td>
<td>0.905</td>
<td></td>
</tr>
<tr>
<td>Gender</td>
<td>-3.96</td>
<td>0.33</td>
<td></td>
</tr>
<tr>
<td>Obesity</td>
<td>7.03</td>
<td>0.064</td>
<td></td>
</tr>
<tr>
<td>R (Regression factor)</td>
<td>0.384</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Significance (ANOVA)</td>
<td>0.294</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

In table 45 the R value is only slightly improved compared with the previous pre-intervention model using un-weighted knowledge as an explanatory variable (see table 41) but the ANOVA significance has improved more so and obesity is nearer to 0.05.
### Table 46. Pre-intervention model 2 with weighted knowledge as an explanatory variable

<table>
<thead>
<tr>
<th>Dependent variable</th>
<th>Wound index</th>
<th>Coefficients</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Constant</td>
<td>42.89</td>
<td></td>
<td>0.023</td>
</tr>
<tr>
<td>Weighted Knowledge mark</td>
<td>-0.299</td>
<td></td>
<td>0.07</td>
</tr>
<tr>
<td>Confidence mark</td>
<td>-0.0015</td>
<td></td>
<td>0.935</td>
</tr>
<tr>
<td>Gender</td>
<td>-2.899</td>
<td></td>
<td>0.401</td>
</tr>
<tr>
<td>Obesity</td>
<td>4.555</td>
<td></td>
<td>0.16</td>
</tr>
<tr>
<td>R (Regression factor)</td>
<td>0.444</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Significance (ANOVA)</td>
<td>0.147</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

There is a reasonable degree of consistency between knowledge and confidence co-efficients in both pre-intervention models using weighted knowledge as an explanatory variable (see tables 42 and 46) but the significance for knowledge ($p=0.07$) means that model 2 is a more reliable Regression model. However, obesity is not significant in the latter model.

### Table 47. Post-intervention model 2 with un-weighted knowledge as an explanatory variable

<table>
<thead>
<tr>
<th>Dependent variable</th>
<th>Wound index</th>
<th>Coefficients</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Constant</td>
<td>42.153</td>
<td></td>
<td>0.032</td>
</tr>
<tr>
<td>Knowledge mark</td>
<td>-0.181</td>
<td></td>
<td>0.254</td>
</tr>
<tr>
<td>Confidence mark</td>
<td>-0.0017</td>
<td></td>
<td>0.933</td>
</tr>
<tr>
<td>Gender</td>
<td>-3.913</td>
<td></td>
<td>0.335</td>
</tr>
<tr>
<td>Obesity</td>
<td>7.056</td>
<td></td>
<td>0.063</td>
</tr>
<tr>
<td>R (Regression factor)</td>
<td>0.384</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Significance (ANOVA)</td>
<td>0.294</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

There is also a reasonable degree of consistency between knowledge and confidence co-efficients in both post-intervention models using un-weighted knowledge as an explanatory variable (see tables 43 and 47 above) but knowledge is not significant. Obesity is close to significance ($p=0.063$) at the 0.05 $p$ value and ANOVA significance is also closer to significance (see table 47) compared with the previous model (see table 43).
Table 48. Post-intervention model 2 with weighted knowledge as an explanatory variable

<table>
<thead>
<tr>
<th>Dependent variable</th>
<th>Wound index</th>
<th>Coefficients</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Constant</td>
<td>40.778</td>
<td>0.018</td>
<td></td>
</tr>
<tr>
<td>Weighted Knowledge mark</td>
<td>-0.289</td>
<td>0.036</td>
<td></td>
</tr>
<tr>
<td>Confidence mark</td>
<td>-0.0033</td>
<td>0.854</td>
<td></td>
</tr>
<tr>
<td>Gender</td>
<td>-2.696</td>
<td>0.425</td>
<td></td>
</tr>
<tr>
<td>Obesity</td>
<td>4.261</td>
<td>0.181</td>
<td></td>
</tr>
<tr>
<td>R (Regression factor)</td>
<td>0.476</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Significance (ANOVA)</td>
<td>0.093</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

From an examination of the two values relating to the validity of the regression models, it can be seen that the latter models have improved in a way that the model reported in table 48 has reached near significance (more than 93% significant). The fact that the models have marginally changed between pre and post-intervention stages of the experiment, is a confirmation that as the wounds have progressed, the linear relation has changed its slope indicating non-linearity. This is an interesting argument and deserves further investigation as new and additional data become available.

In order to clarify the formulations that are presented in the previous tables, the explicit model summarised in table 46 (pre-intervention) and table 48 (post-intervention) using weighted knowledge, are written below:

Pre Wound Index:
42.89−0.299*(Pre weighted knowledge mark (pre WK))− 0.0015*(Pre confidence mark (pre C))
−2.899*(Gender: 0=female, 1=male) + 4.555*(Obesity: 0=not obese, 1=obese)

Post Wound Index:
40.778−0.289*(Post weighted knowledge mark (post WK))− 0.0033*(Post confidence mark (post C))
−2.696*(Gender: 0=female, 1=male) + 4.261*(Obesity: 0=not obese, 1=obese)
Although some of the above explanatory variables are not significant in the existing models, this is expected to change for a larger sample and hence kept in the expressions for future arguments.

The following line chart, figure 31, shows combinations of the calculated (red lines), predicted (blue lines) and upper and lower confidence limits within 95% (black lines) wound indices for pre-intervention. The graph is included for a simple visual assessment of the predictive model. It highlights lack of prediction with regard to a number of wounds like wounds number six and number eight stimulating discussion as well as the closeness of the predicted and observed state of the wound in the majority of the cases. Both the predicted and calculated indices fall within 95% confidence intervals. However, the confidence interval is wide due to sample size restrictions. Each point on the vertical lines represents one wound, each wound having four values: upper and lower confidence limits, predicted and calculated indices. As a feature of normal distribution, values are not restricted to being positive, therefore, some of the lower 95% values fall below 0. Note that 35 of the 38 wounds are displayed as in three cases, wounds 19, 36 and 38, the exact wound duration was not known.
It can be observed that in some cases the pre-intervention predicted indices were very similar to the calculated indices, for example images 7, 10, 13 and 33 whilst in others they were very different, underestimating the index such as in images 6, 8 and 25 or overestimating it, as in images 11, 26 and 28 (see figure 31). A much larger data set may have produced more comparable predicted indices.

Figure 32 presents the post-intervention wound indices.
Post-intervention, predicted indices remained similar to the calculated indices for images 10 and 33 and in addition images 6, 30, and 34. The predicted indices for images 8 and 25 continued to underestimate the calculated indices and those for images 11, 26 and 28 also remained an overestimation. However, in the majority (n=31) of the 35 cases the predicted indices mirrored the same direction of change in wound status as the calculated indices.

The most poorly predicted pre-intervention indices were for images 6, 8 and 11 and post-intervention images 8, 21 and 32 (see table 49).
Table 49. Most poorly predicted pre and post-intervention wound indices

<table>
<thead>
<tr>
<th></th>
<th>Calculated Index</th>
<th>Predicted Index</th>
<th>Difference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Image 6 Pre-intervention</td>
<td>51.7</td>
<td>28.8</td>
<td>22.9</td>
</tr>
<tr>
<td>Image 8 Pre-intervention</td>
<td>56.8</td>
<td>34.2</td>
<td>22.6</td>
</tr>
<tr>
<td>Image 11 Pre-intervention</td>
<td>16.2</td>
<td>36.3</td>
<td>20.1</td>
</tr>
<tr>
<td>Image 8 Post-intervention</td>
<td>36.8</td>
<td>22.9</td>
<td>13.9</td>
</tr>
<tr>
<td>Image 21 Post-intervention</td>
<td>41.2</td>
<td>26.1</td>
<td>15.1</td>
</tr>
<tr>
<td>Image 32 Post-intervention</td>
<td>16.6</td>
<td>29.6</td>
<td>13</td>
</tr>
</tbody>
</table>

Examples of these wounds are presented in figures 33 and 34 for consideration as to the poor agreement between the calculated and predicted indices.

Figure 33. Pre-intervention wound image 6
It can be seen that both wounds are complex and the intricacy of each wound factor may not have been reflected in the predicted indices. It is also possible that some unknown wound and patient variables have been overlooked in the generation of the index tool. Figure 35 examines the relationship between the pre and post-intervention calculated indices.
Results

Pre and post-intervention calculated indices

It can be observed that four wounds deteriorated post-intervention: images 1, 2, 16 and 21. The largest deterioration was 3.7 corresponding to wound image 16 and between 0.73 and 1.13 for the remaining images. In order to explain the deterioration in wound indices, pre and post-intervention images for wound images 16 and 2 are examined in combination with patient factors (figures 36 – 37a).
As indicated in the line graph, image 16 deteriorated from an index of 28.4 to 32.1 post-intervention. On examination of its wound factors, an increase (deterioration) was observed for oedema, colour (yellow) and tissues within the wound (slough) which are reflected in the images. It is interesting to note that the wound reduced in area measurement (improved), emphasising the point that using single wound factors can be misleading. In addition, the patient factors for this image were examined for their impact on the state of the wound. The patient (wound image 16) had become increasingly ill during the intervention period and a new illness had been diagnosed. The patient had also had two digits amputated on the same limb as the ulcer following a fall within this period.
Image 2 deteriorated from an index of 29 to 30.1 post-intervention. In this case wound factors increased (deteriorated) for exudate, colour (yellow), tissues within the wound (slough), ulcer edge (punched out, sloping) and surrounding skin (scaly/flaky, eczema). Conversely, again the area measurement decreased. With regard to patient factors, no changes could be observed. Nurses considered this patient as being non-compliant with treatment, although the above images reflect a deterioration in the state of the wound. It is possible that treatment was inappropriate, incorrectly applied or that the patient had not been educated about their leg ulcer care.
4.7 Summary of Results

In this study the impact of tele-advice on nurses' management of leg ulcers was investigated using a knowledge questionnaire and an attitudinal scale to measure confidence. Nurses were stratified into experimental or control groups based on their nursing qualifications in order to obtain unbiased results. Patients were placed into experimental or control groups according to community nurse grouping and the majority of relevant patient factors were found to be comparable for the two groups.

Statistical tests showed that questions in the knowledge tool were evenly distributed between themes and levels of difficulty and that no significant difference existed for knowledge levels between the two groups (experimental and control) prior to the intervention. Unsurprisingly, results showed that nurses' knowledge of wound physiology was poor compared to the other two categories: wound management and dressings. All the average marks increased post intervention for the experimental group indicating an improvement in the general level of knowledge of 2.13%, whilst for the control group, the overall average mark declined post intervention by 0.22%.

The attitudinal scale was used in order to produce a meaningful single number, based on expert rating, that described individual nurses' confidence towards their wound care practice. As confidence is a behaviour that requires considerable time to acquire, a large increase in the level of community nurses' individual confidence over the 12 week intervention period was not anticipated.
The average mean differences in pre and post-intervention scores was examined for all ten confidence statements but did not reach significance for either group (experimental $p=0.11$, control $p=0.54$). However, a large increase in confidence scores was not anticipated as confidence is a behaviour that takes considerable time to build on.

Visual wound factors which were tele-transmittable were used to design an assessment tool that provided a reliable representation of the state of the wound, the state of the wound index (SWI). A small panel of experts provided minimum and maximum values for each wound factor for the wounds in the study, which were then used to generate a set of virtual nurse responses (VNR). The VNR were combined with area measurement to provide a numerical value – the SWI for each wound. Experienced wound care nurses (panel B) also rated each wound factor using VAS (see chapter 3, section 3.5.4). Little consensus was achieved amongst the nurses and responses differed widely from the VNR.

Linear regression models were built to examine the relationship between knowledge, confidence and the state of the wound and a reasonable degree of consistency between coefficients observed and a formula generated from the models. In conjunction with individual nurses' known knowledge and confidence scores and the patients' gender and obesity status, the formula was used to predict the SWI. In the majority of cases the predicted indices mirrored the calculated indices in the direction of change in wound status.
5.1 The Hypotheses

This study aimed to validate three null hypotheses as they are discussed below:

**Hypothesis 1:** Expert tele-advice has no significant impact on nurses’ knowledge and confidence levels in the care of leg ulcers.

**Hypothesis 2:** Nurses’ knowledge and confidence levels do not play a significant role in the improvement of leg ulcers.

**Hypothesis 3:** No significant relation between the state of the leg ulcer wound, patient factors and nurses’ knowledge and confidence levels for the care of the wound could be established.

In the experimental group, nurses’ marks for overall knowledge increased significantly ($p=0.02$) and marks for levels of difficulty and themes, reached near significance for most categories (see chapter 4, section 4.3). In comparison, the control group showed small, insignificant increases for easy and medium levelled questions, whilst marks for difficult questions ($p=0.0006$) and the overall weighted average ($p=0.08$) deteriorated significantly. With the exception of the small increase observed for wound dressing questions, all the categories deteriorated insignificantly. In addition, the experimental group indicated a narrow range in post-intervention responses, whilst the control group showed a wide variation. Improvement in the level of confidence was not as apparent as that of knowledge, as it was argued that this would require more time than the life of the conducted experiment. Therefore, the findings from this study reject hypothesis 1.
Linear regression models using weighted and un-weighted knowledge marks as explanatory variables were built to establish a relationship between the state of the wound and nurses' knowledge and confidence levels pre and post-intervention. Despite weak significances in these relationships, due to sample size limitations and possible disparities between the wounds, coefficients for knowledge and confidence showed constantly negative signs, indicating that nurses' knowledge and confidence increased as the wound index decreased (improved). Therefore, hypothesis 2 was also rejected.

Eighteen tele-transmittable wound factors were used in the design of a new tool to visually assess the state of the wound. From visually assessing each factor, a single numerical value, the SWI, was generated to represent the state of the wound. The index ranged from 0 (best possible state) to 100 (worst possible state). The index was seen to reliably increase (worsen) when the wound deteriorated and decrease (improve) as the wound improved, when applied to the wounds in this study. Again, the findings from this study reject hypothesis 3.

In the current study, gaps in wound care knowledge were reflected in the individual scores. Deficits in knowledge were particularly evident for the physiology questions as the overall mean scores for this category, pre and post-intervention, were just over 50% (see chapter 4, section 4.3.2, 4.3.3). Of the knowledge questions with the smallest numbers of overall correct responses, three related to physiology and one to wound management. Each of these three physiology questions asked nurses to identify some aspect of the wound healing process.
One of the three physiology questions (Q10) was categorised as being of medium difficulty and asked nurses about secondary healing in cavity wounds. Venous leg ulcers are rarely deep and highly unlikely to develop a cavity unless other complications or conditions also exist. Therefore, one possible explanation for poor nurse response could have been a lack of experience in caring for cavity wounds such as pressure ulcers.

The remaining two physiology questions of interest (Q22, Q37), were both categorised as difficult and asked nurses to identify issues regarding cells involved in the healing process. Unless nurses had read the literature relating to the physiology of wound healing or had undertaken a wound care course, it was possible that they would have been unable to answer the questions correctly.

Previous studies have also focused on nurse knowledge and confidence in an attempt to address any deficits (Bell 1994, Hayes et al. 1994, Provo et al. 1997, Cox & Bowman 2000, Graham et al. 2001). In a study to test nurses’ knowledge of physiology, Bell (1994) found poor levels of understanding and gave consideration to the fact that some questions may have been too difficult. Pre and post-intervention scores for physiology questions were generally low and therefore, questions may have been too complex for the nurses. However, in the current study, the question with the largest overall increase post-intervention related to physiology. Post-intervention, physiology question scores for the control group deteriorated slightly whilst increasing for the experimental group, but neither change was significant.
A large increase in scores for physiology questions was not expected through the intervention, as discussion with the expert was likely to focus on the more practical elements of wound management and dressing choice.

A basic knowledge of the wound healing process including physiology is necessary to assess, evaluate and determine effective wound care. Studies have reported that nurses have experienced difficulty in applying the principles of physiology to wound healing (Emmott 1992, Bell 1994) and from the low scores it would appear that this remains a problematic area. Inadequate teaching of the biological sciences in pre-registration has been suggested as a possible explanation (Akinsanya 1987, Leonard & Jowett 1990, Courtenay 1991). The current study supported the findings of Gould (1992) in that the amount, content and timing of wound care education in pre-registration nurse training was inadequate and required revision. Gould (1992) found the teaching of the care of pressure ulcers was undertaken in the initial stages of nurse training, rarely updated or revised in any detail and generally considered as a low priority topic. In addition, the prevention of pressure ulcers was the main focus and the treatment of established ulcers was rarely covered, potentially due to the denial of patients developing pressure ulcers in the areas covered in the study.

Nurses who receive insufficient pre-registration training in the biological sciences are unlikely to have the knowledge to provide effective wound care. Post-registration training may also be inconsistent and, to date, there are no mandatory requirements for community nurses to undertake basic training in wound care.
Results suggested that physiology should be addressed more rigorously in pre-registration nurse training and that post-registration training is an equally important but neglected area. Education should not cease once nurses are qualified, but be an ongoing dynamic process in line with current government directives of lifelong learning and clinical supervision (NMC 2002).

Only five questions were answered correctly both pre and post-intervention by nurses in both groups, which all related to wound management questions of easy and medium levels of difficulty. Leg ulcer aspects covered in these questions included: Doppler ultrasound and compression, the percentage of ulcers with venous aetiology, wound infection and healing factors. It was unsurprising that the responses to these questions were correct as the issues addressed were likely to be covered in the community nurses' daily practice and would involve decisions surrounding them. They were also fundamental to leg ulcer care and would probably have been included in nurses' daily discussions regarding patient care and any informal sessions and study days attended.

The largest overall decrease in correct post-intervention responses was observed for a question relating to wound management which was categorised as difficult (Q25). The number of correct pre-intervention responses for this question was also poor (see chapter 4, section 4.3.2). As wound management is considered to be the domain of the community nurse and a large part of the nurses' workload (White 1999), the deterioration of scores is concerning.
However, when the actual question is examined:

"What is the estimated actual cost of leg ulcer treatment to the NHS"

the implications of an incorrect response would reflect more on resource planning than clinical practice. In addition, estimates surrounding the cost of treatment vary according to the literature. Therefore, unsurprisingly nurses’ responses were also varied.

Arguably, one question relating to a wound management question of medium difficulty (Q33), reflected concern in clinical practice if answered incorrectly. The question asked nurses at which ABPI they would apply compression bandaging to a leg ulcer. Disappointingly, five nurses gave no response and one answered the question incorrectly pre-intervention and two nurses gave no response and three answered it incorrectly post-intervention. One nurse repeatedly gave no response, one gave no response and then gave an incorrect answer and one nurse gave two different incorrect responses, both pre and post-intervention. Post-intervention, the latter nurse indicated that he/she would apply compression bandaging to a leg ulcer with an ABPI of 0.2.

This is concerning given that Doppler readings below 0.9 are considered indicative of some degree of arterial disease and the lower the ABPI the worse the arterial insufficiency (Brown 2001). A patient with a Doppler reading of 0.2 would most likely be in considerable pain, having clinically significant arterial disease. The affected leg would present as a cold, white, hairless, shiny limb that would require immediate referral to a vascular specialist.
It must be noted that clinical observation is as equally important as Doppler readings. Bradley (2001) pointed out that nurses should have an awareness of the incorrect use of compression therapy in order to practice safely. The consequences of incorrectly applying compression therapy to patients with a diminished arterial blood supply is severe and can lead to amputation (Callam et al. 1987, Finnie 2002) and even mortality.

It is possible that nurses answered this question incorrectly in error. Callam et al. (1987) reported that although most community nurses may know that compression therapy is dangerous when applied to limbs with arterial disease, they may not recognise its presence. However, one would assume that the more severe the degree of arterial disease in the limb, the more clinical symptoms would arise and therefore, the more visually obvious it would appear.

It was anticipated that, as community nurses regularly dealing with venous leg ulcers, all respondents would answer this question correctly. Similarly, nurses who gave an incorrect response for a question which asked them to identify the correct blood pressure format for the ABPI (Q3), may have carried out the task efficiently in practice. However, whilst an incorrect calculation could result in an erroneous ABPI reading in clinical practice, this is more likely to occur with two considerably different diastolic readings, which should alert the nurse to any potential problems. The application of compression therapy at an ABPI of 0.2 is hazardous and nurses should be familiar with this. This is a fundamental issue in the consideration of compression therapy and nurses should receive thorough training before applying bandaging and regular updates in their knowledge and skills throughout their careers.
The overall pre and post-intervention means for wound management questions were acceptable (81.3 and 84.9 respectively), but clearly, certain aspects of wound management training such as the safe application of compression therapy, needed to be addressed. Whilst the study by Callam et al. (1987) is dated, results indicated that this lack of recognition is still prevalent in nursing practice.

The more effectively wound management is carried out, the more likely and possibly the faster that healing will take place. The patients in this study had established wounds with a minimum duration of eight months. Therefore, wounds were either problematic or previous treatment had not been appropriate. Due to sample limitations, it was not possible to include ulcers with similar features exclusively, such as duration, size and colour of the tissues in the study and patient factors must be taken into consideration when examining improvement in the ulcer.

Wound dressings are increasingly sophisticated and nurses should be able to select and use them appropriately (Casey 2002). This is especially applicable to community nurses, who often care for the wound and decide on which dressing to use for their patient in isolation. However, gaps in knowledge for wound dressing questions were also apparent. Of the eight dressing questions, overall correct and incorrect responses were equally distributed post-intervention. Interestingly, an improvement in correct responses was observed for mainly questions categorised as difficult whilst the majority of those determined as medium deteriorated (see chapter 4, section 4.3.2).
The observed improvement in difficult wound dressing questions may be explained through an increased awareness of the wound care products nurses were applying in their treatment of leg ulcers as a result of the knowledge questionnaire, especially for nurses in the experimental group who further discussed such issues with the expert.

Three of the eight wound dressing questions had high levels of correct responses, despite decreasing by one correct response post-intervention (Q36, Q38 and Q39). Questions 36 and 38 both related to patient education and asked about the effect of washing on crepe bandages and how to encourage compliance when applying compression. Therefore, it was important that nurses answered these two questions correctly as they have a responsibility to educate the patient in all areas of their care. Washing crepe bandages reduces their elasticity which may diminish their effect on the limb. Many patients wash their bandages and want to use them repeatedly, thinking this will help to save costs for the health service.

Nurses should be educating their patients to wash bandages correctly and emphasising the importance of applying correct sub-bandage pressures if effective compression is to be achieved. Ryan (1996) highlighted the educational sub-role of the CNS as the most prominent area of their work. This component should not be exclusive to specialist nurses and should include patients as well as healthcare professionals.

The decrease in correct responses to a question enquiring about semi-permeable film dressings (Q40), indicated a deficit in nurses' knowledge of dressing application.
However, the use of a brand name such as Opsite or Tegaderm, may have improved responses as nurses may associate with the brand names more so than the generic term.

The variation in nurses' knowledge of wound dressings found in this study may be explained through applying judgement on non-evidence based information such as personal preference or colleagues' choices. From reviewing previous studies it has been suggested that knowledge of wound care, dressings and physiology are inter-linked (Sprecht et al. 1995, Courtenay 1998) and the poor results observed for physiology questions reinforce the theory that a poor knowledge in the principles of wound care and physiology had an impact on the wound dressing questions.

Studies have suggested that nurses obtain their dressing knowledge through peers (Boxer & Maynard 1999). If colleagues have a limited knowledge of dressings and their appropriate application, misinformation leading to ineffective treatment is reinforced amongst the team. Similarly, it has also been reported that nurses gain much of their wound care knowledge through pharmaceutical representatives (Brereton et al. 1998, Hickie et al. 1998, Hallet et al. 2000). The level of representatives' training and knowledge is unknown. Many are former nurses and may be highly skilled in wound care. However, their knowledge is biased towards specific company products and nurses may not receive objective detailed information.

