

The management of pressure ulcers in  
primary and secondary care  
A Clinical Practice Guideline

22 September 2005

This work was undertaken by the Royal College of Nursing (RCN) Quality Improvement Programme (QIP), and the Guideline Development Group (GDG) convened to develop the Guideline. Funding for the health economics analysis of this Guideline was received from the National Institute for Health and Clinical Excellence (NICE), and this work was undertaken by the Centre for Health Economics (CHE) at the University of York. The RCN is host to the National Collaborating Centre for Nursing and Supportive Care (NCC-NSC) which receives partnership support from the: Centre for Evidence-Based Nursing; Centre for Statistics in Medicine; Clinical Effectiveness Forum for Allied Health Professionals; College of Health; Health Care Libraries (University of Oxford); Health Economics Research Centre; and UK Cochrane Centre.

This Guideline should be read in conjunction with the NICE guideline for risk assessment and prevention of pressure ulcers (beds, mattresses and support surfaces) (NICE, 2003) and is a further addition to clinical guidelines forming the Wound Care Suite.

#### **Other relevant guidelines and documents:**

- *Nutritional support in adults: oral supplements, enteral and parental feeding.* Currently out for public consultation and can be found at the following link:  
<http://www.nice.org.uk/page.aspx?o=33921>
- *National Service Framework for children, young people and maternity services* (2004) DH.  
[http://www.dh.gov.uk/PolicyAndGuidance/HealthAndSocialCareTopics/ChildrenServices/ChildrenServicesInformation/ChildrenServicesInformationArticle/fs/en?CONTENT\\_ID=4089111&chk=U8Ecln](http://www.dh.gov.uk/PolicyAndGuidance/HealthAndSocialCareTopics/ChildrenServices/ChildrenServicesInformation/ChildrenServicesInformationArticle/fs/en?CONTENT_ID=4089111&chk=U8Ecln)
- *National Service Framework for older people* (2001) DH.  
[http://www.dh.gov.uk/PublicationsAndStatistics/Publications/PublicationsPolicyAndGuidance/PublicationsPAmpGBrowsableDocument/fs/en?CONTENT\\_ID=4096710&chk=yLadyl](http://www.dh.gov.uk/PublicationsAndStatistics/Publications/PublicationsPolicyAndGuidance/PublicationsPAmpGBrowsableDocument/fs/en?CONTENT_ID=4096710&chk=yLadyl)

## **Disclaimer**

Clinical guidelines have been defined as systematically developed statements that are designed to assist clinicians, patients and carers in making decisions about appropriate treatments for specific conditions and aspects of care.

As with all clinical guidelines, recommendations may not be appropriate for use in all circumstances. Decisions to adopt any particular recommendations must be made by the practitioners in the light of:

- available resources
- local services, policies and protocols
- the patient's circumstances and wishes
- available personnel and support surfaces
- clinical experience of the practitioner, and
- knowledge of more recent research findings.

When implementing evidence-based guidance it is important that all health care professionals understand the local context in which they work and existing quality improvement structures.

Where the term "carer" is used in the Guideline, this refers to unpaid carers as opposed to paid carers such as care workers.

# **Guideline Development Group membership and acknowledgements**

---

## **Guideline Development Group**

Mrs Sarah Bazin	Chartered Society of Physiotherapy
Mr Malcolm Blanch	Patient Representative, Carers UK
Ms Jane Hampton	Professional Development Nurse, Westminster Primary Care Trust
Mr Hugh Henderson	Royal College of Surgeons
Dr Jacqueline Morris	British Geriatric Society
Mr Mark O'Brien	Paediatric Tissue Viability Nurse, Great Ormond Street NHS Trust. Tissue Viability Nurses Association.
Dr Alison Porter-Armstrong	College of Occupational Therapists
Julie Stevens	Consultant Tissue Viability Nurse, Hounslow Primary Care Trust and West Middlesex University Hospital NHS Trust. Tissue Viability Nurses Forum.
Adam Thomas	Patient Representative, Royal Association of Disability and Rehabilitation
Dr Steve Thomas	Royal Pharmaceutical Society
Mrs Tracy Vernon	Tissue Viability Lead Nurse, Doncaster and Bassetlaw NHS Trust
Dr Paul Yerrell (GDG Lead)	Senior Research Fellow, Oxford Brookes University
Dr Ian Bullock	Acting Director, National Collaborating Centre Nursing and Supporting Care (NCC-NSC) and Senior Research and Development Fellow, Quality Improvement Programme, RCN Institute
Prof Debra Bick	Professor and Chair Midwifery and Women's Health, Thames Valley University; formerly Senior Research and Development Fellow, Quality Improvement Programme, RCN Institute
Mr Will Gray	Research and Development Fellow, Quality Improvement Programme, RCN Institute (Project Lead)
Miss Helen Weatherly	Health Economist, University of York
Mrs Kate Misso	Information Scientist, University of York
Mr Rayhan Rashid	Guidelines Administrator, Quality Improvement Programme, RCN Institute

## **Acknowledgements**

Additional support was received from:

Jo Rycroft-Malone (RCN Institute) especially on consensus methods development. Lisa Askie (UK Cochrane) who assisted with updating systematic reviews. Special thanks to the Cochrane Wounds group at the University of York for providing advice and support in conducting the updates of the systematic reviews, in particular Sally Bell-Syer, Nicky Cullum and Andrea Nelson. We also thank Julie Glanville for conducting the update searches for this Guideline.

## **Stakeholder organisations**

---

The following stakeholders are registered with NICE. All were invited to comment on all drafts of these guidelines.

Cochrane Wounds Group  
Acute Care Collaborating Centre  
Chronic Conditions Collaborating Centre  
Mental Health Collaborating Centre 1  
Mental Health Collaborating Centre 2  
NCC for Cancer  
Nursing & Supportive Care Collaborating Centre  
Primary Care Collaborating Centre  
Women's & Children's Collaborating Centre  
3M Health Care Limited  
Aguettant Limited  
Association of British Health-Care Industries  
Association of the British Pharmaceuticals Industry (ABPI)  
BES Rehab Ltd  
Coloplast Limited  
ConvaTec  
Forest Laboratories UK Limited  
Huntleigh Healthcare Ltd  
Independent Healthcare Association  
Johnson & Johnson Medical  
Kaymed  
KCI Medical Ltd  
Maersk Medical  
Medical Support Systems Limited  
Molnlycke Health Care  
Nutricia Ltd (UK)  
Park House Healthcare Limited  
Pegasus Limited  
Smith & Nephew Healthcare  
SSL International plc  
Surgical Dressing Manufacturers Association  
Surgical Materials Testing Laboratory (SMTL)  
Talley Group Ltd  
Tempur-Med  
Tyco Healthcare  
Vernon Carus Limited  
Westmeria Healthcare Ltd  
Addenbrooke's NHS Trust  
Anglesey Local Health Board  
Ashford and St Peter's Hospitals NHS Trust  
Barnet PCT  
Buckinghamshire Hospitals NHS Trust  
Cambridgeshire & Peterborough Mental Health Partnership NHS Trust  
Craven, Harrogate & Rural District PCT  
Croydon Primary Care Trust  
Gloucestershire Hospitals NHS Trust  
Guy's & St Thomas' NHS Trust  
Herefordshire Primary Care Trust  
Kingston Primary Care Trust

Knowsley Primary Care Trust  
Leeds Teaching Hospitals NHS Trust  
Luton and Dunstable Hospital NHS Trust  
Mid Staffordshire General Hospitals NHS Trust  
National Nurses Nutrition Group  
North Middlesex University Hospital NHS Trust  
Northumberland Care Trust  
Nottingham City PCT  
Nuffield Orthopaedic Centre NHS Trust  
Princess Alexandra Hospital NHS Trust  
Rotherham Primary Care Trust  
Royal Liverpool Children's NHS Trust  
Royal National Orthopaedic Hospital NHS Trust  
Sheffield Teaching Hospitals NHS Trust  
South Birmingham Primary Care Trust  
South Devon Healthcare Trust  
South Essex Partnership NHS Trust  
South West Kent PCT  
Surrey & Sussex NHS Trust  
Tameside and Glossop Acute Services NHS Trust  
The Dudley Group of Hospitals NHS Trust  
The Medway NHS Trust  
The Royal West Sussex Trust  
Trafford Primary Care Trusts  
University College London Hospitals NHS Trust  
Vale of Aylesbury PCT  
West Norfolk PCT  
West of Cornwall Primary Care Trust  
African & Caribbean Diabetes Association  
Help the Aged  
Help the Hospices  
L'Arche UK  
Limbless Association  
Marie Curie Cancer Care  
National Council for Disabled People, Black, Minority and Ethnic Community (Equalities)  
Relatives and Residents Association  
Sue Ryder Care  
All Wales Senior Nurses Advisory Group (Mental Health)  
Association of Surgeons of Great Britain and Ireland  
British Association for Parenteral & Enteral Nutrition (BAPEN)  
British Association of Dermatologists, The  
British Dietetic Association  
British Geriatrics Society  
British Healthcare Trades Association  
British Psychological Society, The  
British Society for Antimicrobial Chemotherapy  
British Society of Rehabilitation Medicine  
Chartered Society of Physiotherapy  
College of Occupational Therapists  
Community District Nurses Association  
Faculty of Public Health  
Health Protection Agency  
Hospital Infection Society  
National Association of Theatre Nurses

Nightingale Care Beds Ltd  
Nuffield Hospitals Acute Care  
Royal Association of Disability and Rehabilitation  
Royal College of General Practitioners  
Royal College of General Practitioners, Wales  
Royal College of Nursing (RCN)  
Royal College of Paediatrics and Child Health  
Royal College of Physicians of London  
Royal College of Surgeons of England  
Royal Pharmaceutical Society of Great Britain  
Skin Care Campaign  
Society of Chiropractors & Podiatrists  
Southern Alliance of Tissue Viability Nurses  
Spinal Injuries Association  
Stoke Mandeville NHS Trust  
The National Association of Assistants in Surgical Practice  
The Royal Society of Medicine  
Tissue Viability Nurses Association  
Tissue Viability Nurses Forum (South)  
Tissue Viability Society (UK)  
Wound Care Society  
British National Formulary (BNF)  
Department of Health  
Healthcare Commission  
Medicines and Healthcare Products Regulatory Agency (MHRA)  
National Patient Safety Agency  
National Public Health Service – Wales  
NHS Modernisation Agency, The  
NHS Quality Improvement Scotland  
Scottish Intercollegiate Guidelines Network (SIGN)  
Welsh Assembly Government (formerly National Assembly for Wales)

**Peer reviewers**

Mark Collier (Lincolnshire)  
Lynfa Edwards (Ealing PCT)  
Jed Rowe (Birmingham)  
Jackie Fletcher (University of Herts)

## Abbreviations

---

### Technical terms

ARR	absolute relative risk
ARr	absolute risk reduction
BMI	body mass index
CI	confidence intervals
DH	Department of Health
GDG	Guideline Development Group
GRP	Guideline Review Panel
HTA	health technology assessment
NNT	number needed to treat
OR	odds ratio
QALY	quality-adjusted life year
RCT	randomised controlled trial
RR	relative risk (risk ratio)
RD	risk difference
SEM	standard error of the mean
PU	pressure ulcer

### Organisations

CHE	Centre for Health Economics, University of York
CRD	Centre for Reviews and Disseminations, University of York
CWG	Cochrane Wounds Group
DH	Department of Health
GIN	Guidelines International Network
JBI	Joanna Briggs Institute
MHRA	Medicines and Healthcare Products Regulatory Agency
NCC-NSC	National Collaborating Centre for Nursing and Supportive Care
NICE	National Institute for Health and Clinical Excellence
RCN	Royal College of Nursing
SIGN	Scottish Intercollegiate Guidelines Network
UKC	UK Cochrane

## **General glossary**

---

<b>Absolute risk reduction</b>	The difference between the observed event rates (proportions of individuals with the outcome of interest) in the two groups.
<b>Basic dressings</b>	Dressings that may cover a wound but do not create an optimum healing environment – e.g. gauze, paraffin gauze and simple dressing pads.
<b>Bias</b>	Influences on a study that can lead to invalid conclusions about a treatment or intervention. This may result from flaws in the design of a study or in the analysis of results, and may result in either an underestimate or an overestimate of the effect. Bias can occur at different stages in the research process – for example in the collection, analysis, interpretation, publication or review of the research.
<b>Case-control study</b>	A study in which the effects of an exposure in a group of patients (cases) who have a particular condition is compared with the effects of the exposure in a similar group of people who do not have the clinical condition (the latter is called the control group).
<b>Case report</b>	Detailed report on one patient (case), usually covering the course of that person's disease and response to treatment.
<b>Case series</b>	Description of several cases of a given disease or condition, usually covering the course of that disease and response to treatment. There is no comparison (control) group of patients.
<b>Carer</b>	An individual who provides unpaid care as opposed to paid carers – for example care workers.
<b>Cohort</b>	A group of people sharing some common characteristics – e.g. patients with the same disease or condition – followed up in a research study for a specified period of time.

<b>Clinical effectiveness</b>	The extent to which an intervention – for example a support surface or treatment – produces health benefits, that is more good than harm.
<b>Cochrane collaboration</b>	An international organisation in which people retrieve, appraise and review available evidence of the effect of interventions in health care. The Cochrane Database of Systematic Reviews contains regularly updated reviews on a variety of issues. The Cochrane library contains the Central Register of Controlled Trials (CENTRAL), and a number of other databases which are regularly updated, and is available as a CD-Rom or on the internet ( <a href="http://www.cochranelibrary.com">www.cochranelibrary.com</a> ).
<b>Cohort study</b>	An observations study that takes a group (cohort) of patients and follows their progress over time to measure outcomes, such as disease or mortality rates, and make comparisons according to the treatments or interventions that patients receive. Thus, within the study group, subgroups of patients are identified and these groups are compared with respect to outcome – for example comparing mortality between groups that did or did not receive treatment. Cohorts can be assembled in the present and followed into the future (a concurrent or prospective cohort study) or identified from past record and followed forward from that time up to the present (a historical or retrospective cohort study). Patients are not randomly allocated to subgroups; these may be quite different in their characteristics and therefore adjustments must be made when analysing the results to ensure that the comparison between groups is as fair as possible.
<b>Co-interventions</b>	Interventions or treatments other than the treatment under study that are applied differently to the treatment and control groups.
<b>Co-morbidity</b>	Co-existence of a disease or diseases in a study population in addition to the condition that is the subject of study.
<b>Concordance</b>	A consultation process between a health care professional and a patient where the focus is on the consultation process rather than specific patient behaviour. There is an underlying ethos of a shared approach to decision-making.

<b>Confidence intervals</b>	A way of expressing certainty about the findings from a study or group of studies using statistical techniques. A confidence interval (CI) describes a range of possible effects (of a treatment or intervention) that is consistent with the results of a study or group of studies. A wide confidence interval indicates a lack of certainty or precision about the true size of the clinical effect and is seen in studies with too few patients. Where it is narrow this indicates precision and is found in studies with larger patient samples. It is usual to interpret a 95% CI as the range of effects within which we are 95% confident that the true effect lies.
<b>Cost-benefit analysis</b>	A type of economic evaluation where both costs and benefits of health care treatments are measured in the same monetary units. If benefits exceed cost, the evaluation would recommend the treatment.
<b>Cost-effectiveness</b>	A type of economic evaluation that assesses the additional costs and benefits of doing something. In cost-effectiveness analysis, the cost and benefit of different treatments are compared. When a new treatment is compared with the current care, its additional costs divided by its additional benefit is called the cost-effectiveness ratio. Benefits are measured in natural units – for example cost per additional pressure ulcer healed or prevented.
<b>Cost-utility analysis</b>	A special form of cost-effectiveness analysis where benefit is measured in quality-adjusted life years. A treatment is assessed in terms of its ability to extend or improve quality of life.
<b>Cost impact</b>	The total cost to the person, the NHS or to society.
<b>Discounting</b>	The process of converting future pounds and future health outcomes to their present value.
<b>Debridement</b>	The removal of dead (devitalised) tissue, cell debris or foreign material from a wound.
<b>Dead tissue</b>	Dead tissue can present in a variety of forms. Dead (necrotic) tissue varies in appearance according to moisture

content. When dry it presents as black eschar (hard leather-like material). If moisture content rises the eschar becomes brown, then yellow, before breaking down to slough (yellow/grey fibrous tissue with a gelatinous surface attached to the wound bed).

<b>Double-blind study</b>	A study in which neither the subject (patient) nor the observer (investigator or clinician) is aware of which treatment or intervention the subject is receiving. The purpose of blinding is to protect against bias.
<b>Economic evaluation</b>	Comparative analysis of alternative courses of action in terms of both their costs and consequences.
<b>Effectiveness</b>	The extent to which interventions achieve health improvements in real practice settings.
<b>Efficacy</b>	The extent to which medical interventions achieve health improvements under ideal circumstances.
<b>Epidemiological study</b>	A study which looks at how a disease or clinical condition is distributed across geographical areas.
<b>Eschar</b>	Brown or black necrotic, devitalised tissue; can be loose or firmly adhered, hard, soft or soggy.
<b>Evidence-based</b>	The process of systematically finding, appraising and using research findings as the basis for clinical decisions.
<b>Evidence-based clinical practice</b>	Evidence-based clinical practice involves making decisions about the care of individual patients based on the best available research evidence rather than on personal opinion or common practice (which may not always be evidence-based). Evidence-based clinical practice involves integrating individual clinical expertise and patient preferences with the best available evidence from research.
<b>Evidence table</b>	A table with information extracted from research papers usually summarising the results of a collection of studies. Together this information represents the supporting evidence for a recommendation in a guideline.

<b>Experimental study</b>	A research study designed to test whether a treatment or intervention has an effect on the course or outcome of a condition or disease, where the conditions of testing are to some extent under the control of the investigator. Controlled trials and randomised controlled trials are examples of experimental studies.
<b>Extrinsic</b>	Factors which are external to the individual.
<b>Follow-up</b>	Observation over a period of time of an individual, group or population whose relevant characteristics have been assessed in order to observe changes in health status or health-related variables.
<b>Gold standard</b>	A method, procedure or measurement that is widely accepted as being the best available.
<b>Health professional</b>	Includes nurses, allied health professionals and doctors.
<b>Health economics</b>	A field of economics that examines the benefits of health care interventions – for example medicines – compared with their financial costs.
<b>Health technology assessment</b>	The process by which evidence on the clinical effectiveness and the costs and benefits of using a technology in clinical practice is systematically evaluated.
<b>Heterogeneity</b>	Or lack of homogeneity. The term is used in meta-analysis and systematic review when the results or estimates of effects of treatment from separate studies seem to be very different, in terms of size of treatment effects and adverse treatment effects. Such results may occur as a result of differences between studies in terms of the patient population, outcome measures, definitions of variables or duration of follow up.
<b>Homogeneity</b>	This means that the results of the studies in a systematic review or meta-analysis are similar and there is no evidence of heterogeneity. Results are usually regarded as

homogenous when the differences between studies are those which can reasonably be expected between studies.

<b>Incidence</b>	The number of new cases of illness commencing, or of persons falling ill, during a specified time period in a given population.
<b>Intervention</b>	Health care action intended to benefit the patient – for example drug treatment, dressings, physiological therapy.
<b>Intrinsic</b>	Factors which present within the individual.
<b>Logistic regression model</b>	A data analysis technique to derive an equation to predict the probability of an event given one or more predictor variables. This model assumes that the natural logarithm of the odds for the event (the logit) is a linear sum of weighted values of the predictor variable. The weights are derived from data using the method of maximum likelihood.
<b>Meta-analysis</b>	A statistical method of summarising the results from a group of similar studies.
<b>Modern dressings</b>	Dressings that aim to create the optimum wound healing environment – e.g. hydrocolloids, hydrogels, foams, films, alginates and soft silicones.
<b>Number needed to treat</b>	The number of patients who need to be treated to prevent one event.
<b>Odds ratio</b>	Odds in favour of being exposed in subjects with the target disorder divided by the odds in favour of being exposed in control subjects (without the target disorder).
<b>Predictive validity</b>	A risk assessment tool would have high predictive validity if the predictions it makes of pressure ulcer development in a sample became true – i.e. it has both high sensitivity and specificity.
<b>Prevalence</b>	The proportion of persons with a particular disease within a given population at a given time.

<b>Quality-adjusted life expectancy</b>	Life expectancy using quality-adjusted life years rather than nominal life years.
<b>Quality-adjusted life years</b>	A measure of health outcome which assigns to each time period a weight, ranging from 0–1, corresponding to the health-related quality of life during that period, where a weight of 1 corresponds to optimal health, and a weight of 0 corresponds to a health state judged as equivalent to death. These are then aggregated across time periods.
<b>Randomised controlled trial</b>	A clinical trial in which the treatments are randomly assigned to subjects. The random allocation eliminates bias in the assignment of treatment to patients and establishes the basis for the statistical analysis.
<b>Relative risk</b>	An estimate of the magnitude of an association between exposure and disease, which also indicates the likelihood of developing the disease among persons who are exposed relative to those who are not. It is defined as the ratio of incidence of disease in the exposed group divided by the corresponding incidence in the non-exposed group.
<b>Retrospective cohort study</b>	A study in which a defined group of persons with an exposure, and an appropriate comparison group who are not exposed, are identified retrospectively and followed from the time of exposure to the present, and in which the incidence (or mortality) rates for the exposed and unexposed are assessed.
<b>Sensitivity</b>	In diagnostic testing, this refers to the chance of having a positive test result given that you have the disease or condition. A 100% sensitivity means that all those with the disease will test positive, but this is not the same the other way round. A patient could have a positive test result but not have the disease or condition – this is called a false positive. The sensitivity of a test is also related to its negative predictive value (true negatives) – a test with a sensitivity of 100% means that all those who get a negative test result do not have the disease. To fully judge the accuracy of a test, its specificity must also be considered.

<b>Specificity</b>	In diagnostic testing, this refers to the chance of having a negative test result given that you do not have the disease. A 100% specificity means that those without the disease will test negative but this is not the same the other way round. A patient could have a negative test result but still have the disease or condition – this is called a false negative. The specificity of a test is also related to its positive predictive value (true positives) – a test with a specificity of 100% means that all those who get a positive test result definitely have the disease or condition. To fully judge the accuracy of a test, its sensitivity must also be considered.
<b>Statistical power</b>	The ability of a study to demonstrate an association or causal relationship between two variables, given that an association exists – for example, 80% power in a clinical trial means that the study has 80% chance of ending up with a p value of less than 5% in a statistical test (statistically significant).
<b>Systematic review</b>	A way of finding, assessing and using evidence from studies (usually randomised, controlled trials) to obtain a reliable overview.
<b>User</b>	Any one using the guideline.
<b>Validity</b>	The extent to which a variable or intervention measures what it is supposed to measure or accomplish. The internal validity of a study refers to the integrity of the design. The external validity of a study refers to the appropriateness by which its results can be applied to non-study patients or populations.
<b>Wound bed preparation</b>	Management of the wound to promote endogenous healing or to facilitate the effectiveness of therapeutic interventions.

This glossary is partially based on *Clinical epidemiology glossary* by the Evidence Based Medicine Working Group, [www.ed.ualberta.ca/ebm](http://www.ed.ualberta.ca/ebm); *Information for National Collaborating Centres and Guideline Development Groups* (NICE, 2001) and the glossary from the Patient Involvement Unit at NICE.