It is of concern that nurses may rely on potentially biased, limited, misinformed or anecdotal information on which to base their treatment decisions.
Ablaza & Fisher (1998) adopted a multidisciplinary approach to wound management using physicians, nurses, enterostomal, occupational and physical therapists, podiatrists, dieticians and home care workers. This is a beneficial option but costly and with potential implications such as the liaison of professionals. In the UK, there is an obvious role for hospital and community pharmacists.

All pharmacists should be able to provide objective, research based information on availability and indications/contra-indications for dressing use. In the one study area, the community pharmacist participated in post-registration nurse and physician teaching and had published widely. However, in this study the pharmacist remained an under exploited healthcare professional. Whilst the pharmacist can provide an important source of wound dressing knowledge, he or she cannot provide the clinical assessment required in wound care.

Marks for questions relating to wound dressings in the control group had a higher mean than for the experimental group at the start of the study, but this was insignificant ($p=0.669$ weighted knowledge mark). However, whilst mean scores improved for both groups post-intervention, the experimental group achieved a higher mean mark, reaching near significance at the value of 0.05 ($p=0.066$) which is reflective of the in-depth discussion with the expert surrounding dressing choice. This was the only theme for the knowledge test in which nurses in the control group improved.
Throughout the study, nurse rating exercises displayed little consensus. This was apparent for the
13 expert nurses (panel F) rating the attitudinal scale statements, although the mode, as a measure
of central tendency, provided consistent results. Only two of the ten statements achieved clearly
homogenous ratings, either all negative (-3 to -1) or positive (+1 to +3) values. The most widely
varied ratings, from extremely negative (-3) to fairly positive (+2), was for a statement relating to
telemedicine and nurse responses may have been indicative of their previous experiences with
technology.

Technological progress in some clinical areas is constrained by financial resources or the
attitudes of senior management. Collins (2001) established a hospital-based telemedicine link,
providing expert advice for nurses caring for patients with leg ulcers using readily available
equipment. The equipment was situated between three hospitals but had not previously been
used. Nurses subjected to situations such as this may feel that the initial outlay of technological
equipment outweighs any potential gain. The level of nurses’ computer literacy and confidence
with technology will also affect their judgement. In some areas nurses are accustomed to fully
computerised systems and their own email account, whilst in others they continue to rely on a
paper-based system.

Similarly, diversity was found amongst the community nurses’ responses, (both agreeing and
disagreeing), for statements in the attitudinal scale in both the experimental and control group.
Statement 5, “A leg ulcer will never heal no matter what treatment I give” was the only
statement that all nurses agreed with the experts (by disagreeing) both pre and post-intervention.
In addition to being extremely negative, this statement could have been interpreted as criticising nursing practice and therefore, it was unlikely that any nurse would have agreed with it. With the exception of one nurse response in the experimental group post-intervention, nurses in both groups agreed with statement 6, “My confidence in dealing with wounds now has improved since I was first registered” both pre and post-intervention. Previous studies have shown that asking nurses about their confidence in their wound care practice directly will produce positive responses (Cox & Bowman 2000, Graham et al. 2001).

Therefore, it was also unsurprising that the majority of nurses agreed to this positive statement, as disagreement may have reflected poorly on practice and the individual’s responsibility to incorporate evidence-based practice (NMC 2002). However, care was taken to reduce social desirability response set bias in the design of the scale through using both positively and negatively worded statements and assuring confidentiality and anonymity.

Interestingly, the one nurse who disagreed with this statement was newly qualified and had commenced employment within the community at the start of the study. It was likely that an inadequate preparation in wound care had not prepared this nurse for community work and had therefore affected the nurse’s confidence level.
For overall confidence levels, the control group deteriorated whilst the experimental group improved. Interestingly, marks for the higher confidence positive levels, +2, +3, either remained the same or increased for the control group but deteriorated for the experimental group (+2 \( p=0.33 \), +3 \( p=0.33 \)). A possible explanation is that discussion with the expert led the nurses to question some aspect of their practice which they may have previously carried out inefficiently. The scores for the control group lead to the assumption that they continued to practice wound management in the same manner, regardless of efficiency.

Previous studies have relied on single factors such as wound area to represent wound progress (Bulstrode et al. 1986, McTaggart 1994, Vowden 1995, Kantor & Margolis 1998, Langemo et al. 1998, Lucas et al. 2002, Øien et al. 2002), which may be misleading. Interestingly, the mean ulcer area in the experimental group, 4.35cm\(^2\), improved by two-thirds, compared to the control group, 1.52cm\(^2\). However, important patient factors such as obesity, age and gender, which may have affected the wound’s healing potential were also considered before reporting that through expert tele-advice, the method of treatment had been effective.

In the design of the assessment tool, it was apparent in this study, that even experienced nurses (panel G) held different wound factors with varying degrees of importance in their ranking. However, the ranking did not differ significantly. This was further reflected amongst wound care nurses who rated wound factors such as inflammation, at both extremes of the VAS, 0 and 100. This emphasised the need for further training, leading to standardisation, in the way in which nurses assess wounds.
Clearly, the skill in which assessment is carried out is dependent on training, which should include thorough patient and wound assessment and evaluation, thus producing comparable results for the same wound amongst practitioners. It was evident from the incorrectly ranked wound assessment factors from two experts in panel G, which were subsequently excluded, and nurses' lack of understanding regarding project information in the introductory letter, that even when the literature was provided, nurses may not have read it.

Insufficient time has been reported as a barrier against nurses implementing research into practice (Kajermo et al. 1998, Parahoo 2000, Retnas 2000, Clifford & Murray 2001, McCaughan et al. 2002, Oranta et al. 2002, Lars et al. 2003), in addition to staff shortages (Parahoo, 2000).

In this study nurses also cited poor staffing levels as an obstacle to attending study day sessions regarding the project. The nurse has a responsibility to deliver care based on best practice and in addition should keep up-to-date with current evidence and research (NMC 2002). However, Flanagan (1998) reported that for many patients with wounds, evidence-based treatment was not being carried out. It is vital that nurses are aware of advances in practice if they are to provide efficient wound care.

Whilst the use of telemedicine in the patients' home is increasing in the United States, few UK studies have used technology in this way or for wound care in the primary setting. However, studies that have reported using technology in wound care required the patient to travel to specialist clinics (Collins 2001, Macduff et al. 2001, Samad et al. 2002, Hayes & Dodds 2003).
Previously, nurses in the study areas had little access to expert wound care advice and therefore, as a result, their patients also had to travel to a designated clinic or hospital. For the more incapacitated, less mobile patients, this was problematic and inconvenient, due to arranging transport and the discomfort experienced. For those who depended on public transport or taxis, the cost may have been prohibitive. Some areas have relied on voluntary transport to transport patients (Stevens et al. 1997) which is dependent on the availability of volunteers and private vehicles and therefore, unreliable. Others have provided free transport (Morison & Moffat 1994, Morrell et al. 1998) which is an additional expense that many trusts could not afford (Carrington 1999) or maintain indefinitely.

The financial benefits of providing expert care through tele-advice are also considerable, not only to the patient but also to the health care provider. Hoffman (1997) found the use of telemedicine to be essential in reducing overheads. In addition to transport costs, clinic and staff costs are greatly reduced when treating the patient in their own home and the patient does not have the inconvenience, cost or discomfort of travelling. The use of good quality digital images to provide tele-advice in this study, combined with nurse discussion with the expert can also assist in reducing unnecessary referrals. Lesions, other than venous leg ulcers requiring subsequent specialist advice such as malignancies, could also be ruled out.
5.2 Linking Knowledge and Confidence with Wound Assessment

The study also aimed to explore the association between nurses’ knowledge and confidence and the state of the wound. It was anticipated that the more knowledgeable and confident the nurse, the lower the resulting index for the wounds they managed, due to more efficient wound management. It was feasible that nurses in the control group had comparable or better levels of knowledge and confidence to those in the experimental group. Therefore, in addition to the larger sample size (control + experimental), combining both groups for this process would produce more reliable results.

As previously discussed, it was interesting to note that even highly skilled and experienced clinicians assessed wounds differently, considering different wound factors to be of utmost importance and rating visual wound factors at VAS extremes. However, a level of consensus would be expected amongst experts in any aspect of nursing. For example, in dealing with an emergency situation such as a cardiac arrest, it would be anticipated that from a list of factors assessing the clinical situation, nurses would rank them in the same way: clearing the airway, checking for breathing and applying chest compression. The wide variation in rankings indicated a disparity in practice and therefore, in educational background. Variation in wound care practice has previously been reported (NHS CRD 1997). While & Rees (1993) found that nurses were able to correctly identify the use of alginate and hydrocolloid dressings whilst, Bux & Malhi (1996) reported a large percentage of hydrocolloid and alginate dressings were used inappropriately.
CHAPTER FIVE

DISCUSSION

The need for consistency in wound care practice and teaching is apparent. Four judges also commented on the difficulty of the task. It must be noted that each wound is unique and often complex. However, clear standardised guidelines for wound assessment would make this exercise more straightforward.

The same expert panel (panel A) that had reviewed the 108 wound factors to produce 20 tele-transmittable factors assessed each wound pre and post-intervention in order to provide minimum and maximum values for each factor. Asking experts to provide a range of values was considered to provide a more reliable estimation than a single specific figure. This expert panel did achieve a consensus for the majority of wound factors. Eleven experienced wound care nurses (panel B) also assessed each wound, but instead of providing a range of values, rated each factor using VAS, thus providing a single point estimate.

In a few cases, mainly more complex wounds, the standard deviation for some minimum and maximum values determined by the expert panel (panel A) was larger than that for the ratings given by the experienced wound care nurses (panel B). Potentially meeting in person, being a small panel and having the opportunity to discuss each factor allowed a consensus to be obtained. Nurses (panel B) rating the wound factors had done so in isolation. However, although the expert panel (panel A) had received different educational experiences, their responses did not vary as widely as those in panel B. This would suggest that the use of a range of figures can provide more reliable results than a specific point.
If the assessment tool is to be adopted in the community setting, consideration should be given to asking nurses to provide such a range of minimum and maximum values rather than a rigid single estimate, thus allowing more flexibility in the assessment process. The diversity of the latter group's responses (panel B) makes it questionable whether they would have reached a narrower range if they had been instructed to provide minimum and maximum values.

The assessment of each factor to provide minimum and maximum values for each wound pre and post-intervention was a time consuming exercise, even for experienced wound care specialists. A total of 1368 assessments were made (see chapter four, section 4.6.2). These assessments were carried out over several sessions in order to maintain equal levels of concentration. As experienced wound care nurses, the panel (panel B) were able to dedicate time within their daily working activities to complete this task, which the community nurses were unable to do due to the requirements of patient care throughout the duration of their shift. The task was also tedious and it was unlikely that inexperienced nurses would have been able to maintain concentration and motivation throughout. As an alternative approach, a VNR set was generated, based on the minimum and maximum values in order to produce pre and post-intervention indices for each wound. This produced a more robust, homogeneous and reliable set of results, avoiding the potential for diversity of scores.

It is interesting to note that in two unsuccessful treatment cases for the control group, where the post-intervention index increased (deteriorated), the patients were regarded as being ‘non-compliant’ with compression therapy.
Non-compliance with treatment has frequently been cited as the main cause for unsuccessful care (Muir Gray 1983). However, it is questionable whether the community nurse had adopted the most suitable treatment regime for the patient and may have required further training to assess the wound adequately, so that, effective treatment could have been prescribed.

As previously discussed, part of the nurse’s role is to educate patients in their care. If a patient is considered ‘non-compliant’ the nursing team may be less motivated to involve the patient as a partner in their care, as is the current philosophy (NHS Plan 2000). The importance of strictly adhering to the nurse’s instructions may not be made clear, especially if the implications are not fully explained. If the patient was empowered with the education and knowledge in understanding more about the relevant treatment advice and the confidence to feel able to play a part in their own ulcer care, compliance may have improved. However, Flanagan (2001) found that community nurses, home carers and patients considered health promotion ineffective. This could be interpreted as the nurse perceiving actual wound treatment to be more important than preventing their development in the first place, as studies have observed with ‘hands on’ care being prioritised over documentation (Meade & Kim 1982, Tapp 1990). Similarly, if the nurse regards health promotion as unimportant, it is likely that their communication with the patient and their carer will be affected. The promotion of health is as equally important as the treatment of the condition. Investing nursing time and energy into caring for the healed ulcer could assist in preventing recurrence, thus ultimately reducing nursing time and resources in the long term.
Whilst the focus of this study was on the nurse, figure 38 displays the link between knowledge and confidence for both the patient and nurse in leg ulcer care. It can be seen that encouraging patient knowledge and confidence in their treatment is beneficial to their care. Kemper et al. (2002) suggested that clinicians lacking knowledge, in this case in CAMs, would be unable to inform their patients of their treatment. If a nurse is unable to answer questions regarding the patient’s treatment, it is likely to cause anxiety. The nurse must possess knowledge and confidence in their patients’ care if they are to instil such attitudes in their patients.

Figure 38. The role of knowledge and confidence for nurses and patients in the care of leg ulcers
Compression therapy is highly effective in healing leg ulcers and is considered to be the gold standard for venous leg ulcer care (Johnson 2002). Patients who do not comply with compression therapy frequently report that it is uncomfortable. This indicates that it has not been applied correctly. Nelson (1996) argued that nurse bandaging techniques were poor. Thus findings in this study would suggest that nurses' knowledge of the science underpinning compression therapy remains sub-optimal, although practical technique cannot be measured through a questionnaire. For example, questions asking nurses to identify the two correct measures to calculate the ABPI (foot and arm systolic) and the main principle of Laplace's law (the pressure on the limb will be greatest at the smallest radius) resulted in a poor number of correct responses both pre and post-intervention (see table 50, appendix XXIII). Regular supervision of training in bandaging techniques is necessary in order to establish and maintain good practice (Nelson et al. 1995, Scanlon 1996), nursing skills, a thorough understanding and remain updated in new techniques.

Bassett (1991) suggested that nurses exhibited little compliance with manufacturers' guidelines for products. For example, manufacturers' may recommend that certain conditions are adhered to when applying their product applications, i.e. ACTISORB* Silver 220 dressings (Johnson & Johnson). This product is an activated charcoal dressing with silver and should not be cut as particles of activated carbon may get into the wound. As well as causing discoloration of the tissues, any foreign matter in the wound may cause infection.
In addition, the manufacturers’ guidelines for the application of Profore, a multi-layer compression bandaging system, clearly stated that the product contained natural rubber latex which may cause allergic reactions. One of the wound indices that deteriorated post-intervention was due to the patient developing an allergic reaction to a component in the treatment product. If the nurse that had applied the treatment had read the manufacturer’s instructions and had been informed of the patient’s allergy, this allergic reaction could have been avoided and a suitable alternative sought. However, the patient had not shown previous signs of allergic reaction to rubber latex, even though the surgical gloves used by nurses when performing wound care contained rubber latex.

In addition to the minimum and maximum ranges for each wound factor provided by the VNR, experienced wound care nurses working in the community rated factors for each wound pre and post-intervention. It was important to see how community nurses responded to this task, as they cared for leg ulcers on a daily basis. As the community nurses had cared for the wounds to be rated, it was possible that they would have recognised their patients’ wounds, biasing their results. Nurses may have unintentionally rated factors more positively (nearer to 0), as the healed wound could have been interpreted as being reflective of their good nursing practice. In addition, the community nurses in the actual study were unable to allocate time specifically for this task.

As in other nurse rating exercises in this study, little consensus was achieved. For the majority of wounds and their accompanying factors, the 11 nurses (panel B) rated them between both VAS extremes, 0 and 100 (see table 39, chapter 4, section 4.6.3).
Again, these findings support the fact that, as the practice of wound assessment was so varied, a formal training programme is necessary. Standardisation of the training programme, in that each educational establishment delivers the same course, would ensure that all nurses assess the wound in the same way.

In the exploration of the association between nurses’ knowledge and confidence and the state of the wound, it was expected that the higher the individual nurse’s knowledge and confidence levels, the more effectively they would manage the wound and therefore, the lower the wound index. In addition, patient factors and their influence on the state of the wound must also be taken into consideration. For example, if a patient is grossly obese their wound will be problematic (Padberg et al. 2003), despite the nurse’s knowledge and confidence levels. In addition to sample limitations, nurses in the control group may possess comparable or higher levels of knowledge and confidence. Therefore, both experimental and control groups were combined and results reported as a whole.

Two sets of linear regression models using both un-weighted and weighted knowledge marks as an explanatory variable were built to establish a relationship between the state of the wound and nurses’ knowledge and confidence levels at pre and post-intervention. One model used all the available patient factors in this study and the other consisted only of those factors that remained consistent and logically sound for both weighted and un-weighted knowledge.
The factors for the second model option, included gender and obesity. It was considered that the inclusion of too many variables, especially with a small sample size, would lead to overparameterisation, confusing the results and rendering them meaningless. The relationship between the state of the wound and knowledge and confidence levels was not expected to be linear as changes in knowledge and confidence would not equate to parallel changes in the state of the wound during different stages of its progress. However, an estimation of this relationship approximated by a linear regression, provided a useful insight into the proportional impact of the various factors considered on the state of the wound. Replication of this exercise with a much larger data set would enable a more reliable relationship to be established.

The first set included models for pre and post-intervention with un-weighted and weighted knowledge marks based on level of difficulty as an explanatory variable and included all the patient factors: age, gender, mobility, obesity, previous ulceration, diabetes and arthritis (see tables 41 – 44, chapter 4, section 4.6.4). Weighted knowledge marks were more representative of actual nurse knowledge as the level of difficulty was accounted for in the marking scheme. The closer the R factor to 1 and the closer the ANOVA significance to 0.0, the stronger the relationship. Whilst in all the models the R factor was 0.506 or lower, in one model the ANOVA significance was near to significance (0.093) and the p value for the explanatory variable, knowledge, was significant at 95% confidence (p=0.036), indicating a reliable and significant relationship between the variables.
In tables 42 and 44 (see chapter 4, section 4.6.4), the co-efficient of mobility was negative which indicated that as mobility increased the wound index decreased (improved) confirming a negative relationship between mobility and the state of the wound. However, in tables 41 and 43 (chapter 4, section 4.6.4), the co-efficient was positive, indicating a positive relationship, as mobility increased or decreased so did the wound index. Therefore, this model indicated that as mobility decreased or worsened, the index also decreased or improved and vice versa, which was not logical. Similarly, other factors displayed the same inconsistency between the factor and the outcome.

As previously discussed, it was possible that too many variables had been included and over-parameterisation had occurred, given the sample size limitations. Therefore, another set of models were created duplicating the previous models but using only the variables which remained consistent in their relationship with the outcome: confidence, gender and obesity, with knowledge as the explanatory variable (see tables 45 to 48, chapter 4, section 4.6.4).

For all but obesity, the coefficients for the remaining three variables, were consistantly negative. This indicated that as knowledge and confidence increased, the index decreased (improved). Gender was recorded as 0 for female and 1 for male and the coefficient was positive indicating that as obesity increased (worsened) so too did the index. The second set of models improved, reaching near ANOVA significance post-intervention for weighted knowledge marks (see table 46, chapter 4, section 4.6.4). In addition, the \( p \) value reached near significance \( (p=0.075, \ p=0.063) \) for obesity in two of the models indicating a more reliable relationship.
The change in pre and post-intervention models indicated an improvement in the wound as the \( p \) value became closer to being 95% significant in the post-intervention models. From the second set of models, specifically the post-intervention model with weighted knowledge as an explanatory variable, a predictive rule was established to predict the wound index from known individual knowledge and confidence scores. In this way, the wound index could be predicted when the values of knowledge, confidence, gender (0 female, 1 male) and obesity (0 not obese, 1 obese) were known. This provided a straightforward formula that could quickly indicate improvement or deterioration in the state of the wound which could also be used to monitor the state of the wound over time. The calculated index was compared with the predicted index for a random sample of wounds (see chapter four, section 4.6.4).

Whilst there was disparity between both the predicted and calculated indices, for the majority of the wounds, the predicted index mirrored that of the calculated in determining improvement and deterioration. As previously discussed, a larger data set would have allowed the predicted index to be further examined and ultimately refined to duplicate the calculated index.
5.3 Summary of Discussion

Statistical tests were performed to confirm that nurses in both the experimental and control groups had similar levels of knowledge and confidence at the start of this study. In this way the impact of expert tele-advice can be demonstrated. Overall average knowledge marks for nurses in the experimental group increased significantly (p=0.02) compared to that of the control group, who deteriorated significantly (p=0.08). With regard to themes within the knowledge test and levels of difficulty, nurses in the experimental group improved in each category, with questions of medium difficulty levels reaching significance (p=0.02) and wound management (p=0.055) and dressings (p=0.06) themes reaching near significance. In the control group a slight, insignificant improvement was observed for questions of easy (p=0.45) and medium (p=0.21) levels and wound dressings (p=0.841). The remaining categories decreased, with physiology questions reaching significance (p=0.0006). In addition, responses for the control group displayed a wide diversity, suggesting more uncertainty in their answers.

Confidence levels were not anticipated to change significantly, as this is a characteristic that takes considerable time to build. These results indicate that the telemedicine consultations regarding leg ulcer patients' and their care benefited nursing knowledge but to a lesser degree as expected, nursing confidence.

From the nurse rating exercises in this study, it has been demonstrated that little consensus was achieved (see chapter 4, section 4.6.3). Therefore, a VNR set was created to produce reliable SWI's for each wound, pre and post-intervention.
The association between nurse knowledge and confidence levels and the SWI was explored, with the assumption that the higher knowledge and confidence levels were, the more efficiently the nurse would manage the wound and therefore, the better (nearer to 0) the SWI. Due to sample limitations and the possibility that nurses in the control group may have possessed comparable or higher levels of knowledge and confidence than those in the experimental group, results for both were considered as a single group for these purposes using linear regression models.

Models were built, using weighted and un-weighted knowledge scores as an explanatory variable and including all patient factors and a selection of these factors, gender and obesity, based on their sign remaining logical for knowledge. A non-linear relationship was anticipated as changes in knowledge and confidence are unlikely to exhibit comparable changes in the wound trajectory, but would provide an understanding of the proportional impact of factors. From these models, a formula was built that could predict the SWI, using known knowledge and confidence scores and values of the two patient factors (gender and obesity). The predicted index was compared with the calculated index. Some disparity was observed but the changes for the majority of the predicted indices were consistently in the same direction as those for the calculated indices (deterioration or improvement). In addition, it was shown that in the cases of higher knowledge and confidence levels, the index was smaller (better).
Chapter Six Conclusions

6.1 Study Conclusions

In this study the impact of tele-advice on nurses' knowledge and confidence levels for the management of leg ulcers was examined. This was performed through the measurement of nurses' knowledge and confidence levels before and after the provision of expert wound care advice. Knowledge, confidence and the state of the wound were examined in order to establish the possibility of expressing the SWI in terms of nurses levels of K and C as well as patient factors.

The study aimed to:

- Develop reliable tools to quantify community nurses' knowledge and confidence in their wound care practice;
- Determine the impact of expert tele-advice on community nurses' knowledge and confidence in the management of leg ulcers;
- Develop a tool to measure the state of the wound from tele-transmittable wound factors;
- Examine the possible link between the state of the wound, community nurses' knowledge and confidence and demographic patient factors;
- Examine the possibility of developing a simple, efficient and cost-effective method of adapting telemedicine for wound care within the patient's home.
The wide variations observed in responses for the wound knowledge test highlighted a gap in nurses' knowledge base about leg ulcers and their treatment, in particular physiology. Confidence levels were found to be lower for statements reflecting mildly and fairly negative and positive confidence, but higher for the extremes. From this work, tele-advice has been shown to be a beneficial method of providing expert care to community nurses, significantly increasing knowledge and improving, but to a lesser extent, confidence levels. This increase in knowledge and confidence is expected to benefit the patient as the nurse will manage the wound more effectively.