## Contents

<b>Disclaimer</b> .....	<b>3</b>
<b>Terminology</b> .....	<b>3</b>
<b>Abbreviations and general glossary</b> .....	<b>8</b>
<b>1 EXECUTIVE SUMMARY</b> .....	<b>19</b>
<b>2 PRINCIPLES OF PRACTICE &amp; SUMMARY OF RECOMMENDATIONS</b>	
2.1 Person-centred care.....	21
2.2 A collaborative inter-disciplinary approach to care .....	21
2.3 Organisational issues .....	21
2.4 Recommendation statements.....	22
<b>3 BACKGROUND TO THE CURRENT GUIDELINE</b> .....	<b>24</b>
3.1 Clinical need for the guideline .....	24
3.2 What are pressure ulcers? .....	26
3.3 Groups at risk .....	27
3.4 What are the main interventions? (for example pressure-relieving support surfaces)?.....	27
<b>4 AIMS OF THE GUIDELINE</b> .....	<b>27</b>
4.1 Who the guideline is for .....	28
4.2 Groups covered by the guideline .....	28
4.3 Groups not covered .....	28
4.4 Healthcare setting .....	28
4.5 Interventions covered .....	29
4.6 Interventions not covered .....	29
4.7 Guideline development group.....	31
<b>5 METHODS USED TO DEVELOP THE GUIDELINE</b> .....	<b>33</b>
5.1 Summary of development process .....	33
5.2 Clinical effectiveness review methods .....	36
5.3 Cost-effectiveness review methods .....	41
5.4 Submission of evidence process .....	50
5.5 Evidence synthesis and grading.....	51
5.6 Results of clinical effectiveness evidence retrieval and appraisal .....	52
5.7 Formulating and grading recommendations .....	52
<b>6 GUIDELINE RECOMMENDATIONS WITH SUPPORTING EVIDENCE</b>	
<b>REVIEWS</b> .....	<b>57</b>
6.1 Holistic assessment.....	55
6.2 Ulcer assessment.....	65.
6.3 Support surfaces for the treatment of pressure ulcers.....	76
6.3.1 Cost-effectiveness of support surfaces.....	88

6.4	Dressings and topical agents in the treatment of pressure ulcers.....	100
6.4.2	Cost-effectiveness of dressings and topical agents.....	121
6.5	Antimicrobial agents for the treatment of pressure ulcers.....	145
6.6	Mobility and positioning.....	154
6.7	Nutrition in the treatment of pressure ulcers.....	159
6.8	Surgery in the treatment of pressure ulcers.....	170
6.9	Topical negative pressure, Electrotherapy, electromagnetic therapy, and therapeutic ultrasound in the treatment of pressure ulcers...	179
6.9.1	Cost effectiveness	198
<b>7</b>	<b>RECOMMENDATIONS FOR RESEARCH .....</b>	<b>206</b>
	<b>ALGORITHM.....</b>	<b>202</b>
<b>8</b>	<b>AUDIT CRITERIA.....</b>	<b>203</b>
<b>9</b>	<b>DISSEMINATION OF GUIDELINES .....</b>	<b>212</b>
<b>10</b>	<b>VALIDATION .....</b>	<b>213</b>
<b>11</b>	<b>Review</b>	<b>212</b>
<b>12</b>	<b>REFERENCES.....</b>	<b>206</b>
<b>Appendix A:</b>	<b>Clinical effectiveness evidence table .....</b>	<b>234</b>
<b>Appendix B:</b>	<b>Search strategies.....</b>	<b>370</b>
<b>Appendix C:</b>	<b>Quality assessment tools A - I .....</b>	<b>467</b>
<b>Appendix D:</b>	<b>Table of excluded studies.....</b>	<b>495</b>
<b>Appendix E:</b>	<b>Quality checklists/data extraction forms.....</b>	<b>504</b>

## 1 EXECUTIVE SUMMARY

The Royal College of Nursing (RCN) and National Institute for Health and Clinical Excellence (NICE or the Institute) collaborated to develop a clinical guideline on the management of pressure ulcers in primary and secondary care. Identification of the topic emerged from a consultation process with RCN members and referral of the topic by the Department of Health and Welsh Assembly Government. This document describes the methods used for developing the guidelines and presents the resulting recommendations. It is the source document for the NICE (abbreviated version for health professionals) and *Information for the public* (patient and carer) versions of the guidelines, which will be published by NICE. The Guideline was produced by a multidisciplinary Guideline Development Group (GDG) and the development process was wholly undertaken by the RCN.

The main areas examined by the Guideline are:

- holistic assessment for the risk of delayed healing or complications of having a pressure ulcer
- the ulcer assessment
- pressure-relieving support surfaces for the treatment of pressure ulcers
- mobility, positioning and re-positioning for the treatment of pressure ulcers
- dressings and topical agents for the treatment of pressure ulcers
- debridement for the treatment of pressure ulcers
- nutritional support
- surgery for the treatment of pressure ulcers
- therapeutic ultrasound for the treatment of pressure ulcers
- electrotherapy and electromagnetic therapy for the treatment of pressure ulcers, and
- topical negative pressure for the treatment of pressure ulcers.

Recommendations for good practice based on the best available evidence of clinical and cost-effectiveness are presented. Literature searching details, including cut-off dates, are reported in the methods section for each topic area. Update searches were performed for each area not less than six months prior to submission of the first consultation draft. Recommendations contained in this document are those considered to be central to the management of pressure ulcers. This is a guide to that management not a textbook of care.

*Health care professionals should use their clinical judgement and consult with patients when applying the recommendations, which aim at reducing the negative personal, physical, social and financial impact of pressure ulcers.*

On completion of the process NICE will publish the versions for health professionals (*Quick reference guide*) and for patients and carers (*Information for the public*), which combine and replace the guideline for risk assessment and prevention of pressure ulcers (beds, mattresses and support surfaces (NICE, 2003).

## **2 PRINCIPLES OF PRACTICE AND SUMMARY OF GUIDELINE RECOMMENDATIONS**

### **2.1 Principles of practice**

The principles outlined below describe the ideal context in which to implement the recommendations in this Guideline. They reflect original research and development work previously produced by the RCN, and enable clinicians using evidence-based guidance to contextualise and understand the importance of preparation and planning before using this evidence-based tool.

#### **2.1.1 Person-centred care**

- Patients and carers should be made aware of the Guideline and its recommendations, and be referred to the version *Information for the public*.
- Patients and carers should be involved in shared decision-making about the management of pressure ulcers.
- Health professionals are advised to respect and incorporate the knowledge and experience of people who have had, or have, a pressure ulcer.
- Patients and carers should be informed about any potential risks, and/or complications, of having a pressure ulcer.

### **2.2 A collaborative interdisciplinary approach to care**

- All members of the interdisciplinary team should be aware of the Guideline and all care should be documented in the patient's health care records.
- The approach to care should be interdisciplinary, involving all those needed in the management of pressure ulcers.

### **2.3 Organisational issues**

- There should be an integrated approach to the management of pressure ulcers with a clear strategy and policy supported by management.
- Care should be delivered in a context of continuous quality improvement where improvements to care following Guideline implementation are the subject of regular feedback and audit.
- Commitment to, and availability of, education and training are needed to ensure that all staff, regardless of profession, are given the opportunity to update their knowledge and are able to implement the Guideline recommendations.

- The health care team should have undergone appropriate training and have demonstrated competence in pressure ulcer management.
- Staffing levels and skill mix should reflect the needs of patients, and are paramount to providing high-quality services for individuals with pressure ulcers.
- Priority should be given to the provision and allocation of resources in the management of patients with a pressure ulcer/s.

## **2.4 Summary of Guideline recommendations**

---

### **Key recommendations**

The following recommendations have been identified as priorities for implementation.

- Record the pressure ulcer grade using the European Pressure Ulcer Advisory Panel Classification System. **[D]**
- All pressure ulcers graded 2 and above should be documented as a local clinical incident. **D[GPP]**
- Patients with pressure ulcers should receive an initial and ongoing pressure ulcer assessment. Where a cause is identified strategies should be implemented to remove/reduce these. Ulcer assessment should include: **[D]**
  - cause of ulcer
  - site/location
  - dimensions of ulcer
  - stage or grade
  - exudate amount and type
  - local signs of infection
  - pain
  - wound appearance
  - surrounding skin
  - undermining/tracking (sinus or fistula)
  - odour, and
  - involvement of clinical experts – e.g. tissue viability nurse.

This should be supported by tracings and or photography (calibrated with a ruler).

- Patients with pressure ulcers should have access to pressure-relieving support surfaces and strategies – for example, mattresses and cushions – 24 hours a day, and this applies to all support surfaces. **[D]**
  
- All individuals assessed as having a grade 1-2 pressure ulcer should, as a minimum provision, be placed on a high-specification foam mattress or cushion with pressure-reducing properties combined with very close observation of skin changes, and a documented positioning and repositioning regime. **[D]**
  
- If there is any perceived or actual deterioration of affected areas or further pressure ulcer development, an alternating pressure (AP) (replacement or overlay) or sophisticated continuous low pressure (CLP) system – for example low air loss, air fluidised, air flotation, viscous fluid – should be used. **[D]** (NB: For individuals requiring bed rails, alternating pressure (AP) overlay mattresses should be placed on a reduced-depth foam mattress to maintain their safety.)
  
- Depending on the location of ulcer, individuals assessed as having grade 3-4 pressure ulcers – including intact eschar where depth, and therefore grade, cannot be assessed – should, as a minimum provision, be placed on an alternating pressure mattress (replacement or overlay) or sophisticated continuous low pressure system – for example low air loss, air fluidised, viscous fluid). **[D]**
  
- If alternating pressure equipment is required, the first choice should be an overlay system, unless other circumstances such as patient weight or patient safety indicate the need for a replacement system. **[D]**
  
- Create the optimum wound healing environment by using modern dressings – for example hydrocolloids, hydrogels, hydrofibres, foams, films, alginates, soft silicones – in preference to basic dressing types – for example gauze, paraffin gauze and simple dressing pads. **[D]**

### 3 BACKGROUND TO THE CURRENT GUIDELINES

#### Background to commissioning the Guideline

NICE (or the Institute) worked collaboratively with the RCN Quality Improvement Programme to develop this Guideline on the management of pressure ulcers in primary and secondary care for use in the NHS in England and Wales. This follows referral of the topic by the Department of Health and the Welsh Assembly Government and the identification of pressure ulcer treatment as a priority topic for nurses by RCN members. The RCN Institute, through its Quality Improvement Programme, has a long-standing and well-respected reputation for national guideline development and implementation work. It has established strong links with key organisations in the field of evidence-based information, both nationally (SIGN) and internationally (GIN and JBI).

The Guideline will provide recommendations for good practice based on the best available evidence to the Guideline Development Group of clinical and cost-effectiveness. This Guideline follows on from the recently published NICE guideline *Risk assessment and prevention of pressure ulcers* (NICE, 2001) and a guideline on the use of pressure-relieving support surfaces (beds, mattresses and overlays) for the prevention of pressure ulcers in primary and secondary care completed in October 2003. It is anticipated that these inter-related topics will provide a compilation of NICE guidance on pressure ulcer care and will form part of the Wound Care Suite of related guidance.

The Institute's clinical guidelines will support the implementation of National Service Frameworks (NSFs) in those aspects of care where a framework has been published. The statements in each NSF reflect the evidence that was used at the time the framework was prepared. The clinical guidelines and technology appraisals published by the Institute after an NSF has been issued will have the effect of updating the framework.

Clinical guidelines have been defined as systematically developed statements that assist clinicians, patients and carers in making decisions about appropriate treatments for specific conditions and aspects of care.

#### 3.1 Clinical need for the guideline

The presence of a pressure ulcer creates a number of significant difficulties – psychologically, physically and clinically – to patients, carers and their families. Clinicians working in a variety of clinical and non-clinical settings, including primary

care and acute trusts, also face challenges when providing holistic, person-centred services for the assessment and treatment of pressure ulcers. These challenges include clinical decisions on methods of assessment and treatments to be used for individuals with an existing pressure ulcer.

Pressure ulcers are more likely to occur in those who: are seriously ill; are neurologically compromised (i.e. individuals with spinal cord injuries); have impaired mobility (Allman, 1997; Berlowitz and Wilking, 1990; Berlowitz et al., 1997; Bianchetti et al., 1993) or who are immobile (including those wearing a prostheses, body brace or plaster cast); suffer from impaired nutrition (Ek et al., 1990, 1991; Casey, 1997; Banks, 1998; Casey, 1998a,b), obesity (Gallagher, 1997), poor posture, or use equipment such as seating or beds which do not provide appropriate pressure relief. Pressure ulcers affect sub-groups in society, including those with spinal cord injury (Krause, 1997; Elliot, 1999; Vesmarovich et al., 1999; Kirsch, 2001), the elderly (Hefley and Radcliffe, 1990; Waltman et al., 1991; Krainski, 1992; Orlando, 1998; Pase and Hoffman, 1998; Spoelhof, 2000; Thomas, 2001; Ronda and Falce, 2002) and pregnant mothers (Prior, 2002). Pressure ulcers have been associated with an increased incidence of infection including osteomyelitis (Darouiche et al., 1994).

Research indicates that pressure ulcers represent a major burden of sickness and reduced quality of life for patients, their carers (Hagelstein and Banks, 1995; Franks et al., 1999; Franks et al., 2002) and their families (Benbow, 1996; Elliott et al., 1999). Often patients require prolonged and frequent contact with the health care system, and suffer much pain (Emflorgo, 1999; Freeman, 2001; Flock, 2003; Healy, 2003; Manfredi et al., 2003), discomfort and inconvenience (Franks et al., 1999).

The presence of pressure ulcers has been associated with a two- to four-fold increase of risk of death in older people in intensive care units (Thomas et al., 1996; Clough, 1994; Bo et al., 2003).

Estimates on pressure ulcer incidence and prevalence from hospital-based studies vary widely according to the definition and grade of ulcer, the patient population and care setting. Based on data that are available, new pressure ulcers are estimated to occur in 4–10% of patients admitted to acute hospitals in the UK (Clark and Watts, 1994), the precise rates depending on case mix. In the community, new pressure ulcers affect an unknown proportion of people as reliable data is not available.

The financial costs to the NHS are considered to be substantial (Bennett et al., 2004). In 1993, the estimated cost of preventing and treating pressure ulcers in a 600-bed general hospital was between £600,000 and £3 million a year (Touché Ross, 1993). The cost of treating a grade 4 pressure ulcer was calculated in 1999 to be £40,000 a year (Collier, 1999). More recent cost data suggest that treating ulcers varies from £1,064 for a grade 1 ulcer to £10,551 for a grade 4 ulcer with total costs in the UK

estimated as being £1.4–£2.1 billion annually, equivalent to 4% of the total NHS expenditure (Bennett et al., 2004).

### 3.2 What are pressure ulcers?

Pressure ulcers, commonly referred to as pressure sores, bed sores, pressure damage, pressure injuries and decubitus ulcers, are areas of localised damage to the skin, which can extend to underlying structures such as muscle and bone (Allman, 1995, 1997). Damage is believed to be caused by a combination of factors including pressure, shear forces, friction and moisture (Allman, 1997). Pressure ulcers can develop in any area of the body (Rycroft-Malone and McInnes, 2000). In adults damage usually occurs over bony prominences, such as the sacrum. Presentation in infants and children is more likely to occur, for example, on the occipital area or ears (Willock et al., 1999; Murdock, 2002; Jones et al., 2001).

#### Definitions and classifications

Definition and classification of pressure ulcers were agreed with the Guideline Development Group at the second group meeting, and will serve to update definitions and classifications used in related published NICE and RCN guidance, *Pressure ulcer prevention: pressure ulcer risk assessment and prevention, including the use of pressure-relieving support surfaces (beds, mattresses and overlays) for the prevention of pressure ulcers in primary and secondary care* (NICE, 2003), available at [www.nice.org.uk](http://www.nice.org.uk) and [www.rcn.org.uk](http://www.rcn.org.uk).

A pressure ulcer is defined as:

*an area of localised damage to the skin and underlying tissue caused by pressure, shear, friction and/or a combination of these.* EPUAP(2003) European Pressure Ulcer Advisory Panel [www.epuap.org.uk](http://www.epuap.org.uk).

#### Classification of pressure ulcer severity

Grade 1: non-blanchable erythema of intact skin. Discolouration of the skin, warmth, oedema, induration or hardness may also be used as indicators, particularly on individuals with darker skin.

Grade 2: partial thickness skin loss involving epidermis, dermis, or both. The ulcer is superficial and presents clinically as an abrasion or blister.

Grade 3: full thickness skin loss involving damage to or necrosis of subcutaneous tissue that may extend down to, but not through, underlying fascia.

Grade 4: extensive destruction, tissue necrosis, or damage to muscle, bone, or supporting structures with or without full thickness skin loss.

<sup>†</sup>EPUAP (2003) classification system. [www.epuap.org.uk](http://www.epuap.org.uk)

### **3.3 Groups at risk**

- Those who are seriously ill, neurologically compromised, i.e. individuals with spinal cord injuries, have impaired mobility or who are immobile (including those wearing a prosthesis, body brace or plaster cast), or who suffer from impaired nutrition, obesity, poor posture, or use equipment such as seating or beds which do not provide appropriate pressure relief.
- Older people and pregnant women are also at risk.

### **3.4 Interventions under consideration**

The guideline will consider interventions such as:  
pressure-relieving support surfaces and supports, including specialised seating and postural support; dressings; removal of devitalised or contaminated tissue (debridement); surgery; nutritional support; electrotherapy; therapeutic ultrasound; low-level laser therapy; topical negative pressure (TPN); and topical antimicrobials.

---

<sup>†</sup> A range of classification systems are used throughout the literature. The one described above is generally accepted.

## 4 AIMS OF THE GUIDELINE

The aims of the Guideline are to:

- evaluate and summarise the clinical and cost-effectiveness evidence for the management of pressure ulcers in primary and secondary care
- highlight gaps in the research evidence
- formulate evidence-based and, where possible, cost-effective clinical practice recommendations for the management of pressure ulcers based on the best evidence available to the GDG.

### 4.1 Who the guideline is for

This Guideline is intended to support decision-making in health professionals who have direct contact with and take decisions on the treatment of patients with pressure ulcers. It is also written for people with pressure ulcers and their carers. An *Information for the public* version of this Guideline will be produced containing all the key information from the recommendations.

### 4.2 Groups covered by the guideline

The Guideline recommendations will apply to all patient groups (adults, older people, infants, children and young people) in primary and secondary care.

### 4.3 Groups not covered

†There are no restrictions.

### 4.4 Health care setting

This Guideline will make recommendations for care given by health professionals who have direct contact with and make decisions about the treatment of patients with pressure ulcers, including those with multiple pathologies, and those suffering from chronic and acute disease, and terminal illness. Recommendations will apply equally across the primary and secondary care interface, including specialist units. The Guideline will also help to guide and inform patients and carers about the

---

† Whilst there are no restriction in terms of inclusion/ exclusion criteria it is clear that the research evidence in some areas and for some groups , e.g. infants, children and pregnant women, is very limited.

management of pressure ulcers by increasing awareness of strategies to both assess and treat individuals with pressure ulcers and prevent re-occurrence.

This is an NHS guideline. Although it will address the interface with other services, such as those provided by social services, the independent sector, secure settings and the voluntary sector, it will not include services exclusive to these sectors.

## **4.5 Interventions covered**

This Guideline will make clinical and cost-effective recommendations on pressure ulcer treatment, based on the best evidence available to the GDG. The recommendations will cover treatments such as:

- pressure-relieving support surfaces and supports, including specialised seating and postural support
- dressings
- removal of devitalised or contaminated tissue (debridement)
- surgery
- nutritional support
- electrotherapy
- therapeutic ultrasound
- low-level laser therapy
- topical negative pressure, and
- topical antimicrobials.

## **4.6 Interventions not covered**

The Guideline will be relevant to, but will not cover, other aspects of pressure ulcer-risk assessment and prevention (such as identifying patients at risk of developing a pressure ulcer, the use of risk-assessment scales, risk factors for the development of pressure ulcers, general skin inspection, and staff education and training).

Recommendations for these areas are included in other guidance produced by the Institute (see Section 6)<sup>†</sup>. This Guideline should be used in conjunction with NICE guidance on related topics.

### **Wound healing**

The process by which tissue repair takes place is termed wound healing. It comprises a continuous sequence of inflammation and repair, in which epithelial, endothelial, inflammatory cells, platelets and fibroblasts briefly come together outside their normal

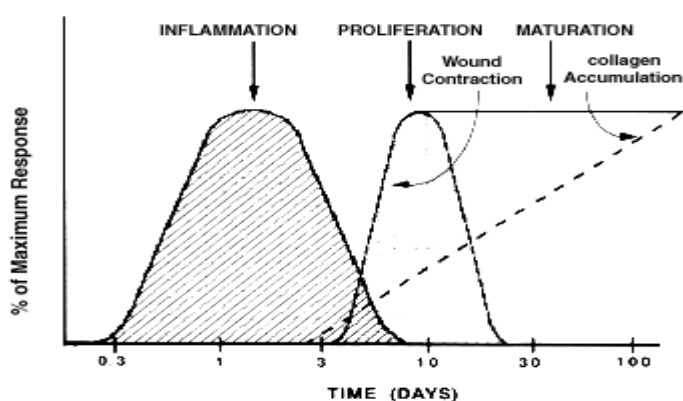
---

<sup>†</sup> *Due to the size of the scope, timelines and resources to complete the guideline it has not been possible to include all interventions indicated in the treatment of pressure ulcers. The topic areas included are those prioritised and agreed through the formal NICE consultation process.*

domains, interact to restore a semblance of their usual discipline and, having done so, resume their normal function.

The process of wound repair differs little from one kind of tissue to another and is to some extent independent of the form of injury. Although the different elements of the wound healing process occur in a continuous, integrated manner, the overall process can be divided into three overlapping phases.

## STAGES OF WOUND HEALING



**Fig. 1** Stages of wound healing. Wound healing can be arbitrarily divided into three phases: inflammation, proliferation and maturation

- Inflammatory
- Proliferate
- Maturation and remodelling

Some wounds will heal with routine wound care – for example wounds with even edges that come together spontaneously (minor cuts) or can be brought together. Wounds with rough edges and tissue deficit (a crater) may take longer to heal. When there is a crater and the edges of a wound are not brought together (left open intentionally), bumpy granulation tissue grows from the exposed tissue. The granulation tissue is eventually covered by skin that grows over the wound from the cut edges to the center. When healing is complete, the granulation tissue develops into tough scar tissue. Wounds heal in three stages.

### Inflammatory stage

This stage occurs during the first few days. The wounded area attempts to restore its normal state (homeostasis) by constricting blood vessels to control bleeding. Platelets

and thromboplastin make a clot. Inflammation (redness, heat, swelling) also occurs and is a visible indicator of the immune response. White blood cells clean the wound of debris and bacteria.

### **Proliferate stage**

After the inflammatory stage, the proliferate stage lasts about three weeks (or longer, depending on the severity of the wound). Granulation occurs, which means that special cells called fibroblasts make collagen to fill in the wound. New blood vessels form. The wound gradually contracts and is covered by a layer of skin.

### **Maturation and remodelling stage**

This stage may last up to two years. New collagen forms, changing the shape of the wound and increasing strength of tissue in the area. Scar tissue, however, is only about 80% as strong as the original tissue. The body's ability to heal during this stage is impaired in the elderly.

Normal wound healing in acute wounds is a co-ordinated and rapid process. This process is impaired in chronic wounds. In chronic wounds the cells become unresponsive to chemical messengers, such as cytokines and growth factors, and such wounds have a prolonged inflammatory response (Van de Berg et al., 1995; Stanley and Osler, 2001).

## **4.7 Guideline Development Group**

The Guideline recommendations were developed by a multidisciplinary and lay Guideline Development Group (GDG) convened by the RCN and NICE with membership approved by NICE. Members include representatives from:

- patient groups
- nursing
- medicine
- surgery
- allied health
- researchers, and
- staff from the RCN.

The GDG met thirteen times between April 2003 and May 2005. Full details of the GDG members can be found on the NICE website ([www.nice.org.uk](http://www.nice.org.uk)) and at the start of this Guideline.

All members of the GDG were required to make formal declarations of interest at the outset, which were recorded. GDG members were also asked to declare interest at

the beginning of each GDG meeting. This information is recorded in the meeting minutes and kept on file at the RCN.

## 5 METHODS USED TO DEVELOP THE GUIDELINE

### 5.1 Summary of development process

The methods used to develop this Guideline are based on those published by NICE – *Guideline development methods: information for National Collaborating Centres and guideline developers* (NICE, 2004). The structure of the recommendations section (section 6) – i.e. recommendations, evidence statements, evidence narrative and Guideline Development Group commentary – came from McIntosh et al. (2001) and has been used in recently published guidelines by the NCC-NSC.

The following sources of evidence were used to inform the guideline:

- Cullum N, Deeks J, Sheldon, TA, Song F and Fletcher AW (2004) Beds, mattresses and cushions for pressure sore prevention and treatment (Cochrane Review) in: *The Cochrane Library*, Issue 1, Chichester, UK: John Wiley & Sons, Ltd.
- Bradley M, Cullum N, Nelson EA, Petticrew M, Sheldon T and Torgerson D (1999b) Systematic reviews of wound care management: (2) Dressings and topical agents used in the healing of chronic wounds. *Health Technology Assessment*,3(17),pt. 2.
- Bradley M, Cullum N and Sheldon T (1999a) The debridement of chronic wounds. *Health Technology Assessment*,3(17),pt. 1.
- Langer G, Schloemer G, Knerr A, Kuss O and Behrens J (2004) Nutritional interventions for preventing and treating pressure ulcers (Cochrane Review) in: *The Cochrane Library*, Issue 3, Chichester, UK: John Wiley & Sons, Ltd.
- Flemming K and Cullum N (2000) Therapeutic ultrasound for pressure sores. *The Cochrane Database of Systematic Reviews*, Issue 4.
- Flemming K and Cullum N (2001) Electromagnetic therapy for treating pressure sores. *The Cochrane Database of Systematic Reviews*, Issue 1.
- Evans D and Land L (2001) Topical negative pressure for treating chronic wounds. *The Cochrane Database of Systematic Reviews*, Issue 1.

The stages used to develop this guideline were as follows:

- develop scope of guideline
- convene multidisciplinary GDG
- review questions set
- identify sources of evidence
- retrieve potential evidence
- evaluate potential evidence relating to cost/economics, quality of life and epidemiology for eligibility, quality and relevance

- extract relevant data from studies meeting methodological and clinical criteria
- interpret each paper taking into account the results – including, where reported, the beneficial and adverse effects of the interventions, cost, comfort and acceptability to patients, level of evidence, quality of studies, size and precision of effect, and relevance and generalisability of included studies to the scope of the Guideline
- prepare evidence reviews and tables which summarise and grade the body of evidence
- formulate conclusions about the body of available evidence based on the evidence reviews by taking into account factors above
- develop and utilise formal consensus methods to generate a consensus statement for areas lacking sufficient research evidence
- agree final recommendations and apply recommendation gradings
- submit first drafts (full version) of guidelines for feedback from NICE registered stakeholders
- consideration by GDG of stakeholders' comments
- submit final drafts of all Guideline versions (including *Information for the public* version, algorithm and audit criteria) to NICE for second stage of consultation
- consideration by GDG of stakeholders comments
- final copy submitted to NICE.