The wound assessment tool designed in this study, the SWI, provided an objective method of assessing wound status using tele-transmittable wound factors. In most cases, the predicted indices mirrored that of the calculated indices in reporting the direction of change in the wound. Therefore, once certain factors have been identified, the SWI can be calculated, thus providing a reliable method of determining wound progress.

It was anticipated that the higher the nurses' knowledge and confidence levels, the lower the SWI for the wounds they managed. Therefore, linear regression models were built to investigate the relationship between nurses' knowledge and confidence and the state of the wound. Nurses' knowledge and confidence scores and patient gender and obesity status were found to be reliable explanatory variables in estimating the SWI.
The benefits of expert tele-advice, as used in this study, included the provision of a new way in which nurses could practice efficient wound care, accommodating the fact that many patients would prefer to receive care at home. It has been reported that technology has the potential to spread isolated expert advice over a large area and in this study, one wound care expert was able to provide advice to community nurses in two trusts, covering approximately a 420 mile radius. With the lack of specialist practitioners observed in the study areas, tele-advice provided an efficient platform to fill the gap. Furthermore, the provision of expert advice by a CNS was financially more viable than that of the provision of consultant physicians for different health centres.

Venous leg ulcers present social and economic burdens, especially within the primary care setting. In order to provide appropriate, evidence-based care, nurses need sound knowledge and confidence in their wound practice. The provision of tele-advice has demonstrated a positive impact on the nursing care of leg ulcers.
6.2 Contributions to New Knowledge

The contribution to knowledge produced as a result of this study comprised:

1. **Demonstration of the successful use of technology in providing expert advice in wound care through tele-advice.**

   The provision of expert tele-advice resulted in a significant improvement in nurses' knowledge and, to a lesser extent, confidence.

2. **A new tool to visually represent the state of the wound, the SWI.**

   Eighteen identified tele-transmittable wound factors were identified and used to design a new tool that objectively evaluated wound status.

3. **The design of a new tool to measure nursing confidence in wound care practice.**

   Ten statements were generated to reflect nurse confidence in wound care, from extremely negative to extremely positive pre and post-intervention.

4. **The adaptation of an existing questionnaire to measure nursing knowledge in wound care practice.**

   From an established tool, 40 multiple-choice questions representing wound care themes and differing levels of difficulty were adapted to measure knowledge pre and post-intervention.
5. **The successful demonstration of the relationship between nursing knowledge, confidence and the state of the wound.**

   From the building of regression models, nurses’ knowledge and confidence scores and patient gender and obesity status were found to be reliable explanatory variables.

6. **A new means of creating objective values –VNR.**

   Through a range of values provided by experts, 100 virtual nurse responses were generated in SPSS. The VNR established a mean for wound factors for each wound pre and post-intervention.
Chapter 7  Recommendations and Limitations

7.1  Recommendations

There is great potential for the provision of tele-advice in the management of leg ulcers by community nurses. For this to be successful there is the need to:

- Improve nurses' knowledge of wounds, specifically in terms of physiology. Increased knowledge and skills will assist in increasing confidence levels and reflective practice. This could be achieved through pre and post-registration training and supervisory sessions to update clinical skills, in line with the NMC (2002) directives of lifelong learning. Comprehensive wound management modules should be included within the nursing curriculum.

- Provide further nurse training in developing their ability to assess wounds visually to give a more robust evaluation and monitoring of wound progress.

- Provide continuous training and a programme of dissemination of new and relevant research and information to keep nurses' up to date in the assessment, monitoring and management of leg ulcers.
7.2 Limitations

The project initially sought to recruit the population of community nurses within two local health care trusts. From a population of 174 community nurses, a final sample of 38 agreed to participate and were recruited. As this is a relatively small sample caution is needed in generalising these results to the population as a whole.

Given a larger sample; a stricter classification within the inclusion/exclusion criteria could have been followed within which different levels of variability could have been better represented. For example, different age groups, wounds at different stages of their progress and recurring wounds. The possible non-linearity between the SWI and knowledge and confidence could have been investigated further leading to a more reliable and objective association between the wound factors.
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APPENDICES
In normal venous return (see figure 39) blood drains from the tissues into the superficial veins at low pressure, passes through the valves into the perforator veins and into the deep veins where the calf muscle pump increases the pressure. The pump action forces the blood upwards through the valves at the back of the knee to the heart. The deep veins can take the increased pressure because they are supported by the calf muscle, whereas the superficial veins do not have such support.

Venous return can be compromised in several ways (see figure 39a). Loss of ankle movement will reduce the power for the calf muscle pump. This can be due to trauma or disease, such as arthritis. Damage to the valves can occur through general wear and tear or a thrombus (clot) physically damaging the valve. The valves located below the damaged valve have to take greater pressures and may also fail in time. Eventually, the higher pressure blood leaks into the superficial veins which are not designed to take such high pressures and they become distended.
This high pressure continues to the capillaries giving rise to leakage of proteins and haemosiderin. Incompetent valves of the deep or perforating veins are more commonly present in venous ulceration but the superficial veins may also be involved. The more extensive and the more distal the reflux, the greater the probability that an ulcer will form (Bjørdal 1988).
APPENDIX II
**Fibrin Cuff Theory**

Browse and Burnard (1982) first proposed the fibrin cuff hypothesis as an explanation for the cause of venous ulceration. When venous pressure increases, the permeability of the capillaries increase and large molecules, such as fibrinogen, escape into the surrounding interstitial tissue. The fibrinogen breaks down into fibrin forming a peri-capillary cuff inhibiting the passage of oxygen and nutrients. This leads to cell death and resulting ulceration.

**White Cell Hypothesis**

Coleridge Smith *et al.* (1988) suggest the white cell hypothesis as a cause of venous ulceration. In opposition to Browse and Burnard (1982) this theory proposed that an increase in venous pressure, through standing or walking, reduces capillary flow rate. As a result of this reduced flow, white cells are trapped which then clog the capillaries. Areas of ischaemia occur around the capillary loops which attract substances that damage the capillaries and attract further white cells.

**Trap Hypothesis**

Falanga & Eagelstein (1993) proposed that as a result of venous hypertension, fibrin and other macromolecules leak into the dermis “trapping” growth factors and matrix material which then become unavailable for tissue repair and for the maintenance of tissue integrity.

Debate still surrounds these hypotheses and further studies are needed to support or oppose these theories.
Arterial Leg Ulceration

Atherosclerosis is a process in which fatty substances, especially cholesterol and triglycerides are deposited in the walls (tunica intima) of medium-sized and large arteries in response to certain stimuli (Tortora & Anagnostakos 1990) (see figure 40). Fatty streaks are common in the artery wall and in the absence of damaging influences such as high cholesterol, carbon monoxide (cigarette smoking), hypertension and diabetes, do not accumulate and disperse.

Figure 40. Diagrammatic representation of atheromatous plaque within an artery. MedWeb 2002. 
In atherosclerosis these fatty masses form plaques or atheroma. This gradually leads to the vessel lumen narrowing and occluding arterial blood flow restricting the delivery of oxygen and nutrients to the tissues which can result in hypoxia and necrosis.

Figure 41 shows a normal coronary artery, with a patent lumen that can provide adequate blood to the myocardium. In figure 41a the artery has severe atherosclerosis and the lumen is greatly decreased in circumference, thus reducing the blood flow.

Arterial ulcers are considered more prevalent in smokers, diabetics and those suffering from hypertension (Phillips & Dover 1991). Some studies suggest that arterial disease is more common in males but provide no supporting evidence (Phillips & Dover 1991, Verhage 1998).
As previously mentioned in the aetiology of venous ulceration, there is an increased risk of atherosclerosis in the diabetic patient and patients with rheumatoid arthritis, due to the associated macro and microvascular disease. Less common causes of arterial ulceration are emboli (which can consist of blood clot, air bubble, fat, or pieces of debris), Thromboangitis obliterans and Raynaud’s disease.
Bandages can be classified into 3 main classes (Eagle 2001):

**Class 1**
Conforming/retention lightweight stretch. Used to keep dressings in place.

**Class 2**
Light support for joints. Limits oedema.

**Class 3**
Compression.

Compression bandages are then further categorised according to the degree of compression they produce at the ankle (Thomas 1990, Cullum & Roe 1995, Nelson *et al.* 1996, Simon 1996, Eagle 2001):

**Class 3a**
Light compression (14 – 17 mmHg). Used for the management of superficial or early varices, varicose veins formed during pregnancy. Not generally suitable for controlling or reducing existing oedema.

**Class 3b**
Moderate compression (18 – 24 mmHg). Used for the treatment of varicose veins during pregnancy, varices of medium severity, control of mild oedema, prevention and treatment of venous leg ulcers.

**Class 3c**
High compression (24 – 35 mmHg). Used for control of gross varices, post-thrombotic venous insufficiency, management of venous leg ulcers and gross oedema in limbs of 'average' circumference.

**Class 3d**
Extra high compression (up to 60 mmHg). Used for oedematous legs for extended periods of time.

In addition to these classifications bandages may be applied in:

- multiple-layers [usually a wool padding layer to protect the limb, one or two layers to apply compression and a crepe layer to hold the bandages in place],
- long stretch [a single layer] to achieve high compression,
- short-stretch bandage [a single layer] to achieve low resting pressure but high pressure during activity.
- Electrical stimulation  
  (Vicktor & Schultz-Ehrenburg 2000)
- Enzymatic and chemical debridement  
  (Wayman et al. 2000, Thomas & Jones 2001)
- Fibrinolytic therapy  
  (Zeegelaar et al. 1997, Valencia et al. 2001)
- Growth factors  
  (Valencia et al. 2001)
- Hyperbaric oxygen therapy  
  (Hammarlund & Sundberg 1994)
- Laser therapy  
  (Ashford et al. 1999)
- Punch-skin grafting  
  (Phillips 1999)
- Skin grafts  
  (Kirsner et al. 1997, Ruffieux et al. 1997)
- Surgery  
  (Loftus 2001)
- Ultrasound therapy  
  (Flemming & Cullum 2000)
- Unna’s boot  
  (Cullum et al. 2001)
- Vasoactive drugs  
  (Roelens 1989, Janssen et al. 1989)
- Wound dressings  
  (Falanga 1999)
APPENDIX VI
### Rationale for use of wound dressings

<table>
<thead>
<tr>
<th>Wound Type</th>
<th>Nursing Actions</th>
<th>Example of dressing</th>
</tr>
</thead>
<tbody>
<tr>
<td>NECROTIC</td>
<td>Necrotic tissue needs to be debrided before new tissue can form.</td>
<td>Hydrogel e.g. <em>Intrasite Gel</em>, <em>Granugel</em></td>
</tr>
<tr>
<td>SLOUGHY</td>
<td>Sloughy tissue needs to be removed before healing can progress. It may also encourage infection.</td>
<td>Alginate e.g. <em>Sorbsan</em>, <em>Kaltostat</em></td>
</tr>
<tr>
<td>GRANULATING</td>
<td>Granulation tissue is fragile and needs to be kept moist to allow migration of epithelialising cells.</td>
<td>Hydrocolloid e.g. <em>Granuflex</em>, <em>Comfeel</em></td>
</tr>
<tr>
<td>EPITHELIALISING</td>
<td>Epithelial tissue is delicate and needs to be kept moist and protected.</td>
<td>Film e.g. <em>Opsite</em>, <em>Tegaderm</em></td>
</tr>
<tr>
<td>INFECTED</td>
<td>Establish infection – local or systemic then treat appropriately. Dressings may need to be odour absorbent and deal with exudate.</td>
<td>Foam e.g. <em>Lyofoam</em>, <em>Allevyn</em></td>
</tr>
</tbody>
</table>

The National Institute for Clinical Excellence (NICE) have developed guidance on many aspects of wound care such as ‘Guidance on the use of debriding agents for difficult to heal surgical wounds’ (NICE 2001/14). A new guideline ‘Clinical guidance on woundcare management, including the prevention of skin breakdown’ is part of a suite of guidelines and is currently under development.
<table>
<thead>
<tr>
<th>Title</th>
<th>Author</th>
<th>Year</th>
<th>Design</th>
<th>Sample Size</th>
<th>Hospital</th>
<th>Hospital and Community</th>
<th>Not Known</th>
<th>Not Known</th>
<th>Not Known</th>
<th>Hospital and Community</th>
<th>Pressure ulcer management</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pit study</td>
<td>Hospital</td>
<td>Not known</td>
<td>Not known</td>
<td>Not known</td>
<td>Hospital and Community</td>
<td>Pressure ulcer management</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Wound care group</td>
<td>Hospital and Community</td>
<td>Not known</td>
<td>Not known</td>
<td>Not known</td>
<td>Hospital and Community</td>
<td>Pressure ulcer management</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Notes:**
- **Pit study:** This column indicates the type of study or methodology used.
- **Hospital:** Refers to the setting where the study was conducted, either in a hospital or hospital and community setting.
- **Pressure ulcer management:** Indicates the focus of the study on pressure ulcer management.
**Bloom *et al.* (1956) Taxonomy of the Cognitive Domain**

The taxonomy is presented below with sample verbs and a sample behaviour statement for each level.

<table>
<thead>
<tr>
<th>LEVEL</th>
<th>DEFINITION</th>
<th>SAMPLE VERBS</th>
<th>SAMPLE BEHAVIORS</th>
</tr>
</thead>
<tbody>
<tr>
<td>KNOWLEDGE</td>
<td>Student recalls or recognises information, ideas, and principles in the approximate form in which they were learned.</td>
<td>Write, List, Label, Name, State, Define</td>
<td>The student will define the 6 levels of Bloom's taxonomy of the cognitive domain.</td>
</tr>
<tr>
<td>COMPREHENSION</td>
<td>Student translates, comprehends, or interprets information based on prior learning.</td>
<td>Explain, Summarise, Paraphrase, Describe, Illustrate</td>
<td>The student will explain the purpose of Bloom's taxonomy of the cognitive domain.</td>
</tr>
<tr>
<td>APPLICATION</td>
<td>Student selects, transfers, and uses data and principles to complete a problem or task with a minimum of direction.</td>
<td>Use, Compute, Solve, Demonstrate, Apply, Construct</td>
<td>The student will write an instructional objective for each level of Bloom's taxonomy.</td>
</tr>
<tr>
<td>ANALYSIS</td>
<td>Student distinguishes, classifies, and relates the assumptions, hypotheses, evidence, or structure of a statement or question.</td>
<td>Analyse, Categorise, Compare, Contrast, Separate</td>
<td>The student will compare and contrast the cognitive and affective domains.</td>
</tr>
<tr>
<td>SYNTHESIS</td>
<td>Student originates, integrates, and combines ideas into a product, plan or proposal that is new to him or her.</td>
<td>Create, Design, Hypothesise, Invent, Develop</td>
<td>The student will design a classification scheme for writing educational objectives that combines the cognitive, affective, and psychomotor domains.</td>
</tr>
<tr>
<td>EVALUATION</td>
<td>Student appraises, assesses, or critiques on a basis of specific standards and criteria.</td>
<td>Judge, Recommend, Critique, Justify</td>
<td>The student will judge the effectiveness of writing objectives using Bloom's taxonomy.</td>
</tr>
</tbody>
</table>
Details of Expert Panels

Each panel was determined by their qualifications and suitability for the tasks. Panels are independent of each other.

Panel A

A panel of three experienced health care researchers. Two researchers were post-doctoral fellows and had supervised previous health care research studies and the third was a nurse consultant who had submitted their own doctoral thesis.

The panel reviewed generated statements relating to confidence to verify the pilot group's findings, reviewed wound factors to determine those which were tele-transmittable under strict criteria and provided a range of minimum and maximum values for factors for each wound.

Panel B

Eleven experienced wound care nurses working in the community. The educational director of Cardiff WHRU identified these nurses for the task due to their experience in wound management and qualifications.

Nurses rated factors for pre and post-intervention images of each wound using WoundView®.
Panel C

This panel comprised four members, two registered nurses and two non-nurses. All were employed in a higher education establishment as research assistants. Nurses were qualified to first degree level, one registered for a doctorate, the other nearing completion of their masters degree. Both non-nurses were nearing completion of their doctorate.

The panel piloted the training manual for camera use in a 30 minute training session.

Panel D

Ten registered nurse colleagues and three non-nurse colleagues. All participants were employed by higher education establishments and involved in other research projects. All nurses were qualified to a minimum of first degree level and had been registered for at least six years. Participants had an interest in wound care and 4 taught this subject on a regular basis.

The panel tested the wound knowledge test for face validity.

Panel E

Five registered nurse tutors formed panel E. Their teaching areas included sociology, psychology and research methods. The panel reviewed the 254 generated confidence statements under strict exclusion criteria.
Panel F

Thirteen registered nurses experienced in wound care. Similarly to panel B, nurses were identified as suitable by the educational director of Cardiff WHRU, as each nurse was considered skilled and experienced in wound care and with appropriate qualifications. However, these nurses differed in that they were based in a specialist centre and not in the community.

These nurses rated 97 statements relating to confidence under strict inclusion criteria.

Panel G

Twenty-four wound care experts identified through having good quality, peer reviewed publications relevant to wound assessment. This panel included both nurses and physicians.

The panel ranked 20 wound assessment factors from 1 (most important) to 20 (least important) in expressing the state of the wound.
Dear Named Community Nurse

Community nurse participation in research project

I am a registered nurse with several years experience of community care and a PhD student at the University of Glamorgan. As a community nurse working within name of trust your name was given to me by name of nurse manager who thought you may be interested in this study. This letter is to briefly tell you about my study and to ask if you would be interested in taking part.

My project is focusing on the nursing management of venous leg ulcers. I am exploring the impact of providing expert tele-advice on wound outcome and nursing knowledge and confidence in wound care. Improving these factors could potentially reduce patient suffering and the community nurses’ workload. A specialist nurse will offer wound advice by phone following the receipt of an image of the wound via a mobile phone and portable laptop computer, in the patients’ own home.

I am only looking at patients with venous leg ulcers and those not already included in any other research project. To exclude patients with ulcers that are not venous in origin a Doppler reading will be carried out in addition to clinical assessment. The study will last for twelve weeks or until the ulcer has healed, if sooner. Full ethical approval and consent from the trust and community nurse managers has been obtained. Informed consent from the patient in writing, prior to recruitment onto the study will also be sought.
I will be responsible for visiting the patients to collect the data. A clinical nurse specialist with many years experience in wound care will provide the tele-advice. As a community nurse participating in this study you would need to approach appropriate leg ulcer patients initially. This would be to ask them if they would be interested in taking part and if so, reading through some simple written project information and preliminary consent form with them. I have enclosed several copies of project information and consent forms along with stamped addressed envelopes for the patient to return the consent form to me. The preliminary consent form merely allows me to visit the patient in their home to talk about being in the study, it does not mean that they are automatically recruited on to the study. If the patient agrees to this I will then accompany you at a pre-arranged time visit to talk to the patient. This could be carried out during one of your routine calls to the patient, to avoid too much disruption to you and the patient. If the patient decides to take part in the study you would be shown how to take pictures of their ulcer with a digital camera and receive a copy to put in the nursing notes. I understand that community nurses have a busy, frequently unpredictable workload and therefore, this simple training would be undertaken at a time and place convenient for you. Actually taking the picture would only add a few minutes to your visit. You would also be required to complete a self-test assessment and attitudinal scale regarding wound care immediately before visiting the patients and at the end of the study. This would take about 30 minutes. No-one other than myself and my project supervisor would see your answers.

Patients will be randomly put into one of two groups. The experimental group, who will have their ulcer photographed and receive expert wound care advice (the intervention) and the control group, who will also have their ulcer photographed but will continue with their usual wound care treatment. Nurses in the experimental group will speak to the expert by phone to discuss their patients' wound care treatment and also receive a short written report outlining the treatment advice given. The community nurse remains responsible for her/his patients' treatment and is free to use their judgement to accept or refuse the expert advice. Each nurse will be responsible for one patient in the study.

I will contact you by phone on date to make an appointment to visit you and talk about the project. If you would like to discuss any aspect of the study before then, have any concerns or would like any part of the enclosed information further explained or require additional copies, please do not hesitate to contact me by phone on 01443 483082. I can also be contacted by email: mpeters@glam.ac.uk or fax: 01443 483190. If you think you have any suitable patients please approach them and I will take their details when I contact you. Should you be interested in the findings of my study I will gladly provide you with a short report on completion.

Thank you for taking the time to read this. I look forward to meeting you in the near future.

Your sincerely

Melanie Peters

Research Student, University of Glamorgan

TEL: 01443 483082 FAX: 01443 483140 e-mail: mpeters@glam.ac.uk
Compression therapy for venous leg ulcers

Venous leg ulcers are a major cause of morbidity, especially in older people. There is wide variation in practice, and evidence of unnecessary suffering and costs due to inadequate management of venous leg ulcers in the community.

Routine application of high compression therapy using one of a number of systems such as 3-, or 4-layer or short stretch bandages, Unna's boot or compression stockings, possibly with the addition of intermittent pneumatic compression, can significantly improve healing rates.

Use of compression stockings should be encouraged to prevent the recurrence of venous leg ulcers. However, there is little evidence to support the use of drug therapy using stanozolol or oxerutins.

Patients with arterial disease are not suitable for high compression therapy. Arterial disease can be diagnosed more accurately if highly trained operators measure the ratio of ankle to brachial systolic pressure (ABI) rather than feel for foot pulses alone.

Community nurses should be adequately trained in leg ulcer management, including patient assessment and bandage application.

The issues raised in this bulletin should be discussed with providers of primary care and community nursing services and relevant hospital specialists so as to co-ordinate services, ensure adequate nurse education and establish systems to monitor standards of care.

The contents of this bulletin are likely to be valid for around one year, by which time significant new research evidence may have become available.
A. Background

A.1 The importance of leg ulceration: Leg ulcers are areas of loss of skin below the knee on the leg or foot which take more than 6 weeks to heal. Leg ulceration is a common chronic recurring condition and a major cause of morbidity and suffering (Fig. 1). Annual costs to the NHS of leg ulceration have been estimated to be as high as £230-400 million (1991 prices) of which nursing time is a major element.

Fig. 1 A venous ulcer

About 1.5-3.0 per 1,000 population have active leg ulcers and prevalence increases with age up to around 20 per 1,000 in people over 80 years. Leg ulceration is strongly associated with venous disease (e.g. varicose veins and a history of deep vein thrombosis). Arterial disease is present (alone or with venous problems) in approximately 20% of cases of leg ulceration.

Leg ulcer disease is typically chronic and patients with active ulceration for more than 60 years have been documented. There is wide variation in reported recurrence with re-ulceration rates of 26% to as high as 69% at one year being reported. People at higher risk of recurrence include those with a previous ulcer size greater than 10cm², a history of deep vein thrombosis and those unable to wear compression stockings.

A.2 The management of venous leg ulceration: Most people with leg ulcers are managed by GPs and community nurses but a significant number are managed in hospital settings. Audits have shown wide variation in the clinical management of leg ulcers. Numerous types of wound dressings, bandages and stockings are used in the treatment of venous leg ulcers and the prevention of recurrence. A survey of 301 patients with leg ulcers in the Wirral found 26 different primary dressings in use and 42 different preparations being applied to the surrounding skin. A similar audit in Stockport identified 31 different dressings, 28 bandages and 59 topical preparations in use.