The main clinical questions addressed were as follows:

What assessment process(es)/tools should be used to identify modifiable risk factors/complications for those with pressure ulcers?

Epidemiological systematic review of prospective cohort studies

What are the modifiable risk factors for individuals with existing pressure ulcers?

Epidemiological systematic review of prospective cohort studies.

What assessment process(es)/tools should be used to assess a pressure ulcer?

Narrative review of studies assessing wound measurement.

What is the evidence that pressure-relieving support surfaces (beds, mattresses or overlays and seating cushions) are effective and cost-effective in treating pressure ulcers?

Systematic review of effectiveness.

<p>What is the most effective positioning (sitting and lying) technique for people with pressure ulcers? Systematic review of effectiveness.</p> <p>What is the evidence that dressings are effective and cost-effective in treating pressure ulcers? Systematic review of effectiveness.</p> <p>What is the evidence that debridement is effective and cost-effective in treating pressure ulcers? Systematic review of effectiveness.</p> <p>What is the evidence that nutritional support is effective and cost-effective in treating pressure ulcers? Systematic review of effectiveness.</p> <p>What is the evidence that topical antimicrobials are effective and cost-effective in treating pressure ulcers? Systematic review of effectiveness.</p> <p>What is the evidence that surgical interventions are effective and cost-effective in treating pressure ulcers? Narrative review of case series.</p>
--

Additional questions addressed by the evidence reviews included:

<p>Are there any differences in comfort and acceptability rating?</p> <p>Have there been any adverse events or patient complaints/comments for any of the included interventions?</p> <p>Is there any information about the ease of use and acceptability of interventions for patients, carers or nursing staff?</p> <p>What studies have been done looking at the quality of life implications of having a pressure ulcer for both patients and carers in a broad sense of quality of life?</p> <p>What studies have been done that measure quality of life implications of pressure ulcers that we can use to compare the implications of having a pressure ulcer with other health problems?</p>
--

Are there any studies looking at the implications of quality of life of different equipment use?

RCN staff worked with an information specialist from the Centre for Reviews and Disseminations at the University of York to develop the search strategies for the topic areas covered in this Guideline. The information scientist ran the searches and all results were saved and stored in bibliographical software. RCN staff sifted all topic areas and conducted systematic reviews, either fully in cases where there were no existing reviews, or updated in cases where there were existing reviews or health technology appraisals. The RCN graded the evidence and composed successive drafts of the recommendations and the full guideline documents – which includes the full version of guidelines, NICE *Quick reference guide* (QRG) and *Information for the public* version – based on the evidence reviews, and GDG input and deliberations. The GDG formulated and graded the recommendations.

The methods for each review are reported in section 6. The results are also reported in section 6.

More details of the individual trials can be found in the evidence tables found in Appendix A.

The resulting recommendations are in section six for each review area.

## 5.2 Clinical effectiveness review methods

The search strategies and databases used are presented in Appendix B. All searches were comprehensive and included a large number of databases (see Appendix B). All search strategies were adapted for smaller or simpler databases, or for web-based sources, which did not allow complex strategies or multi-term searching.

A combination of subject heading and free text searches were used for all areas. Free text terms were checked on the major databases to ensure that they captured descriptor terms and their exploded terms.

Extensive hand-searching was not undertaken following NICE advice that exhaustive searching on every guideline review topic is not practical and efficient (Mason et al., 2002).

Reference lists of articles were checked for articles of potential relevance.

### Search strategy

#### Terminology

The terms for the search strategies were identified by discussion between an information officer and the research team, by scanning the background literature, and by browsing the Medline Thesaurus (MeSH). Once drafted, the initial strategy of pressure ulcer terms was circulated round the GDG for comment.

### **Management of references**

As several databases were searched, some degree of duplication resulted. To manage this issue, the titles and abstracts of bibliographic records were downloaded and imported into bibliographic management software to remove duplicate records. Further studies were identified by examining the reference lists of all included articles.

### **Preliminary literature search**

An initial search was undertaken by an RCN Research and Development Fellow to:

- identify any existing guidelines, systematic reviews and Health Technology Assessments (HTAs) covering pressure ulcer management to prevent duplication, and
- *estimate* the potential size of the literature for this topic area.

All databases were searched from inception date, which varies for each database.

The following databases and websites were searched using keyword search terms:

- British Nursing Index (OVID) (up to 2002, 10)
- Cinahl (OVID) (up to 2002, 10)
- Cochrane Library Issue 3. 2002 (internet)
- The Database of Abstracts and Reviews of Effectiveness (DARE) (up to 2002, 10)
- eGuidelines (up to 2002, 10)
- Health Technology Assessment database (HTA) (up to 2002, 10)
- National Guideline Clearing House (up to 2002, 11)
- New Zealand Guidelines Group (up to 2002, 10)
- Sign – Scottish Intercollegiate Guidelines Network (up to 2002, 10)
- Specialist Trials Register of Cochrane Wounds Group (up to 2002, 10) .

### **Main literature searches**

The following databases were searched:

- Medline (OVID)
- Medline In-Process Citations (OVID)

- Embase (OVID)
- Cinahl (OVID)
- British Nursing Index (OVID)
- Health Management Information Consortium (SilverPlatter)
- Database of Abstracts of Reviews of Effectiveness (DARE) (internal CRD interface)
- AMED (OVID)
- Cochrane Library (internet)
- System for Information of Grey Literature in Europe (SIGLE) (SilverPlatter)

Search dates are reported in the relevant review.

A search of the Cochrane Wounds Group specialist trials register was undertaken for each of the reviews.

### **Sifting process**

Articles were retrieved and stored in an Endnote library and were subject to the following sifting process.

<b>1st sift:</b>	Remove any irrelevant material based on title/abstract.
<b>2nd sift:</b>	Identify material that potentially met eligibility criteria based on title/abstract.
<b>3rd sift:</b>	Order full papers if they appear relevant and eligible, and where relevance/eligibility was not clear from the abstract or the abstract was not available but the title was relevant.
<b>4th sift:</b>	Appraise full articles that met eligibility criteria.

### **Data abstraction**

Data from included trials were extracted by one or two reviewers into pre-prepared data extraction tables. Discrepancies were discussed and resolved.

The following data were extracted from each study:

- patient inclusion/exclusion criteria
- care setting
- key baseline variables by group
- description of the interventions and numbers of patients randomised to each intervention
- description of any co-interventions/standard care

- duration and extent of follow up
- outcomes, and
- acceptability and reliability if reported.

If data were missing from reports, then attempts were made to contact the authors to complete the information necessary for the critical appraisal. If studies were published more than once, the most detailed report was used as the basis of the data extraction.

No statistical analysis of inter-rater reliability of dual data extraction was performed. Differences were resolved by discussion.

Masked assessment, whereby data extractors are blind to the details of journal and authors, was not undertaken because there is no evidence to support the claim that this minimises bias (Cullum et al., 2003).

Once individual papers were retrieved, the articles were checked for methodological rigour (using quality checklists appropriate for each study design), applicability to the UK and clinical significance. Assessment of study quality concentrated on dimensions of internal validity and external validity. Information from each study which met the quality criteria was summarised and entered into evidence tables.

All data extraction forms are contained in Appendix A.

### **Appraisal of methodological quality**

The methodological quality of each trial in the effectiveness reviews was assessed by two researchers. The following quality criteria were used:

- description of inclusion and exclusion criteria used to derive the sample from the target population
- description of *a priori* sample size calculation
- evidence of allocation concealment at randomisation
- description of baseline comparability of treatment groups
- outcome assessment stated to be blinded
- outcome measurement, and
- clear description of main interventions.

Methods of measuring wound healing can be subjective in the studies included in the reviews of this Guideline but had to incorporate at least one objective assessment – such as change in ulcer size, rate of healing, frequency of complete healing or time to complete healing – to meet the inclusion criteria.

Change in ulcer size is presented as a percentage or absolute change over a period of time. Objective methods of measuring changes on wound size include tracing the

ulcer outline followed by counting grids on graph paper, weighing uniform-density tracing paper, planimetry or computerised image analysis.

A single standard outcome measure for wound healing does not exist. Both objective and subjective measures are widely used by researchers. However the validity of many of these measurements remain the subject of ongoing investigation and debate.

Objective measures of healing are usually based on wound area. Planimetry, often aided by computer analysis, is the most frequently used method of calculating wound area. Other methods, such as the measurement of wound diameter or weight of a tracing drawn around the area of the wound, are also used. Measurements of wound volume are infrequently reported in the literature; these methods are often cumbersome and their accuracy has not been proven. Computerised image analysis may prove to be a useful technique in the future for the assessment of wound volume, as the equipment becomes more affordable and portable.

Even though objective measures reduce or eliminate subjective biases and reduce random measurement errors, they have certain inherent biases if the patients being compared have wounds with different baseline size. A change in wound area is often expressed as the percentage change which, unlike the absolute change in area, takes into account the initial size of the wound. For two wounds healing at the same linear rate (as measured by diameter reduction), percentage area calculations will show a larger change for a small wound than for a big wound. The converse is true when the absolute change in area is measured, as for any unit reduction in wound radius, a bigger area reduction will occur for a large wound.

This has important consequences for the validity of trial results where there is poor comparability in initial wound size at baseline between the treatment groups. In large trials, randomised allocation should ensure that the mean wound size and variance in each group is similar. In a small trial random allocation is unlikely to result in an even distribution of wound sizes. In a trial where there is poor comparability between groups for wound size at baseline, and the outcome is based on the change in area, the result can only be considered valid if it is obtained either: against the anticipated direction of the bias for wound size; or where percentage area change and absolute area change are in the same direction. If baseline data are not given then it is not possible to determine the direction of bias and the validity of the result cannot be determined. Despite the potential for objective outcomes to be biased by differences in wound size at baseline, they remain the most reliable assessment of wound healing as, unlike subjective measures, they reduce the biases of the assessor which cannot be estimated.

## **Data synthesis**

For each trial, relative risk (RR) was calculated for outcomes such as complete healing. When sufficient detail allowed their calculation, 95% confidence intervals (95% CI) were included. NNT were calculated where possible and appropriate. The results from replicated studies were plotted onto graphs and discussed by narrative review. Unique comparisons were not plotted and the relative risk is stated in the text. Individual study details are presented in the evidence tables (Appendix A). Where there was more than one trial comparing similar interventions using the same outcome, and in the absence of obvious methodological or clinical heterogeneity, statistical heterogeneity was tested for by chi-squared test. In the absence of significant statistical heterogeneity, studies with similar comparisons were pooled using a fixed effects model (Clarke, 1999). If heterogeneity was observed, both random and fixed effects models were used to pool the data. All calculations were made using Revman 4.2.3 software.

## **5.3 Cost-effectiveness review methods**

### **Aims**

The aim of this section is to assess the economic evaluation literature on pressure ulcer management interventions. While the clinical effectiveness sections systematically assess the evidence on whether products can and do work, this section also considers the resource use and cost implications associated with interventions. To assess cost-effectiveness, alternative treatment options are compared in terms of their costs and effects. The technique is used to assess whether an intervention is worth using, compared with other uses to which the same resources could be put.

### **Background**

Pressure ulcers have a substantial impact on the health-related quality of life of patients, and in terms of the financial burden on the health service, patients and their families, and society as a whole. Recent cost estimates suggest that the cost of treating a pressure ulcer varies from £1,064 for a grade 1 pressure ulcer to £10,551 for a grade 4<sup>i</sup> pressure ulcer, with higher grade pressure ulcers taking longer to heal and being associated with a higher incidence of complications (Bennett et al., 2004). Bennett et al. (2004) estimated that in the UK the annual cost of treating pressure ulcers is between £1.4 and £2.1 billion (price year 2000), that is about 4% of total NHS expenditure.

A plethora of interventions are available for the treatment and management of pressure ulcers. However, it is not always clear what works best, given the resource use and cost implications of different pressure ulcer treatments.

Previous systematic reviews, in which pressure ulcer interventions are assessed, found little evidence available on the cost-effectiveness of different treatment options (Bradley et al., 1999ab; Cullum et al., 2001; O'Meara et al., 2000). The importance of obtaining economic evidence in this area has been reiterated with calls for additional research that incorporates economic evaluations in high-quality clinical trials (Cullum et al., 2001). As has been suggested before: *"Measures of clinical effectiveness alone are rarely sufficient to guide health care decision-makers, since small incremental improvements in clinical effectiveness may not be worth the costs"* (O'Meara et al., 2000). In recognition of this the RCN, in collaboration with NICE, have funded this Guideline to include a review of the cost-effectiveness evidence in this field. The benefits of incorporating health economics within NICE guidelines were discussed and formalised within the Guideline development methods (Richardson et al., 2004). As stated: *"Clinicians already take resources and value for money into account in clinical decisions, and the incorporation of good-quality health economic evidence into clinical guidelines can help make this more consistent."*

## Methods

### Search questions

Searches for economic evaluations were undertaken to assess the cost-effectiveness evidence on ten different questions:

- A. What assessment process tools are most cost-effective in identifying modifiable risk factors/complications associated with treating pressure ulcers?
- B. What assessment tools are most cost-effective in assessing pressure ulcers?
- C. What is the cost-effectiveness evidence on pressure-relieving support surfaces to treat pressure ulcers?
- D. What is the cost-effectiveness evidence on pressure ulcer dressings to treat pressure ulcers?
- E. What is the cost-effectiveness evidence on pressure ulcer debridement strategies?
- F. What is the cost-effectiveness evidence on nutritional support to treat pressure ulcers?
- G. What is the cost-effectiveness evidence on adjunct therapies in the treatment of pressure ulcers?
- H. What is the cost-effectiveness evidence on topical antimicrobials used to treat pressure ulcers?
- I. What is the cost-effectiveness evidence on surgical interventions to treat pressure ulcers?

**J.** What is the cost-effectiveness evidence on mobility and positioning techniques to treat pressure ulcers?

### **Databases searched**

For each question the following databases were searched from inception date to early 2004 followed by an update search in August-September 2004 (see Appendix B for full details):

- Medline (1966-) (OVID interface)
- Medline In-Process Citations (OVID interface)
- Embase (1980-) (OVID interface)
- Cinahl (1982-) (OVID interface)
- British Nursing Index (1985-) (OVID interface)
- Health Management Information Consortium (OVID interface)
- AMED (1985-) (OVID interface)
- PsycInfo (1872-) (SilverPlatter interface)
- System for Information of Grey Literature in Europe (SIGLE) (1980-) (SilverPlatter interface).

Where possible, searches were limited to retrieve literature published in English, and to omit animal studies and letters, comments and editorial publication types.

As well as searches undertaken to answer specific questions, three specialist economics databases were searched to retrieve all references to pressure ulcers from inception date to September 2004:

- EconLit (1969-) (SilverPlatter interface)
- HEED (CD-rom)
- NHS Economic Evaluation Database (NHS EED) (1994-) (CRD administration database)

This search is referred to in this document as the core search.

### **Search terms**

Given the number of questions and databases searched, all search strategies are presented in Appendix B. The information officer, in consultation with the health economist, identified *economics terms* to use in the strategy. Terms were based on the NHS EED health economics filter strategy (CRD Report 6 (2nd Edition 2001)) with additional quality of life terms. On assessment the quality of life terms were found to introduce high numbers of irrelevant records so the records, once loaded into

Endnote bibliographic management software, were filtered for assessment by searching on core economic terms:  
cost\* or economic\* or price\* or expenditure\* or pharmacoeconomic\* or budget\* or quality\*

The *pressure ulcer terms* for the search strategies were identified via discussion between an information officer and the guideline research team, by scanning the background literature, and by browsing the MEDLINE Thesaurus (MeSH). Once drafted, the initial strategy of pressure ulcer terms was circulated round the GDG for comment.

For Question A the search results from the clinical effectiveness results were used, as they had not been restricted by study design. The results were loaded into Endnote and searched there using economics terms to identify a subset of references of potential relevance to the health economist.

Questions B, C and J were searched separately. Questions D, E, F, G, H and I were combined into a single search strategy to maximise efficient use of searching time.

### **Selection criteria**

For a study to be *included* in the review the following criteria were applied.

- The study assessed interventions to manage and treat pre-existing pressure ulcers.
- The study compared the costs and effects of two or more interventions.
- The interventions that were assessed compared A, B, C, D, E, F, G, I or J.
- The study had a sample size of two individuals or more.

For a study to be *excluded* from the review the following criteria were applied.

- The study assessed interventions to prevent pressure ulcers.
- The study did not report on costs associated with the interventions.
- The study did not report on outcomes associated with the interventions.
- The study was only available as a conference abstract or conference presentation.
- The study was not written in English and no translation of the data into English was available.

### **Data extraction**

Data on the eligible economic evaluations were abstracted (see Appendix A) for presentation purposes. Study details were provided including the method of economic evaluation used, the study design, the results and an overview of the conclusions with brief comments.

### **Quality assessment**

Eligible studies were quality assessed using a quality checklist by Drummond et al. (1996) (see Appendix C). This checklist asks 35 questions about the study design, data collection, and analysis and interpretation aspects of the economic evaluation.

### **Economic evaluation review**

The types of economic evaluations reviewed were full economic evaluations: cost-utility analysis, cost-benefit analysis, cost-effectiveness analysis and cost-minimisation analysis studies *and* partial economic evaluations including cost-consequence analysis. Full economic evaluations combine costs and health effects whereas, for cost-consequence analysis, costs are reported separately from health effects.

As implied by the names of the different types of economic evaluations, they differ in the way that health effects are measured. Health effects for use in cost-utility analyses measure individual or society-based preferences for a set of health states. A utility associated with a particular health state may be adjusted by the length of time spent in that state to calculate a generic outcome such as a Quality-Adjusted Life Year (QALY).

Like health effects measured in cost-utility analysis, the effects measured in cost-benefit analysis are also generic, in the sense that they can be used to compare effects across interventions. The difference, compared to cost-utility analysis, is that they are reported in monetary terms. Techniques such as contingent valuation may be used to obtain people's willingness to pay for the effects associated with a particular health state.

The health effects in cost-effectiveness analysis are measured in the most appropriate natural or physical units such as, in this case, time to complete heal of the pressure ulcer. If the effects are shown to be equivalent then a cost-minimisation analysis may be performed, however, in practice this is very rare. Finally, cost-consequence analysis involves the use of multiple outcome measures and these are not combined with cost (Drummond et al., 1997).

A treatment is deemed cost-effective (a collective term which may be used for all full economic evaluations) based on the following decision criteria:

- If a treatment has lower costs and more health effects than its comparator it is cost-effective and cost-saving (area (iv) in Figure 2).
- If a treatment has higher costs and more health effects than its comparator (area (ii) in Figure 2) it may be cost-effective, however incremental cost-effectiveness analysis is required. The question then becomes whether the extra costs are worth the extra effects. If so, the treatment is considered to be cost-effective. If not, the resources used to provide the treatment may produce higher-valued effects elsewhere.
- If a treatment has lower costs and lower health effects than its comparator (area (iii) in Figure 2) it may be cost-effective, however incremental analysis is required.
- If a treatment has higher costs and lower health effects than its comparator (area (i) in Figure 2) it is not cost-effective.

Incremental cost-effectiveness or incremental net health benefit (if a monetary measurement of health effect is used) is calculated by comparing the difference in cost of treatment 1 to treatment 2 with the difference in outcome of treatment 1 to treatment 2 (see Figure 2).

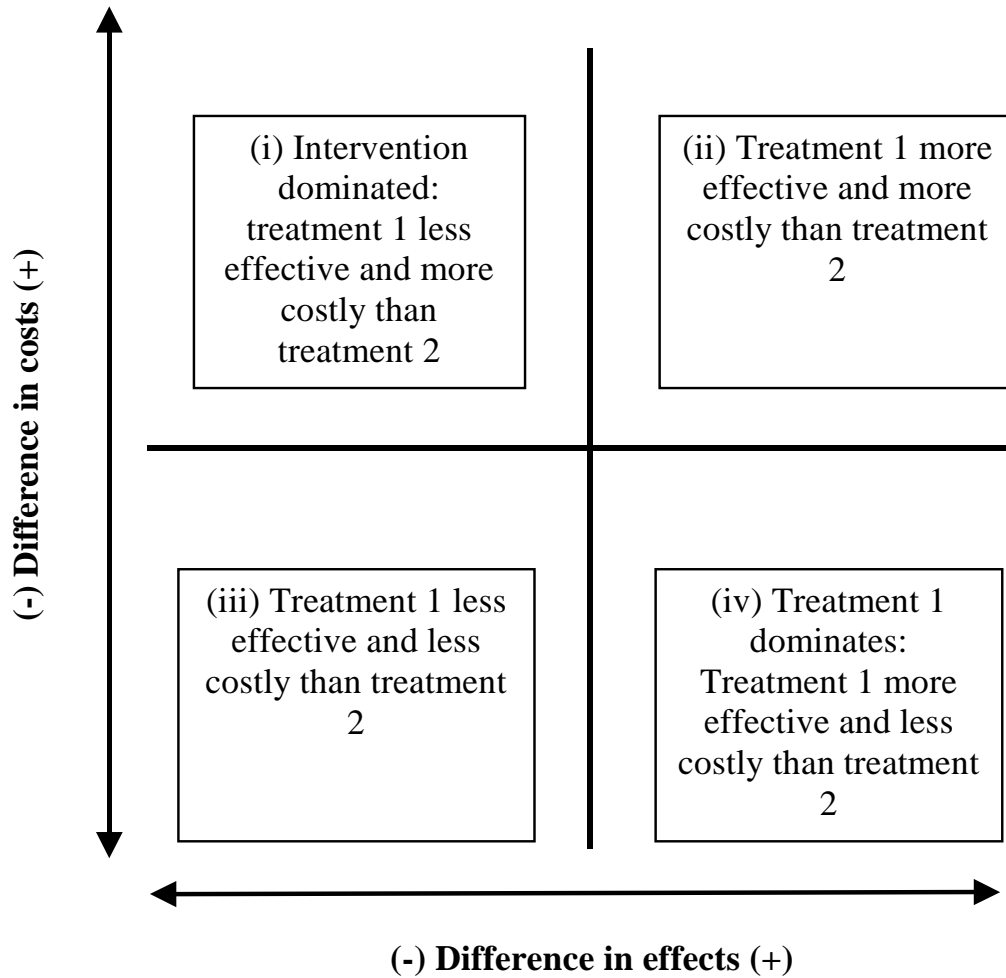


Figure 2: Cost-effectiveness plane



## **Findings**

### **Literature search**

#### **Search results and management of references**

As several databases were searched, some degree of duplication resulted. To manage this issue, the titles and abstracts of bibliographic records were downloaded and imported into Endnote bibliographic management software to remove duplicate records. In total, 3,049 abstracts were assessed for eligibility.

The number of unique records loaded into Endnote are shown below:

**A.** See clinical effectiveness searches + 703

**B.** 417

**C.** 487

**D, E, F, G, H, I.** 989

**J.** 304

**Core.** 149

**Total.** 3,049

The selection criteria were applied to the abstracts stored in Endnote and 185 studies were ordered. The selection criteria were then applied to each paper and a total of 26 economic evaluations were included in the review including the following:

<b>Intervention</b>	<b>Numbers of studies reviewed</b>
Assessment tools	0
Pressure-relieving support surfaces (beds, mattresses and overlays), mobility and positioning	3
Dressings and topical agents including debridement	21
Adjunct therapies (topical negative pressure, therapeutic ultrasound, electrotherapy and electromagnetic therapy)	2
Antimicrobials	0
Nutritional support	0
Surgical interventions	0

**Table 1: Economic evaluations**

## **5.4 Submission of evidence process**

Stakeholders registered with NICE, listed at the beginning of the document, were invited to submit a list of evidence for consideration to ensure that relevant material to inform the evidence base was not missed. The criteria for the evidence included:

- systematic reviews
- randomised controlled trials (RCTs) that examine clinical or cost-effectiveness and/or quality of life, and economic analyses based on these findings
- representative epidemiological observational studies
- qualitative studies/surveys that examine patient/carer experiences
- studies of any design which have attempted to formally:
  - assess the cost-effectiveness/utility of pressure ulcer treatment
  - assess the cost of having a pressure ulcer
  - assess quality of life or used cost-utilities in relation to pressure ulcer management.

Information not considered as evidence included:

- studies with weak designs when more robust study designs are available
- commercial in confidence material
- unpublished secondary endpoint trial data, data-on-file and economic modelling
- promotional literature
- papers, commentaries or editorials that interpret the results of a published study
- representations or experiences of individuals not collected as part of properly designed research.

Initial submissions were received from:

- British Healthcare Trades Association
- Nutricia Ltd
- Coloplast
- Hill-Rom
- College of Occupational Therapists
- Pegasus UK

Submissions were followed up to request the full references.