This issue of Effective Health Care summarises the results of research on the effectiveness and cost-effectiveness of different forms of compression in the treatment of venous ulceration; on interventions to prevent recurrence; and on methods of diagnosing venous ulceration. The methods used in this systematic review are outlined in the appendix and given in more detail in the Cochrane Library. The bulletin does not consider the effectiveness of dressings, debridement or skin grafts which are the subject of future review work.

B. Compression therapy

Below-knee compression graduated from toe (highest) to knee (lowest), in the form of bandaging or stockings, is viewed as a key component of treatment when venous leg ulceration occurs in the absence of significant arterial disease (Fig 2). A range of compression systems are used (see Box), which apply varying levels of compression, using different materials with varying degrees of elasticity. There is considerable uncertainty however, as to the most effective method. The preferred treatment for leg ulcers in the USA is Unna's boot; in other parts of Europe short stretch bandaging is more popular, whilst 4-layer bandaging is increasingly advocated in the UK. Twenty randomised controlled trials (RCTs) evaluated different forms of compression bandaging on venous ulcer healing in a wide range of age groups. Two of these incorporated economic evaluations. Two compared compression stockings with compression bandages and 2 evaluated intermittent pneumatic compression. Overall, the quality of trials is poor, a summary is available elsewhere.

B.1 Compression versus no compression: Six RCTs assessed whether compression therapy was better than no compression (Table 1). These show that compression provided either by Unna's boot, 2-layer, 4-layer or short stretch bandages improve healing rates compared to treatments using no compression. One study showed that compression therapy was more cost-effective because the faster healing rates saved nursing time.

B.2 High compression versus low compression: Three RCTs compared elastic high compression 3-layer bandaging (two using Tensopress and one Setopress as a component) with low compression (using
I bandaging healed faster than make up a 4-layer bandage/ 9 and a provides all the constituents to compared with both a kit that bandage (see Box) has been compared directly in RCTs. The original 'Charing Cross' 4-layer bandage (see Box) has been compared with both a kit that provides all the constituents to make up a 4-layer bandage, and a regimen adapted to achieve similar levels of compression using materials available on prescription. No statistically significant difference in outcome was found in either study, although the latter trial was very small (Table 3).

Four-layer bandaging has also been compared with short stretch and with Unna's boot in 4 RCTs. No differences were found in the healing rates. However, because these studies were small in size, we cannot be confident that there are not clinically important differences in effectiveness (Table 4).

The advantage of multilayer high compression systems over single layer systems is shown by 1 large and 2 small trials which found more ulcers healed at 24 weeks using 4-layer bandaging than were healed using a single layer, adhesive compression bandage (Table 5).

Even though 3-layer, 2-layer and other compression bandages have been shown to be effective, they appear not to have been directly compared with 4-layer bandaging in RCTs. A trial comparing 3-layer with 3-layer bandaging is however, being carried out at St. Thomas's Hospital, London.

Compression stockings have also been used to treat current ulcers. A combination of 2 compression stockings has been shown to increase the rate of healing compared to a short stretch bandage (Odds Ratio = 4.9, 95% CI: 1.3, 18.3) (Table 6).

**B.4 Intermittent pneumatic compression treatment:** Two small studies showed that more ulcers healed when intermittent pneumatic compression was used in addition to compression stockings or Unna's boot (pooled OR = 10.0; 95% CI: 2.96, 33.8) (Table 7).

C. **Prevention of recurrence**

Seven RCTs comparing interventions to prevent recurrence were identified; their quality is summarised in Table 8.

**C.1 Compression stockings:** No RCT was found which compared recurrence rates achieved with and without compression stockings in people with healed ulcers. One trial however, showed that 3–5 year recurrence rates were lower in patients using strong support from class 3 compression stockings (21%) than in those randomised to receive medium support from class 2 compression stockings (52%) (p=0.034); class 2...
<table>
<thead>
<tr>
<th>Study</th>
<th>Patients and interventions</th>
<th>Initial ulcer size &amp; duration</th>
<th>Results</th>
</tr>
</thead>
<tbody>
<tr>
<td>Charles 1991</td>
<td>53 community-based patients from inner London</td>
<td>11: mean ulcer area (cm²) 12: mean duration (mths)</td>
<td>Complete healing 11: 71%; 12: 25%</td>
</tr>
<tr>
<td></td>
<td>11: short stretch bandage applied by project nurse (Rosidal K) 12: usual treatment applied by district nurse</td>
<td>Follow up: 3 mths</td>
<td></td>
</tr>
<tr>
<td>Eriksson 1984</td>
<td>44 patients, setting unclear</td>
<td>11: mean ulcer area (cm²) 12: mean duration (mths)</td>
<td>No statistical analysis reported.</td>
</tr>
<tr>
<td>Sites 1985</td>
<td>84 patients from vascular surgery clinics with 87 ulcers</td>
<td>11: mean ulcer area (cm²) 12: mean duration (wks)</td>
<td>Complete healed at 6 mths</td>
</tr>
<tr>
<td>Kito et al 1988</td>
<td>36 consecutive ambulatory patients</td>
<td>11: mean ulcer area (cm²) 12: mean duration (wks)</td>
<td>Life table analysis: ulcers healed at 15 wks</td>
</tr>
<tr>
<td>Rubin et al 1990</td>
<td>13 male patients (42 ulcers), a convenience sample from outpatient vascular surgery clinic</td>
<td>11: mean ulcer area (cm²) 12: mean duration (wks)</td>
<td>Life table analysis: ulcers healed at 15 wks</td>
</tr>
<tr>
<td>Taylor et al</td>
<td>30 patients referred to the clinic by GPs</td>
<td>11: mean ulcer area (cm²) 12: mean duration (wks)</td>
<td>Life table analysis: ulcers healed at 15 wks</td>
</tr>
</tbody>
</table>

stockings however, were better tolerated by patients (Table 9).41

C2 Pharmacological and surgical interventions: Two drugs have been investigated for their effects on leg ulcer recurrence: stanozolol, an anabolic steroid which increases fibrinolysis; and rutoside (Paroven) an oxerutin which is said to decrease capillary permeability. These drugs have been compared with placebo in 2 RCTs in which all patients also received class 2 compression stockings.42,43 Both trials found that neither drug reduced recurrence.

Surgery in which incompetent communicating veins are ligated and varicose veins are eradicated has been compared in 2 small trials with the drug stanozolol (both combined with compression stockings) (Table 10). These gave conflicting results; one showing a lower recurrence rate with surgery within 1 year17 and the other showing reduced recurrence with drug therapy at 5 years.44

One trial appeared to show a moderately reduced rate of recurrence when surgery was carried out in addition to the use of elastic stockings, however the study was small and poorly reported (see Table 9).45
Table 2: RCTs of elastic high compression bandaging versus low compression

<table>
<thead>
<tr>
<th>Study</th>
<th>Patients and interventions</th>
<th>Initial ulcer size &amp; duration</th>
<th>Results</th>
</tr>
</thead>
<tbody>
<tr>
<td>Collin et al 1992</td>
<td>132 patients from leg ulcer clinics (multicentre)</td>
<td></td>
<td>Complete healing</td>
</tr>
<tr>
<td></td>
<td>Male and female</td>
<td></td>
<td>11: 35/65 (54%); 12: 19/67 (28%).</td>
</tr>
<tr>
<td></td>
<td>1: elastic compression: Soffban + Tensopress + Tensogrip</td>
<td></td>
<td>[p = 0.01]</td>
</tr>
<tr>
<td></td>
<td>12: non-elastic compression: Soffban + Elastocrepe + Tensoplastude</td>
<td></td>
<td>However, patients were only followed up for 12 wks and at this point a large number of 12 patients were almost healed.</td>
</tr>
<tr>
<td></td>
<td>Follow up: 3 mths</td>
<td></td>
<td>Attrition: 11: 8; 12: 20</td>
</tr>
<tr>
<td>Northcut 1990</td>
<td>108 patients presenting to outpatient clinic</td>
<td>Not stated</td>
<td>Complete healing</td>
</tr>
<tr>
<td></td>
<td>11: 3-layer bandage (Calaband + Elastocrepe + Tensogrip)</td>
<td></td>
<td>11: 21% ; 12: 64% [p = 0.01]</td>
</tr>
<tr>
<td></td>
<td>12: 3-layer bandage (Calaband + Tensopress + Tensogrip)</td>
<td></td>
<td>Attrition: 3</td>
</tr>
<tr>
<td>Gold et al 1993</td>
<td>39 ambulatory patients [46 ulcers] from general practices attending outpatient clinic</td>
<td></td>
<td>Healed or progressed</td>
</tr>
<tr>
<td></td>
<td>11: elastic compression (Setopress) + medicated paste bandage + elasticised viscose stocking</td>
<td></td>
<td>11: 11 (28%); 12: 7 (35%) [p&lt;0.05]</td>
</tr>
<tr>
<td></td>
<td>12: inelastic bandage (Elastocrepe) + medicated paste bandage + elasticised viscose stocking</td>
<td></td>
<td>Attrition: 7 patients (10 ulcers)</td>
</tr>
<tr>
<td></td>
<td>1 wk prior to treatment patients wore Setopress bandage</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Follow up: 16 wks</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Daby et al 1993</td>
<td>67 patients (76 legs)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>11: orthopaedic wool + short stretch bandage (Comprilan) + Tresilox net covering</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>12: 4-layer bandage (orthopaedic wool + crepe bandage + Elastocrepe + Tubigrip)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Follow up: 3 mths</td>
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</tbody>
</table>

Table 3: Comparing between different multilayer high compression systems

<table>
<thead>
<tr>
<th>Study</th>
<th>Patients and interventions</th>
<th>Initial ulcer size &amp; duration</th>
<th>Results</th>
</tr>
</thead>
<tbody>
<tr>
<td>McCollum et al 1997</td>
<td>232 patients from community leg ulcer services</td>
<td>Percentage = 10%²</td>
<td>Complete healing</td>
</tr>
<tr>
<td></td>
<td>1: ‘original’ Charing Cross 4-layer</td>
<td></td>
<td>11: 82% ; 12: 84% [p&lt;0.05]</td>
</tr>
<tr>
<td></td>
<td>12: new proprietary 4-layer (Profore system)</td>
<td></td>
<td>Attrition: 11: 16%; 12: 15%</td>
</tr>
<tr>
<td>Wilkinson et al 1997</td>
<td>35 legs in 29 patients recruited through district and practice nurses</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>1: Charing Cross 4-layer bandage</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>12: ‘final bandage’ Tubifast + separate strips of lint applied horizontally + Setopress + Tubifast (to secure bandage)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>[Patients were stratified by ulcer size]</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Follow up: 6 mths</td>
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</tbody>
</table>

D. Diagnosis

The high rates of co-morbidity in patients with leg ulceration mean that careful assessment of all patients is important. This is particularly the case as considerable damage can be caused by inappropriately applying high compression in patients with arterial and small vessel disease. There is debate about how arterial status should be assessed and whether this assessment should be undertaken routinely by nurses. Research into the precision and accuracy of the nursing assessment of leg ulcer patients is lacking.
### Table 4: RCTs of elastic high compression bandaging versus inelastic compression

<table>
<thead>
<tr>
<th>Study</th>
<th>Patients and interventions</th>
<th>Initial ulcer size &amp; duration</th>
<th>Results</th>
</tr>
</thead>
<tbody>
<tr>
<td>Daly 1993&lt;sup&gt;11&lt;/sup&gt;</td>
<td>See Table 2</td>
<td>Median ulcer area (cm²) 11: 12.4; 12: 8.16</td>
<td>Healing rate 11: 60%; 12: 60%</td>
</tr>
<tr>
<td>London and Strueven&lt;sup&gt;16&lt;/sup&gt; UK</td>
<td>30 ambulant patients 11: 4-layer bandage (orthopaedic wool, crepe, Elset, Coban) 12: short stretch (orthopaedic wool, short stretch, Coban) Follow up: 1 yr</td>
<td>Median ulcer area (cm²) 11: 18; 12: 24</td>
<td>Attrition: 11: 4</td>
</tr>
<tr>
<td>Colgan et al&lt;sup&gt;7&lt;/sup&gt; Ireland</td>
<td>30 patients at routine venous ulcer outpatient clinic 11: modified Unna’s boot (paste bandage + Elastocrepe + Elastoplast + class II compression sock) 12: 4-layer bandage (Profore) (4LB) 13: Lyofoam dressing + Setopress compression bandage Follow up: 3 mths</td>
<td>Median ulcer area (cm²) 11: 7; 12: 9; 13: 20</td>
<td>Complete healing: 11: 6/10 (60%); 12: 7/10 (70%); 13: 2/10 (20%)</td>
</tr>
<tr>
<td>Knight &amp; McCulloch 1996&lt;sup&gt;12&lt;/sup&gt; USA</td>
<td>10 patients randomly chosen from patients at a wound care centre 11: 4-layer bandage (Profore) 12: Unna’s boot Follow up: 6 wks</td>
<td>Median ulcer area (cm²) 11: 24; 12: 10; 13: 12</td>
<td>Mean bandage costs in IRE 11: 282.54; 12: 660.24; 13: 558.33</td>
</tr>
</tbody>
</table>

### Table 5: RCTs of multilayer high compression systems versus single-layer bandage systems

<table>
<thead>
<tr>
<th>Study</th>
<th>Patients and interventions</th>
<th>Initial ulcer size &amp; duration</th>
<th>Results</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nelson et al 1995&lt;sup&gt;15&lt;/sup&gt; UK</td>
<td>200 patients referred by GPs and community nurses, age &gt; 18 years, attending leg ulcer clinic 11: 4-layer bandage (orthopaedic wool + crepe + Elset + Coban) 12: single layer bandage (Granuflex adhesive compression bandage) [Primary dressing randomised to knitted viscose dressing or hydrocolloid dressing. Patients were also randomised to oxpentifylline or placebo] Follow up: not stated</td>
<td>Mean ulcer area (cm²) 11: 15.5; 12: 11</td>
<td>Complete healing: 11: 69%; 12: 49% Odds ratio = 2.4; 95% CI: 1.3–4.3 Attrition: greater in 11 than 12</td>
</tr>
<tr>
<td>Kraft &amp; Kosicek&lt;sup&gt;16&lt;/sup&gt; Slovenia</td>
<td>40 in- and outpatients 11: 4-layer bandage (Profore) 12: single layer bandage (Porelast) + hydrocolloid dressing (lagoasorb) Follow up: 6 mths</td>
<td>Mean ulcer area (cm²) 11: 16.6; 12: 17.2</td>
<td>Complete healing: 11: 7/20 (44%); 12: 8/20 (44%) Attrition: 11: 4; 12: 2</td>
</tr>
<tr>
<td>Towers et al 1992&lt;sup&gt;17&lt;/sup&gt; UK</td>
<td>27 patients attending leg ulcer clinic 11: self adhesive 1-layer bandage (Porelast Acryl) 12: 3-layer bandage (Colaband + Tensapress + Tensagrip) Follow up: 6 mths</td>
<td>Mean ulcer area (cm²) 11: 31; 12: 23</td>
<td>Reduction in ulcer area: 11: 85%; 12: 83% (no sig. diff.) Bandage costs equivalent Attrition: none</td>
</tr>
</tbody>
</table>
## E. Organisation of care

A recent trial in Sheffield (Table 11) showed that care delivered in leg ulcer clinics, by trained nurses, following a treatment protocol which included use of 'Charing Cross' 4-layer bandaging resulted in better healing at 1 year (65%) than in patients who continued their usual treatment at home provided by their district nurse, who did not routinely have access to the 4-layer bandage (55%).

The clinic was also more cost-effective. Improved healing associated with specialist clinics using 4-layer bandaging was also shown in a second small trial. These 2 trials do not however, provide information on the relative impact of, or interactions between, the various elements of setting, nurse training, compression bandaging, and protocols for treatment and referral. It is possible for example, that similar improvements in healing could be achieved without the use of clinics or by using other high compression therapies.

A survey in Leeds found that district nurses' knowledge of the assessment and management of leg ulcers was often inadequate. Another survey reported that 50% of nurses made a diagnosis of the cause of the ulcer based on visual assessment alone.

### Table 6 RCTs of compression stockings versus compression bandaging

<table>
<thead>
<tr>
<th>Study</th>
<th>Patients and interventions</th>
<th>Initial ulcer size &amp; duration</th>
<th>Results</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hendricks &amp; Sollow 1985</td>
<td>21 patients attending outpatients clinic&lt;br&gt;11: Unna's boot + Kerlix roll + elastic bandage&lt;br&gt;12: open toe, below knee graduated compression stockings&lt;br&gt;Follow up: 18 mths</td>
<td>Median ulcer area (cm²): 2.35&lt;br&gt;Median duration: 4.5 yrs</td>
<td>Complete healing&lt;br&gt;11: 7/10 (70%); 12: 10/14 (71%) but 3 of these were transferred from 11&lt;br&gt;Patients cross between arms depending on progress. No intention to treat analysis carried out</td>
</tr>
<tr>
<td>Horakova &amp; Portsch 1994</td>
<td>59 patients attending a dermatology clinic&lt;br&gt;11: Short stretch bondage (Rosidal K)&lt;br&gt;12: Thrombo stocking + compression stocking&lt;br&gt;(Sigvaris - removed at night)&lt;br&gt;Follow up: 3 mths</td>
<td>Median ulcer area (cm²): 3.2; 12: 6.0&lt;br&gt;Mean duration (mths): 11: 2; 12: 5</td>
<td>Complete healing&lt;br&gt;11: 13/25 (52%); 12: 21/25 (84%)&lt;br&gt;[p &lt; 0.05]&lt;br&gt;Attrition: 11: 6, 12: 3</td>
</tr>
</tbody>
</table>

### Table 7 RCTs of intermittent pneumatic compression treatment

<table>
<thead>
<tr>
<th>Study</th>
<th>Patients and interventions</th>
<th>Initial ulcer size &amp; duration</th>
<th>Results</th>
</tr>
</thead>
<tbody>
<tr>
<td>Coleridge Smith et al 1990</td>
<td>45 patients (48 ulcers) attending venous ulcer outpatient clinic&lt;br&gt;11: graduated compression stockings&lt;br&gt;12: IT + intermittent sequential gradient pneumatic compression used daily in the home&lt;br&gt;Follow up: 3 mths</td>
<td>Median ulcer area (cm²): 11: 17.3; 12: 49.8&lt;br&gt;Median duration (yrs): 11: 3.5; 12: 3.9</td>
<td>Completely healed&lt;br&gt;11: 17/24 (44%) patients; 12: 10/21 (48%) patients&lt;br&gt;[p = 0.009]&lt;br&gt;11 contained patients with 2 ulcers&lt;br&gt;Attrition: none</td>
</tr>
<tr>
<td>McCulloch et al 1994</td>
<td>22 patients attending vascular surgery clinic&lt;br&gt;11: Unna's boot only&lt;br&gt;12: IT + intermittent one cell pneumatic compression applied for one hour, twice a week after cleansing&lt;br&gt;Follow up: 6 mths</td>
<td>Median ulcer area (cm²): 11: 0.4 - 59.4&lt;br&gt;12: 0.4 - 45.0</td>
<td>Completely healed&lt;br&gt;11: 8/10 (80%); 12: 12/12 (100%)&lt;br&gt;Attrition: none</td>
</tr>
</tbody>
</table>

Arterial disease of the leg is most commonly detected by a combination of general clinical examination and either manual palpation of foot pulses or by measuring the ratio of the systolic blood pressure at the ankle to that in the arm (the ankle:brachial pressure index ABPI). The ABPI ratio is measured using a handheld Doppler ultrasound together with a sphygmomanometer. An ABPI ratio of less than 1.0 is viewed as indicative of some arterial impairment. The cut-off point below which compression is generally not applied in clinical practice is often quoted as 0.8; however, many trials use the higher cut-off of 0.9.

There is generally poor agreement between manual palpation of foot pulses and ABPI. Two large studies have shown that 67% and 35% of limbs respectively with an ABPI < 0.9 had palpable foot pulses, with the consequent risk of applying compression to people with arterial disease. Even though ABPI measurement appears to be better than manual palpation for excluding arterial disease, ABPI measurement has been shown to be unreliable when carried out by inexperienced operators. Reliability can however, be significantly improved if people are highly trained.
### Table 8: Quality of RCTs of interventions to prevent recurrence of venous ulcers

<table>
<thead>
<tr>
<th>Study</th>
<th>Clear inclusion and exclusion criteria reported</th>
<th>Sample size [arms]</th>
<th>A priori sample size calculation?</th>
<th>Method of randomisation</th>
<th>Baseline comparability or treatment groups</th>
<th>Blinded outcome assessment</th>
<th>Withdrawals reported by group with reasons</th>
<th>Analysed by intention to treat/life table method</th>
</tr>
</thead>
<tbody>
<tr>
<td>Franks et al 1995</td>
<td>✓</td>
<td>166 [2]</td>
<td>✓</td>
<td>not stated</td>
<td>✓</td>
<td>not stated</td>
<td>none stated</td>
<td>✓</td>
</tr>
<tr>
<td>McMillan et al 1991</td>
<td>✓</td>
<td>48 limbs [2]</td>
<td>not stated</td>
<td>not stated</td>
<td>not stated</td>
<td>✓</td>
<td>✓ but no individual details for previously ulcerated limbs</td>
<td>unclear</td>
</tr>
<tr>
<td>Legatella et al 1995</td>
<td>brief</td>
<td>105 [2]</td>
<td>not stated</td>
<td>not stated</td>
<td>not stated</td>
<td>not stated</td>
<td>X</td>
<td>reasons given for 22 withdrawals but a further 19 people are missing from the data</td>
</tr>
<tr>
<td>Stacey et al 1990</td>
<td>✓</td>
<td>30 [41 limbs] [2]</td>
<td>not stated</td>
<td>not stated</td>
<td>only for venous status</td>
<td>not stated</td>
<td>not stated</td>
<td>unclear</td>
</tr>
<tr>
<td>Stacey et al 1990</td>
<td>brief</td>
<td>55 [8 limbs] [2]</td>
<td>not stated</td>
<td>not stated</td>
<td>✓</td>
<td>not stated</td>
<td>✓</td>
<td>X</td>
</tr>
</tbody>
</table>

### Table 9: RCTs of prevention of recurrence of venous ulceration using compression stockings and venous surgery

<table>
<thead>
<tr>
<th>Study</th>
<th>Patients and interventions</th>
<th>Initial ulcer size &amp; duration</th>
<th>Results</th>
</tr>
</thead>
<tbody>
<tr>
<td>Franks et al 1995</td>
<td>166 patients from community leg ulcer clinics with newly healed ulcers, mean age 72 yrs&lt;br&gt;11: class 2 below knee stockings (Medi, UK) 12: class 2 below knee stockings (Scholl)&lt;br&gt;New stockings prescribed every 3 months&lt;br&gt;Follow up: 18 mths</td>
<td>Median ulcer (cm²): 11: 3.3; 12: 3.5&lt;br&gt;Median ulcer duration (mths): 11: 5.7; 12: 2.0&lt;br&gt;Mobility: chairbound; walk+aid: walk freely 11: 4(4%); 27(29%); 61(67%)&lt;br&gt;12: 1(1%); 23(31%); 50(68%)</td>
<td>Recurrence rate at 18 mths&lt;br&gt;11: 24%; 12: 32%; Adjusted RR = 1.16; 95% CI 0.65–2.04&lt;br&gt;Attrition: none stated&lt;br&gt;Overall 83% all day wear (no difference)</td>
</tr>
<tr>
<td>Harper et al 1995</td>
<td>300 patients with newly healed venous leg ulcers&lt;br&gt;11: Class 2 stockings&lt;br&gt;12: Class 3 stockings&lt;br&gt;Refitting and supply of new stockings every 4 months&lt;br&gt;Follow up: 5 yrs</td>
<td>Not stated</td>
<td>Recurrence within 36–60 mths&lt;br&gt;11: 32%; 12: 21% [p=0.034]</td>
</tr>
<tr>
<td>Stacey et al 1988</td>
<td>30 patients with 41 previously ulcerated limbs attending surgical outpatients&lt;br&gt;11: surgery – ligation of incompetent communicating veins and obliteration of incompetent superficial veins plus permanent below-knee elastic stockings (Sigvaris)&lt;br&gt;12: stockings – below-knee stockings (Sigvaris)&lt;br&gt;NB. Limbs rather than patients were randomised&lt;br&gt;Follow up: 1 yr</td>
<td>11: 8 had evidence of past DVT&lt;br&gt;12: 10 had evidence of past DVT</td>
<td>Ulcer recurrence:&lt;br&gt;11: 1 (5% limb); 12: 5 (24% limbs)&lt;br&gt;Attrition: not stated</td>
</tr>
</tbody>
</table>
Table 10: RCTs of pharmacological interventions for the prevention of recurrence of venous ulceration