## 5.5 Evidence synthesis and grading

For the update of the clinical effectiveness reviews, data from existing trials of effectiveness were synthesised with new trials. If there were sufficient trials to warrant the re-analysis of existing meta-analyses, this was done. The data from included studies pertaining to costs, economic evaluation, epidemiology and quality of life were also qualitatively synthesised into a narrative format. Information from the reviews on costs, economic evaluations and epidemiology was used in the economic modelling. All included studies are summarised in evidence tables (Appendix A) as well as discussed in the appropriate evidence reviews.

Evidence gradings were assigned to each evidence review using the evidence hierarchy shown below (Table 2), which is the only hierarchy recommended by NICE at the time of writing. (It should be noted that the hierarchy strictly applies to questions of effectiveness.)

**Table 2: Levels of evidence**

1++	High-quality meta-analyses, systematic reviews of RCTs, or RCTs with very low risk of bias.
1+	Well-conducted meta-analyses, systematic reviews of RCTs, or RCTs with low risk of bias.
1-	Meta-analyses, systematic reviews of RCTs, or RCTs with high risk of bias*
2++	High-quality systematic reviews of case-control or cohort studies.  High-quality case-control or cohort studies with very low risk of confounding bias or chance and high probability that relationship is causal.
2+	Well-conducted case-control or cohort studies with low risk of confounding bias or chance and a moderate probability that relationship is causal.
2-	Case-control or cohort studies with a high risk of confounding bias or chance and a significant risk that the relationship is not causal*
3	Non-analytic studies – for example case reports, case-series.
4	Expert opinion, formal consensus.  *Studies with a level of evidence - should not be used as a basis for making a recommendation.

Reproduced with permission from the Scottish Intercollegiate Guidelines Network

The evidence tables and reviews were distributed to GDG members for comment on the interpretation of the evidence and grading.

## **5.6 Results of clinical effectiveness evidence retrieval and appraisal**

### **Study quality**

A summary of the methodological quality of each study of the trials is shown in Appendix C.

Characteristics of excluded studies are shown in Appendix D.

### **Comparisons**

The comparisons, relevant to this Guideline, able to be made on the basis of the included studies were:

## **5.7 Formulating and grading recommendations**

For the GDG to formulate a clinically useful recommendation, it was agreed that the following factors be considered:

- The best available evidence with preference given to empirical evidence over expert judgement, including:
  - a profile of the cost data
  - results of economic modelling
  - effectiveness data taking into account the strength of evidence (the level, quality, precision) as well as the size of effect and relevance of the evidence
  - where reported, data on additional outcomes such as comfort, adverse effects and patient acceptability
  - a comparison between the outcomes for alternative interventions where possible.
- The feasibility of interventions, including the cost of the intervention, acceptability to clinicians, patients and carers and appropriateness of the support surface.
- The balancing of benefits against risks – including, where reported, all patient-relevant endpoints (including adverse effects, comfort and acceptability where reported) – and the results of the economic modelling.
- The applicability of the evidence to groups defined in the scope of the Guideline, having considered the profile of patients recruited to the trials, and data obtained from our review of the epidemiological data and quality of life literature.

This information was presented to the group in the form of evidence tables and accompanying summaries which were discussed at GDG meetings. Where the GDG identified issues which impacted on considerations of the evidence and the ability to formulate implementable and pragmatic guideline recommendations, these were summarised in the GDG commentary sections.

Issues with the available data identified by the GDG included:

Issues with the data, interpretation of the evidence and the wording were discussed until there was agreement on the wording and grading.

Where the GDG decided that further higher level evidence was essential before any recommendations could be considered, recommendations for future research were made (see section 7). The group then ranked these in order of importance so that the top five could be included in the NICE version.

The grading of the recommendations was agreed at GDG meetings using the scheme below.

**Table 3: Recommendation grading**

A	At least one meta-analyses, systematic review, or RCT rated as 1++, and directly applicable to the target population <i>or</i> A systematic review of RCTs or a body of evidence consisting principally of studies rated as 1+, directly applicable to the target population and demonstrating overall consistency of results Evidence drawn from a NICE technology appraisal
B	A body of evidence including studies rated as 2++, directly applicable to the target population and demonstrating overall consistency of results <i>or</i> Extrapolated evidence from studies rated as 1++ or 1+
C	A body of evidence including studies rated as 2+, directly applicable to the target population and demonstrating overall consistency of results, <i>or</i> Extrapolated evidence from studies rated as 2++
D	Evidence level 3 or 4, <i>or</i> Extrapolated evidence from studies rated as 2+, <i>or</i> Formal consensus
D(GPP)	A good practice point (GPP) is a recommendation for best practice based on the experience of the Guideline Development Group

Adapted with permission from the Scottish Intercollegiate guidelines Network

The recommendations with accompanying evidence reviews are presented in section 6 and can be found in a summarised version in the quick reference guide for this guideline.

## **Formal consensus methods**

### **Background**

Clinicians often need to make decisions even where there is a variable or undetermined evidence base. Limiting recommendations to where evidence exists may reduce the scope of guidelines and thus limit their value to clinicians (Eccles et al., 1996). Woolf (1992) describes three methods of guideline development but also adds that in reality these are not mutually exclusive and it is possible to draw from each one.

In *evidence-based guideline development* recommendations are based on a systematic review of the literature, and make explicit reference and linkage to the level of supporting evidence, which should enable clinicians to make decisions about adhering to them. Grimshaw et al. (1995) argue that in cases where there is a strong level of supporting evidence clinicians should have a very good reason for choosing not to comply with them. However, as Woolf (1992) states, while this approach can be credited with enhancing the scientific rigour of guidelines, in the absence of acceptable evidence, one is unable to produce recommendations.

Woolf (1992) suggests that the most common method of guideline development is *informal consensus*. This method is probably most frequently used at a local level where committees formulate recommendations without drawing on research evidence (Grimshaw and Hutchinson, 1995). By definition, this method tends to be based on poorly defined criteria and lacks the adoption of explicit consensus. Consequently, the resulting guidelines tend to be subjective and ill-defined in nature.

*Formal consensus development methods*, such as Delphi or Nominal Group Technique, provide a structure to the group decision-making process by, for example, adopting rating methods to represent the extent of agreement about predefined issues or questions. In reality, given situations such as poor or lacking evidence, guideline developers have to adopt strategies based on a framework that utilises facets of more than one guideline development method.

As already described, the evidence base available for this Guideline is variable. Despite published and updated systematic reviews, which form the main basis of the Guideline development, there are some areas where systematic searches of the evidence revealed little good-quality research evidence. Given this, it was decided to devise and implement a formal consensus process to augment the weaker and more variable evidence base for areas of the Guideline. The premise for this decision was that a guideline that contained both evidence-linked and consensus-based

recommendations would be more useful to practitioners than one confined to the limited outcomes of available research-based evidence.

Authors, such as Grimshaw and Russell (1993a), Shekelle et al. (1999) and Rycroft-Malone (2001), have acknowledged the use of consensus opinion to formulate recommendations in cases where there is an absence of evidence. They stress, however, that the process adopted has to be explicit and that the source of recommendations made in the resulting guideline clearly documented. Thus the process devised and used here is based on current best practice of formal consensus in guideline development and also that used in the development of the NICE-inherited guideline for the risk assessment and prevention of pressure ulcers (NICE, 2002, 2003).

GDG members were asked to rate a number of elements of statement and statements as to the level of importance or to indicate “don’t know” if it was outside of their expertise or knowledge base. Ratings were aggregated, and mean and interquartile range was calculated. The results were used to develop recommendations statements, which would then enter the next phase and formal voting consensus.

**Example:**

The following refer to statements for risk factors of delayed healing/complications of having a pressure ulcer.

Please indicate how you rate the importance of each statement.

**1. A consensus statement about the holistic assessment for those with pressure ulcers may include:**

Extremes of age

Not	1	2	3	4	5	6	7	8	9	Very	□
Important				2	1			2	3	Important	

Reduced mobility

Not	1	2	3	4	5	6	7	8	9	Very	□
Important							1	1	8	Important	

\*Indicates GDG responses.

A modified nominal group technique was used to finalise the recommendations and good practice points. A facilitator was used to chair the meeting. The consensus process was facilitated by computerised voting consoles, which assured anonymity

and allowed percentages to be quickly calculated. It also allowed the GDG to view the range of responses in the form of a graph immediately voting had occurred.

Consensus was set at 80% unless a significant group within the GDG all voted against a recommendation – for example if all the allied health professionals, nurses or physicians voted against a recommendation, even though 80% agreement was achieved, a consensus agreement was not considered to have been reached.

Before voting on each recommendation and good practice point, discussion took place and modifications were made as necessary. Recommendations were reworded if necessary and then displayed on a screen so that GDG members could see the recommendation or good practice point on which they were voting. If consensus was achieved the GDG moved on to discuss the next recommendation or good practice point. However, if consensus was not achieved, the recommendation or good practice point was discussed a second time, modifications made to reflect the concerns of the GDG and re-voting took place. After debate on some areas, consensus was achieved for all recommendations submitted for first-stage consultation.

## **6. EVIDENCE REVIEWS WITH GUIDELINE RECOMMENDATIONS**

### **6.1 The holistic assessment of individuals with pressure ulcers**

#### **Background**

Pressure ulcer management approaches and techniques are continuously developing and there remains no overall consensus about them. Over the last thirty years a number of risk assessment tools and scales have been developed with the primary aim of identifying those individuals at risk of developing pressure ulcers. Interventions should then be implemented to help prevent ulceration.

The predictive validity of these assessment tools and scales in predicting which patients go on to develop pressure ulcers has been evaluated (Bergstrom, 1987; Deeks, 1996). These clearly identify variation in sensitivity, which means some tools are more effective in identifying and predicting those who are at elevated risk, and thus may go on to develop a pressure ulcer.

The importance of using risk assessment tools and scales as an adjunct to, but not a replacement for, clinical judgement has been stressed (Cullum et al., 1995; Cullum, 2001; Rycroft-Malone and McInnes, 2000). There still remains little evidence that indicates using a risk tool or scale is better than clinical judgement. The fact that they should be chosen on the basis of their suitability for a particular care setting or patient group, as well as the research evidence demonstration of their predictive validity, has also been highlighted (Cullum, 2001).

Perhaps more interestingly for this review, their effectiveness and validity for use in those individuals with established pressure ulcers is even more unclear, with indications that some perform poorly in identifying patients with existing ulcers as at risk (Williams et al., 2000). Yet these same tools and scales appear to be used widely in this patient group in both clinical and non-clinical settings in the UK. One explanation may be that the individual is recovering and is therefore no longer at risk, however the validity of this is unclear. Also research indicates that those with existing ulcers are also at elevated risk of developing further ulcers – this is not consistent with indications that some people with pressure ulcers are not found to be at risk according to some risk assessment tools.

To what extent these individuals are at further risk, not only of developing additional pressure ulcers but complications such as infections and delayed healing, is also unclear.

Reported characteristics of individuals with existing ulcers

- Activity, mobility, or functional limitation or immobility.
- Incontinent.
- Altered level of consciousness.
- Sensory impairment.
- Impaired nutrition.
- Acute illness.
- Dehydration.
- Chronic illness.
- Terminal illness.

### Clinical question

What assessment process should be used to identify modifiable risk factors for people *with* existing pressure ulcers?

### Objectives

The objective was to undertake a systematic review of the evidence of assessment of people with pressure ulcers to determine:

- What are the characteristics of people *with* pressure ulcers?
- What are the risk factors for people *with* pressure ulcers?
- What are the priorities for assessment?
- What is the empirical evidence that this process is effective in the management of pressure ulcers?

### Selection criteria

#### Types of studies

Prospective cohort studies of risk factors and characteristics or complications associated with having a pressure ulcer(s), and studies of characteristics and interventions predictive of healing. Prospective cohort studies comparing assessment processes for individuals with pressure ulcers, and studies evaluating their effectiveness in individuals with pressure ulcers in the treatment of pressure ulcers.

### **Types of participants**

All: adults and children, including those in primary and secondary care, residential homes, nursing homes, secure settings and the home.

### **Types of outcome**

Risk factors linked to healing/delayed healing, healing, complications and predictors of healing of pressure ulcers and severity.

## **Search strategy**

The databases searched are found in the review methods section 5 . The full search strategies are listed in Appendix B. Databases were searched in July 2003 and update searches performed in August 2004.

### **Appraisal of methodological quality**

Criteria for inclusion (methodological quality found in Appendix C) and pre-defined principles as outlined in Appendix E .

### **Selection**

Eligible participant population with well-defined demographic information.

High percentage of participants equal to or greater than 80% of those approached.

Identification of risk factors, characteristics and effectiveness of assessment process.

Risk factors and characteristics conceptually relevant to subject of interest.

Explicit details of how risk factor and characteristic information are measured.

Clear description of assessment process and measurements with comparison clearly defined.

### **Confounding**

Statistical adjustment carried out; evidence of sensitivity analysis with method described.

### **Outcomes**

Clear outcome measurements used.

## Follow up

Participation rates high with explicit details of losses to follow up.

## Search results

Results of search strategy	
Initial search results	2,871
N screened for relevance following sift	197
N included	3
N excluded	11

## Research evidence

A total of 197 studies were identified from the sifting process and subsequently full papers ordered. This number also included those studies referenced with relevant titles but where the abstract was absent in the citation. After sifting full papers for relevance and duplicates at this stage, 183 papers were opinion pieces, editorials, anecdotal reports or fell outside the inclusion criterion for this review. Out of the five selected studies, 11 were excluded and three included.

### Included studies

- The gold standard study design to investigate risk factors is the prospective cohort design. Only three studies were found which met the inclusion criteria.
- Generally the studies were medium-quality prospective cohort studies.

#### *Allman et al. (1995)*

Allman et al. (1995) carried a prospective inception cohort study to identify specific demographic, medical, functional status and nutritional characteristics that predict the development of stage 2 pressure ulcers or greater. A total of 286 patients met the inclusion criteria: admission within the past three days, age 55 years or more, expected to be confined to bed or chair for at least five days and/or hip fracture, and without grade 2 or greater pressure ulcers. The main outcome of the study was in-hospital time to develop a grade 2 or greater ulcer.

Results of multivariate analysis shows that grade 1 pressure ulcer (RR 7.52 CI 1.0-59.12), lymphopenia (RR 4.86 CI 1.70-13.89), immobility (RR 2.36 CI 1.14-4.85), dry skin (RR 2.31 CI 1.02-5.21) and decreased body weight (RR 2.18 CI 1.05-4.52) are independent and significant risk factors for the development of grade 2 pressure ulcers in hospital patients. In this study only 24 of the original 286 has a diagnosed grade 1 pressure ulcer at baseline and it is not clear if this subgroup of patients were analysed separately. The result of this may mean that the results cannot be generalised to patients with existing pressure ulcers.

Risk factor	Risk ratio	95% CI	p
Stage 1 pressure ulcer	7.52	1.0-59.12	<0.001
Lymphopenia	4.86	1.70-13.86	<0.001
Immobility	2.36	1.14-4.85	<0.001
Dry skin	2.31	1.02-5.21	<0.001
Decrease body weight	2.18	1.05-4.52	<0.001

Results of multivariate analysis

*Reed et al. (2003)*

Reed et al. (2003) conducted a longitudinal prospective cohort study involving 2,771 subjects from 47 Veterans Affairs hospitals. The aim was to determine if three risk factors (low serum albumin, faecal incontinence and confusion) were significant risk factors for the development of grade 2 or greater pressure ulcers. Multivariate analysis shows low albumin OR 1.40 and confusion OR 1.45 to be both statistically significant risk factors of grade 2 ulcer development while faecal incontinence was not. While this paper shows that the identification of a stage 1 pressure ulcer is a risk factor for more severe grade 2 and above ulcers or an open wound, it does not tell of the extent to which the other identified risk factors contribute to delayed healing or more severe pressure ulcers.

Risk factor	Odds ratio	95% CI	p
Stage 1 pressure ulcer	3.13	2.41-4.06	<0.001
Malnourished	1.69	1.31-2.19	<0.001
Urinary catheter on	1.55	1.38-1.75	<0.001

admission			
DNR order	1.40	1.22-1.90	<0.001

Multiple regression analysis for development of grade 2 or greater risk factors

*Williams et al. (2000)*

Williams et al. (2000) undertook a prospective study of 267 subjects of which 12.8% had a pressure ulcer present on admission to an acute care environment. The study's aim was to investigate predictors of pressure ulcer presence and severity using the Braden scale for pressure ulcer risk assessment. Pressure ulcer risk was evaluated and skin inspection was performed. Demographic, physiological and laboratory data were obtained as well as medical history and patient acuity. Inter-rater reliability of data collection was reported as good. Statistical testing was performed using Statistical Package for Social Sciences (SPSS).

The study found that the mean Braden score for people without ulcers was 19.7 and 15.9 for those with ulcers ( $P < .05$ ), indicating that the Braden scale either failed to highlight patients with ulcers at high risk or detected recovery in those patients with recovering ulcers. It is not possible to deduce which from the study. The study did however have a cut-off point of 16 to indicate high risk – the lower the score, the higher the risk of pressure ulcer development. Analysis of variance showed that subjects with pressure ulcers had significantly lower albumin levels, total lymphocyte count, haematocrit levels and haemoglobin levels. The paper reports this as indicating poorer nutritional status.

Subjects with pressure ulcers were also significantly older and had longer length of stay (LOS). Regression showed that albumin level, oxygen saturation and length of stay were associated with pressure ulcer presence, and that albumin level and length of stay ( $P < .001$ ) accounted for 11.2% of the variance in pressure ulcer severity. Poorer nutritional status and decreased oxygen perfusion were found to be predictors of pressure ulcers on admission while nutritional status and length of stay were predictors of ulcer severity. In this study nutritional status was operationalised by using biochemical markers such as albumin and haematocrit levels as well as the subscale of the Braden scale and body mass index.

This study does not provide information on the role of co-morbidity and the presence of pressure ulcers nor on pressure ulcer severity. A high proportion of subjects ( $n = 141$ ) were on a surgical unit; the effect of this on the presence and severity of pressure ulcers, if any, is unclear. The study claims to have calculated odds ratios for significant factors but they are not reported in the paper.

## **Reviewer's conclusions**

The objective of this review was to determine the following:

- What are the characteristics of people *with* pressure ulcers?
- What are the risk factors for people *with* pressure ulcers?
- What are the priorities for assessment?
- What is the empirical evidence that this process is effective in the management of pressure ulcers?

It remains unclear what assessment process should be used to identify modifiable risk factors in people with *established* pressure ulcers. There is not one gold standard assessment available. There is not sufficient evidence to recommend one process or tool over another. What is clear is that the same risk assessment tools and processes are used in both populations: those people with established ulcers and those who are at risk of developing pressure ulcers. Some studies report that the predictive validity of assessment tools in those with existing ulcers is poor.

There is limited evidence reporting on the characteristics of those with *existing* ulcers on admission to a primary or secondary care environment.

What is clear from the available evidence is that the existence of a grade 1 pressure ulcer is a significant risk factor for the development of a more severe ulcer and therefore an open wound.

There is limited evidence reporting on other modifiable risk factors and complications for those with *established* pressure ulcers. Where characteristics are identified they are consequently identified as risk factors. Not all risk factors are modifiable and it is not clear whether it is the individual effects of each risk factor which is significant or the collective effect. The risk factors in individuals with ulcers are not only the risks of developing further pressure ulcers but the risks of delayed healing, and the risks of infection and complications. Further research is required to identify the risk factors of having a pressure ulcer. Rigorous intervention studies need to be carried out to determine the significance of risk factors.

The issue of effectiveness in the assessment process was not found to have been evaluated in the studies.

No economic evaluations assessing tools used to identify modifiable risk factors and/or complications for those with established pressure ulcers were found.

Level of evidence	Evidence statement
2+	The identification of a grade 1 pressure ulcer is a significant risk factor for the development of a more severe ulcer and therefore an open wound.

## Recommendations: holistic assessment

Patients with pressure ulcers should receive an initial and ongoing holistic assessment. Both intrinsic and extrinsic factors have been identified as important factors for assessment. This assessment should include: **[D]**

- health status
  - acute, chronic and terminal illness
  - co-morbidity – e.g. diabetes and malnutrition
- mobility status
- posture (pelvic obliquity and posterior pelvic tilt)
- sensory impairment
- level of consciousness
- systemic signs of infection
- nutritional status
- previous pressure damage
- pain status
- psychological factors
- social factors
- continence status
- medication
- cognitive status, and
- blood flow.

Assessment of mobility should include all aspects of independent movement including walking, ability to reposition – for example in bed or a chair – or transfer – for example from bed to chair. **[D]**

Presence of any sensory impairment in an individual with a pressure ulcer should be recorded. **D[GPP]**



Level and duration of impaired consciousness should be recorded. **D[GPP]**



Presence of acute, chronic or terminal illness and its potential impact on ulcer healing should be recorded. **D[GPP]**



Previous pressure damage (site/location, stage or grade of previous ulcer and previous interventions) should be recorded. **[D]**



Pain assessment should include: whether the individual is experiencing pain; the causes of pain; level of pain (using an appropriate tool); location and management interventions. **[D]**



In the presence of systemic and clinical signs of infection in the patient with a pressure ulcer, systemic anti-microbial therapy should be considered. **D[GPP]**



Psychological assessment should include concordance and abilities of the individual to self-care (mood, motivation and aptitude). **[D]**



Assessment of social factors should include the suitability of the home environment, level of supportive provision and the involvement of local support services. **[D]**



Continence assessment should include whether the individual is continent of urine, faeces and continence interventions, which may affect ulcer healing and impair the function of pressure-relieving support surfaces – for example pads or bedding. **D[GPP]**



Holistic assessment is the responsibility of the inter-disciplinary team and should be carried out by health care professionals. **[D]**

**Guideline Development Group commentary**

Intervention	Commentary
	<p>The EPUAP is the classification tool of choice as it identifies not only the skin colour change of grade 1 pressure ulcers but also other physiological signs resulting from tissue damage that many other tools ignore – namely the changes in skin temperature and skin texture due to the inflammation process.</p> <p>Many clinicians identify any redness as a grade 1 pressure ulcer. A level of redness is normal – for example following crossed legs where the lower leg has a red mark when the upper leg is removed. This is not the redness of a grade 1 pressure ulcer – and it is not hot to touch etc. The classification system is about what the skin/tissue looks like and is not related to patient group/environment/context – these items are part of pressure ulcer risk assessment tools.</p>
<b>Research recommendations</b>	
<p>Well-designed, large-scale, prospective cohort studies, including those with pressure ulcers and including relevant identified risk factors, to show how the identified risk factors lead to more severe ulcers or delayed healing or complications.</p>	

## 6.2 Ulcer assessment

### Background

The assessment of the pressure ulcer together with the holistic assessment is the basis for initiating, developing, maintaining and evaluating the plan of care for an individual with a pressure ulcer. The assessment of the pressure ulcer should provide information or data to facilitate the communication of information about the severity of the pressure ulcer and the change of the pressure ulcer over time.

The research identifies many subjective methods of assessing both wound characteristics and wound healing (Cutler et al., 1993; Griffin et al., 1993; Melhuish et al., 1994; Thomas and Humphreys, 1994 ; Plassmann, 1995 ; Shubert, 1997; Bates-Jensen, b, 1992, 1993 , 1995; and Houghton and Kincaid, 2000).

However it is a consistently accurate assessment of pressure ulcers which is key to monitoring changes in pressure ulcer characteristics that will determine treatment interventions. A number of characteristics are identified in the literature (Bohannon and Pfaller, 1983; Bulstode et al., 1987; Cooper, 1990; Ayello, 1992; Bates-Jensen, 1992; Emparanza et al., 2000; Gardner, 2001) as important indices to include in the pressure ulcer assessment. These include: location, size, depth, stage, condition of wound edges, tunnelling or undermining, signs of infection, necrotic tissue, exposed bone, granulation tissue presence, epithelialisation, exudates and odour. The importance and relevance of these indices to ensure the most effective outcomes is the focus of this review together with a clearer understanding of the consistency and accuracy of these measurements in pressure ulcer assessment.

To date there is not one method of assessing pressure ulcer status that is used universally. Yet the importance of a thorough, accurate, consistent and objective assessment of pressure ulcers is strongly advocated (Verhonick, 1961; Bohannon and Pfaller, 1983; Bulstode et al., 1987; Gosnell, 1977; Garrigues, 1987; Preston, 1987; Maklebust, 1987; Ayello, 1992; Emparanza et al., 2000; Gardner, 2001). A number of tools have been developed specifically to assess pressure ulcer status. However there remain contentious issues about their validity and reliability. It is now almost ten years since the publication of the Agency for Health Care Research and Quality (AHRQ, formerly AHCRQ) guidelines on pressure ulcer prevention and management, in which a classification system for pressure ulcers was recommended as well as indices to include in the assessment of a pressure ulcer ([www.ahcpr.gov/](http://www.ahcpr.gov/)).

Despite these national guidelines there remain problems among health care professionals in the communication of pressure ulcer status (Garrigues, 1987; Preston, 1987; Maklebust, 1987; Ayello, 1992; Emparanza et al., 2000; Gardner,

2001). Assessment of the ulcer together with the holistic assessment is viewed as fundamental in ensuring the right interventions or treatment modalities are applied (Bates-Jensen et al., 1992). A number of evidence-based tools have been developed and are widely used to assess the status of pressure ulcers. They include the Pressure Sore Status Tool (Bates-Jensen et al., 1992, 1995a, 1995b and 1997), the Pressure Ulcer Scale for Healing (Thomas et al., 1997), the Sussman Wound Healing Tool (Sussman and Swanson, 1997), the Sessing Scale (Ferrell et al., 1995) and the Wound Healing Scale (Krasner, 1997).

To what extent these tools are valid and reliable for implementation and use in general UK populations is not clear. A recent review (Woodbury et al., 1999) suggests that generally the validity and reliability of such tools are variable. However Woodbury et al. (1999) suggest that there is sufficient published evidence for the Pressure Sore Status Tool and the Sessing Scale to be considered as valid and reliable.

Many of the techniques advocated in the literature are reported to be inappropriate for routine use in a clinical environment. There are many high and low-tech methods of assessing pressure ulcers status – e.g. size, depth and volume of pressure ulcers using scaling gauges, dental impression material, sodium chloride, ultrasound, tracings, photographs, planimeter and video image analysis among others. The effectiveness of these is not clear from the small studies evaluated. It is also not clear what benefit they have to patients or how they link to wound healing, ensuring that pressure ulcers are assessed accurately to inform the clinical decision-making process.

### **Clinical question**

What assessment process should be used to most accurately assess a pressure ulcer?

### **Objectives**

The objective was to undertake a systematic review of the evidence of pressure ulcer assessment to determine:

- What are the wound characteristics of pressure ulcers?
- What is the significance of these in pressure ulcer assessment?
- What are the priorities for pressure ulcer assessment?
- What are the existing evidence-based tools/instruments for assessment/evaluation of pressure ulcers?

- What is the empirical evidence that these processes are effective in the management of pressure ulcers?

## **Selection criteria**

### **Types of studies**

Diagnostic studies reporting the reliability, accuracy and impact of pressure ulcer diagnostic tools/processes; studies comparing methods of pressure ulcer assessment, and evaluating their effectiveness in individuals with pressure ulcers in the treatment of pressure ulcers. Studies comparing methods of measurement.

### **Types of participants**

All: adults and children, including those in primary and secondary care, residential homes, nursing homes, secure settings and the home.

### **Types of outcome**

Staging performance, sensitivity, specificity, reliability, accuracy and impact linked to healing/delayed healing, healing, complications and pressure ulcers, and severity.

## **Search strategy**

The databases searched are found in the methods section 5) . The full search strategies are listed in Appendix B. Databases were searched in July 2003 and update searches performed in August 2004.

### **Appraisal of methodological quality**

Criteria for inclusion (methodological quality is reported in the evidence tables) and pre-defined principles as outlined in Appendix E.

### **Selection**

Eligible participant population with well-defined demographic information.

High percentage of participants equal to or greater than 80% of those approached.

### **Identification of effectiveness of assessment process**

Clear description of assessment process and measurements with comparison clearly defined.

### **Confounding**

Statistical adjustment carried out; evidence of sensitivity analysis with method described.

### **Outcomes**

Clear outcome measurements used.

### **Search results**

<b>Results of search strategy</b>	
Initial search results	1,759
N screened for relevance following sift	165
N included	5
N excluded	2

### **Research evidence**

A total of 165 studies were identified from the sifting process as potentially relevant to the topic and subsequently full papers ordered. This number also included those studies referenced with relevant titles but where the abstract was absent in the citation. After sifting full papers for relevance and duplicates at this stage, 153 papers were opinion pieces, editorials, anecdotal reports or fell outside the inclusion criterion for this review. Out of the seven selected studies, two were excluded and five included.

### **Included studies**

- The gold standard systematic review for this type of clinical question is a systematic review of diagnostic and screening tests. While it was intended to conduct this type of review, it must be acknowledged that diagnostic reviews are a newly developing methodology.
- The research evidence on this topic area (assessing the diagnostics of pressure ulcer assessment) is limited.

- Where studies have addressed and assessed issues such as accuracy, sensitivity and specificity, these tend to be small studies and heterogenic; they use varied ulcer measurement parameters and it is not clear how representative these data are. Also raw data are too limited in the appraised papers to allow any further analysis.
- Where a tool or instrument has been evaluated in terms of reliability these have been included in the evidence tables.

*Cutler et al. (1993)*

This was a cross-sectional study to evaluate and compare the various methods of measuring the characteristics of pressure ulcers, namely area. The study included a population of initially 20 patients with 17 remaining on completion. There was a mix of male and female patients; few other demographic details are explicit in the study. Ulcers were judged as at stage 3 or 4 with a size range between 2 and 150cm<sup>2</sup>. Patients with signs of infection, exposed bone or cellulitis were excluded from the study. Numbers excluded were not included in the reporting.

All ulcer assessments were performed by the same research nurse. Initial baseline assessment was taken with weekly assessments thereafter. Compared measurements included direct measurement at the bedside of longest length, longest width and depth at the deepest point of the ulcers. Tracings and photographs were calibrated with a ruler. All measurements detected a statistically significant change in wound size and volume at week four assessment. Sub-group analysis showed that in the <10cm<sup>2</sup> group a statistically significant change in wound size was detected earlier than in the >10cm<sup>2</sup> group.

*Griffin et al. (1993)*

This study aimed to compare test-retest reliability of measurements obtained by the use of photographic methodology and those obtained by transparency method, and to compare wound surface area measurements obtained. Twenty patients were included in the study, 18 male and two female, from a rehabilitation centre in Memphis. Measurements were made of 22 ulcers identified, all in the pelvic region. The range of wound size was 688mm +/- 228mm.

Three photographs were taken at each wound assessment and three tracings were taken of each wound at each assessment. Both sets of tracing were digitalised. Test-retest reliability was obtained measuring five ulcers using both methodologies and repeating assessments after one hour. To compare the two methodologies all 22 ulcers were measured on a single occasion. To compare the two methodologies over time, 16 ulcers were measured at five-day intervals for 20 days (four occasions).

Test-retest reliability ICC = .99, comparison on a single occasion PCC = .99 and comparison over time  $r = .996 - .999$   $p = .001$ . No evidence of superiority was found with the two methodologies.

*Houghton (2000)*

This study examined the validity and reliability of using photographs of wounds to accurately assess wound status. Thirteen patients with pressure ulcers and 46 with leg ulcers were included in the study. Ulcers that had extensive tunnelling or undermining were too deep and could not be visualised, so were excluded from the study. Measurements were performed by a trained health care professional. It was a blinded assessment but details are not explicit.

Six measurement parameters were assessed using the photographic method: wound edges, necrotic tissue/type and amount, skin colour, granulation tissue type and epithelialisation. Total scores were assigned by one trained rater viewing 56 photographs of 13 pressure ulcers on two separate occasions ICC +0.96. Intrarater reliability for scores were assigned on two occasions for 81 photographs of 34 leg ulcers ICC = 0.86. Wound size estimates from photographs ICC = 0.96. Interrater reliability for pressure ulcers ICC = 0.75. Correlation for the same observer for individual domain  $r = 0.75$  and with the exception of skin colour  $r = 0.56$ . The between raters correlation for six domains  $r = 0.75$  with the exception of wound edges  $r = 0.68$ . The concurrent validity was assessed for the Pressure Sore Status Tool and PWAT  $r = 0.70$  for PSST and  $r = 0.66$  for six domain PWAT. PSST was used as a reference standard in this research, and the photographic method had good interrater and intrarater reliability with scores ICC = 0.75. Reliability was found to be higher for pressure ulcers than leg ulcers in this study. This could be explained by the fact that the PSST is a pressure ulcer specific assessment tool.

*Shubert (1997)*

This study evaluated pressure ulcer surface area measurement using four different methods. The number of patients was not clear. It was set in the Division of Geriatric Medicine, University Hospital Huddinge, Sweden. Demographic details were limited. Four measurements were used and included: direct measurement with digital planimeter, length and width measurement, number of whole squares, and number of whole and partial squares. Planimeter was used as the reference standard. A total of 373 different pressure ulcers were measured in the study.

Measurement of length and width gave values significantly higher than the reference value 31%,  $p = 0.001$ . Counting the number of whole squares gave a significantly lower value than the reference standard -13%,  $p = 0.001$ . Counting the number of

whole and partial squares inside the boundary line gave values that were much closer to the reference value +1%. Counting the number of whole and partial squares within the tracing area gave the best estimate of wound size.

*Plassmann and Jones (1998)*

This was a controlled trial comparing the performance of the MAVIS instrument against three traditional methods of wound measurement for area and volume. The three traditional techniques included: use of ruler, transparency tracing and alginate for volume measurement. Precision was established on mock wounds made using plaster cast and each was measured 20 times for each technique. There were fifty patients, although demographic detail was limited. Among excluded patients were those with painful ulcers, undermining, and extremely flexible, small and large ulcers. Measurements were taken by structured light. Area and volume measurements were taken simultaneously. Results were reported in graphical form without clear axis. It was reported that MAVIS gave overall more precise results for area and volume than the other three methods.

### **Quality of the studies**

The quality assessment for each study is reported in the evidence table for each study. There are not well-established quality criteria for assessing some of the designs included in this narrative review. Generic assessment tools (Appendix E) were used to assess each study according to study design. Generally the studies' aims were clear and although the sample sizes were small, with the exception of Shubert (1997), they were justified. Statistical methods were well described in all the studies with clear rationale for their use. There was limited reporting in the studies on excluded patients and those that did not finish the study.

### **Reviewer's conclusion**

The original objective was to undertake a diagnostic review of the evidence of pressure ulcer assessment to determine:

- What are the wound characteristics of pressure ulcers?
- What are the significance of these in pressure ulcer assessment?
- What are the priorities for pressure ulcer assessment?
- What are the existing evidence-based tools/instruments for assessment/evaluation of pressure ulcers?
- What is the empirical evidence that these processes are effective in the management of pressure ulcers?

The research evidence in this area is limited and it has not been possible to conduct a diagnostic review for several reasons: 1. The research evidence in this area is limited. 2. There is a lack of a generally accepted reference standard both for the assessment of individual parameters for ulcer assessment or a pressure ulcer assessment tool. 3. The reporting of the research evidence lacks raw data for any further analysis to be performed.

While a number of tools have been developed, they have not been evaluated fully. A number of research-based pressure ulcer assessment tools, such as the PSST, have undergone a systematic process of development and their reliability has been assessed. However this review did not find evidence for the use of such tools widely in the UK, nor did it find evidence that these have been tested against an agreed gold standard. It remains unclear how these tools are linked to outcomes – i.e. the healing of pressure ulcers – as this is not reported in the literature.

Wound size, that is surface area and volume, appears to be the specific parameter that has been assessed in the literature most frequently, and is reported as being a useful marker of wound change over time. Various methods of determining this parameter are advocated in the literature; however caution should be taken when interpreting the authors' findings as they are generally from small studies. There is also considerable heterogeneity both within and between the studies to be able to combine any of these data.

The inclusion of location, stage, condition of wound edges, tunnelling or undermining, signs of infection, necrotic tissue, exposed bone, granulation tissue presence, epithelialisation, exudates and odour in the ulcer assessment is advocated in the research. However the evidence base in support of their inclusion is limited. It is also not clear from this evidence whether these parameters are, firstly, suitable to include in assessment on the basis of their being consistently identifiable by the same assessor or, secondly, identifiable at a repeated assessment by the same or different assessor either within the same patient or between patients.

It is also not clear what effect the context has on the wound assessment. Reporting of this information was limited in the research evidence. In terms of who should carry out assessments, one study found significantly better assessments carried out by trained health care professionals compared with students with limited training and experience. How often an assessment should take place is also not clear from the evidence.

No economic evaluations assessing tools used to assess a pressure ulcer were found.

Recommendations for this area of the Guideline were sought via formal consensus as outlined in the methods section.

## **Recommendations: ulcer assessment**

The aim of the ulcer assessment is to:

- establish the severity of the pressure ulcers
- to generate a personal ulcer profile to develop a plan of care from which treatment interventions will be initiated
- to evaluate treatment interventions
- to assess for complications, and
- to communicate information about the pressure ulcer to those involved in pressure ulcer management.

Patients with pressure ulcers should receive an initial and ongoing pressure ulcer assessment. Ulcer assessment should include: **[D]**

- cause of ulcer
- site/location
- dimensions of ulcer
- stage or grade
- exudate amount and type
- local signs of infection
- pain
- wound appearance
- surrounding skin
- undermining/tracking (sinus or fistula), and
- odour.

This should be supported by photography and or tracings (calibrated with a ruler).

The pressure ulcer grade should be recorded using the European Pressure Ulcer Advisory Panel Classification System.

Pressure ulcers should not be reverse graded (retrograding). A grade 4 pressure ulcer does not become a grade 3 as it heals. As the ulcer heals it should be described as a healing grade 4 pressure ulcer. **D[GPP]**

Those carrying out ulcer assessments should consider the aims and objectives of the assessment to ensure that maximum benefit to the individual is gained. **D[GPP]**

The dimensions of the pressure ulcer should be measured recording the longest length/longest width as an estimate of surface area (use of tracings); the deepest part of the wound should also be measured using a sterile probe. **[D]**

Initial and ongoing ulcer assessment is the responsibility of the inter-disciplinary team and should be carried out by health care professionals. **[D]**

Reassessment of the ulcer should be performed at least weekly but may be required more frequently, depending on the condition of the wound and the result of holistic assessment of the patient. **[D]**

All pressure ulcers graded 2 and above should be documented as a local clinical incident. **D[GPP]**

	<b>Guideline Development Group commentary</b>
	<p>Despite the lack of research evidence from which to generate recommendations the GDG felt that it was important to guide clinicians as to the most important parameters to include in an ulcer assessment. Many different variations of tools are used to gather information about pressure ulcers in a variety of NHS settings. A comprehensive and accurate assessment of the pressure ulcer was considered to be paramount to ensuring that the plan of ulcer care reflected ulcer severity.</p>

	<b>Research recommendations</b>
	<p>Research needs to focus on what methods of measurement, and which parameters, are of use to clinicians to allow accurate wound evaluation.</p>

### **6.3 Support surfaces for pressure ulcer treatment**

The methods described in this review were those used to update the following systematic review:

Cullum N, Deeks J, Sheldon TA, Song F and Fletcher AW (2004) Beds, mattresses and cushions for pressure sore prevention and treatment (Cochrane Review) in: *The Cochrane Library*, Issue 1, Chichester, UK: John Wiley & Sons, Ltd.

This review was used as the main source to develop recommendations for this area of the Guideline.

There is much debate in the literature and among experts about the appropriateness of the term pressure-relieving. The use in this Guideline is consistent with that of previously published NICE guidance on pressure ulcer prevention. Pressure-relieving is used as an umbrella term for all pressure-reducing and pressure-redistributing devices.

#### **Background**

A range of interventions are currently used in pressure ulcer management. Pressure-relieving support surfaces aim to reduce the magnitude and/or duration of pressure between an individual and the support surface, which is referred to as the "interface pressure". Some support surfaces may also minimise friction and shear, and may also address micro-climate needs such as temperature and moisture. Such support surfaces include cushions, mattress overlays, replacement mattresses or whole bed replacements. The cost of these interventions varies widely; from over £30,000 for some bed replacement systems to less than £100 for some foam overlays. Information on the relative clinical and cost-effectiveness of this equipment is clearly needed to enable clinicians to make evidence-based decisions for their use.

Pressure-relieving surfaces can be divided into two main categories: continuous low pressure (CLP) and alternating pressure (AP).

Continuous low pressure surfaces aim to mould around the shape of the individual to redistribute pressure over a greater surface area. Alternating pressure surfaces mechanically vary the pressure beneath the individual, so reducing the duration of the applied pressure.

CLP support surfaces can be grouped according to their construction:

- Standard foam

The conformability and resilience of foam products may vary considerably between manufacturers. Foam may be shaped, convoluted (“egg crate foam”), of various densities or of a combination of densities.

- Visco-elastic foam

This is specialised foam, available in varying densities, that moulds to body shape in response to body temperature.

- Air flotation

This is an inflated mattress replacement/overlay that manually or automatically adjusts airflow allowing immersion and redistribution of pressure. It is adjustable to individual reposition to maintain immersion and redistribution of pressures.

- Air fluidised

A constant flow of air is passed into a deep tank containing minute silicone beads retained by a permeable membrane. The agitated beads take on the properties of a fluid. Lying on the surface allows significant immersion and therefore redistribution of pressure.

- Low air loss

A constant flow of air inflates a row of permeable fabric cells. Manual or automatic adjustment of airflow allows significant immersion and therefore redistribution of pressure.

- Gel/fluid

Fluid surfaces – e.g. water-filled mattresses – which allow significant immersion and therefore redistribution of pressure. The density/viscosity of the gel/fluid will govern the degree of immersion and how stable the support surface is in terms of posture.

- Combination products

Many CLP surfaces, particularly cushions, use a variety of materials to provide optimum pressure relief and postural stability.

N.B. The type and construction of cover material may have a significant impact on the conformability of the surface.

Alternating pressure support surfaces provide pressure relief by inflating and deflating alternate air-filled cells. The inflated cells support the body while the deflated cells provide pressure relief. The duration and sequence of alternation varies between manufacturers. Such support surfaces are available as cushions, mattress overlays, and single- or multi-layer mattress replacements.

Pressure ulcer treatment strategies usually comprise a combination of pressure relief (in the form of support surfaces), positioning and repositioning, and wound management strategies including wound dressings, debridement techniques, physical

therapies, antibiotics and antiseptics. Pressure ulcer management is therefore considered to be multi-faceted and this approach to care is strongly advocated in the research literature.

## **Objectives**

To undertake a systematic review of pressure-relieving beds, mattresses and cushions in pressure ulcer treatment.

Questions to be answered were:

- Do pressure-relieving beds, mattresses and cushions increase the healing rate of existing pressure ulcers compared to standard support surfaces?
- Which types of pressure-relieving surface are most effective in the treatment of pressure ulcers: a) in different patient groups, and b) settings?

## **Selection criteria**

### **Types of studies**

Randomised controlled trials (RCTs) comparing beds, mattresses and cushions which measured pressure ulcer healing as an objective measure of outcome.

### **Types of participants**

Patients with existing pressure ulcers (of any grade) in any setting.

### **Types of interventions**

Studies which evaluated the following interventions for pressure ulcer treatment were included:

- alternating pressure mattresses/overlays
- standard foam mattresses
- specialised foam mattresses/overlays – e.g. convoluted foam, cubed foam
- gel-filled mattresses/overlays
- fibre-filled mattresses/overlays
- water-filled mattresses/overlays
- air flotation beds
- low air loss beds
- sheepskins
- turning beds/frames
- bead beds, and

- wheelchair support surfaces.

#### **Types of outcome measures**

- Healing rates of existing ulcers: trials were included if they measured healing by some objective method – such as time to complete healing, or rate of change in the area/volume of the ulcer.
- Costs of the support surfaces.
- Patient comfort.
- Durability of the support surfaces.
- Reliability of the support surfaces.
- Acceptability of the support surfaces.

Trials which only measured surrogate outcome measures, such as interface pressure, were excluded on the basis that interface pressure measurements have not been demonstrated to reliably predict the clinical performance of support surfaces.

### **Search strategy**

The search strategy included all trials identified up to August 2004. Databases were searched initially in November 2003 and then updated on 24 June 2004.

#### **Main literature search**

Searches were not limited by study design but were limited to retrieve literature published in English, and to omit animal studies and letters, comments and editorial publication types.

#### **Methods of the review**

Full details can be found in the methods section.

References identified from searches were reviewed by two reviewers who jointly made a decision to include or exclude a study against the eligibility criteria.

References were entered into a bibliographic software package. Details of eligible studies were extracted by the primary reviewer and summarised using a data extraction sheet. Data extraction was checked by a second reviewer.

#### **Description of studies**

Fifteen eligible randomised trials were identified. Fourteen trials involved patients with pressure ulcers and assessed the treatment efficacy of pressure-relieving supports

(Allman, 1987; Caley, 1994; Clark, 1999; Day, 1993; Devine, 1995; Evans, 2000; Ferrell, 1993; Groen, 1999; Keogh, 2001; Mulder, 1994; Munro, 1989; Russell, 2000; Russell, 2003; Strauss, 1991). One further trial evaluated surface effects for both prevention and treatment of pressure ulcers in the same trial (Ewing, 1964).

Two additional trials were identified that also evaluated pressure-relieving support surfaces for both the prevention and treatment of pressure ulcers (Bennett, 1998; Lazzara, 1991). However, neither of these trials reported pressure ulcer healing data so were excluded from the review. One further eligible ongoing trial (Nelson, 2003) was also identified and these results will be incorporated in future updates of the review.

The studies included a variety of patients and settings – for example those in nursing homes, care of the elderly, medical and surgical wards.

Only one trial evaluated the use of a cushion as a pressure-relieving support surface. One trial assessed the use of sheepskins, and the remaining studies evaluated different mattresses, mattress overlays and beds.

### **Methodological quality of included studies**

The methodological quality of the trials was generally poor. Details on the quality of each individual study are included in the Table of Included Studies (Appendix A). Adequate allocation concealment was evident in nine (60%) of the fifteen trials (Allman, 1987; Clark, 1999; Day, 1995; Devine, 1995; Evans, 2000; Ferrell, 1993; Keogh, 2001; Groen, 1999; Russell, 2003). In eight of the fifteen included trials the method of randomisation was unclear.

Blinded outcome assessment is rarely used in wound care studies and this was certainly the case in these evaluations of pressure-relieving support surfaces. It can be difficult or impossible to disguise the surface, on which a patient is, for assessment of outcome. Patients are often too ill to be removed from their bed for assessment of their pressure areas. Nevertheless, some studies minimise bias in outcome assessment by having a second assessor and presenting interrater reliability data, or by presenting photographic evidence of pressure area status, which can then be assessed by an assessor blinded to treatment. Of the 15 randomised trials in this review, we could be confident that some form of blinded outcome assessment had been used in only four trials (Allman, 1987; Evans, 2000; Strauss, 1991; Russell, 2003).

Importantly in pressure ulcer treatment trials it is essential to ensure baseline comparability for initial area of ulcers. A change in wound area is often expressed as the percentage change, which unlike the absolute change in area, takes into account the initial size of the wound. For two wounds healing at the same linear rate (as measured by diameter reduction) percentage area calculations will show a larger change for a small wound than a big wound. The converse is true when the absolute change in area is measured, since for any unit reduction in wound radius a bigger area reduction will occur for a large wound.

This has important consequences for the validity of trial results where there is poor comparability in initial wound size at baseline between the treatment groups. In large trials, randomised allocation should ensure that the mean wound size and variance in each group is similar. In a small trial random allocation is unlikely to result in an even distribution of wound sizes. In a trial where there is poor comparability between groups for wound size at baseline, and the outcome is based on the change in area, the result can only be considered valid if it is obtained either: against the anticipated direction of the bias for wound size; or where percentage area change and absolute area change are in the same direction. If baseline data are not given then it is not possible to determine the direction of bias and the validity of the result cannot be determined.

There were 15 trials of beds, mattresses and cushions for treating pressure ulcers included in this review and of these:

- eight presented data for baseline ulcer area (Allman, 1987; Clark, 1999; Day, 1993; Devine, 1995; Evans, 2000; Ferrell, 1993; Groen, 1999; Munro 1989)
- six further treatment trial reports did not present baseline ulcer areas (Caley, 1994; Keogh, 2001; Mulder, 1994; Russell, 2000; Russell, 2003; Strauss, 1991).
- one trial by Ewing (Ewing, 1964) focused on the effect of sheepskin on resolving red skin and therefore the area of the damaged skin is less important.

The other major deficiency in most of the included trials was the small sample sizes used. Although seven reports described an *a priori* sample size calculation, 12 of the 15 trials involved a total of 100 patients or fewer. The larger trials, involving over 100 patients, were Groen (1999) (120 patients), Russell (2000) (141 patients) and Russell (2003) (158 patients).

Quality was not used to weight the studies in the analysis using any statistical technique. However methodological quality was drawn upon in the narrative interpretation of the results. Methodological flaws are discussed for each study in the Table of Included Studies (Appendix A).

## **Results**

Results of dichotomous variables are presented as relative risk (RR) with 95% confidence intervals (CI). Relative risk has been used rather than odds ratios as event rates are high in these trials and odds ratios would give an inflated impression of the magnitude of effect (Deeks, 1998). Relative risk is the rate of the event of interest – for example pressure ulcers healed – in the experimental group divided by the rate of this event in the control group, and indicates the chance of pressure ulcers healing on the experimental treatment compared with the control treatment.

As, by definition, the risk of an event occurring in the control group is 1, then the relative risk reduction associated with using an experimental treatment is  $1-RR$ . The relative risk indicates the relative benefit of a therapy but not the actual benefit, that is it does not take into account the number of people whose pressure ulcer would have healed anyway without treatment.