<table>
<thead>
<tr>
<th>Study</th>
<th>Patients and interventions</th>
<th>Initial ulcer size &amp; duration</th>
<th>Results</th>
</tr>
</thead>
<tbody>
<tr>
<td>Loqololla et al. 1995*</td>
<td>136 patients with healed venous ulcers attending outpatients clinic &lt;br&gt; 11: Stanozolol 5mg bd for 12 months plus compression stockings &lt;br&gt; 12: surgery – ligation of calf, perforating veins plus compression stockings &lt;br&gt; Follow up: 5 yrs</td>
<td>Not stated</td>
<td>11: 10/42 recurrences (24%) 12: 13/41 recurrences (32%) Life table analysis: increased ulcer-free survival in surgery group (NS) Attrition: 11: 9; 12: 13</td>
</tr>
<tr>
<td>McMullin et al. 1991*</td>
<td>48 limbs with healed venous ulcers out of a total of 85 limbs in 60 patients being treated for lipodermatosclerosis &lt;br&gt; 11: Stanozolol 5 mg bd + below knee class II graduated compression stocking (Venosan, Switz) &lt;br&gt; 12: placebo tablet + stockings as in 11 &lt;br&gt; Follow up: not stated how much beyond 6 mths treatment</td>
<td>Not stated</td>
<td>Recurrence of ulceration: &lt;br&gt; 11: 7/25 limbs (28%) 12: 4/23 limbs (17%) (p=0.6) Attrition: 11: 6/30; 12: 3/30</td>
</tr>
<tr>
<td>Wright et al. 1991*</td>
<td>138 patients with recently healed venous ulcer recruited at first follow up appointment &lt;br&gt; 11: Oxerutins (Paroven, Zyma, UK) 500 mg bd + below knee class II graduated elastic stockings &lt;br&gt; 12: identical placebo + stockings as in 11 &lt;br&gt; Stockings replaced where necessary at 3 monthly intervals, equal numbers in each group randomised to surgery &lt;br&gt; Follow up: 18 mths</td>
<td>Mean duration (mths): &lt;br&gt; 11: 8.9; 12: 8.8 &lt;br&gt; Additional illnesses &lt;br&gt; No significant differences between groups</td>
<td>Cumulative recurrence at 18 mths: &lt;br&gt; 11: 34%; 12: 32% (p = 0.93 log rank test) Attrition: not stated</td>
</tr>
</tbody>
</table>

Table 11: RCTs of compression from trained nurses and/or specialised clinics versus usual district nurse treatment

<table>
<thead>
<tr>
<th>Study</th>
<th>Patients and interventions</th>
<th>Initial ulcer size &amp; duration</th>
<th>Results</th>
</tr>
</thead>
<tbody>
<tr>
<td>Marnall et al. 1991*</td>
<td>233 ambulant patients from 8 clinics who had suspected venous ulcers &lt;br&gt; 11: 4-layer bandaging delivered by project nurses in clinic &lt;br&gt; 12: ‘usual care’ from district nurses at home &lt;br&gt; Follow up: 1 yr</td>
<td>Mean ulcer area (cm²): &lt;br&gt; 11: 16.2; 12: 16.9 &lt;br&gt; Mean duration (mths): &lt;br&gt; 11: 22.5; 12: 29.7</td>
<td>Complete healing at 12 mths &lt;br&gt; 11: 65%; 12: 35%; Difference in percentage healed = 11.95% Ct -0.02 – 0.34 Overall there is a statistically significant difference in healing rate p = 0.03 log rank test Attrition: 11: 16; 12: 13</td>
</tr>
<tr>
<td>Taylor et al. 1997*</td>
<td>See Table 1</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
people with venous ulcers should have a significant impact on healing rates and save time spent by community nurses. Despite the promotion in the UK of 4-layer bandaging, there is little reliable evidence for its superiority over other high compression techniques.

- High compression bandage systems and their components vary in their availability in the community. Orthopaedic wool padding, a component of most high compression systems, is not available on prescription, and purchasers and providers should consider how this can be made readily available to community nurses.

- Whichever high compression approach is employed, it is important that it is used correctly so that sufficient (but not excessive) pressure is applied. Community nurses and other practitioners should be better trained and monitored in leg ulcer management, including patient assessment, and bandage application.

- Use of compression stockings should be encouraged for the prevention of recurrence. However, there is little evidence to support the use of drug therapy using stanozolol or oxerutins.

- Systems should be put in place to monitor standards of care as measured by structure (e.g. the proportion of appropriately trained staff); process (e.g. the proportion of patients whose arterial status has been determined by ABPI measurement, and the proportion with uncomplicated venous ulcers receiving high compression therapy); and outcome (e.g. the prevalence of active ulceration, proportion of patients healed, rates of healing and adverse outcomes due to incorrectly treated arterial disease or excessive compression).

- The issues raised in this bulletin should be discussed with providers of primary care and district nurse services and relevant hospital specialists so as to co-ordinate services, ensure nurse training and supervision and establish systems to monitor standards of care.

- Further RCTs of sufficient size and follow-up are necessary. In particular there is a need to determine the most cost-effective high compression systems, whether surgery for certain groups of patients confers any added benefit, and the additional importance (if any) of the organisation of care once proper compression systems are in place.

- The Royal College of Nursing is leading the development of a clinical guideline on leg ulcer assessment and management, based on this Effective Health Care bulletin. It is expected that the guideline will be available in mid-1998.

Appendix: Methods used to review the research

A systematic review of research with no restriction on date or language was carried out using 18 electronic databases including MEDLINE, CINAHL and EMBASE. Relevant journals and conference proceedings were handsearched and experts consulted. Published and unpublished RCTs which measured ulcer healing were included because in RCTs statistically significant differences in outcomes can be more confidently attributed to a particular treatment. Studies which compared healing rates using a new treatment with historical controls were excluded as this design is more susceptible to bias. The methodological quality of each study was assessed using a checklist, by two reviewers working independently.

References

17. Taylor AD, Taylor RJ, Marcussen BW. Prospective comparison of healing rates and therapy costs for conventional and four layer high compression bandaging treatments of venous leg ulcers. Unpublished.
If you have been involved in a randomised controlled trial which has not been published in full, including trials that have only been published as an abstract, please send details to Medical Editors Trial Amnesty, BMJ, BMA House, Tavistock Square, London WC1H 9JR. Fax: 0171 383 6418. Alternatively the information can be sent by e-mail to meta@ucl.ac.uk

Amnesty for Randomised Controlled Trials

The editors of BMJ, Lancet, Annals of Internal Medicine and several other leading medical journals have announced an amnesty for unpublished randomised controlled trials. The aim is to ensure that all RCTs, published or unpublished, are registered so that reviews of research can be more comprehensive and avoid publication bias.
The Effective Health Care bulletins are based on systematic review and synthesis of research on the clinical effectiveness, cost-effectiveness and acceptability of health service interventions. This is carried out by a research team using established methodological guidelines, with advice from expert consultants for each topic. Great care is taken to ensure that the work, and the conclusions reached, fairly and accurately summarise the research findings. The University of York accepts no responsibility for any consequent damage arising from the use of Effective Health Care.
17th May 2000

Ms M Peters,
Research Student,
School of Care Sciences,
University of Glamorgan,
Pontypridd,
CF37 1DL.

Dear Ms Peters,

00/3417 - Using digital imaging in the management of venous leg ulcers by community nurses

Thank you for your letter of the 11th May 2000.

I have considered your response to my earlier letter of the 19th April 2000, and write to confirm that I have taken ‘Chairman’s Action’ to grant full ethical approval to the above application.

Yours sincerely,

Mrs Anne Dowden
Chairman, Panel B,
Local Research Ethics Committee
Ms M Peters,
Research Student,
School of Care Sciences,
University of Glamorgan,
Pontypridd,
CF37 1DL

Dear Ms Peters,

00/3417 - Using digital imaging in the management of venous leg ulcers by community nurses

At the Local Research Ethics Committee (Panel B) meeting on the 19th April 2000, the above research application was considered and I am pleased to inform you that ethical approval was granted subject to the following condition:-

1. The Panel was concerned about the proposed approach to patients. Members agreed that, in order to avoid any possible breach of patient confidentiality, the community nurse must make the initial approach to potential volunteers. Only when a patient has confirmed that they would be willing to discuss participating in the trial should you approach them. The community nurse should therefore be given an introductory letter from you to patients. You should also provide the nurse with a consent form for the patient to complete, together with a stamped addressed envelope. The initial consent form would allow patients to confirm that they had no objections to you approaching them to discuss the project in more detail. The stamped addressed envelope would allow patients to return the initial consent forms to you.

The Panel requested that you provide a written assurance that this method of approaching patients would be adopted.

2. The consent form must be revised to include space for a witness signature.

Your research may not proceed until you have complied with the condition of approval. A formal written response is required indicating your compliance and attaching any amended or additional documentation to the Executive Officer of the Local Research Ethics Committee at the above address. I will consider your response and if satisfactory a letter will be sent to you indicating that your research may proceed.
You will no doubt realise that whilst the Local Research Ethics Committee has given approval for your project on ethical grounds, it is still necessary for you to obtain approval, if you have not already done so, from the relevant Clinical Director and/or Chief Executives of Trusts (or U.W.C.M.) in which the work will be carried out.

I enclose for your information a copy of the Bro Taf Membership list on which the Members of Panel B, who were present at the meeting on the 19th April 2000, are indicated. I confirm that the Bro Taf Local Research Ethics Committee complies with the ICH Guidelines for Good Clinical Practice as they relate to an Independent Ethics Committee. A copy of the Committee’s Constitution and Terms of Reference is available on request.

The committee attach certain standard conditions to all ethical approval. These are that if staff conducting research should change, any new staff should read the research programme submitted to the committee for ethical approval and this letter (and any subsequent letter I may write concerning this application for ethical approval); that if the procedures used in the research programme should change or the programme itself should be changed you should consider whether it is necessary to submit a further application for any modified or additional procedures to be approved and if the employment or departmental affiliation of the staff should change you should notify me of that fact. Any material changes to the structure or operation of the trial (including the recruitment of subjects) must be submitted to, and approved by, the Committee before being adopted. The Committee also ask that if any serious adverse events occur or if you should encounter any unexpected ethical issues, you will inform them of what these are. Full ethical approval needs to be resought if any study does not begin within two years of the date of this letter.

Yours sincerely,

Mrs Anne Dowden  
Chairman, Panel B,  
Local Research Ethics Committee
APPENDIX XII
Date _____________

Dear Patient’s name

Taking part in a research study

I would like to invite you to take part in a research study. Your community nurse Community nurse’s name, has suggested that you may be interested. Before you decide, it is important for you to understand why the research is being done and what it will involve. Please could you spend a few minutes reading this letter and talk it over with your community nurses, friends, relatives and GP if you wish.

I have listed some questions and answers, which you may find helpful. If there is anything you do not understand or would like to know more about please do not hesitate to ring me on 01443 483082 during normal working hours, 9am – 5pm. You can also leave a message and I will get back to you as soon as possible.

The Questions and Answers:
Why am I being asked?
I have contacted all the community nurses in this area and asked for a list of patients with leg ulcers. You are being invited to take part in the study because you have a leg ulcer.

Who is carrying out this study?
My name is Melanie Peters. I am a qualified nurse and a research student at the University of Glamorgan. I have worked in hospitals and the community for several years. I am undertaking this study as part of a higher degree.

What is the study about?
The main point of the study is to see if taking pictures of leg ulcers and sending those pictures for advice can help them get better and help the nurses to give better care. You may or may not receive any direct improvement from taking part in this study. However, any information I may find during the study could help to better understand your leg ulcer. It may also help us in choosing treatments for future patients.
What will I have to do?
You would have a picture taken of your leg ulcer. One will be taken at the start of the study and another twelve weeks later.

Will I have to go into hospital if I agree to be in this study?
No. The pictures would be taken in your own home.

Will I have to fill out forms?
You will need to sign two consent forms. This first one will show that you would be happy for me to visit you and discuss the study further. The second consent form is to show that you would be willing to join the study.

What happens if I say yes to taking part in the study but then change my mind?
You can leave the study at any time. This will not affect your care in any way.

How many people are in the study?
It is difficult to put an actual figure upon patients with leg ulcers in this area. All suitable patients with a leg ulcer will be approached.

Does my doctor know about the study?
Yes. Each patient’s own doctor will have been given information about the study and their permission sought before you are asked.

What will happen to any information about me?
Any information that is collected about patients during the study will be kept strictly private.

What do I need to do if I decide to join the study?
If you are happy to join the study then I will make an appointment to come and see you. Please return the preliminary patient consent form to me in the self addressed envelope if you would like me to tell you more about the study.

Thank you for taking the time to read this.

Melanie Peters
"Using photographs in leg ulcer care"

PRELIMINARY PATIENT CONSENT FORM

➢ I am willing for the research student, MELANIE PETERS to visit me in my home and tell me more about the study.

➢ I understand that if she visits me I do not have to take part in the study.

Name: ____________________________________________________________

Address: __________________________________________________________

_________________________________________________________________

Telephone Number: ________________________________________________

Signature: ___________________________ Date: ________________________

PLEASE RETURN THIS FORM IN THE ENVELOPE PROVIDED - IF YOU ARE HAPPY FOR ME TO VISIT YOU AND TELL YOU MORE ABOUT THE STUDY.
"Using photographs in leg ulcer care"

PATIENT CONSENT FORM

The research project in which I have agreed to take part has been fully explained to me. I have been given the chance to ask questions and be given more information.

I understand that being in this research project will involve photographs of my leg ulcer being taken. I understand that any pictures and/or paperwork about my leg ulcer will remain private. Only those staff involved in the research project will be able to see it. I understand that MELANIE PETERS will hold any pictures and they may be used for educational purposes, such as teaching nurses how to care for leg ulcers. No one will be able to recognise me from the pictures.

I understand that I may leave this research project study at any time without my care or treatment being affected.

I: (name)
of:(address)

hereby give consent to be in this research project.

signature of patient ___________________________ date ______________

signature of witness ___________________________ date ______________

If you are unable to physically sign this form but want to be in the project, a relative/carer must be with you, and sign it for you.

signature of relative/carer ___________________________ date ______________

TEL: 01443 483082 FAX: 01443 483140 e-mail: mpeters@glam.ac.uk
Dear Named General Practitioner

PATIENT INCLUSION IN DOCTORAL RESEARCH PROJECT

I am a PhD student at the University of Glamorgan and a registered nurse with several years experience of community care. This letter is to inform you of the nature of my study.

My research is focusing on the management of venous leg ulcers. I am exploring the impact of tele-advice on wound outcome and community nurse knowledge and confidence. A specialist will offer community nurses wound advice by mobile phone and laptop computer. Success in encouraging better wound management has the potential to reduce patient suffering and staff and financial resources.

I am looking only at patients with venous leg ulcers. To exclude patients with ulcers that are not venous in origin, a Doppler reading will be carried out in addition to clinical assessment. The study will last for twelve weeks or until the ulcer has healed, if sooner. Full ethical approval and consent from the Trust have been obtained in addition to informed consent from the patient in writing, prior to recruitment onto the study.

This is to inform you that your patient:

NAME:
ADDRESS:

has kindly given his/her permission to be included in the study.

If you would like to discuss any aspect of the study, please do not hesitate to contact me by telephone on 01443 483082. I can also be contacted by fax on 01443 483140 or e-mail mpeters@glam.ac.uk. I am including a paper which studied the views of GP’s towards store-and-forward teledermatology, for you consideration.

Should you be interested in the findings of my study I shall be pleased to supply you with a synopsis on completion.

Yours sincerely

Melanie Peters

Research Student
University of Glamorgan
Prepayment communication

General practitioners' perceptions of store-and-forward teledermatology

Karen Collins, Paula Nicolson, Ian Bowns and Stephen Walters

School of Health and Related Research, University of Sheffield, Sheffield, UK

Summary

We studied the views of 26 general practitioners (GPs) towards store-and-forward teledermatology before its introduction into their practices. A postal questionnaire was developed using Likert-type questions with respondents able to explain their answers in free text. Questions related to the GPs' knowledge, perceptions and expectations of teledermatology, as well as their attitudes towards being part of a research trial. Most of the GPs had limited prior knowledge of teledermatology. They perceived its role to relate to quicker access to specialist opinions, decreased referrals, increased convenience for patients, diagnosis, and education and teaching. There was an overwhelming view that any system needed to be quick, easy to use, efficient and reliable. Concerns were expressed about being part of the clinical trial, using new technology and an increased workload. The future of teledermatology was thought to depend on the clinical adequacy of the system.

Introduction

Studies relating to the acceptance of telemedicine, and more specifically teledermatology, have tended to focus on patient satisfaction. Few studies have reported physicians' perceptions of telemedicine. Doctors have universal but superficial knowledge of teledermatology, an appreciation of the value of technology, but low usage of the telemedicine services available to them. Medical students also felt telemedicine would become very important in the future.

Studies to date have tended to focus on the physicians' actual experience of using asynchronous or realtime telemedicine. An early study found that the major benefit reported by physicians using telemedicine was improved access to health-care. The availability of equipment and the time required for telemedicine consultation were the two main problems. A more recent study also found satisfaction to be high among four dermatologists who had been engaged in live teledermatology consultations with patients. They were satisfied with the interpersonal aspects of both the face-to-face and video-visits, although face-to-face examinations were preferred. For all face-to-face examinations and 81% of video-examinations, the doctors were also satisfied with their ability to examine the patients' skin. The most frequent problems were the on-screen icons that partially obstructed the view of the patient, certain anatomical locations (lower legs, feet, genitals and scalp) being difficult to examine, inability to touch the skin and difficulties with fine focus in some cases. The GPs liked the rapid opinion and the opportunity to initiate action quickly for their patients. They also appreciated the teaching aspect of the consultation and being able to discuss various treatment options. Another study also reported satisfaction among 43 GPs using telemedicine in 10 different specialties between an outpatient department and six general practices. There appear to be no reported studies of the views of GPs towards teledermatology before its introduction into their practices.

Methods

A randomized controlled trial of telemedicine in dermatology was being planned. In advance of the trial, a postal questionnaire was sent to GPs from seven practices in Sheffield that had agreed to take part in it.
Ethical approval was obtained from the appropriate research ethics committee.

The questionnaire was designed to identify the GPs' knowledge, perceptions and expectations of teledermatology, as well as their views about being part of the clinical trial. The questionnaire comprised 20 pre-coded items, generated through prior discussions with doctors, a review of the relevant literature and from the researchers' knowledge of the area. A preliminary paragraph pointed out that the questionnaire related specifically to the store-and-forward teledermatology system and explained that this was where the GP or practice nurse took a picture of the skin problem and sent it electronically, along with details of the patient's problem, to the dermatologist, who then returned a diagnostic and management option by a similar mechanism.

Quantitative data were analysed using the Statistical Package for Social Sciences Version 6 using chi-square, Mann-Whitney and Kendall's tau tests. Qualitative data were analysed thematically. The questionnaire was piloted by three GPs. As a result of the pilot, two questions were added and the wording of two questions was modified.

Results

The questionnaire was posted to all GPs (n = 35). The response rate after two weeks was 51% (n = 18). Following a telephone reminder this increased to 74% (n = 26). Fifty-four per cent (n = 14) of the sample were women, 39% (n = 10) were men and this information was not supplied by two of the respondents (8%).

Most of the respondents perceived their knowledge of teledermatology to be either limited or very limited (79%, n = 20; 95% CI 50-100%). The male respondents' perceived knowledge of teledermatology was significantly higher than that of the female respondents (P = 0.025). None of the respondents reported any previous experience or involvement with teledermatology. Ninety-one per cent (n = 23; 95% CI 64-96%) had not heard any talks or conference papers on teledermatology and only 32% (n = 8; 95% CI 9-45%) had ever read any articles about teledermatology.

The respondents who perceived themselves to be knowledgeable about teledermatology were more likely to anticipate difficulties with the system than those who felt that their knowledge was limited (Kendall's tau = -0.33, P = 0.064). There was also a relationship between prior knowledge and expectations. Respondents who perceived themselves to be knowledgeable about teledermatology were more likely to have high expectations of the system than those who felt that their knowledge was limited (Kendall's tau = -0.33, P = 0.077). Furthermore, those who perceived their knowledge of teledermatology to be high were more likely to feel confident about diagnosis and management using teledermatology than those who felt that their knowledge was limited (Kendall's tau = -0.41, P = 0.017).

Half of the respondents had no prior computer knowledge (Table 1). Male respondents' computer knowledge was significantly greater than that of female respondents (P = 0.001). Furthermore, those who reported their knowledge of computers to be low were significantly more likely to say that their knowledge of teledermatology was also limited (Kendall's tau = 0.49, P = 0.001). There was also some suggestion that those who described their computer knowledge to be good were more likely to feel confident about diagnosis and management using teledermatology than those who felt that their computing knowledge was limited (Kendall's tau = -0.30, P = 0.08).

Most of the respondents (81%, n = 21; 95% CI 55-91%) anticipated problems with implementing the system. None felt that there would be few or no problems, and 19% (n = 5; 95% CI 7-41%) felt that they were not sure. Other views are summarized in Table 2.

Only 15% (n = 4; 95% CI 5-36%) of respondents said that their expectations of teledermatology were high. Eighty-one per cent (n = 21; 95% CI 55-91%) felt that they were not sure, and only one respondent (4%) had low expectations. Respondents who had high expectations of teledermatology were more likely to say that they felt teledermatology would improve

<table>
<thead>
<tr>
<th>General practitioners' level of computer knowledge</th>
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<tbody>
<tr>
<td>Complete novice—never used a computer and would not know where to start</td>
</tr>
<tr>
<td>Novice used computers a little and with help could use at least one program</td>
</tr>
<tr>
<td>Intermediate used computers quite a lot, know how to copy files, load and run a program, do backups and with good documentation could use an unfamiliar computer</td>
</tr>
<tr>
<td>Regularly used a computer and could easily install a new package, transfer data between packages and sort out problems</td>
</tr>
<tr>
<td>Designed and implemented systems</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>n</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>13</td>
<td>50</td>
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<tr>
<td>5</td>
<td>9</td>
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<tr>
<td>7</td>
<td>27</td>
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<td>1</td>
<td>4</td>
</tr>
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<td>1</td>
<td>4</td>
</tr>
</tbody>
</table>
K Collins et al. GPs' perceptions of teledermatology

Table 2 General practitioners' views of teledermatology

<table>
<thead>
<tr>
<th>Question</th>
<th>Yes</th>
<th>No</th>
<th>Unsure</th>
</tr>
</thead>
<tbody>
<tr>
<td>Do you think that teledermatology will make things better for you as a GP?</td>
<td>8</td>
<td>0</td>
<td>18</td>
</tr>
<tr>
<td>Do you feel that teledermatology will improve patient and/or health care?</td>
<td>13</td>
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<tr>
<td>Have you any concerns relating to the doctor–patient relationship?</td>
<td>&lt;</td>
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<tr>
<td>Have you any concerns relating to the image of doctors?</td>
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<tr>
<td>Have you any concerns relating to ethical problems?</td>
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<td>12</td>
<td>5</td>
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<tr>
<td>Have you any concerns relating to patient and professional privacy/confidentiality?</td>
<td>6</td>
<td>23</td>
<td>3</td>
</tr>
<tr>
<td>Have you any concerns relating to medical liability?</td>
<td>6</td>
<td>23</td>
<td>4</td>
</tr>
<tr>
<td>Do you feel that teledermatology will influence developments in the future?</td>
<td>15</td>
<td>58</td>
<td>11</td>
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<tr>
<td>Do you have any fears about using the teledermatology system?</td>
<td>12</td>
<td>46</td>
<td>2</td>
</tr>
</tbody>
</table>

Discussion

Owing to the small sample size, it is difficult to generalize from the findings of the present study. The GPs had already agreed to take part in the research trial when they completed the questionnaire, so that the sample may not have been representative of GPs in general. There is also the potential for response bias—the non-responders may have been indifferent to the introduction of teledermatology into their practices and we have no information about the non-responders in this study.

The qualitative data from the open-ended questions provided information about some of the subjective perceptions and concerns of the GPs about teledermatology and its introduction into their practices. The GPs perceived their knowledge of teledermatology to be limited. Similar findings have been reported elsewhere.3,9,10 Despite this, these GPs expressed clear views about what they viewed as the role of teledermatology. There was a perception that teledermatology in general practices would result in quicker diagnosis and treatment, decreased referral rates and improved medical education and training. There was an overwhelming view that a telemedicine system needed to be quick, easy to use, efficient and reliable.

Almost half of the GPs expressed concerns about being part of a teledermatology research trial. There were fears of increased workload, time commitment and consultation time. There were also concerns about the quality of images transmitted and the reliability of the equipment, as well as about the security of the system, patient confidentiality and medical liability.

Despite many of the GPs not knowing what to expect of teledermatology in their practices, none of them expressed the view that it would not improve patient care. However, only one in four of the GPs felt...
K Collins et al. GPs' perceptions of teledermatology

confident about diagnosis and management using teledermatology. This may be related to the GPs' limited knowledge of teledermatology and its applications. The implication is that teledermatology may be less likely to be introduced and accepted into practices if GPs do not feel confident about its potential to diagnose and manage skin problems effectively. It may therefore be necessary to provide education and training to GPs to increase their knowledge and awareness of new techniques such as telemedicine.

The present study suggested that GPs are cautious about the introduction of teledermatology into their practices. It also suggests that confidence with management and diagnosis through teledermatology may increase as GPs become more knowledgeable about its application. The findings have implications for teledermatology in the National Health Service. Managers need to be aware of and address some of these concerns if teledermatology is to ‘have a key role to play in the Government’s plans to modernise the NHS’.

Acknowledgements The research trial of telemedicine in dermatology is funded by the NHS R&D Health Technology Assessment Programme, but the views expressed are those of the researchers. We thank the GPs participating in the trial, especially those who completed the questionnaire as part of the study.

References


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GUIDELINES FOR TAKING DIGITAL IMAGES

MELANIE PETERS
RESEARCH UNIT
SCHOOL OF CARE SCIENCES

UNIVERSITY OF GLAMORGAN
PRIFYSGOL MORGAN
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Guidelines for taking digital images 2
INTRODUCTION

You will receive full training for using the camera in conjunction with these guidelines. They are then intended as an ‘aide memoire’ if necessary.

The guidelines are laid out in sections. This will enable you to turn to the section you require, rather than you having to read the entire contents.

Whilst the camera is relatively easy to use it has many specialised features. Some are obscure and would not be used within the confines of this project. For example, CCD RAW. This gives a very high quality image (or picture) but is such a large file that it would not be practical to use.

Some functions can be done in a number of ways; for example, there is a short cut to deleting pictures. To avoid providing confusing, unnecessary and duplicated information, only the most straightforward and relevant functions are covered. However, if you are interested in further details, a copy of the manufacturer's handbook can be made available. If there are any features that have not been covered or any that you would especially like to see added to this manual, please do not hesitate to ask the researcher.

Should you require any further information regarding the camera or this manual, a list of contact numbers are provided below:

01443 483082 Melanie Peters – work phone (voicemail – to leave a message)
0788 1550355 Project mobile phone
0771 3418527 Researcher’s mobile phone
01443 483092 Trish Millard – research unit secretary (to leave a message)

If you cannot reach me, leave a message and I will get back to you as soon as possible.

HOW DOES THE DIGITAL CAMERA WORK?

A compact flash (CF) card is inserted into the camera and the pictures are captured on this card. The card can then be placed into a computer and the pictures seen immediately. There is no need for film processing. This makes digital images more secure and convenient than traditional photography for wound care.
In order to ensure everyone takes their pictures in the same way, a few simple rules need to be followed. This will allow the pictures to be reliably compared.

(1) All pictures need to be taken from the same pre-determined distances. Whilst it would be ideal to take exact measurements, this is not practical for community work. Therefore, a length of string with three pre-determined measurements will be attached to the camera. The green marker is at 5” (18cms) the red marker at 10” (25.5cms) and the blue marker at 15” (38 cms) and you will take a picture from each distance. Holding the string taut, place the mark as close as possible to the patient’s ulcer without touching it – this will determine how far away you need to place the camera to take the picture. (Take care not to touch the ulcer with the string as this could be a source of cross-contamination between patients.) This will provide an approximate, quick and straightforward rule.

(2) All pictures need to be taken at the same angle. Whenever possible pictures need to be taken at a perpendicular angle. That is at a 90° degree angle, preferably looking straight down at the wound.
The lighting needs to be the same for each picture.
This has been tested in various conditions and the most favourable method is to turn the flash on permanently. Details of how to turn the flash on are given on page 17. Any other source of light such as lamps and fluorescent lighting, need to be turned off. Where possible natural daylight also needs to be reduced, for example draw curtains and close blinds. Ask the patient if you may take the picture in a different room if you usually carry out their ulcer care in a bright or sunny room.

The background needs to be the same for each picture.
To give the most accurate wound representation pictures they should have the same background. Pale green is a good colour to use a photographic background. The researcher will provide green paper towels for you.

Each picture needs to be clearly identified.
To ensure that a wound picture does not get mistaken for another, each picture will have a unique code. This will identify the patient by numerical code only. It will also identify the nurse taking the picture, the date, your trust and the distance from the patient’s ulcer that the picture has been taken. Write the details on the paper ruler and place it in the bottom of the picture.

The macro mode needs to be on
As the pictures are being taken close up, the macro mode needs to be permanently on. This will help to prevent the picture becoming blurred. Details of how to put the macro mode on are on page 17.

A filter needs to be placed upon the camera and the flash
You may wonder why the Blue Peter type cardboard is placed over the camera lens and a piece of grey plastic over the flash. Light often bounces back off objects. This could make parts of the ulcer appear white and patchy. Therefore, the light needs to be filtered to make the picture clearer. As the camera has a retractable zoom lens it was not possible to buy a ready-made filter that could be fitted onto the camera. The homemade filters will be fitted upon the camera AND THEY NEED TO BE LEFT THERE. If there are any problems with them please ring me and I will advise you.

Guidelines for taking digital images
PREPARATION

For ease of use all the camera parts are labelled with coloured stickers. The green sticker denotes which camera (1 of 3) and the red sticker denotes the camera part (1 of 17).

1. Ensure that you have all the necessary equipment:
   - Camera  (red sticker number 1)
   - CF card  (red sticker number 2)
   - Ruler

2. Ensure that the camera battery has enough charge to take a picture. When the battery is low the following icon will appear in the display panel:

![Low battery icon](image)

One or two pictures can still be taken if it is not possible to charge the battery at this point, but it is advisable to have a fully charged battery. The researcher will endeavour to keep the camera batteries fully charged. However, if this is not feasible instructions are given on page 19.

3. Check that your patient has previously received and signed a consent form. Your patient will have received information explaining the nature of the project to them. When you use the equipment, a simple brief reminder of the procedure should be adequate.

4. Confirm that the patient is satisfied for you to proceed. Although the patient has already consented, they may be occasions when they simply do not wish to participate.

5. Place the patient in a comfortable, appropriate position.

6. Take a test picture to check the patients’ positioning and lighting. View the picture on the camera’s LCD screen. If necessary, modify steps 5 – 6 until the most beneficial situation is achieved. Further details are included in the following pages.

7. You will find you get the most benefit from discussing treatment options with the wound care specialist if you have specific information to hand. This information is:

   (i) the patient’s medication
   (ii) the patient’s Doppler readings
   (iii) current and previous treatment
   (iv) any known tests (whilst both in hospital and the community)
GENERAL CAUTIONS

These guidelines are taken from the manufacturer's handbook. Many are self-explanatory, some are not relevant to the community nurse and some are an insult to your intelligence! However, as safety is a key issue they have been included.

1. Avoid leaving the camera in places subject to extreme temperatures. For example, the dashboard of a car. You may need to carry the camera in the boot of your car when travelling to patient’s homes but don’t leave it in the boot for long periods, such as all day.

2. Do not touch the flash as it becomes very hot.

3. Do not handle the power cord if your hands are wet. For example, hand washing prior to a dressing change.

4. If you have the camera for an extended period of time but do not use it, remove the battery.

5. Don’t charge the battery in poorly ventilated areas.

6. Don’t use the battery charger to charge batteries other than those supplied with the camera.

7. Don’t leave the battery to charge for more than 24 hours. Any longer can damage the battery. Also make sure the battery charger is disconnected following charging.

8. It is advisable to only charge the battery when it is completely empty.

9. Remove the battery after using the camera.
1. The Camera Parts

FRONT VIEW

- Viewfinder
- Autofocus
- Flash
- Red eye reduction lamp
- Video terminal
- Digital terminal
- Lens

BACK VIEW

- Viewfinder
- CF card slot cover
- Lock for CF card slot cover
- LCD panel
- DC coupler cable cover
- Battery cover
- Battery cover lock
- Tripod socket

OPERATION PANEL

- Indicators
- Shutter button
- Mode dial
- Flash/+ button
- Set button
- Macro/jump button
- LCD/video
- Menu button
- Continuous/self timer/+ button
- Zoom buttons

Guidelines for taking digital images 8
2. THE CAMERA MODES

1. On the top of the camera is a dial with several features or modes.

![Diagram of camera modes]

- **Programme Mode**
  - Flash, Red-eye button
  - This mode allows for manual selection of flash and continuous settings.

- **Auto Mode**
  - Macro button

- **Lock**

**Stitch Assist Mode**

**PC Mode**

**MULTI**

**Multi Mode**

**Play Mode**

**Figure 5  The camera modes**

The modes are used for taking pictures, playing the pictures back and sending the pictures via computer.

PICTURE TAKING MODES
Three modes are used for taking pictures.

(1) **Auto Mode**
This is used for taking standard pictures. Focus, exposure, white balance and flash are automatically controlled by the camera.

Also available in auto mode:

- **Macro Button**
  When using the auto mode, you can also access the macro button. This is used when you want to get close to the subject you’re photographing – 17 to 50 cms (6 1/2 to 20 inches).

(2) **Program Mode P**
This is also used for taking pictures but the flash and continuous settings can be manually selected. Focus and exposure remain controlled by the camera.

Also available in program mode:

- **Flash, Red-eye button**
  When using the program mode, you can access the flash on, flash off and red-eye button.

(3) **Stitch Assist Mode**
This mode allows you to merge several pictures into one, such as a panoramic view.

When using these modes, the camera lens cover will close and the camera will reserve power after three minutes.
PLAYBACK MODES
Two modes are used for playing back pictures.

(1) PLAY: Play Mode
This allows you to view pictures on the LCD screen, whilst the CF card containing them is in the camera. The pictures are shown one at a time. Pressing the + and – buttons will display the previous and next picture.

(2) MULTI: Multi Mode
This allows you to view pictures on the LCD screen, whilst the CF card containing them is in the camera. The pictures are shown in groups of nine. Pressing the + and – buttons will display the previous and next picture.

When you are using these modes the camera will reserve power if not used for five minutes.

DATA TRANSMISSION MODE
The following mode is used for sending pictures by computer.

PC: PC Mode
This is used for viewing and processing pictures with a computer.

LOCK MODE
L: Lock Mode
This simply locks the camera so it cannot be used. When you are not using the camera turn the mode dial to the lock position. The lens cover will close and the camera will reserve power. Ensure that you turn the mode dial to lock before you change a battery, eject a CF card or connect the camera to the laptop computer.
3. THE DISPLAY PANEL

1. The display panel on the top of the camera shows information about the camera. This includes settings, battery levels, camera errors and number of pictures that can be stored on the CF card.

   ![Display Panel Image]

   Number of images left on CF card
   Auto mode
   Size of image
   Display panel
   Beep on

   Figure 6
   The display panel and an example of messages displayed

THE DISPLAY PANEL MESSAGES

There are many messages that may appear in the camera’s display panel. They are listed below with the symbols that accompany them and a brief explanation:

- **Single Mode**
  *For taking single shots*

- **Flash On**
  *Flash remains on for all photos*

- **Continuous Mode**
  *Up to 15 photos will be shot*

- **Flash Off**
  *Flash remains off for all photos*

- **Self-timer Mode**
  *For taking photos after 10 seconds*

- **Red Eye Reduction**
  *Prevents red eye in photos*

- **Fine**
  *High quality photos*

- **Macro Mode**
  *For taking close up photos*
### Guidelines for taking digital images

<table>
<thead>
<tr>
<th>Setting</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Normal</td>
<td>Normal quality photos</td>
</tr>
<tr>
<td>CCD Raw</td>
<td>Very high quality photos</td>
</tr>
<tr>
<td>Large</td>
<td>Larger photos</td>
</tr>
<tr>
<td>Small</td>
<td>Smaller photos</td>
</tr>
<tr>
<td>Pb:</td>
<td>Image being prepared for display</td>
</tr>
<tr>
<td>Lb:</td>
<td>Battery needs recharging immediately</td>
</tr>
<tr>
<td>Busy:</td>
<td>Image is being recorded</td>
</tr>
<tr>
<td>Cannot Record!:</td>
<td>No CF card in camera</td>
</tr>
<tr>
<td>Shaking hands</td>
<td>The photographer's hands or the camera are shaking</td>
</tr>
</tbody>
</table>

- **Exposure Compensation**: Allows adjustment of exposure settings
- **Beep On**: Makes sounds when camera functions are completed
- **Low Battery**: Battery needs charging
- **Clock Not Set**: Time and date not set
- **CF: or No CF card**: No CF card in camera
- **Battery charge low**: Battery charge low
- **Card full**: Card full
- **No images on CF card**: No images on CF card
4. THE INDICATOR LIGHTS

Two lights are located to the left of the viewfinder. These lights will shine or flash to confirm the camera is performing various functions, when the shutter button is pressed.

Upper Indicator
- Green: Ready to take picture, flash off
- Flashing green: Recording data from CF card
- Red: Ready to take picture, flash on
- Flashing red: Flash set to off, but is needed as there is not enough light

Lower Indicator
- Orange: Macro mode on (for taking close ups)
5. INSERTING A COMPACT FLASH CARD INTO THE CAMERA

1. Ensure that the mode dial is turned to LOCK.

2. Open the CF card slot on the back of the camera by sliding the CF OPEN button downwards.

3. Gently insert the CF card into this opening slot. The card is inserted on its side. The grey number 8 should be facing you and the grey or white arrowhead pointing toward the camera.

4. Close the CF card cover on the camera. Do not attempt to remove a CF card whilst the camera is capturing a picture.
6. REMOVING A COMPACT FLASH CARD FROM THE CAMERA

1. Ensure that the mode dial is turned to LOCK.

2. Open the CF card slot on the back of the camera by sliding the CF OPEN button downwards.

3. Push in the release button on the bottom right corner of the camera.

4. Close the CF card cover on the camera.

Never remove a CF card unless the mode dial is set to LOCK.
7. INSERTING THE BATTERY INTO THE CAMERA

1. Ensure that the mode dial is turned to the LOCK position.

2. Slide the battery lock cover to the release position (towards the LCD panel). A small red dot should become visible.

![Opening the battery cover](image)

3. Slide open the battery cover.

4. Drop the battery in. It will only fit in the correct position. Gently push it all the way in and close the battery cover.

5. Slide the battery cover lock to the locked position – no red dot visible. The camera will not work unless this is locked.

Do not attempt to remove the battery immediately after taking a picture.
8. TAKING A PICTURE

1. Settle your patient into a comfortable but convenient position.

2. Ensure the CF card and the battery are correctly inserted and that the battery cover is locked.

3. Set the flash to the ‘On’ mode.
   This is done by turning the mode dial to P: Program function.
   Press the minus (-) button next to the mode dial. This will allow you to scroll through four choices which will be displayed to the right of the display panel:
   - No symbol
   - Auto mode (the camera will determine if the flash is needed or not)
   - Red eye reduction mode
   - Flash Off mode
   - Flash On Mode
   Leave the mode dial set to P to take the photograph.

4. Measure the first standard distance – 5” green marker - from the patients’ ulcer.

5. Ensure that the identification of the patient and their ulcer is correctly recorded and placed close to the ulcer. Switch on the LCD panel and use this to compose your picture.

6. When you are satisfied with the picture press the shutter button halfway. This automatically sets the focus and exposure. When the camera is ready to take a picture it will beep and the green light will shine.

7. Press the shutter button fully. A single beep will indicate that the picture has been taken and after several seconds the green light will flash next to the viewfinder. The picture on the LCD panel will freeze for a few seconds and the busy icon will be displayed at the bottom of the panel. Wait for the green light to stop flashing before you continue.

8. Repeat steps 5 to 7 using the other two distances – 10" and 15”.
   Turn the mode dial to the LOCK position until you are ready to take another picture. The lens cover will close and the camera will reserve power if it is not used for 3 minutes. Pressing any button or turning the mode dial will restore the power.

Guidelines for taking digital images
9. LOOKING AT A PICTURE

1. Turn the mode dial to the PLAY position.

2. The busy icon will appear and a green light next to the viewfinder will flash several times.

3. The first picture will appear. Press the + and – buttons to see the previous and next pictures. If you are not happy with the result, delete the unwanted picture and take another. (See page 17 for details on deleting pictures).

4. When you have finished viewing your pictures, turn the mode dial to the LOCK position.

5. MULTI mode is similar to PLAY mode but allows you to look at up to 9 pictures at a time.
10. DELETING PICTURES

1. Turn the mode dial to the PLAY position.

2. The busy icon will appear and the green light will flash next to the viewfinder.

3. The first picture will appear. The + and – buttons will allow you to scroll through the menu choices. Press the + and – buttons to find the picture you want to delete.

4. Press the menu button. You will see the following choices:

   ![Play Menu](image)

   **Figure 10**  The play menu

5. Press the + button to go to the Erase function. The selected function will become highlighted in green.

6. Press the SET button.

7. You will then see the following choices:

   ![Play Menu](image)

   **Figure 11**  Deleting a picture
8. Press the SET button.

9. You will then see the following screen:

![Erase](image)

Figure 12  Erasing an image

10. Press the SET button again. A dialogue box will ask you again if you want to cancel deleting the picture or OK it. Press the + and – buttons to select OK. Press the SET button again.

11. Erase will appear in the top left corner and the busy icon. When the picture is erased the camera will move on to the next picture.

12. Turn the camera mode dial to the LOCK position when you have finished getting rid of unwanted pictures.

There is a quicker way to delete pictures but using the above process asks you to check at each step. This ensures that the time and effort taken to achieve a good picture cannot be accidentally deleted.
1. Attach the AC power cord (red sticker number 5) to the compact power adapter (red sticker number 6).

Figure 13  Charging the battery

2. Plug it into an electrical socket.

3. Remove the battery from the camera and place it into the power adapter. The battery will only fit into the charger in the correct position.

4. Whilst charging, the charging indicator light on the power adapter will flash green. Once the battery is fully charged it will stop flashing and remain constantly lit. The battery takes approximately 90 minutes to charge fully. A fully charged battery will last for approximately 70 images with the display panel on and 280 images with the display panel off.

**First principle:**
The information to be contained in personal data shall be obtained, and personal data shall be processed, fairly and lawfully.

**Second principle:**
Personal data shall be held only for one or more specified and lawful purposes.

**Third principle:**
Personal data held for any purpose or purposes shall not be used or disclosed in any manner incompatible with that purpose or purposes.

**Fourth principle:**
Personal data held for any purpose or purposes shall be adequate, relevant and not excessive in relation to that purpose or those purposes.

**Fifth principle:**
Personal data shall be accurate and, where necessary, kept up to date.

**Sixth principle:**
Personal data held for any purpose or purposes shall not be kept for longer than is necessary for that purpose or those purposes.

**Seventh principle:**
An individual shall be entitled –
(a) at reasonable intervals and without undue delay or expense
   (i) to be informed by the data user whether he holds
      personal data or which that individual is the subject; and
   (ii) to access to any such data held by a data user; and
(b) where appropriate, to have such data corrected or erased.

**Eight principle:**
‘Appropriate security measures shall be taken against unauthorised access to, or alteration, disclosure or destruction of, personal data and against accidental loss or destruction of personal data.’
Reducing Specular Reflection by Polarising Filters

Specular reflections occur on smooth or wet surfaces. They are tiny mirror images of the light source reflecting back to the observer. A photographic image of a wound can be spoilt by these reflections since they can be so intense that important wound features are no longer visible.

Since specular reflections are only visible if the illumination angle is equal to the viewing angle it is easy to avoid specular reflections on absolutely flat surfaces by changing either the viewing angle of the illumination angle.

On wounds, however, this approach does not work. Wounds are rather "bumpy" and there are always areas where the orientation of the wound surface is 'just right' so that a light source such as a window, lamp or camera flash gets reflected back to the observer or camera. A more sophisticated method is therefore required.

A ray of light can be considered as a collection of many single waves. These waves have, amongst other things, the habit of oscillating in planes. In normal light these planes can have any orientation in space, each wave 'wobbling' in its own plane.

At this point we introduce polarising filters. These are optical filters made of plastic or glass and they have the remarkable property of allowing only light waves with a certain orientation to pass through. They can be imagined as an array of slits where only light waves with roughly the same orientation as the slit are allowed to pass through.
Since the majority of waves are unfortunate enough to oscillate in the wrong planes any illumination through a polarising filter looses a lot of brightness. This is the reason why the polarising filter itself appears grey.

Let's now assume we illuminate a wound through one of these filters. The wound is now hit by lots of light waves which all oscillate in roughly the same direction. (These filters are never perfect, some waves that are slightly out of the polarisation plane also manage to squeeze through, that's why I said "roughly"). The wound now reflects these light waves but it does that in two distinct ways:

1. Wherever there is an area of specular reflection this area reflects the waves in such a way that the polarisation plane they are oscillating in does not change.
2. All other areas (they are called diffusely reflecting, by the way) not only reflect the waves they also randomly change the plane in which they are oscillating.