The absolute risk reduction (ARR) can be calculated by subtracting the event rate in the experimental group from the event rate in the control group. The ARR tells us how much the reduction is due to the experimental treatment itself, and its inverse is the number needed to treat, or NNT. Thus a healing rate, for example, of 30% on a control treatment that was reduced to 15% with an experimental treatment, translates into an ARR of  $30-15=15\%$  or 0.15, and an NNT of 7. In other words seven patients would need to receive the experimental treatment to cure one additional pressure ulcer.

Secondary outcomes such as comfort, durability, reliability and acceptability were not well reported, and valid and reliable measures for these concepts are under-developed. Where data were presented, they appear in the Table of Included Studies (see Appendix A). However they are not incorporated in the meta-analysis.

### **Air-fluidised therapy (AFT)**

Three trials compared AFT with a range of conventional therapies for the treatment of pressure ulcers (Allman, 1987; Munro, 1989; Strauss, 1991). These studies measured outcomes in slightly different ways and none reported the variability around the mean healing rate data. A meta-analysis of two of these studies showed significantly enhanced pressure ulcer healing associated with air-fluidised beds when used in hospital (Allman, 1987; Munro, 1989) (see Figure 3). A home-based study (Strauss, 1991) also showed a benefit from air-fluidised therapy on re-hospitalisation outcomes (see Figures 4 and 5). Munro (1989) showed no significant impact on

nursing time associated with the use of air-fluidised beds compared with standard care (see Figure 6).

Figure 3:

Review: Beds, mattresses and cushions for pressure sore treatment  
 Comparison: 04 Air-fluidised bed vs standard care  
 Outcome: 04 Proportion of patients improved

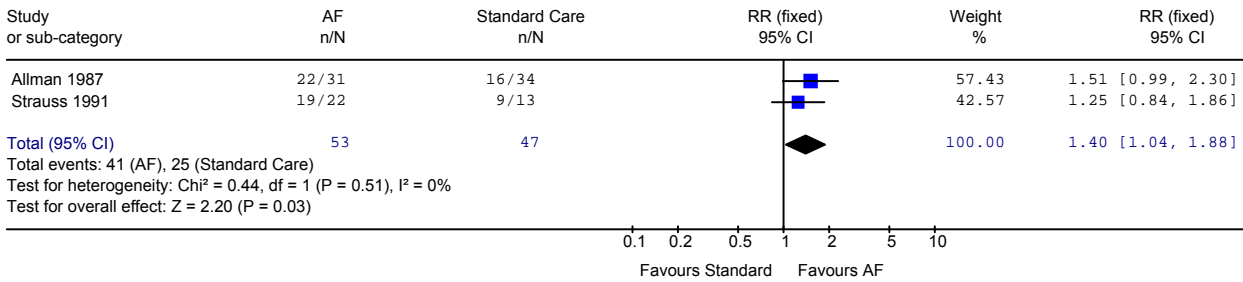


Figure 4:

Review: Beds, mattresses and cushions for pressure sore treatment  
 Comparison: 04 Air-fluidised bed vs standard care  
 Outcome: 02 Pressure sore related hospital days per patient

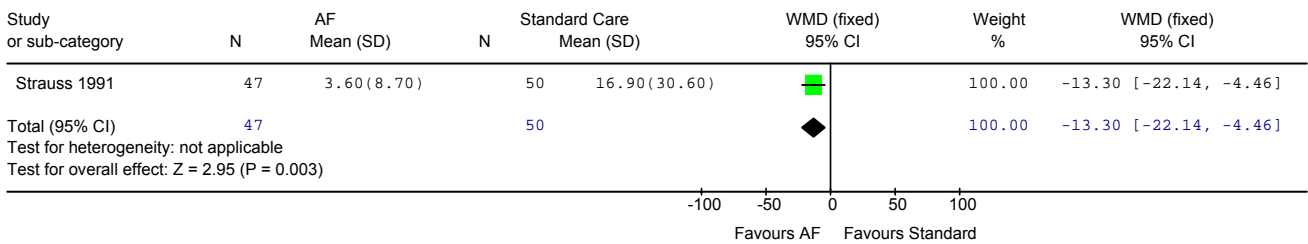


Figure 5:

Review: Beds, mattresses and cushions for pressure sore treatment  
 Comparison: 04 Air-fluidised bed vs standard care  
 Outcome: 03 Pressure sore related hospitalisations

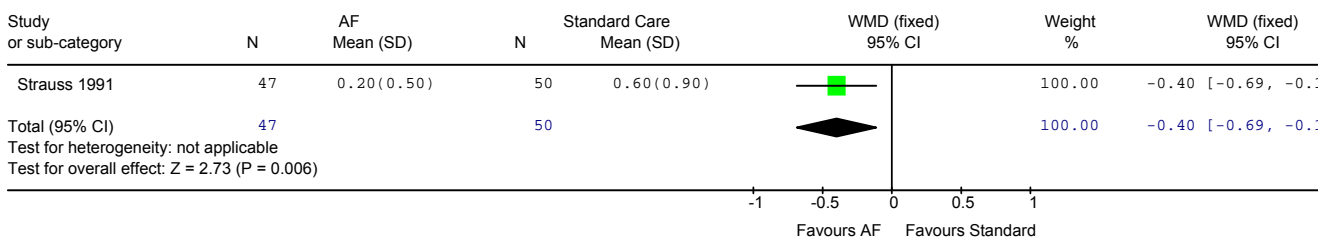
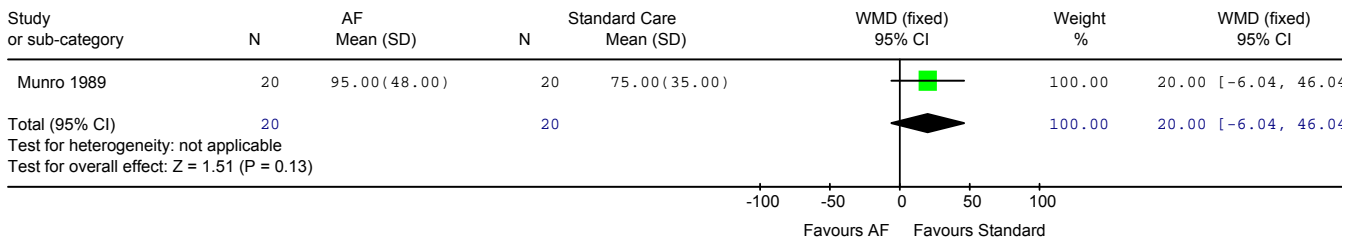


Figure 6:

Review: Beds, mattresses and cushions for pressure sore treatment  
 Comparison: 04 Air-fluidised bed vs standard care  
 Outcome: 06 Nursing Time (mins per 8 hour shift)

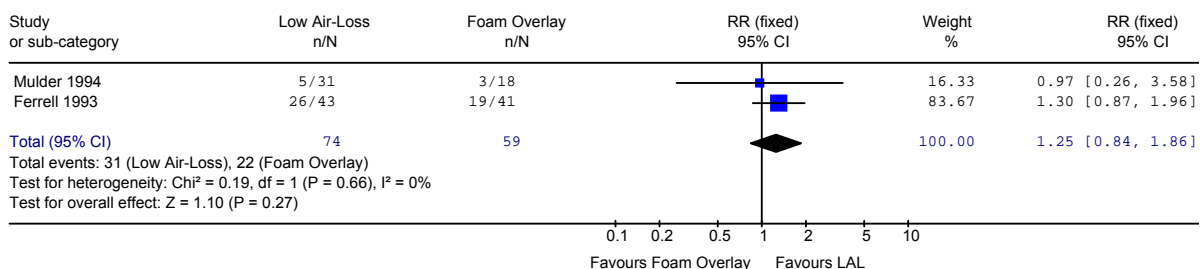


### Low air loss therapy (LAL)

Three trials were identified which compared LAL with a foam mattress overlay (Day, 1993; Ferrell, 1993; Mulder, 1994). The combined analysis from two trials (Ferrell, 1993; Mulder, 1994) showed pressure ulcer healing rates on the LAL bed were not significantly different to healing rates when using a corrugated foam overlay (see Figure 7). Only one trial has compared different types of low air loss support surfaces (Caley, 1994). This trial showed no significant differences in healing rates between the two interventions but was small and of questionable quality.

Figure 7:

Review: Beds, mattresses and cushions for pressure sore treatment  
 Comparison: 05 Low air-loss vs foam mattress overlay  
 Outcome: 01 Sores Completely Healed



### Alternating pressure (AP)

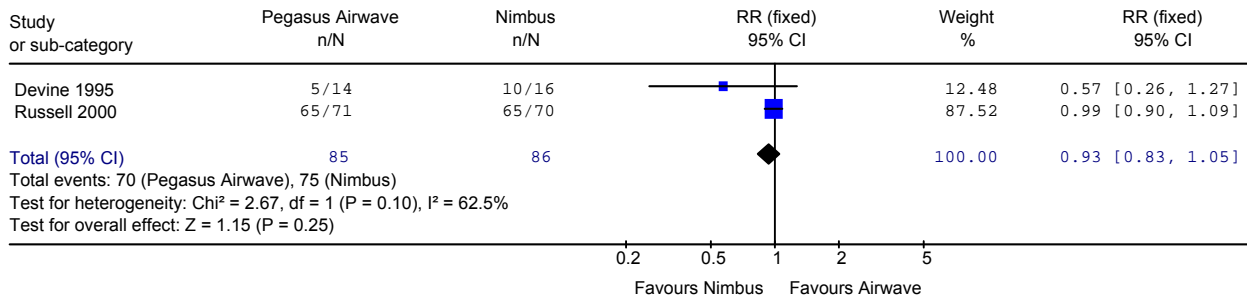
A variety of alternating pressure (AP) supports are used in hospital and in the community. The depth of the air cells and mechanical robustness can vary between support surfaces, and these factors may be important in determining effectiveness. It is worth emphasising that most of the trials of AP supports did not adequately describe the equipment being evaluated, including the size of the air cells, which may limit the utility of the evidence to clinical practice.

One small trial of 41 patients (Devine, 1995) compared the effectiveness of the Nimbus I DFS (composed of rows of figure-of-8-shaped cells) and the Pegasus Airwave for the treatment of existing pressure ulcers but found no significant difference. A more recent, larger trial (Russell, 2000) also failed to demonstrate any

significant difference in pressure ulcer healing between two newer AP support surfaces, the Nimbus 3 and the Pegasus Cairwave therapy system (see Figure 8).

Figure 8

Review: Beds, mattresses and cushions for pressure sore treatment  
 Comparison: 07 Comparison between two alternative alternating pressure mattresses  
 Outcome: 01 Ulcers completely healed

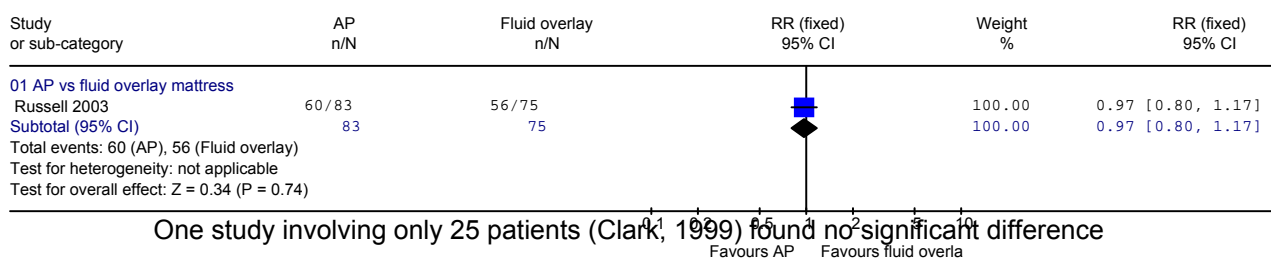


In a study by Evans et al. (2000), which was conducted in both hospital and nursing home patients, an alternating pressure mattress replacement system (Huntleigh Nimbus 3) resulted in no significant improvement in any measure of wound surface area when compared with either another alternating pressure mattress replacement system for hospital patients (Pegasus Biwave, Pegasus Airwave, or AlphaXcell) or an alternating mattress overlay for nursing home patients (AlphaXcell or Quattro).

A large trial of 158 patients (Russell, 2003) also compared the Nimbus 3 alternating pressure mattress with a static fluid overlay mattress, RIK static, and again found no significant difference in rates of pressure ulcer healing (see Figure 9). However, in this trial the co-intervention of re-positioning frequency was not standardised, and patients could request additional turning. As this variable appears to be disproportionate between the groups, the lack of treatment effect may be due to either the non-effect of the experimental support surface and/or the effect of the differential co-intervention distribution.

Figure 9:

Review: Beds, mattresses and cushions for pressure sore treatment  
 Comparison: 03 Alternating pressure vs constant low pressure mattress  
 Outcome: 01 Pressure sore healing



One study involving only 25 patients (Clark, 1999) found no significant difference between a dry flotation and an alternating pressure cushion in the number of ulcers completely healed, as measured by either the proportion of ulcers healed (see Figure

10) or the rate of change in pressure ulcer surface area for either superficial (see Figure 11) or deep (see Figure 12) ulcers.

Figure 10:

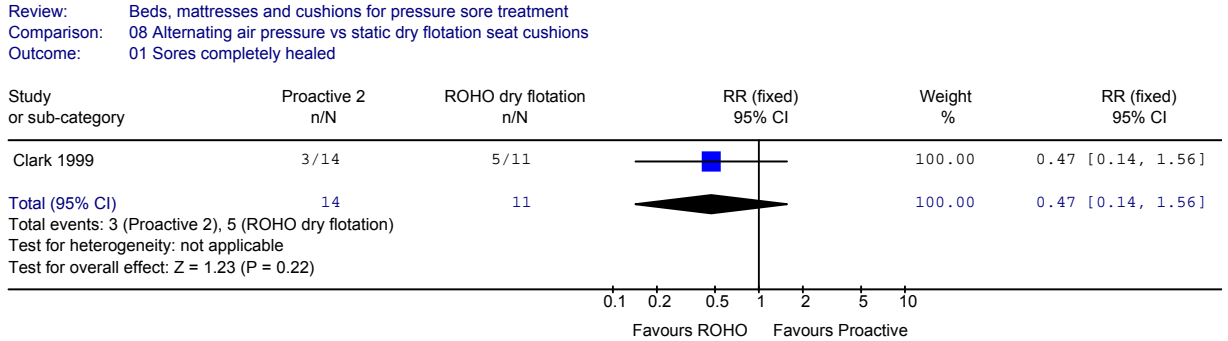


Figure 11:

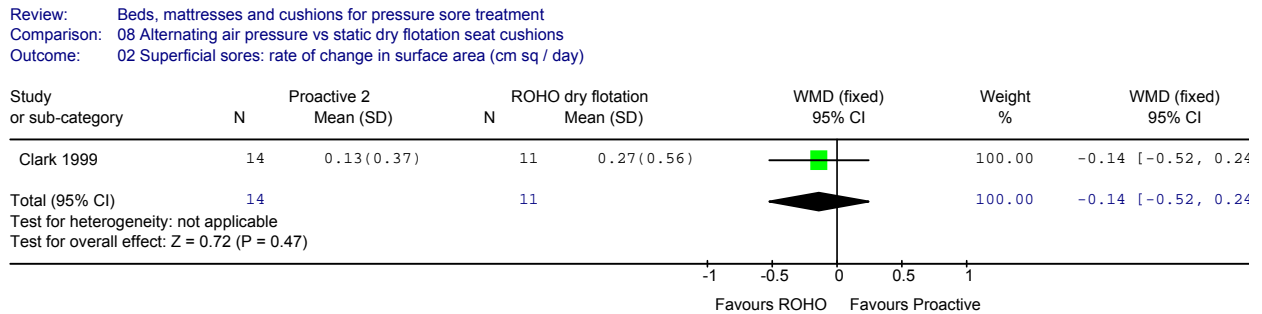
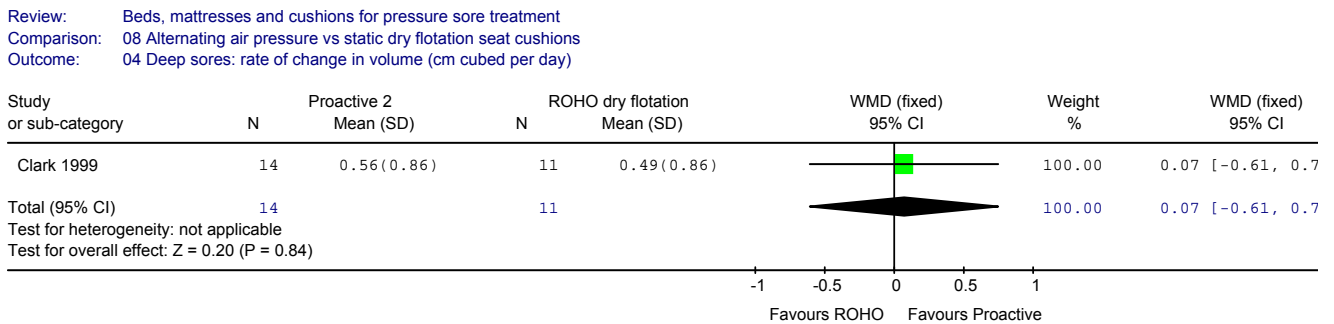


Figure 12:



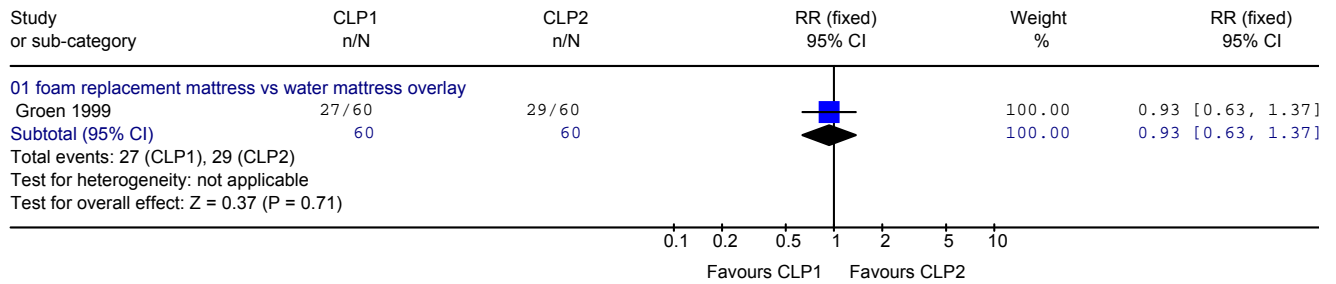
**Continuous low pressure supports (CLP)**

One small trial which used standard hospital mattresses with and without sheepskin overlays was inconclusive and of poor quality (Ewing, 1964).

A trial of 120 nursing home patients with grade 3–4 ulcers (Groen, 1999) found no difference in ulcer healing rates between foam replacement mattresses and the Secutex water mattress overlay (see Figure 13).

Figure 13:

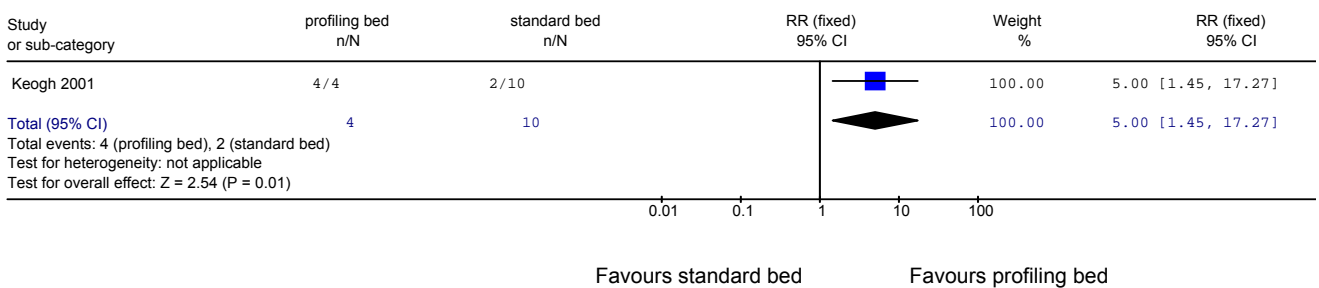
Review: Beds, mattresses and cushions for pressure sore treatment  
Comparison: 02 Comparisons between continuous low pressure supports  
Outcome: 01 Pressure sore healing



In the Keogh (2001) trial a bed that enabled individual profiling was compared with a standard hospital bed, both also with a pressure-reducing foam mattress or cushion. In this small trial (14 patients) the proportion of those with existing grade 1 ulcers was significantly improved using the profiling bed (see Figure 14). However these results should be interpreted with caution as they are only a small subgroup of the 100 patients randomised in the trial for which further data are unavailable.

Figure 14:

Review: Beds, mattresses and cushions for pressure sore treatment  
Comparison: 09 Profiling vs standard beds  
Outcome: 01 Healing of existing grade 1 sores



## Discussion

Despite the frequency of pressure ulcer incidence and the myriad of treatment modalities, this review demonstrates the paucity of good-quality evidence that guides current clinical practice for the selection of pressure-relieving support surfaces.

The confidence with which we can draw firm conclusions from the studies detailed in this review is greatly tempered by (a) the poor quality of many of the trials and (b) the lack of replication of most comparisons.

There is some evidence to show that air flotation supports reduce the size of more established pressure ulcers compared to a modified alternating pressure support, or standard care (standard bed with CLP supports, sheepskin, gel pads, air-filled supports, water-filled mattresses and high-density foam pads).

There is no conclusive evidence to support the superiority of either alternating pressure support surfaces or continuous low pressure supports in the treatment of existing pressure ulcers.

Many of the trials included in this review are under-powered and therefore run a risk of failing to detect clinically significant differences as statistically significant. Other common methodological flaws – such as open randomisation, lack of baseline comparability and lack of blind outcome assessment – further reduce the confidence with which we can regard many of the individual study findings. Future trials should consider the findings of this review and address these deficiencies.

### **6.3.1 Cost-effectiveness of pressure-relieving support surfaces (beds, mattresses and overlays), mobility and positioning**

Three economic evaluations of pressure-relieving support surfaces were identified for review (Branom et al., 2001; Ferrell et al., 1995; Strauss et al., 1991). One study was a full economic evaluation (Ferrell et al., 1995), the other two were partial economic evaluations.

Ferrell et al. (1995) conducted a cost-effectiveness analysis comparing low air loss therapy beds to conventional foam mattresses used in nursing homes in the US (see data extraction table 25, Appendix A). Patients with grade 2, 3 or 4 pressure ulcers were followed up until complete heal, death or transfer to another facility. Effectiveness data to compute this included a statistically significant reduction in surface area of grade 3 and 4 pressure ulcers across the two treatments (9.9mm<sup>2</sup> per day vs. 0.7mm<sup>2</sup> per day, p<0.02).

Pressure ulcers took an average of 75 days to cure for low air loss therapy and 172 days for conventional foam mattresses. Use of the pressure-relieving support surfaces and associated nurse time was costed. While the lease cost per day of the

low air loss mattresses evaluated was higher than the cost per day of the conventional foam mattress, on average the low air loss bed was cost-saving due to a much shorter time to heal.

Final results were reported as cost per added day free of a pressure ulcer and were obtained by dividing the additional cost of the low air loss therapy by the additional days without an ulcer. The cost-effectiveness estimate for low air loss therapy was \$26 per added day free of a pressure ulcer (1992 prices). No uncertainty associated with this estimate was reported. However, a few one-way sensitivity analyses were conducted and findings were sensitive to the lease cost of the low air loss bed as well as patient and pressure ulcer healing characteristics.

The economic evaluation was based on an analysis of the RCT reported in Ferrell et al. (1993) that is included in the clinical effectiveness review of pressure-relieving support surfaces. In the clinical effectiveness review the healing rates of this trial were combined with the Mulder et al. (1994) results. This revealed that pressure ulcer healing rates were not statistically significantly different to healing rates using a corrugated foam overlay.

Branom et al. (2001) conducted a cost-consequence analysis comparing constant force technology with low air loss therapy beds used in patient care in the US (see data extraction table 24, Appendix A). Patients with grade 3 or 4 pressure ulcers were followed up for a maximum of eight weeks. Study exit criteria included discharge from inpatient status, flap surgery and death.

Effectiveness results included: on average a smaller size pressure ulcer recorded at discharge from the study for the constant force technology group (6.6cm<sup>3</sup> vs. 24.6cm<sup>3</sup>), the average amount closed at discharge from the study was higher (25.8cm<sup>3</sup> vs. 22.2cm<sup>3</sup>), the average rate of closure per week was faster (3.5cm<sup>3</sup> vs. 2.8cm<sup>3</sup>), the average proportion of pressure ulcers closed (60.0% vs. 39.6%) and a higher average proportion of pressure ulcers closed per week (9.0% (+/-4.8) vs. 5.0% (+/-3.7)) for the constant force technology group compared to the low air loss group.

The purchase price of constant force technology was \$1,080 (price year not stated) while the daily rental cost of the low air loss mattress was \$35 per day, that totalled to \$1,960 over the maximum eight-week follow-up period.

In general, although costs and outcomes were not synthesised, results suggest that constant force technology dominated low air loss therapy beds since associated costs were lower and effects better. A number of caveats should be considered when drawing conclusions from this study. This is the only economic evaluation to assess the effectiveness of constant force technology beds. The study is based on a clinical

trial but patients were allocated to treatments sequentially, which is not truly random and can introduce bias. Only the costs of the mattresses were included, and the use of nursing time or other resources used in conjunction with the interventions were omitted. The total cost of the low air loss mattress was dependent on the length of use. Very limited statistical analyses were reported to investigate uncertainty associated with the results.

Strauss et al. (1995) conducted a cost-consequence analysis comparing air-fluidised therapy to conventional therapy in the US (see data extraction table 26, Appendix A). Patients with grade 3 or 4 pressure ulcers were followed up in the RCT over a considerable length of time (36 weeks). However, only 50% of patients receiving air-fluidised therapy completed the study compared to 56% in the conventional therapy group. Two nurses independently assessed outcomes, blind to treatment groups. For each patient who completed the 36-week regimen, and for whom interpretable photographs were available, the nurses assessed the photographs and clinical notes. They categorised each patient's pressure ulcer as (i) improved (ii) unchanged (iii) worse or (iv) not assessable<sup>ii</sup>.

A higher proportion of pressure ulcers in the air-fluidised bed group were classified as improved (82% classified as improved by one nurse versus 91% by the other nurse for the air-fluidised bed group compared to 77% or 62% for the conventional therapy group), however differences were not significant. Additionally, a small proportion of pressure ulcers in this group were classified as unchanged.

The cost of treatments used was computed from the medical charges perspective, and the Medicare DRG and doctor payment perspective. Cost per patient for the former was \$29,016 versus \$34,747 for air-fluidised therapy compared to conventional therapy respectively, and this was not statistically significantly different. Cost per patient for the latter was \$16,415 compared to \$16,800 for air-fluidised therapy compared to conventional therapy respectively, and again this was not statistically significantly different.

Costs and outcomes were not synthesised and the cost-effectiveness implications are not straightforward to determine. Overall, costs per patient were similar across groups in spite of significant inpatient cost differences. No significant improvement in pressure ulcers was detected across the two groups either.

The economic evaluation was included alongside the results of the RCT on which it was based, and these results are reported in the clinical effectiveness review of

---

<sup>ii</sup> These categories were defined explicitly for the nurses

pressure-relieving support surfaces. There the air-fluidised therapy showed a statistically significant benefit compared to standard care on re-hospitalisation outcomes. Typically such an outcome would not be used in an economic evaluation since the cost of hospital stays are factored into the cost analysis.

## **Overview of pressure-relieving support surfaces**

Although the three studies reviewed are based on level one or two effectiveness evidence, the economic evaluation quality assessments (see Appendix C) show that there were a number of study limitations. Data collection aspects for the Branom et al. (2001) and Ferrell et al. (1995) studies were moderate, but resource use and cost data for the Strauss et al. study (1991) were less strong. Analysis and interpretation of results were not strong for any of the studies, particularly in terms of exploration of the uncertainty associated with costs and outcomes reported.

### **6.3.2 A cost analysis of an alternating pressure mattress replacement system compared to a high-specification foam mattress with an alternating pressure overlay for the management of pressure ulcers**

To inform the recommendations on pressure-relieving surfaces, the GDG suggested a comparison of two options: (i) an alternating pressure management replacement system (APMRS) with (ii) a high-specification foam mattress and an alternating pressure overlay.

No suitable comparison of products was found in the systematic review of the effectiveness literature and therefore the analysis was based on the expert opinion of the GDG. They argued that the benefits associated with each option are the same and therefore a cost-minimisation analysis was undertaken. The cost analysis was undertaken from the NHS perspective. The costs relate to the financial year 2004/5 and include 17.5% VAT.

The unit cost of the two options was calculated based on data obtained from the NHS Purchasing and Supplies Agency (NHS PASA). A number of companies supply these support surfaces and there is variation in the unit price of the products and their specifications. Therefore an average (mean) cost was obtained based on standard support surfaces. Two clinicians from the GDG checked that the products included in the costing exercise were appropriate.

**Table 4: Unit cost of APMRS and a high-specification foam mattress with an alternating pressure overlay**

Product	Number	Average (mean) cost	Standard Deviation	Minimum cost	Maximum cost
APMRS	24	£2,830	£1,393	£376	£5,451
High-specification foam mattress	207	£250	£140	£53	£938
Alternating pressure overlay	21	£1,128	£734	£353	£3,139

Table 4 presents the unit costs of the pressure-relieving support surfaces being analysed. The average (mean) cost of APMRS (£2,830) is more than twice that of a high-specification foam mattress used with an alternating pressure overlay (£250 + £1,128 = £1,378).

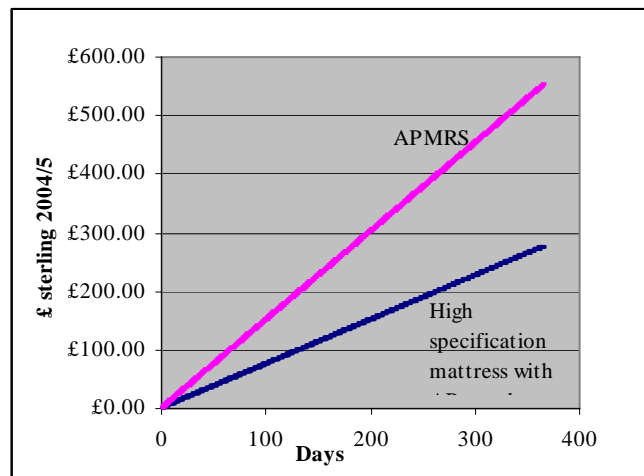
Assuming that for the five-year life span of the products, each option was used every day, the daily cost of each option would be, on average, £1.55 for the APMRS and £0.75 for the average high-specification mattress with an alternating pressure overlay. The difference in costs over a one-year period is illustrated in Figure 15 below. This information suggests that, on average, option (ii) using a high-specification foam mattress with an alternating pressure overlay provides greater value for money compared to option (i) APMRS.

<b>NHS usage vignette</b>	<b>APMRS</b>	
<b>HSFM+APO</b>		
Usage of one or other systems by 1,000 patients:	2,830,000	1,378,000
Usage of one or other systems by 10,000 patients:	28,300,000	13,780,000
Usage of one or other systems by 100,000 patients:	283,000,000	137,800,000

These figures taken across a five-year lifespan of the equipment then equate to per year in GRP as actual cost to the NHS based on mean calculations:

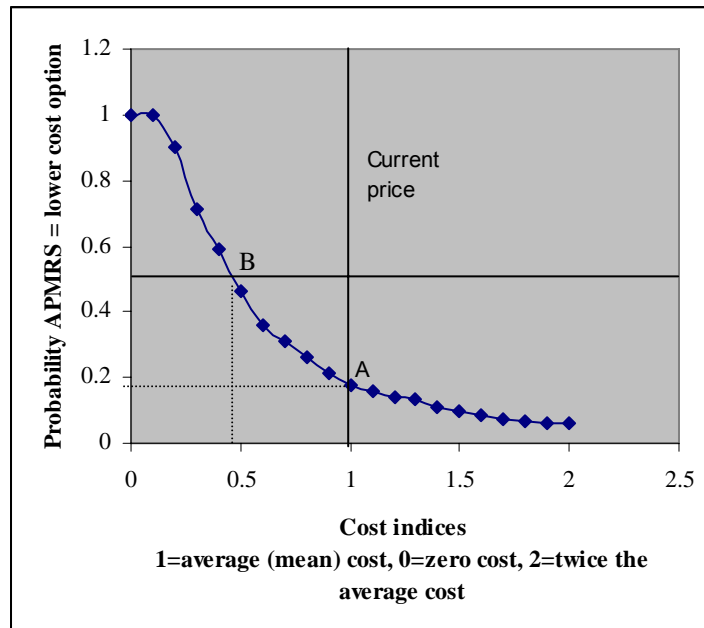
<b>APMRS</b>	<b>HSFM+APO</b>	
Usage of one or other systems by 1,000 patients:	566,000	275,600
Usage of one or other systems by 10,000 patients:	5,660,000	2,756,000
Usage of one or other systems by 100,000 patients:	56,600,000	27,560,000

**Figure 15: Daily cost of APMRS compared to a high-specification foam mattress used with an alternating pressure overlay**



Based on the minimum cost data in Table 4, it is worth noting that the minimum cost of APMRS supplied via the NHS PASA is £376 compared to £406 for the high-specification foam mattress and alternating pressure overlay (£53 for the mattress and £353 for the overlay). Therefore, APMRS is not always the more costly option. To take this into consideration, an additional analysis was undertaken.

**Figure 16: Assessing the probability that APMRS is cost-minimising compared to a high-specification foam mattress with an alternating pressure overlay**



If the individuals purchasing these options are unaware of the price of the products and the products are chosen independently then, as Figure 16 illustrates, there is a

probability of less than 20% (point A) that the APMRS option will be the lower cost option, whereas there is a probability of about 80% that the foam mattress with an alternating pressure overlay will be the lower cost option. The cost of APMRS would need to be more than halved (point B), on average, if there was to be an equal probability (50%) of APMRS being the lower cost option compared to the high-specification foam mattress with an alternating pressure overlay.

A number of assumptions underline the analysis and these are important to bear in mind when interpreting the results. A key assumption was that the benefits associated with each type of product were the same and therefore that it was appropriate to conduct a cost-minimisation analysis. No empirical effectiveness evidence was found which compared these particular pressure-relieving support surfaces. It was also assumed that the resource inputs, such as labour time, required to use either option were the same so that the only cost to be considered was the cost of the products themselves. An attempt was made to include the unit costs of standard pressure-relieving support systems. Therefore products for use on, for example, double beds and those produced specifically for bariatric patients or for children, were also excluded. The unit costs obtained from NHS PASA related to the purchase price of one product. In practice, products may be purchased in bulk and if so, the unit cost per product is likely to fall.

**Evidence summaries**

Level of evidence	Evidence statement
<p>1++</p> <p>1+</p> <p>1+</p>	<p><b>All pressure-relieving support surfaces:</b> No conclusive research evidence to indicate which pressure-relieving support surfaces are most effective in the treatment of pressure ulcers.</p> <p><b>Air-fluidised therapy:</b> some evidence from meta-analysis of two trials indicate that ulcer healing was improved compared to modified AP and a range of other CLP supports in adults with grade 2-4 pressure ulcers (conventional therapy).</p> <p><b>Low air loss therapy:</b> no evidence of a difference for complete ulcer healing found when compared to foam mattress overlays in individuals with grade 2-4 pressure ulcers.</p>
<p>1++</p> <p>1+</p>	<p><b>Alternating pressure therapy:</b> no evidence of a difference in complete ulcer healing found comparing different alternating pressure support surfaces.</p> <p>No evidence of a difference found compared to static fluid overlay mattresses or cushions in the elderly with grade 2 or greater pressure ulcers.</p> <p><b>Continuous low pressure therapy:</b> no evidence of a difference in ulcer healing rates for water-filled mattresses compared with foam replacement mattresses in adults with grade 3 pressure ulcers. Limited evidence of difference in ulcer healing for profiling beds compared with standard hospital beds in adults with grade 1 or greater pressure ulcers.</p>

**Recommendations: pressure-relieving support surfaces**

Patients with pressure ulcers should have access to appropriate pressure-relieving support surfaces and strategies – for example mattresses, cushions, and repositioning – 24 hours a day and this applies to all support surfaces. **[D]**



Decisions about choice of pressure-relieving support surfaces for patients with pressure ulcers should be made by registered health care professionals. **[D]**

Initial choice and subsequent decisions, following re-assessments, related to the provision of pressure-relieving support surfaces for patients with pressure ulcers should be based on: **[D]**

- ulcer assessment (severity)
- level of risk: from holistic assessment
- location and cause of the pressure ulcer
- general skin assessment
- general health status
- acceptability and comfort for the patient
- lifestyle of the patient
- ability of the patient to reposition themselves
- availability of carer/health professional to reposition the patient, and
- cost consideration.

There is no conclusive research evidence that any one pressure-relieving support technology is superior to another. However professional consensus recommends that:

- all individuals assessed as having a grade 1-2 pressure ulcer should, as a minimum provision, be placed on a high-specification foam mattress or cushion with pressure-reducing properties combined with very close observation of skin changes, and a documented positioning and repositioning regime. **[D]**
- if there is any perceived or actual deterioration of affected areas or further pressure ulcer development, an AP (replacement or overlay) or sophisticated CLP system – for example low air loss, air fluidised, air flotation, viscous fluid – should be used. **[D]** N.B. For individuals requiring bed rails, AP overlay mattresses should be placed on a reduced-depth foam mattress to maintain safety.

- individuals assessed as having grade 3-4 pressure ulcers (including intact eschar where depth, and therefore grade, cannot be assessed) should, as a minimum provision, be placed on an AP mattress (replacement or overlay) or sophisticated CLP system – for example low air loss, air fluidised, viscous fluid. [D]
- if alternating pressure equipment is required the first choice should be an overlay system, unless other circumstances such as patient weight or patient safety indicate the need for a replacement system. N.B. To ensure maximum effect the inflated cells of the overlay must support the body weight of the patient in all bed positions (during use of backrest, knee break) and all patient positions (sitting up, side lying). [D]

### Safe use of pressure-relieving mattresses

When selecting pressure-relieving devices consider the following factors: **D[GPP]**

1. Ensure that the mattress does not elevate the individual to an unsafe height in relation to bed rails if used. *(For individuals requiring bed rails, AP overlay mattresses should be placed on a reduced-depth foam mattress.)*
2. Ensure that the individual is within the recommended weight range for the mattress.
3. Children and alternating pressure
  - Cell size of mattress – small children can sink into gaps created by deflated cells causing discomfort and reducing efficacy.
  - Position of pressure sensors within the mattress in relation to the child – small children positioned at the top of the mattress may not register as the weight sensor is positioned in the middle of the mattress, thus producing inappropriate cell calibration.
  - Many alternating pressure mattresses have a permanently inflated head end which may place the occiput at risk in young children.

### Guideline Development Group commentary

Intervention	GDG commentary
Air-fluidised therapy	AFT is now rarely used in clinical practice. There is little evidence of difference over AP or many other CLP surfaces, and there may be considerations in terms of patient positioning, and moving and

<p><b>Low air loss therapy</b></p>	<p>handling.</p> <p>Basic mattress replacement versions often require user calibration (barrel test) which is very subjective. Tends to favour pressure relief at sacrum at expense of the head and heels. Requires constant power/pumped air supply (deflates if power supply removed) placing patient at risk while being transported. High-end systems have more sophisticated pressure monitoring but are often integrated into bed frames and are therefore expensive for general use.</p>
<p><b>Alternating pressure</b></p>	<p>Mechanical robustness is an artefact of old trials in early days of technology. Small cell systems are rarely used.</p> <p>AP is widely used in clinical practice. However more research is required to understand the ideal depth, inflation pressure and cycle time.</p>

<p><b>Research recommendations.</b></p>	
	<p>Independent, well-designed, multi-centre, randomised, controlled trials are needed to compare the clinical and cost-effectiveness of different types of pressure-relieving support surfaces to treat existing pressure ulcers for patients in a variety of settings. In particular, this research should aim to compare:</p> <ul style="list-style-type: none"> <li>• alternating pressure support surfaces with continuous low pressure supports.</li> </ul> <p>Future research must address the methodological deficiencies associated with much of the research described in this review. Attention should be paid to:</p> <ul style="list-style-type: none"> <li>• description of inclusion and exclusion criteria used to derive the sample from the target population</li> <li>• evidence of an <i>a priori</i> sample size calculation</li> <li>• evidence of allocation concealment at randomisation</li> <li>• description of baseline comparability of treatment groups</li> <li>• evidence of blinded outcome assessment</li> <li>• clear description of main interventions</li> <li>• adequate description of associated care, and</li> </ul>

	<ul style="list-style-type: none"><li>• withdrawals reported by treatment group with reasons.</li></ul> <p>Patients should:</p> <ul style="list-style-type: none"><li>• be truly randomised (with concealed allocation)</li><li>• be of sufficient size to detect clinically important differences and have clear criteria for measuring outcomes</li><li>• have blinded interventions and assessment</li><li>• have adequate follow-up, and</li><li>• appropriate statistical analysis.</li></ul> <p>Measure patient experiences of pressure-relieving equipment:</p> <ul style="list-style-type: none"><li>• comfort</li><li>• pain</li><li>• ease of use</li><li>• appropriateness for users and settings, and</li><li>• durability of equipment.</li></ul> <p>The studies should also have evaluations of the cost-benefit trade off of pressure ulcer treatment alternatives undertaken.</p>
--	---

## 6.4 Dressings and topical agents in the treatment of pressure ulcers

The methods described in this review were those used to update the following systematic review:

Bradley M, Cullum N, Nelson EA, Petticrew M, Sheldon T and Torgerson D (1999b) Systematic reviews of wound care management: (2) dressings and topical agents used in the healing of chronic wounds. *Health Technology Assessment*, 3(17) pt 2.

Bradley M, Cullum N and Sheldon T (1999a) The debridement of chronic wounds. *Health Technology Assessment*, 3(17) pt 1.

### Background

Technological advances have extended the range and complexity of dressing products, making meaningful classification increasingly difficult.

For the purposes of this document dressings are divided into five basic categories:

#### 1) Contact layers

The key features of a contact layer should be their ability to prevent adherence to the wound bed and allow free drainage of exudate. These materials tend to be used on superficial or lightly exuding wounds – for example paraffin gauze (tulle gras), knitted viscose, silicone-coated fabric dressings .

#### 2) Passive dressings

Dressings that create a local wound environment conducive to healing by controlling the local wound environment but which do not change their physical state or directly modify or interfere with the physiology of the wound. Such dressings are commonly used to control exudate but they may also be used, for example to prevent contamination or control odour. Examples include films, foams and hydrogels.

#### 3) Interactive dressings

Dressings that change their physical state in contact with wound exudate. Such products commonly form a gel-like covering on the wound surface that is claimed to promote healing. Examples include hydrocolloids, alginates and products containing carboxymethylcellulose fibre.

#### 4) Active dressings

Products that aim to directly influence the physiology or biochemistry of the wound healing process. They include:

- Products containing physiologically active components that act at a biochemical level in the wound bed. Typically influencing cell growth or correcting chemical deficits – for example growth factors, collagen and hyaluronic acid.
- Skin grafts – the transplanting of human or animal skin onto a wound bed. May be patient's own (autograft), donated (allograft) or animal – usually pig (Xenograft).
- Tissue-engineered products.
- Also known as skin substitutes or skin replacements. Products that replicate a layer (or layers) of human skin.

#### 5) Antimicrobial dressings

Dressings containing antimicrobials agents – for example iodine, chlorhexidine silver and honey.

A number of characteristics of the ideal dressing have been described by pharmacists (see box, *Functions of an ideal dressing*). Many manufacturers refer to these characteristics when marketing their products. However, as this is an ideal list, none of the dressings in current use fulfil all of the criteria.

**Gauze** Woven or non-woven fabric produced from cotton, viscose, polyester, or other suitable fibres formed into a swab. Should not be used as a primary dressing as it adheres strongly to wound bed due to capillary looping into the structure.

**Contact layers** Includes simple products such as paraffin gauze (tulle gras) (cotton or cotton and viscose woven fabric, which has been impregnated with white soft paraffin) and knitted viscose dressings. More advanced products such as silicone-coated net dressings and hydrocolloid or gel-impregnated viscose nets are now generally preferred. Contact layers have no absorbent properties and generally require a secondary absorbent layer.

### **Wound dressing pads**

The basic wound dressing pad consists of an absorbent layer such as cellulose fibre enclosed in a sleeve of a nonwoven fabric. Some pads have a perforated plastic film layer to reduce adherence to the wound surface – e.g. Melolin, Smith & Nephew Healthcare Ltd.

### **Semi-permeable**

#### **film dressings**

Consist of a transparent polyurethane film coated with a thin layer of adhesive to enable the dressing to adhere to intact skin but not the wound surface. These dressings are permeable to moisture vapour and gases but impermeable to water and microorganisms.

### **Hydrocolloid**

#### **dressings**

These dressings comprise an absorbent gel-forming mass, commonly consisting of carboxymethylcellulose, which is contained within their structure together with elastomers and adhesives. The dressings are usually presented in the form of a self-adhesive wafer that absorbs wound exudate and traps it in the form of a gel.

Hydrocolloid colloid dressings are generally occlusive in their intact state but become semipermeable once in contact with wound fluid.

### **Hydrogels**

These consist of hydrophilic polymer commonly made from carboxymethylcellulose or modified starch dissolved or dispersed in water or a mixture of water (80%) and propylene glycol (20%) as a humectant and preservative. They have the ability to absorb exudate or rehydrate slough or necrotic tissue in a wound depending on whether the wound is exuding heavily or dry and necrotic – for example Intrasite®, Smith & Nephew Healthcare Ltd.

### **Alginate**

#### **dressings**

These are derived from seaweed, usually prepared as the calcium salt of alginic acid. When in contact with serum, wound exudate or

solutions containing sodium ions, the insoluble calcium alginate is partially converted to the soluble sodium salt, and a hydrophilic gel is produced.

**Foam dressings** Most foam dressings are designed to absorb and retain fluid. Modern foams are available in a variety of formats (shaped, adhesive, non-adhesive, bordered, cavity) with varying levels of absorbency and permeability.

**CMC fibrous**

**dressing** A primary wound dressing made from sodium carboxymethylcellulose fibres woven into a fleece similar in appearance to the alginates.

**Capillary dressing** A three-layer, non-woven/woven, low-adherent dressing, which comprises 100% polyester filament outer layers and 65%/35% poly/cotton fibres.

**The functions of an ideal dressing**

- Allows excess exudate to be removed from the wound surface.
- Provides a moist micro-environment.
- Is sterile/contaminant free.
- Does not shed dressing material in the wound.
- Reduces wound pain.
- Is easy to remove and apply.
- Does not cause allergic reactions.
- Causes no trauma when removed.
- Is impermeable to micro-organisms.
- Provides thermal insulation.

**Topical preparations**

Topical preparations eligible for inclusion in the present review include growth factors, oxygen-free radical scavengers, zinc oxide paste, tri-peptide copper complex, and silver sulphadiazine cream. Topical antiseptics and antibiotics are not covered here

but have been reviewed elsewhere.

Several of these preparations are applied to the wound to compensate for a deficiency in a particular element considered important for wound healing. An example of such a topical agent is zinc oxide; zinc deficiency has been associated with poor wound healing. Other preparations are thought to modify the wound environment by killing harmful bacteria – for example silver sulphadiazine.

## **Debridement**

Debridement involves the removal of dead or necrotic tissue, or other debris, from the wound to reduce the wound's biological burden. A number of terms are used to describe dead tissue in wounds:

- necrosis
- slough, and
- eschar.

There are six main methods of debridement:

- autolytic
- enzymatic
- sharp (or surgical)
- chemical
- mechanical
- larval therapy, the use of sterile maggots

## **Debridement agents**

All non-mechanical debridement agents, including the use of dressings and larval therapy, were included in this review. These include:

- dextranomer polysaccharide beads or paste
- cadexomer iodine polysaccharide beads or paste
- hydrogels
- enzymatic agents, and
- adhesive zinc oxide tape.

Mechanical debriding agent wet-to-dry dressings (saline gauze) were also included in this review. Other types of mechanical debriding agents, such as surgery or sharp debridement, were excluded from this review and will be examined separately.

## **Non-mechanical debridement techniques**

Numerous non-mechanical techniques are available for wound debridement. Many

are easy to apply and may have additional properties that are beneficial for wound healing. Such interventions include hydrogels and hydrocolloids. These materials have largely replaced enzymatic agents and dextranomer beads.

Several different enzyme preparations are available that digest slough and necrotic tissue. In the UK, only the formulation containing streptokinase and streptodornase (Varidase Topical®, Wyeth Laboratories) is licensed for use. This enzyme breaks down the proteins fibrin and pus cells but is ineffective against collagen and elastin, the main structural components of skin and by extension necrotic eschar/slough. Other enzymatic debriding agents are available and used internationally; these include trypsin and collagenase.

Dextranomer polysaccharide is supplied as anhydrous, porous beads with a diameter of 0.1-0.3 mm or as a paste. The beads are highly hydrophilic and rapidly absorb exudate from a necrotic sloughy mass. Prostaglandins, hormones and other relatively small molecules enter the matrix of the beads, while larger particles such as bacteria and wound debris become concentrated at the surface of the dextranomer layer. When the beads are changed by washing with saline, the absorbed and trapped necrotic material is removed.

Cadexomer iodine is similar to dextranomer, consisting of small spherical beads that are hydrophilic in nature. The beads are made from a modified starch infused with iodine at a concentration of 0.9%. Absorption of fluid from the wound results in a slow controlled displacement of iodine from the matrix, which acts as a bactericidal agent. The slow and consistent release of iodine overcomes the problem of iodine inactivation by protein absorption in the wound. The antibacterial property, biodegradability and high rate of fluid absorption distinguish cadexomer iodine from dextranomer. Bead dressings are difficult to apply and remove, and are for this reason now generally used in the form of pastes.