As a result the observer now sees two different kind of light waves, those that are nicely aligned with the polarisation plane of the filter and those that are not. Although for human eyes or cameras this is not apparent we can now use this effect to get rid of those waves that come from areas of specular reflection. The trick is to use a second polarising filter in front of the camera. If this filter is rotated by exactly 90 degrees with respect to the illumination filter, all those waves that have been reflected specularly are cut out but some of those coming from diffusely reflecting areas that were fortunate enough to be rotated into a plane that happens to be the polarisation plane of the 2nd filter can pass through.

Unfortunately a lot of light is lost again in this 2nd filtering process, but a lot of the specular reflection has disappeared. Unfortunately the filters are not perfect in their blocking properties and some specular reflection may still be visible. Most of it has, however, disappeared.

The problem of light loss (approximately 75%) can be compensated for by using a brighter light source (e.g. more flash power in a camera) or by using a film with higher sensitivity (in electronic cameras use more amplification).

Plassmann 2003.
APPENDIX XVII
# Leg Ulcer Assessment Sheet

**Patient’s name:**

**Allergies:**

**Medication:**

**DOB:**

**Sex:** M/F

**GP:**

**Consultant:**

**Date:**

**Assessor:**

## Predisposing

<table>
<thead>
<tr>
<th>Condition</th>
<th>L</th>
<th>R</th>
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<tr>
<td>Previous ulcer</td>
<td></td>
<td></td>
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<tr>
<td>Phlebitis</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cellulitis</td>
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<td></td>
</tr>
<tr>
<td>Fracture</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Vascular surgery</td>
<td></td>
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<tr>
<td>Orthopaedic surgery</td>
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<tr>
<td>Intermittent claudication</td>
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<tr>
<td>Abdominal surgery</td>
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</tr>
<tr>
<td>Ischaemic heart disease</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hypertension</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Transient isch. attacks</td>
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<td></td>
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<tr>
<td>Cerebral vasc. accident</td>
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<td></td>
</tr>
<tr>
<td>Rheumatoid arthritis</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Diabetes</td>
<td></td>
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</tr>
</tbody>
</table>

## Perpetuating

<table>
<thead>
<tr>
<th>Condition</th>
<th>L</th>
<th>R</th>
</tr>
</thead>
<tbody>
<tr>
<td>Poor ankle movement</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fixed ankle joint</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Limited mobility</td>
<td></td>
<td></td>
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<tr>
<td>Tobacco usage</td>
<td></td>
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<tr>
<td>Undernourishment</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Obesity</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Social isolation</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lack of information</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Impediments to circulation:</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Any other relevant problems:

## Presenting

1. **General observations**
   - Urinalysis/Glucocheck
   - BP
   - Doppler API (L)
   - Doppler API (R)

2. **Affected limb**
   - Ankle circumference
   - Calf circumference
   - Oedema
   - Inflammation
   - Staining
   - Eczema
   - Induration
   - Ankle flare
   - Varicose veins
   - Strong pedal pulses
   - Weak/absent pulses
   - Pain (circle):
     - Severe/moderate/day/night

3. **Baseline measurements**
   - Ulcer 1: L — R
     - Site
     - Size
     - Colour
     - Edge
   - Ulcer 2: L — R
     - Site
     - Size
     - Colour
     - Edge
   - Ulcer 3: L — R
     - Site
     - Size
     - Colour
     - Edge

Attach perimeter outline(s)
Reassess regularly

---

Paula ErtI, RGN, NDNCert, DPNs, BSc(Hons), District Nurse Liaison Sister, Eastbourne District General Hospital

**Key**

- Site
- Size
- Max length (cm)
- Max width
- Edge
- Sloping
- Rolled
- Cliff ('punched out')
- Colour (wound classification)
  - Black: necrotic – covered with hard, dry layer of dead skin
  - Yellow: sloughy necrotic – covered or filled with soft slough
  - Red: clean and filled with granulation tissue
  - Pink: epithelialising – covered with layer of new pink skin
APPENDIX XVIII
The correct answer for each question is indicated with a tick. The theme and level of difficulty for each question is also indicated in red italics.

WOUND CARE SELF-ASSESSMENT QUESTIONNAIRE

This self-assessment questionnaire is purely to explore current levels of wound care understanding in your area. It has not been designed to highlight the individual’s knowledge basis and your answers will be totally confidential. Overall scores will be the focus of interest in this study.

Should you be interested in the correct answers and your score, these can be made available upon completion of the study.

The questionnaire comprises 40 questions of differing levels of complexity. Registered nurses from two local Trusts, will carry out this exercise. The information obtained will be used in the final research project, potentially with recommendations for wound care practice.

Thank you for giving your time and completing this exercise.

Melanie Peters
WOUND CARE SELF-ASSESSMENT QUESTIONNAIRE

For each of the questions or statements below there is one best answer.

EXAMPLE

Tick the box of your chosen answer.

(1) The most common cause of wound complication is
   (a) contracture [ ]
   (b) keloid [ ]
   (c) vascularisation [ ]
   (d) infection [✓]

(1) The use of a Doppler ultrasound is useful in the assessment of:
   (a) pressure sores [ ]
   (b) pilonidal sinus [✓]
   (c) arterial disease [✓]
   (d) weight control [ ]

(2) What percentage of leg ulcers are due to venous ulcer disease:
   (a) 10% [ ]
   (b) 70% [✓]
   (c) 1% [ ]
   (d) 5% [ ]

(3) Before compression is applied it is important to determine the ankle/brachial pressure index. This is obtained by measuring the blood pressure in the arm and foot and calculating the required ratio from which of the following:
   (a) arm systolic [ ]
       foot systolic [ ]
   (b) foot systolic [✓]
       arm systolic [✓]
   (c) arm diastolic [ ]
       foot diastolic [ ]
   (d) foot diastolic [ ]
       arm diastolic [ ]

(4) What does a hydrocolloid dressing do:
   (a) it provides cleaning and debriding properties [✓]
   (b) it provides haemostatic properties [ ]
   (c) it reduces the number of micro-organisms at the wound interface [ ]
   (d) it provides a way to constantly observe the wound [ ]

MARKED EITHER PRE OR POST
ACCORDING TO STAGE IN STUDY
(5) The outermost layer of the skin is the:
   (a) stratum corneum  [✓] physiology
   (b) stratum spinosum
   (c) stratum malpighian
   (d) stratum basale

(6) What is the most important advice you can give patients with recently healed venous leg ulcers?
   (a) to keep the leg dry  [✓] management
   (b) to wear compression hosiery for life
   (c) to attend regular physiotherapy
   (d) to keep the leg rested

(7) Wound remodelling:
   (a) can take several years  [✓] physiology
   (b) begins immediately after wounding
   (c) precedes the inflammatory response
   (d) is required before contraction phase takes place

(8) What is the preferred method of ulcer cleansing:
   (a) soak in salt water
   (b) bathe with an antiseptic solution
   (c) keep the ulcer dry
   (d) tap water  [✓]

(9) Autolysis can be described as:
   (a) the natural formation of new blood vessels
   (b) the migration of epithelial cells to resurface a wound
   (c) the natural degradation of devitalised tissue  [✓]
   (d) the automatic release of leukocytes into damaged tissue

(10) Secondary healing of a cavity wound requires mainly the process of:
    (a) epithelialization
    (b) contraction  [✓] physiology
    (c) vascularisation
    (d) coagulation

(11) The key inflammatory cell involved during normal wound healing is the:
    (a) platelet
    (b) red blood cell
    (c) macrophage  [✓]
    (d) leucocyte

MARKED EITHER PRE OR POST
ACCORDING TO STAGE IN STUDY
12. The best method of minimising cross-contamination of wound organisms is to:
   (a) nurse patients in isolation
   (b) employ a good handwashing technique [✓ easy]
   (c) nurse patients in the community [ ]
   (d) use only sterile dressing and equipment [ ]

13. Which of the following statements is not true in relation to an arterial ulcer:
   (a) the ulcer has a 'punched out' appearance [ ]
   (b) the ulcer is deep [ ]
   (c) the ulcer is sloughy [ ]
   (d) there is surrounding eczema [✓]

14. Hydrogel dressings can be used on necrotic tissues because:
   (a) they digest necrotic tissue [✓ dressing]
   (b) they keep the wound bed dry [ ]
   (c) they facilitate autolysis [ ]
   (d) they have a bacteriocidal action [ ]

15. What is the main cause of venous leg ulcers:
   (a) venous disease [✓ physiology]
   (b) rheumatoid arthritis [ ]
   (c) arterial disease [ ]
   (d) diabetes [ ]

16. What is the effect of corticosteroid therapy on wound healing:
   (a) no effect [ ]
   (b) accelerated rate of healing [✓ difficult]
   (c) decrease in inflammatory response [✓]
   (d) research is inconclusive at this time [ ]

17. What is the ankle pressure in mmHg, to achieve optimum compression:
   35 - 40 mmHg [✓]
   15 - 20 mmHg [ ]
   18 - 24 mmHg [ ]
   80 - 100 mmHg [ ]

18. Wound infection is not caused by:
   (a) poor surgical technique [management]
   (b) presence of foreign body in wound [ ]
   (c) contamination during or after surgery [ ]
   (d) good nutritional status [✓]

MARKED EITHER PRE OR POST
ACCORDING TO STAGE IN STUDY
19. In a healthy wound, granulation tissue would appear as:
   (a) reddish, velvety carpet with yellow cobblestones  ✓ physiology medium
   (b) bright red, vascular tissue which bleeds easily to the touch
   (c) yellowish-greenish tissue covering the base of the wound
   (d) pink, silvery tissue appearing at the wound edge

20. Which of the following statements should not be given as advice to a patient with arterial ulcers:
   (a) give up smoking ✓ easy
   (b) elevate leg above heart
   (c) exercise
   (d) elevate leg level with heart

21. There are many factors that can adversely affect wound healing. Which one does not:
   (a) patients' age ✓ management medium
   (b) patient's nutritional status
   (c) location of the wound
   (d) gender

22. Platelets and macrophages release important growth factors including:
   (a) vitamins A and C
   (b) growth hormone and somatomedin ✓ difficult
   (c) PDGF and TGD-β ✓
   (d) oxygen and carbon dioxide

23. The quickest way to debride a necrotic or sloughy wound is by:
   (a) use of hydrocolloid dressings
   (b) use of hydrogels
   (c) the process of autolysis ✓
   (d) surgical excision

24. Delayed primary healing is used when:
   (a) the wound is clean ✓ easy
   (b) only the epithelium is lost
   (c) the tissue is burned
   (d) there is suspected infection ✓

25. What is the estimated annual cost of leg ulcer treatment to the NHS:
   (a) £20,000,000 - £40,000,000 ✓ difficult
   (b) £300,000,000 - £600,000,000
   (c) £750,000 - £800,000,000
   (d) £150,000,000 - £200,000,000
26) Compression is a major factor in the successful management of which of the following types of leg ulcers:
   (a) venous [✓] management easy
   (b) arterial
   (c) diabetic
   (d) traumatic

27) What would be the preferred dressing choice for an infected, heavily exuding leg ulcer:
   (a) film
   (b) hydrogel
   (c) hydrocolloid
   (d) foam [✓] dressing medium

28) What is the main principle of Laplace's Law:
   (a) the pressure on the limb will be greatest at the largest radius [✓] physiology difficult
   (b) the pressure on the limb will be the same at the largest radius
   (c) the pressure on the limb will be greatest at the smallest radius
   (d) the pressure on the limb will be least at the smallest radius

29) Why is it important to promote walking and leg exercise to patients with venous ulcers?
   (a) to prevent neuropathy
   (b) to assist the calf muscle pump in venous return [✓] medium
   (c) walking and exercise are not recommended
   (d) to keep the limb warm

30) After ingesting bacteria and foreign bodies, the monocyte is transformed into a:
   (a) lymphocyte [✓] physiology difficult
   (b) platelet
   (c) macrophage
   (d) erythrocyte

31) What is the most common cause of arterial ulcers:
   (a) atheromatous plaques [✓] physiology medium
   (b) rheumatoid arthritis
   (c) incompetent valves
   (d) formation of fibrin cuffs

32) Which of these is not a compression bandage system:
   (a) Profore
   (b) Ultrafour
   (c) Ulzerfore [✓]
   (d) System 4
When would you apply compression bandaging to a leg ulcer:
(a) ABPI 0.8
(b) ABPI 0.5
(c) ABPI 0.65
(d) ABPI 0.2

Colonisation of a wound occurs when:
(a) there is bacteria present on the wound surface, but not in the underlying tissues
(b) there is bacteria present on the wound surface and in the underlying tissues
(c) micro-organisms have entered the deep tissues
(d) a wound is cross-contaminated by poor aseptic technique

The most important factor in healing of venous ulcers is:
(a) contact dressings
(b) compression therapy
(c) position of ulcer
(d) weight control

What is the effect of washing on a crepe bandage:
(a) reduction in flexibility
(b) increase in elasticity
(c) no change in flexibility
(d) reduction in elasticity

Monocytes are attracted to the wound site by chemical signals given off by bacteria. The process is known as:
(a) phagocytosis
(b) autolysis
(c) chemotaxis
(d) diapedesis

How could you encourage patient compliance when applying a four layer bandage:
(a) apply the bandages loosely
(b) educate the patient about the importance of compliance
(c) only apply the necessary layers
(d) teach them how to apply the bandages themselves

What is the optimum time for a compression bandage to be left in place:
(a) one day
(b) three days
(c) one week
(d) ten days

MARKED EITHER PRE OR POST
ACCORDING TO STAGE IN STUDY
What would you use a semi-permeable film dressing for:
(a) cavity wounds
(b) heavily exuding wounds
(c) superficial skin loss
(d) wounds healing by delayed primary closure

Thank you.
Please complete the following questions overleaf.

MARKED EITHER PRE OR POST
ACCORDING TO STAGE IN STUDY
(i) How long have you been qualified as a nurse?

(ii) Please list below your qualifications:

(iii) Please list below any wound care courses, with dates, you have attended:

(iv) How long have you worked in the community?

(v) What is your age group?

- 21 – 30 [ ]
- 31 – 40 [ ]
- 41 – 50 [ ]
- 51 – 60 [ ]
- 61+ [ ]

Thank you

MELANIE PETERS

MARKED EITHER PRE OR POST ACCORDING TO STAGE IN STUDY
WOUND CARE OPTIONS

Please read the following 10 statements. If you AGREE with a statement tick the box next to it.

1. If a colleague disagrees with my treatment choice I will change it straightaway. [ ]
2. I think community nurses are competent in carrying out leg ulcer care. [ ]
3. I always refer patients to the leg ulcer clinic when necessary. [ ]
4. The GP always decides on my patients leg ulcer treatment. [ ]
5. A leg ulcer will never heal no matter what treatment I give. [ ]
6. My confidence in dealing with wounds has improved since I was first registered. [ ]
7. Telemedicine is too complex to be relevant in wound care. [ ]
8. I will sometimes question a colleagues treatment rational if I can improve on it. [ ]
9. I would need to be fully informed about a wound before making a treatment decision. [ ]
10. My patients leg ulcers are slow to heal because I am short-staffed. [ ]
# Wound Assessment Form

<table>
<thead>
<tr>
<th>Category</th>
<th>Details</th>
</tr>
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<tbody>
<tr>
<td>Age</td>
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<td>Date of admission</td>
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<tr>
<td>Date of operation</td>
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<tr>
<td>Diagnosis</td>
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<tr>
<td>Present medication</td>
<td></td>
</tr>
<tr>
<td>Previous wound care</td>
<td></td>
</tr>
<tr>
<td>Treatment summary</td>
<td></td>
</tr>
<tr>
<td>Inhalation problems: Yes/No</td>
<td></td>
</tr>
<tr>
<td>Smokes: Yes/No</td>
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</tr>
<tr>
<td>General skin condition: Good/Fair/Poor</td>
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</tr>
<tr>
<td>Nutritional supplement given</td>
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</tr>
<tr>
<td>General nutrition: Yes/No</td>
<td></td>
</tr>
<tr>
<td>Nutritional status: Good/Fair/Poor</td>
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</tr>
<tr>
<td>Type of closure (surgical wounds)</td>
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</tr>
<tr>
<td>Size: DIAM.</td>
<td></td>
</tr>
<tr>
<td>Dimensions: Increasing</td>
<td></td>
</tr>
<tr>
<td>Dimensions: Decreasing</td>
<td></td>
</tr>
<tr>
<td>Dimensions: Static</td>
<td></td>
</tr>
<tr>
<td>Sketch shape/dimensions/type of tissue on film</td>
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</tr>
<tr>
<td>Duration of wound: Days/Weeks/Months/Years</td>
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</tr>
<tr>
<td>Pressure sore risk assessment scale used</td>
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<tr>
<td>Score</td>
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<tr>
<td>Doppler reading: mm Hg</td>
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<tr>
<td>Index</td>
<td></td>
</tr>
<tr>
<td>Body temperature</td>
<td></td>
</tr>
<tr>
<td>Pain at wound site: Y/N</td>
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<tr>
<td>Tenderness at wound site: Y/N</td>
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<tr>
<td>Pain continuous</td>
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<tr>
<td>Pain intermittent</td>
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<td>Pain at specific times</td>
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<tr>
<td>Pain at dressing change</td>
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<tr>
<td>Severity of pain</td>
<td></td>
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<tr>
<td>No pain</td>
<td></td>
</tr>
<tr>
<td>Exudate/discharge from wound: Y/N</td>
<td></td>
</tr>
<tr>
<td>1a. Blood/Serum/Serum with blood/Yellow pus</td>
<td></td>
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<tr>
<td>1b. Minimal/Moderate/Excessive</td>
<td></td>
</tr>
<tr>
<td>Exudate levels: Increasing</td>
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</tr>
<tr>
<td>Exudate levels: Decreasing</td>
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<tr>
<td>Exudate malodorous</td>
<td></td>
</tr>
<tr>
<td>Wound inflamed: Y/N</td>
<td></td>
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<tr>
<td>Indicate extent of inflammation (area covered)</td>
<td></td>
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<tr>
<td>Wound colour</td>
<td></td>
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<tr>
<td>Wound malodorous: Y/N</td>
<td></td>
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<tr>
<td>Swelling around wound site: Y/N</td>
<td></td>
</tr>
<tr>
<td>Indicate area involved: Moderate/Minimal/Severe</td>
<td></td>
</tr>
<tr>
<td>Decubitus of area surrounding wound site: Y/N</td>
<td></td>
</tr>
<tr>
<td>What colour</td>
<td></td>
</tr>
<tr>
<td>Colour of wound edges</td>
<td></td>
</tr>
<tr>
<td>Decubitus with hardened area beneath surface: Y/N (closed surgical wounds)</td>
<td></td>
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<tr>
<td>Gaping: Y/N (closed surgical wounds)</td>
<td></td>
</tr>
<tr>
<td>Where</td>
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</tr>
<tr>
<td>Necrotic tissue (black/yellow-brown) at wound site: Y/N (pressure ulcers/ulcers)</td>
<td></td>
</tr>
<tr>
<td>Where</td>
<td></td>
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<tr>
<td>Slough present: Y/N</td>
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<tr>
<td>Yellow/creamy: Y/N</td>
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<tr>
<td>Greasy: Y/N</td>
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<tr>
<td>Where</td>
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<tr>
<td>Obliteration tissue (very red) Y/N</td>
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<tr>
<td>Where</td>
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</tr>
<tr>
<td>Epithelialising</td>
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<td>Truax</td>
<td></td>
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<tr>
<td>Vexy</td>
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<tr>
<td>Which is most predominant</td>
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<td>---------------------------</td>
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<tr>
<td>wound bed % cover black (necrotic)</td>
<td></td>
</tr>
<tr>
<td>wound bed % cover yellow (sloppy)</td>
<td></td>
</tr>
<tr>
<td>wound bed % cover red (granulating)</td>
<td></td>
</tr>
<tr>
<td>wound % cover pink (epithelializing)</td>
<td></td>
</tr>
<tr>
<td>Wound Margin/Surrounding skin: macerated</td>
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</tr>
<tr>
<td>Wound margin/surrounding skin: oedematous</td>
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</tr>
<tr>
<td>Wound margin/surrounding skin: erythema</td>
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<tr>
<td>Wound margin/surrounding skin: eczema</td>
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</tr>
<tr>
<td>Wound margin/surrounding skin: fragile</td>
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<tr>
<td>Wound margin/surrounding skin: dry/scale</td>
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<tr>
<td>Wound margin/surrounding skin: cellulitis</td>
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<tr>
<td>Wound margin/surrounding skin: healthy/intact</td>
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</tr>
<tr>
<td>Any factors to prevent healing</td>
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<tr>
<td>Infection</td>
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<tr>
<td>Anaemia</td>
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<td>Immobility</td>
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<tr>
<td>Poor Nutritional Status</td>
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<td>Medications</td>
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<td>Allergies</td>
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<tr>
<td>Non-compliance</td>
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<tr>
<td>Others</td>
<td></td>
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<td>Infection suspected</td>
<td></td>
</tr>
<tr>
<td>Suspect infection if granulation tissue bleeds easily</td>
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<tr>
<td>Suspect infection if fragile bridging of epithelium occurs</td>
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</tr>
<tr>
<td>Suspect infection if odour increase</td>
<td></td>
</tr>
<tr>
<td>Suspect infection if healing is slower than anticipated</td>
<td></td>
</tr>
<tr>
<td>Suspect infection if wound breakdown</td>
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<tr>
<td>Suspect infection if pain increases</td>
<td></td>
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<tr>
<td>Swab taken</td>
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<td>Swab results</td>
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<td>Dr informed</td>
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<td>Antibiotic therapy</td>
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<td>Referral requested</td>
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<td>CNS</td>
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<td>Dermatologist</td>
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<td>Vascular Surgeon</td>
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<td>Dietitian</td>
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<td>Chiropodist</td>
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<tr>
<td>Others</td>
<td></td>
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<tr>
<td>Date of dressing change</td>
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</tbody>
</table>
APPENDIX XXII
### Table 50. Nurses' responses to wound knowledge test.

<table>
<thead>
<tr>
<th>QUESTION NUMBER</th>
<th>THEME</th>
<th>LEVEL OF DIFFICULTY</th>
<th>EXP PRE</th>
<th>CTRL PRE</th>
<th>OVERALL TOTAL PRE</th>
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APPENDIX XXIII
Awards:

2000  Smith & Nephew Research Fellowship  
Smith & Nephew Foundation

1999  Travel Bursary  
European Wound Management Association

1998  Major Scholarship  
Hospital Savings Association

Publications:

Ameen, J, Coll, AM, Peters, M 2003 The impact of tele-advice on the community nurses’ knowledge for the care of venous leg ulcers  
Journal of Advanced Nursing, Accepted for publication.

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Journal of Tissue Viability 12 (1) p.24 - 28

Peters, M 2000 Measuring and Assessing wounds Effectively  
Invited paper: Nurse Prescriber/Community Nurse August 6 (7) p.39 - 40

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Book Reviews:

Invited review: Nursing Times February 8 97 6 p.31

Milholland, K 2000 Telehealth & Telenursing: Nursing and Technology Advance Together.  
Invited review: Nursing Times September 28 96 39 p.34
APPENDIX XXIV
Recording wound care effectiveness

Peter Plassmann¹ and J Melanie Peters²

¹Senior Lecturer, School of Computing ²Research Student, School of Care Science, University of Glamorgan, Pontypridd, UK

As more and more wound treatment regimes and wound care products become available, clinicians nowadays face the difficult task of choosing the right approach for individual patients amongst an ever expanding array of options. They find increasingly that a conventional subjective description of wound status and management approach in the patient’s notes can no longer answer questions such as how effective a treatment regime is or what the efficacy a selected wound care product may be at a given stage of the healing process. The only way to answer these questions and, ultimately, to improve patient care is the objective recording and documentation of the status of the wound and treatment related parameters. This paper outlines progress in a variety of technologies that are now beginning to become available in clinical practice, enabling practitioners to produce immediate, objective and quantifiable portraits of the healing process.

Keywords: wound measurement, oxygen, colour, temperature, blood flow, structure, size.

Introduction

The treatment of skin wounds is a matter of clinical experience and in the past, was often regarded as a process that could be monitored subjectively. The ever increasing amount of interventions available to clinicians today, however, make it necessary to monitor each stage of the healing process closely with objective means in order to identify the most effective treatment regime.

The objective measurement of the physical parameters of wounds is an excellent way to record the progress of healing, assess the influence of clinical interventions and to verify clinical trials. Additionally a statement made by Hibbs in 1987 is gaining importance: ‘Litigation awards (becoming increasingly common in this area of care as pressure sores are regarded as 95% preventable’. As far as the law is concerned ‘not documented’ is equivalent to ‘not done’.

This paper reviews the performance and usability of a range of measurement techniques for oxygen, colour, temperature, blood flow, wound structure and size. These techniques have in common that they can be performed in ‘real time’ at the patient’s bed side and in the clinic. They often require specialised equipment, but the results are available instantaneously.

Establishing New Wound Measurement Techniques

Any wound measurement technique has to demonstrate that it produces better patient care and that it is cost effective. For the technique to become accepted, its users also have to be convinced that it offers real benefits to them in terms of time savings and usability. In the case of the mercury thermometer it took over 100 years before the medical community generally accepted and used it as a matter of course. The consensus was that it was much faster to determine patient temperature by touch alone and that temperature had little relevance at all. Similarly, it will take several decades before electronic patient records and new technologies become generally accepted. This summarises the main problems any innovative process has to face: educating about the need and overcoming human inertia which occasionally can be coupled with anxiety.

Figure 1 summarises wound measurement techniques available currently which are capable of delivering values for oxygen, colour, temperature, blood flow, structure, size within the time of a normal patient visit. Not all of these techniques are based currently on instrumentation that is fully portable and easy to use and some may even prove to be of little value. Those, however, that can demonstrate their value will no doubt be...
Real Time wound measurement techniques. (1) assessment and monitoring of wounds, (2) assessment of blood perfusion, (3) diagnosis of underlying diseases

TEMPERATURE (1,2)
- IR imaging
- IR spectroscopy

BLOOD FLOW (2,3)
- ultrasound doppler
- laser doppler
- plethysmography

STRUCTURE (1)
- fractal signal
- strength

COLOUR (1,3)
- inflammation
- wound status

SIZE (1)
- area, volume
- limb size

Wound Measurement Protocols

To measure means 'to compare'. For a measurement to be of any value it must be possible to compare it with other measurements. In other words: the measurement has to be repeatable. Repeatability can only be achieved if measurements are always made under precisely the same conditions using the same procedures, otherwise the quality of the measurement is questionable. If one clinician traces a wound through a transparency sheet in order to measure the area of a leg ulcer, this has to be done in precisely the same way as another clinician will do it in the following week. Both have to agree on details such as whether the thickness of the felt pen they use is part of the wound area or not and also if they trace the outside or the inside of the wound. Experiments where these factors were deliberately not made clear resulted in differences in measurement results of over 20% in area for the same wound\(^2\). As a result the clinician may arrive at the wrong conclusion as to the current status of the wound and adopt an unsuitable treatment regime.

This highlights the importance of using protocols for each measurement technique used. These protocols do not need to be elaborate but they have to encompass all variables of the respective measurement method that may have an influence on the result. Measurements without protocols are not only useless but can be dangerous!

Wound Measurement Techniques

Oxygen
A key factor for successful wound healing is oxygen. The degree of oxygen saturation in the blood can be measured non-invasively by so called pulse oximeters which are used frequently in neonatal care. In wound patients, the blood's saturation with oxygen is rarely a problem unless they suffer from lung dysfunction or are heavy smokers. More important is how much oxygen is really available for the healing tissue at the wound site\(^2\)\(^3\). This can be determined by measuring oxygen tension using transcutaneous oximeters. These instruments are based on the electrode invented by Clark\(^5\): when the electrode makes contact with the tissue, oxygen diffuses from the tissue through a semi-permeable membrane into an electrolyte solution (potassium chloride). The higher the oxygen tension in the tissue the more can diffuse, causing a proportionally higher current between a platinum anode and a silver cathode that dip into the electrolyte.

A variety of oxygen tension measurement instruments are on the market and some of them even compensate for some of the parameters that influence the precision of the measurements. The most important are: electrode temperature, air pressure and the age of the electrolyte (which needs to be replaced in regular intervals). A measurement protocol is required that accounts not only for these variables but also others such as the preparation of the wound prior to treatment and the precise location of the measurement site. The latter is important since parts of a wound can be underperfused while others enjoy a perfectly normal blood supply.

Colour
Wound colour can be a powerful descriptor of the status of the wound\(^6\). In burn wounds it has been successfully
used to predict healing time\(^7\). Ongoing research suggests that it may be possible to detect the onset of an inflammatory response (which may be indicative of infection)\(^8\) at a very early stage. Figure 2 shows how much the colour distribution of a healthy granulating wound differs from that of a severely infected one. In a pilot study, 60 wounds were observed over a period of several weeks. Thirty wounds became infected at some time during this time showing signs of inflammation, the remaining 30 remained unaffected. An experimental computer setup was successful in classifying 80% of the wounds correctly into inflamed or not inflamed. Unfortunately the change from healthy to inflamed is gradual and external influences such as the colour of ambient lighting and flower patterned cubicle curtains can influence the measurement as much as certain dressings that are based on alginates (causing a bright red appearance) or contain iodine (brown). Again it is vital that these variable parameters are understood well and documented in a measurement protocol\(^9\).

Temperature detection of inflammation can also be performed by the non-invasive infrared imaging method\(^10\). Infrared cameras are sensitive to thermal radiation (ie the temperature) of the observed area rather than to visible light. In diabetic foot ulcers, Harding et al\(^11\) found that thermal imaging can detect the onset of osteomyelitis at an early stage before the bone in question is severely damaged.

Figure 3 shows the thermal image of an infected leg ulcer. Cold areas are dark. The warmer an area is, the brighter it appears. An exception is the ulcer itself which appears to be colder than the surrounding skin. This, however, is caused by the lower emissivity of wound fluid, ie its ability to radiate heat. In reality the temperature is identical to that of the surrounding tissue. This is only one of the factors that needs to be considered in a measurement protocol. Other important parameters such as the precise setup of the camera, acclimatisation time of the patient and the posture of the limb need to be standardised as well\(^12\).

Thermal imaging can also identify areas around a leg ulcer which appear colder, indicating compromised blood perfusion. This is normally the case in the 'travelling wound' phenomenon where the ulcer is healing at the well perfused side but deteriorates and appears to 'move' towards poorly perfused areas.

**Blood flow**

Laser Dopplers like infrared cameras produce images and scan only the surface of the body\(^13,14\). A laser beam is scanning the wound site and the Doppler effect is used to measure the speed of the topical blood flow. In contrast to infrared cameras, laser Dopplers can also produce meaningful measurements from inside the wound area\(^15\) but care must be taken when interpreting the results. Laser Doppler instruments produce a result in an arbitrary unit called 'flux' which is an indication of the speed of the blood flow - not the absolute volume.

In any case: poor topical blood perfusion at the wound site is probably due to an underlying arterial or venous condition which can be diagnosed using either plethysmography or the well established hand held Doppler ultrasound machine (eg by using the Ankle-Brachial...
Index, ABI) and thus provide important indications with respect to the expected healing. Plethysmography is not used directly on wounds, can be dangerous and on some patients it should not be performed at all, whereas the ultrasound Doppler is a powerful and safe tool in the hand of the clinician. Although the Doppler is easy to use, it still requires the user to apply a strict standard procedure in order to produce repeatable and thus reliable results. The points where measurements are made and patient posture are only two of the factors which can influence the outcome of the measurement.

Structure
Wound healing is not finished when the wound is finally closed and fully covered by skin. If the healed skin is of poor quality and tensile strength a minor incident may lead to severe damage. For obvious reasons, it is impossible to measure the breaking strength of healed skin in vivo but high frequency Doppler ultrasound machines are capable of producing a high resolution scan of the former wound site. The structure of the tissue in the area of the formal wound site can be quantified in terms of its so called ‘fractal signature’ – a measure for the complexity of the structure. Due to a strong collagen matrix the tissue of a well healed wound appears very complex and diversified in the scan while a poorly healing result characterised by an almost featureless area on the scan. The quality of healing is again linked to underlying factors and it has been shown that the likelihood of renal transplants being accepted by the body is directly linked to the quality of the operation scar.

Size
The measurement of wound size is probably the easiest way to determine whether a wound is responding to treatment or not. For length and depth measurements rulers are normally the preferred method while wound area is traced through a sterile sheet of acetate. Wound volume can be measured either by measuring the amount of saline that is required to fill a wound covered with an adhesive film or more commonly by using a quickly solidifying alginate material in order to produce a cast that can then be measured. It has been recognised that these techniques make contact with the wound thus increasing risk of infection and discomfort to the patient. On top of this all the above techniques suffer from a high degree of uncertainty due to factors such as the manual skill and experience of the measuring clinician. Determining precisely what defines the length of a wound, where the edge is located and what manifests its volume is a highly subjective exercise and produces the considerable measurement errors shown in Figure 4.

This has been recognised long and non-invasive area measurement techniques based on digital photography are now becoming both less expensive and more readily available. The authors have developed a computer program, ‘Tracer’, which allows users to measure the area of wounds by analysing scanned transparency tracings or images taken by virtually any digital camera. The programme has been in reliable use for several months by over 20 users. Its precision is shown in the ‘digital photography’ and ‘tracings’ columns of Figure 4. It is available from the authors as ‘shareware’ which means that a fully working trial version is free of charge.

Although a variety of non-contact and precise volumetric measurement instruments have been developed and tested experimentally for a number of years, their complexity, limitations and price have prevented them from being used outside dedicated wound healing establishments. Figure 5 shows that the error margins of volumetric measurements can be large. This will probably change in the future when more ‘intelligent’ and less expensive systems will come onto the market.

Conclusions
At the moment only simple and cheap instrumentation such as rulers, tracings and hand held Dopplers is used widely in wound clinics and in the community. Complex and expensive instruments are the domain of research
units and it will take some time until the systems evaluated and developed there become more usable.

Even simple methods and instruments for the measurement of wound parameters require a well defined protocol, otherwise measurements made are at best useless and at worst dangerous in their consequences. Although no measurement method is perfect and results need to be interpreted in the light of variable parameters listed in the measurement protocols, it is not professionally acceptable not to measure and document wound status. As far as the law is concerned 'not documented' is equivalent to 'not done'.

Address for correspondence
P. Plassmann, School of Computing, University of Glamorgan, Pontypridd, Mid Glamorgan CF37 1DL. Tel: 01443 483486; Fax: 01443 482715; e-mail: plassma@glam.ac.uk

References
In this case, a wound area of 3.58cm² was calculated using a Tracer computer program.

Photography allows comparison of wound healing and evaluation of treatment chosen over time.

Measuring and assessing wounds effectively

Wound assessment, like many features of wound care, has traditionally been seen as the nurse's responsibility. In the case of leg ulcers, once a diagnosis has been made, the nurse invariably takes responsibility for patient care and treatment choices. This calls for a sound knowledge of the complexities of wound healing and thorough information regarding the wound.

The main aim of wound assessment is to provide this detailed knowledge, in order to make valid clinical judgements. Measuring wound size is crucial to this process and using a wound assessment tool in the first instance is essential. Ensuring that information is recorded from the first observation of the wound and surrounding skin is essential to form a baseline from which a treatment regime can be planned. But however good a wound assessment tool may be, it becomes useless if not universally adopted or used as a one off.

Effective wound assessment
Accurate and consistent wound assessment can help nurses in many areas of general wound management.

Treatment and dressing choice
The last decade has seen a dramatic increase in wound care awareness. The resulting proliferation of wound care products can be confusing for nurses. Lack of knowledge may mean the nurse simply redresses the wound with the previous nurse's choice, even though this may now be inappropriate.

Many factors need to be considered — such as wound type and dressing cost — when determining treatment. Wound care is not just about which dressing to use, but identifying the most appropriate and beneficial way to manage the wound.

Evaluation of treatment and dressing choice
Assessment and continued reassessment will help determine whether treatment has been effective and if a particular course of treatment should be continued, giving nurses the opportunity to examine their own treatment regimen critically.

As there is still no universally applicable dressing, the dressing needs to change with the dynamics of the
wound. For example, a debriding agent may give way to a hydrocolloid to promote epithelialisation. This emphasises how important it is to document the rationale behind each choice/change of dressing.

**Standardisation of wound care**

Wide variations in nurses' knowledge and practice need to be corrected. If wound care was standardised, nurses would all adopt the same treatment regimen, even if they had not seen the wound before. In this way, continuity of care would be achieved through documenting the same characteristics. This would only work if nurses were trained in the chosen method of assessment to ensure they could use it competently.

A key factor in standardising wound care is the need for a universal language. The wound description 'smaller than last week' will make sense to the assessing nurse but will be meaningless to colleagues. A structured assessment would play a vital role in reducing subjectivity. A good example of confusing terminology is the term 'pressure ulcer'. This has a bewildering array of alternative names which include 'bed sore', 'decubitus ulcer' and 'trophic ulcer'.

**Setting achievable goals**

One would think that the desired outcome in any wound care plan would be healing. But this is not always the case. In the example of a terminally ill patient with a necrotic area, surgical debridement may be inappropriate and could cause unnecessary suffering. In this instance, keeping the patient as comfortable and pain-free as possible would be the aim.

Setting reasonable goals means that the treatment regimen can be monitored. This can have the added bonus of motivating both nurse and patient, if the treatment plan would be healing. But this is not always the case. In the example of a terminally ill patient with a necrotic area, surgical debridement may be inappropriate and could cause unnecessary suffering. In this instance, keeping the patient as comfortable and pain-free as possible would be the aim.

**Concise documentation**

An increasing trend today's is litigation. In the legal sense 'not written equals not done'. If a nurse does not clearly document her course of action then there is no concrete evidence that it has been performed and litigation can result.

The chosen assessment tool needs to be realistic. Community nurses have a significant quantity of paperwork to complete. Choose aesthetically appealing, six-page wound assessment forms may look inviting but it is unlikely they will be thoroughly completed upon each visit. This is supported by Tapp's study, which indicated that nurses prioritise hands-on-care above documentation and feel there is insufficient time to do both.

A single-sided A4 sheet which provides space for reassessments should reduce time spent on documentation, avoid duplication and encourage completion.

**Wound measurement**

Basic and accurate wound measurements provide a point of reference for the treatment regime, indicating how well it is working and how long the wound will take to heal. Surprisingly, this practice is not carried out infallibly: 'wound measurement is inconsistent, infrequent and may only be recorded once'.

There are many methods of wound measurement (see Table 1) which can be classified into contact and non-contact. The most widely practiced techniques are linear measurement and tracing. These all share a range of flaws, some being specific to an individual method, others universal and mainly to do with accuracy and reproducibility. For example, the wound gauge uses a mathematical formula to calculate area and volume of the wound, but has been criticised for underestimating the area of large or irregularly shaped wounds. Even simple linear measurement can be fallible.

The ideal measurement technique should be accurate, non-invasive, fast and easy to use. It also needs to be a secure place for storing data. As yet, no such tool exists, but the development of a universal system to measure wounds and healing rates would allow objective comparison of treatments and have the potential to develop predictive wound healing models.

**Digital imaging and telemedicine in South Wales**

With rapid developments in communication systems and technology, telemedicine will play a major role in the provision of primary care in the 21st century. The government's white paper The NHS: Modern, Dependable sees telemedicine as a way of ensuring specialist skills are available to all parts of the community.

Leg ulcers remain a significant and costly problem. They affect approximately 1% of the UK population and treatment costs the NHS between £100-400 million annually. A high percentage of leg ulcers are managed entirely in the community.

A project in south Wales is investigating the feasibility of using a remote expert in community nurses' care of venous leg ulcers. Nurses receive a thorough training programme before being equipped with a digital camera, laptop computer and data-compatible mobile telephone.

In action, they either use 'real-time' or 'store and forward' methods. In real-time, the nurse takes a digital photograph in the patients' home, then sends it to an expert via mobile phone and laptop computer for immediate treatment advice. 'Store and forward' occurs when the image is sent at a later date. The project is also using a simple software programme to measure wound area.

This project has many potential benefits for patients, namely those of allowing the patient to remain in the comfort and security of their own home and yet have rapid access to specialist consultation.

Melanie Peters, RN, BSc (Hons) is a research student at the University of Glamorgan.
Telemedicine in wound care

By looking at an old problem in a new way Melanie Peters has been awarded a Smith and Nephew Research Fellowship to support a collaborative project between the schools of computing and care sciences at the University of Glamorgan.

It is estimated £400m per annum is spent on largely ineffective chronic wound care. With the current trend toward nursing patients in their own home, the burden of care will fall more on the community. It is imperative that resources are appropriately allocated. One aim of this project is to improve cost-effectiveness through more appropriate treatment.

The project incorporates both qualitative and quantitative methods. Nurses will receive thorough training in using digital cameras and laptop computers before starting the data collection. Patients will be randomly allocated to either one of two experimental groups or the control group. The first group will use 'Store-and-forward' methods — where the image of their wound is transmitted at a later date to an expert for treatment advice. The second group has an image of their wound transmitted to an expert for treatment advice immediately. Those in the control group continue with their usual wound advice immediately.

Communication is an essential part of good practice,' explains Melanie. Patients can make an informed choice only if they are given clear information at every stage of care. The nurse is in a unique position to give advice on the condition of patients' eyes, teach the importance of regular eye screening and provide an opportunity to discuss anxieties.'

The project incorporates an innovative outreach project that detects problems early. A clinical specialist, then based at Moorfields eye hospital and trained in medical retinal nursing, was approached by Millway Medical practice to improve care for diabetic patients.

Diabetic retinopathy screening

One of the commonest causes of blindness in working-age people in the west is diabetic retinopathy. Early detection and treatment is essential for maintaining good visual acuity and usual screening is recommended. Angela Connolly describes an innovative outreach project that detects problems early. A clinical specialist, then based at Moorfields eye hospital and trained in medical retinal nursing, was approached by Millway Medical practice to improve care for diabetic patients.

Communication is an essential part of good practice,' explains Angela. Patients can make an informed choice only if they are given clear information at every stage of care. The nurse is in a unique position to give advice on the condition of patients eyes, teach the importance of regular eye screening and provide an opportunity to discuss anxieties.'

The project incorporates an innovative outreach project that detects problems early. A clinical specialist, then based at Moorfields eye hospital and trained in medical retinal nursing, was approached by Millway Medical practice to improve care for diabetic patients.

A preliminary assessment including an accurate ophthalmic history, visual assessment and intraocular pressure check took place. In the absence of abnormalities the pupils were then dilated in preparation for further investigation. While waiting for dilation, patients met with other members of the multidisciplinary diabetic team to maximise the use of time. A fundoscopy was then recorded, with two fundal photographs taken of each eye — one disc and one macula to improve the sensitivity of screening. If no diabetic retinopathy is detected or only mild background changes that are non-sight threatening, patients are asked to see the ophthalmic nurse in one year: if abnormalities are found a referral is arranged for the patient to be seen at the medical retinal clinic at Moorfields. Later, back at Moorfields all screening photographs are viewed by Angela and an ophthalmologist. This is helpful when other pathology has been identified and further investigations improve the quality of screening.

The screening project has been successful, rewarding and well evaluated — both by the patients and the staff involved. Patients are now acutely aware of the importance of regular, expert screening in the prevention of diabetic retinopathy and consider the eye clinic as part of their annual diabetic review.

Look out for a series on diabetes in Nursing Times during February.

Angela Connolly is now ward manager and GPN Trust link nurse, Western Eye Hospital, Marylebone.
Reviews

Epidemiology: An introduction
John Moon, Myles Gould, Tim Cleary, et al

Epidemiology, although an important aspect of health care, is not a subject that generally engenders excitement. Increasingly more it appears on curricula, is a part of research courses and is used in the delivery of evidence-based care.

Easy to read without being simplistic, this book examines epidemiology in a way that is understandable and interesting. The authors have deconstructed epidemiology, explored its parts and made it accessible.

There are some excellent questions that help to clarify many of the confusing aspects of quantitative research. A useful aspect of the book is the activities sections at the end of each chapter. They can be worked through alone or used as part of a group exercise.

As a teacher I have found them to be valuable tools in getting over a sometimes dry and difficult topic. This book explicitly links the theory of epidemiology to the reality of practice and makes its nature and value evident. In short it makes epidemiology interesting.

JACQUI FERNELL
Senior nurse lecturer

An eye-catching and helpful resource

Pressure Ulcer Care System: A Complete Guide to Pressure Ulcer Management CD-ROM
Jacqui Fletcher and Mark Collier
Smith and Nephew, £49.95

This CD-ROM is a useful addition to the existing range of resources that focuses on the topic of pressure ulcers. The guide takes the viewer through a range of information that includes anatomy and physiology, dressings, pressure relief, skin care and cost to the NHS.

In the section dealing with dressings for pressure ulcers the ones identified are, as you might expect, all Smith and Nephew products. However, in the pressure relief section generic terms are used to describe the range of products available.

There is a section on risk assessment and this is referenced, allowing the viewer to follow up with further reading, as are the other sections.

The programmes uses illustrations throughout but users may already have seen a number of the clinical ones in the Wound Management Education System, published by Smith and Nephew in 1991.

Some of the sections could have a bit more detail, for example in the section explaining the functions of the skin, sweating is used as an example in the reference to elimination but no further detail is given as to the constituents of sweat. But overall this is an eye-catching and helpful compendium.

KEITH CUTTING
Principal lecturer

The Water Babies
by Charles Kingsley

As a child, The Water Babies by Charles Kingsley alerted me to children's differing experiences depending on whether they are rich or poor. It helped me to form my social conscience.

It is the tale of Tom, an orphan, who is forced to sweep chimneys and longs to be comfortable, clean and well fed. Throughout his adventures, he meets people who try to help him and I have attempted to emulate one of these, Mrs Do-as-you-would-be-done-by.

Her name encompasses Florence Nightingale's dream that hospitals and their staff should do the patient no harm.

Enduring inspiration to help others

As a teacher I have found them to be valuable tools in getting over a sometimes dry and difficult topic. This book explicitly links the theory of epidemiology to the reality of practice and makes its nature and value evident. In short it makes epidemiology interesting.

JACQUI FERNELL
Senior nurse lecturer


MULTIMEDIA

Braving the brave new world

Telehealth: Nursing and Technology
K Milholland

From 2001, all health improvement programmes must demonstrate that they have considered telemedicine and telecare options.

With the current focus on nursing patients in the home, telehealth is an imminent reality.

This monograph provides an intelligent overview of many elements of telehealth and telenursing, with the key strength that it is written by a nurse. The majority of technical terminology, such as health telematics, telehealth and telemedicine vary globally and the author provides much-needed explanations.

Twelve core principles were developed by the American Nurses Association in 1997. These are covered in the monograph and provide a framework for telehealth guidelines. However, these were designed for US nurses, who have more experience of telehealth. While standards and quality assurance in telenursing are discussed, there is a need for universally standardised protocols, in which nurses use the same language and practice, to be established.

Professional indemnity is a huge minefield in the field of telehealth. This is especially important when nurses are providing care across trusts. The monograph touches upon this pertinent issue.

The author also acknowledges the danger of technology rapidly becoming outdated and avoids focusing upon current products.

MELANIE PETERS
Research Student University of Glamorgan