Hydrogels are a group of agents that were primarily developed as debriding agents. These gels are biologically inert and have a significant water content. They complement the body's natural debriding process by providing an advantageous environment for autolysis, while still acting to preserve living healthy tissue. The hydrogel is usually applied directly into the wound bed and held in place by a non-adherent dressing. Once the gel is fully hydrated it is unable to absorb the copious quantities of exudate that are released by some wounds. For this reason hydrogels are often used in conjunction with a highly absorbent dressing. In addition to the amorphous gel, hydrogels are also available in a sheet form. Several types of hydrogel are available manufactured under different trade names (Intrasite® Gel,

Smith & Nephew Healthcare Ltd; Sterigel®, Seton Healthcare Group plc; Granugel®, CovaTec UK Ltd).

Larval therapy, also known as maggot therapy or biosurgery, exploits the natural feeding behavior of maggots of *Lucilia sericata*, the common green bottle, for the benefit of the patient. When placed in a wound maggots have the ability to selectively and rapidly remove slough and necrotic tissue leaving healthy tissue intact. They also ingest living bacteria from within the wound which are killed as they pass through the insect's gut.

In clinical practice there is wide variation in the use of debriding agents and no consensus on which agent is most appropriate for use in pressure ulcers.

### **Mechanical debriding agents**

These involve the use of physical force to remove necrotic tissue and debris from the wound surface. Simple methods include the use of wet-to-dry dressings which remove tissue, although unselectively – i.e. healthy and unhealthy tissue. Other methods include wound irrigation – cleansing and pressure irrigation, whirlpool therapy, ultrasonic therapy and laser therapy.

### **Objectives**

To systematically assess the evidence for the effectiveness of dressings and topical agents in the treatment of existing pressure ulcers.

## **Selection criteria**

### **Types of studies**

Only randomised controlled trials (RCTs) were included in this review. Studies that did not use true random allocation of participants to treatment groups, such as quasi-experimental designs, were excluded. The units of allocation had to be patients or lesions. Studies in which wards, clinics or physicians were the units of allocation were excluded because of the possibility of non-comparability of standard care. Both published and unpublished studies were included.

### **Types of participants**

Studies that recruited people with existing pressure ulcers, of any grade or severity, were eligible for inclusion in the review. The study could be in any setting including

hospital, clinic, community facilities or home.

### **Types of interventions**

Trials in which a dressing or topical agent was compared with another dressing or topical agent(s), or were compared with a placebo, usual care, or no treatment were eligible for inclusion in the review. All types of dressings or topical agents were eligible for inclusion with the exception of topical antimicrobial agents (in a separate review). Non-dressing mechanical debriding agents, sharp and surgical debridement were excluded.

### **Types of outcome measures**

The primary outcome was wound healing.

## **Search strategy**

### **Clinical effectiveness searching – debridement**

#### **Main literature search**

Searches were undertaken to update the following Health Technology Assessment reviews for the aspects which were relevant to pressure ulcers:

Bradley M, Cullum N and Sheldon T (1999a) The debridement of chronic wounds. *Health Technology Assessment*, 3(17) pt 1.

Lewis R, Whiting P, Ter Riet G, O'Meara S and Glanville J (2001) A rapid and systematic review of the clinical effectiveness and cost-effectiveness of debriding agents in treating surgical wounds by secondary intention. *Health Technology Assessment*, 5(14).

### **Clinical effectiveness searching – dressings**

#### **Main literature search**

Searches were undertaken to update the following Cochrane review:

Bradley M, Cullum N, Nelson EA, Petticrew M, Sheldon T and Torgerson D (1999b) Systematic reviews of wound care management: (2) dressings and topical agents used in the healing of chronic wounds. *Health Technology Assessment*, 3(17) pt 2.

Searches were limited by study design to retrieve randomised controlled trials. Searches were also limited to retrieve literature published in English, and to omit animal studies and letters, comments and editorial publication types.

Databases were searched in April 2004 and searches were updated in August 2004.

The strategies are listed in Appendix B.

### **Description of included studies**

Sixty eligible randomised trials, involving 3,230 participants, were identified for inclusion in the review.

Most of the trials were conducted in either hospital or an aged-care facility, hence most of the enrolled patients were elderly, around 70–80 years old. There was a range of pressure ulcer severity included in the trials with baseline area at enrolment from 1-200cm<sup>2</sup>. This reflects the differing ulcer stages for participants in the trials. On average, ulcers would be at grade 3-4 at the start of treatment. Thus, many of the ulcers treated within the included trials had persisted for between three and 12 months without resolution.

In studies of pressure ulcer treatment it is important for trialists to report on the baseline comparability of the treatment groups for important variables such as baseline ulcer size. A change in wound area is often expressed as the percentage change which, unlike the absolute change in area, takes into account the initial size of the wound. For two wounds healing at the same linear rate (as measured by diameter reduction) percentage area calculations will show a larger change for a small wound than for a big wound. The converse is true when the absolute change in area is measured, as for any unit reduction in wound radius, a bigger area reduction will occur for a large wound.

This has important consequences for the validity of trial results where there is poor comparability in initial wound size at baseline between the treatment groups. In large trials, randomised allocation should ensure that the mean wound size and variance in each group is similar. In a small trial random allocation is unlikely to result in an even distribution of wound sizes. This problem will persist in small trials, even when the average wound size appears to be comparable between groups, because the distribution of wound sizes about the mean is likely to differ. In a trial where there is poor comparability between groups for wound size at baseline, and the outcome is

based on the change in area, the result can only be considered valid if it is obtained either against the anticipated direction of the bias for wound size, or where percentage area change and absolute area change are in the same direction. If baseline data are not given then it is not possible to determine the direction of bias and the validity of the result cannot be determined. Twenty-eight of the 60 trials included in this review presented data on baseline ulcer size.

In some studies there were concurrent intervention and follow-up periods, ranging from two to 25 weeks. Other studies delivered the intervention for less than the full follow-up period. Twenty-two of the 61 included studies used photographic techniques as part of their objective measurement of wound healing. Others used planimetry (n=22), observer opinion of improvement (n=5), and other methods (n=13) such as water displacement techniques and rating scales. Many trials used a combination of these methods, while others failed to describe their assessment techniques in any detail.

Topical interventions were assessed in 31 studies. One trial (n=14) compared a topical agent against no treatment, nine trials (n=405) assessed a topical agent against a placebo, seven trials (n=548) compared one topical agent versus another, seven trials (n=197) examined topical agents compared with traditional dressings, and a further seven trials (n=444) compared topical agents with modern dressings. Modern dressings were compared with traditional dressings in 12 trials (n=573), with other modern dressings in 16 trials (n=994), and against a placebo in one trial (n=49). The Table of Comparisons details the individual comparisons examined under these broad groupings.

There were 22 studies that were excluded from the review. The citations and reasons for exclusion are detailed in the Table of Excluded Studies (Appendix D). The most common reasons for exclusion were non-randomised study design or lack of objective outcome measures reported.

### **Methodological quality of included studies**

Details of the quality assessment of each study are outlined in the Table of Included Studies (see Appendix A). The key components of quality that were assessed included: *a priori* sample size calculations, allocation concealment, masking of outcome assessment and reporting of withdrawals by treatment group.

Sample size ranged from 14 to 168 patients per trial, with only six of the 60 trials recruiting more than 100 patients (Rees, 1999; Pullen, 2002; Colin, 1996; Brown-Etris, 1996; Belmin, 2002; Honde, 1994). *A priori* power calculations were reported in

only six trials. In 40 of the 61 included trials, the method of random sequence generation was not stated. Only six trials (Sayag, 1996; Thomas, 1997; Banks, 1994c; Graumlich, 2003; Meaume, 2003; Price, 2000) described the method of randomisation in enough detail that the reader could be sure of adequate allocation concealment.

Of the 10 trials that used a placebo comparator, only three described the placebo in sufficient detail to be confident that treatment allocation was masked to patients and caregivers (Robson, 2000; Ritz, 2002; Landi, 2003). Thirteen trials reported masked assessment of outcomes (Mustoe, 1994; Robson, 1992a,b; Robson, 2000; Landi, 2003; Pullen, 2002; Nasar, 1982; Moberg, 1983; Brown-Etris, 1996; Alm, 1989; Graumlich, 2003; Bale, 1998b; Ritz, 2002).

Thirty-six of the 60 included studies reported their withdrawal rates and reasons by treatment group. Withdrawals were common, and 34 studies reported withdrawals by treatment group and gave reasons for these withdrawals. There were sufficient data reported in 35 studies to enable results to be extracted and analysed on an intention-to-treat basis.

No attempt was made to weight the studies in the analysis using any statistical technique. However methodological quality was drawn upon in the narrative interpretation of the results.

## **Results**

Many of the comparisons included in this review include only one eligible trial and many of these are of poor methodological quality. Hence, robust conclusions cannot be drawn from such results.

### **Topical agents versus no treatment**

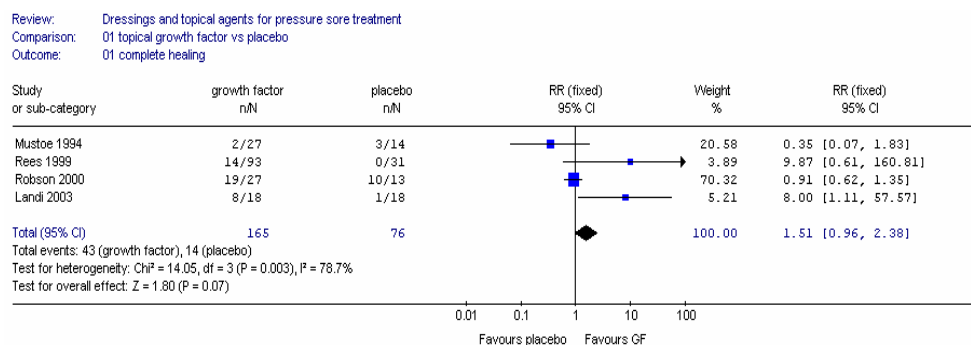
There was only one trial that was included in this comparison category. The incremental benefit of topical insulin (twice a day for five days) in addition to routine supportive nursing care was assessed in a single small trial (van Ort, 1976). The statistical analysis suggested that the addition of insulin resulted in a significant improvement in both the healing rate and the number of days that treatment was required. However, this trial was small (n=14) and no primary data or findings were presented, so firm conclusions cannot be drawn from these results.

### Topical agents versus placebo

Nine trials compared a topical agent with a placebo. One assessed an active cream, referred to as F1400140 (formulation not stated but contained a barley plant extract) (Le Vasseur, 1991), one assessed collagenase (Lee, 1975), and a further seven trials assessed topical growth factors (rhPDGF-BB, rbFGF, interleukin I-beta, GM-CSF) compared to placebo (Rees, 1999; Mustoe, 1994; Robson, 1992a,b; Robson, 1994; Robson, 2000; Landi, 2003).

A meta-analysis of available data on complete ulcer healing from four of these seven trials (n=241) showed that overall, compared to placebo, there was no evidence that topical growth factors significantly improved healing rates (relative risk for complete healing with growth factor treatment 1.51; 95% confidence interval 0.96 to 2.38) (see Figure 17).

Figure 17:



However, as there is considerable heterogeneity in these results, both statistical (I<sup>2</sup> statistic 78.7%) and clinical, an assessment was made of the two trials (Mustoe, 1994; Rees, 1999) that used the same growth factor (rhBDGF-BB) in the same dosages (100µg/ml, 300µg/ml) compared with placebos. Both dosages of this topical agent showed evidence of improvement in ulcer healing (relative risk for ulcer healing with 100µg/ml rhBDGF-BB 7.17; 95% confidence interval 1.40 to 36.69) (see Figure 18); (relative risk for ulcer healing with 300µg/ml rhBDGF-BB 6.23; 95% confidence interval 1.17 to 33.34) (see Figure 19). It should be noted that, although these are statistically significant differences, the confidence intervals are wide, suggesting the results should be interpreted with caution.

No other data from this category of studies was suitable for pooling using meta-analysis.

Overall, topical growth factors did appear to reduce mean ulcer size. Robson and colleagues (Robson, 1992a,b; Robson, 1994; Robson, 2000) found increased reduction in wound size or volume with increasing concentrations of various growth factors (see Table of Included Studies for individual results, Appendix A).

Figure 18:

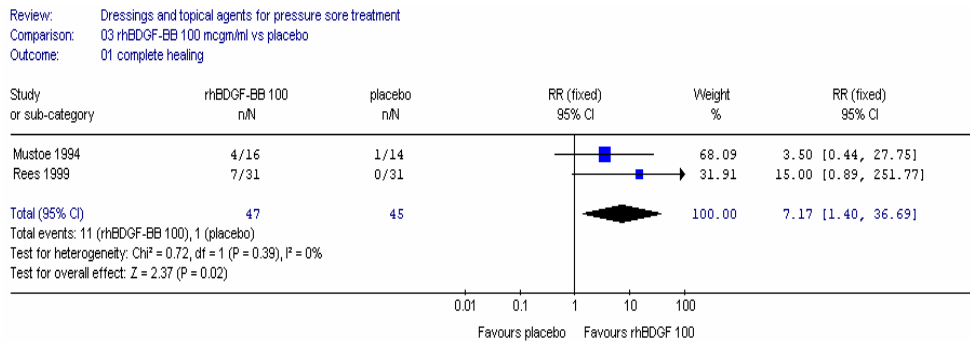
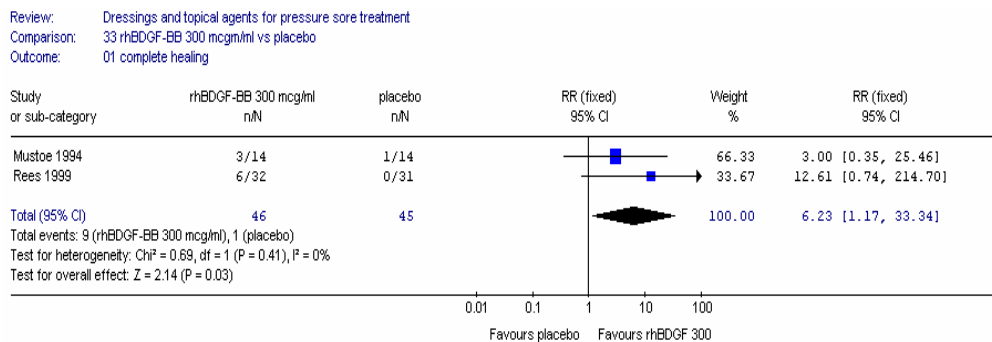


Figure 19:



A recent trial that assessed the effect of 2.5S murine nerve growth factor compared with placebo (Landi, 2003) found that this treatment reduced ulcer area by 74cm<sup>2</sup> in the treatment group compared to 49cm<sup>2</sup> for those receiving placebo. This topical agent also improved the rate of complete ulcer healing from one in 18 in the placebo group to eight of 18 in the treatment group (see Figure 17).

### Topical agents versus topical agents

One trial compared topical collagenase with a topical fibrinolysis agent (Pullen, 2002). It reported no significant change in wound area, healing or depth, but primary data for these results were not given. The one small trial (n=28) that compared topical collagenase papain-urea ointment (Alvarez, 2002) showed that the percentage of non-viable tissue after four weeks of treatment was only 1% in the collagenase group compared with 75% in the group that received papin-urea ointment (weighted mean difference -74.00; 95% confidence interval -121.17 to -26.83).

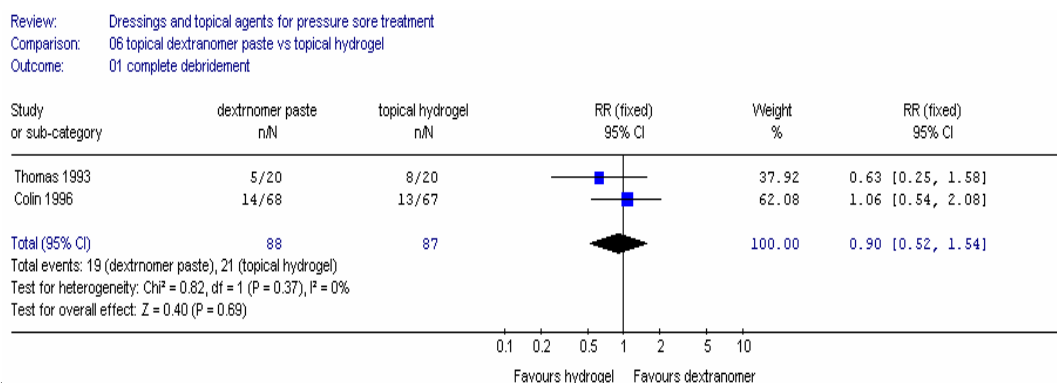
Another trial which compared collagenase paste (Santyl) with dextranomer polysaccharide paste (Debrisan) (Parish, 1979) showed no difference in ulcer healing rates (relative risk for ulcer healing for dextranomer paste 4.71; 95% confidence interval 0.66 to 33.61).

One larger trial which compared collagenase ointment in two dosing regimes (Burgos, 2000a) (24 versus 48 hours) showed no difference in healing rates (relative risk of ulcer healing 1.33; 95% confidence interval 0.63 to 2.830).

Although evidence in the form of RCTs is lacking, many clinicians believe that debridement facilitates wound closure by removing necrotic tissue that acts as a barrier to new tissue growth. This suggests that if debridement really does aid wound closure, then the effectiveness of a debriding agent should be measured by an outcome based on wound healing. Even though the debriding agent is not necessarily used throughout the entire healing process, an outcome measure based on healing remains valid as long as both comparison groups follow a similar schedule of nursing care after the debridement period. In this way, any difference in healing rates between groups can be attributed to the debriding agent used. Some researchers, however, have attempted to estimate the effectiveness of these agents by measuring the degree of debridement expressed as the percentage area of wound covered in necrotic material. This measurement may not be a reliable indication of treatment effect as the extent of debridement does not appear to have been scientifically validated as a surrogate or proxy measure of wound healing.

Dextranomer polysaccharide paste (Debrisan) was compared with a hydrogel (Intrasite) in two well designed trials (Colin, 1996; Thomas, 1993). The resulting meta-analysis of data from these trials showed no evidence of a significant difference in the rate of complete debridement (relative risk of complete debridement 0.90; 95% confidence interval 0.52 to 1.54) (see Figure 20). However, as neither of these trials reported complete ulcer healing, these results should be interpreted in light of the aforementioned comments.

Figure 20:

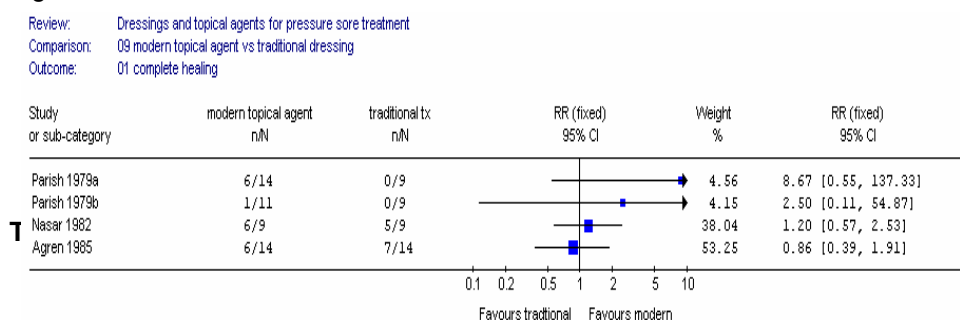


## Topical agents versus traditional dressings

Modern topical agents – such as dextranomer polysaccharide paste (Debrisan), collagenase (Santyl), cadexomer iodine polysaccharide powder (Iodosorb), streptokinase preparation (Varidase) and hydrogel (Clearsite) – were compared with traditional dressings such as saline-soaked gauze, zinc oxide gauze, eusol and paraffin packs, and sugar and egg white in six trials (Ljungberg, 1998; Nasar, 1982; Parish, 1979; Moberg, 1983; Agren, 1985; Mulder, 1993).

As these agents all had different pharmacology and modes of action, it was inappropriate to combine the results from these trials in a meta-analysis. None of the three trials that reported complete wound healing found a significant improvement in ulcer healing rates with the use of either Debrisan (Parish, 1979; Nasar, 1982), Santyl (Parish, 1979) or Varidase (Agren, 1985) compared to traditional dressings (see Figure 21). Again, however, all these trials were small (ranging from 18 to 28 participants) and of only fair methodological quality.

Figure 21:



Seven trials that met the inclusion criteria compared a topical agent with a modern dressing. Three trials compared a hydrocolloid with a hydrogel (Brown-Etris, 1996; Darkovitch, 1990; Mulder, 1993), two studies compared polysaccharide beads with either a calcium alginate dressing (Sayag, 1996) or a collagen sponge dressing (Palmieri, 1992), and two compared a hydrocolloid dressing with either collagenase ointment (Burgos, 2000b) or a polyhydroxyethyl methacrylate paste (Brod, 1990).

One trial (Darkovitch, 1990) reported twice the rate of wound ulcer healing with the use of a hydrogel compared to a hydrocolloid dressing (relative risk for ulcer healing with hydrogel 2.23; 95% confidence interval 1.23 to 4.07). However a smaller, more recent trial, which compared a hydrogel with a modified version of the previous hydrocolloid (Mulder, 1993), found no significant difference in mean percent ulcer area reduction (weighted mean difference -4.70; 95% confidence interval -20.12 to

10.72) with the use of a hydrogel. A further comparison of a hydrogel with the same modified hydrocolloid (Brown-Etris, 1996) reported insufficient data to estimate a measure of statistical precision and hence meta-analysis of these results was not possible.

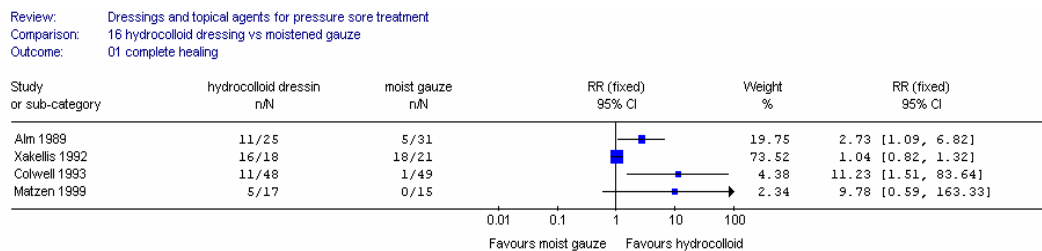
In both comparisons between polysaccharide beads and an alternative dressing (Palmieri, 1992; Sayag, 1996), the results indicated a benefit for the alternative treatment. However, this only reached statistical significance in the comparison with calcium alginate dressings, which showed a mean difference of 2.12cm<sup>2</sup>/week in ulcer area reduction in favour of the alginate dressing (weighted mean difference 2.12; 95% confidence interval 0.74 to 3.50). Unfortunately neither of these authors reported ulcer healing rates, hence the significance of these findings should be interpreted with caution.

### Modern dressings versus traditional dressings

Six trials (n=296) that met the inclusion criteria compared a hydrocolloid with the traditional treatment of saline-soaked gauze (Mulder, 1993; Alm, 1989; Colwell, 1993; Xakellis, 1992; Chang, 1998; Matzen, 1999). Due to significant clinical and statistical heterogeneity and missing outcome data for some trials, meta-analysis of results was deemed inappropriate.

Four of these trials reported wound healing results (Alm, 1989; Xakellis, 1992; Colwell, 1993; Matzen, 1999) (see Figure 22). The results are varied – some trials found large improvements in ulcer healing (Alm, 1989), others found little difference between the modern hydrocolloid dressing and traditional saline-soaked gauze (Xakellis, 1992). As these trials had quite different patterns of ulcer severity at enrolment, such differences might be expected.

Figure 22:

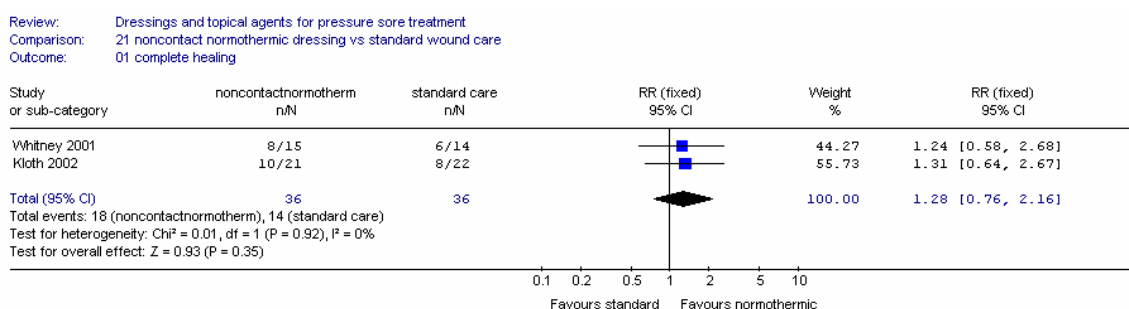


The comparisons of saline-soaked gauze and other modern dressings (semi

occlusive dressings, polyurethane dressings or hydrogel dressings) were only undertaken in small, single trials. They either had insufficient power to detect differences or showed no statistically significant differences between the groups for measures of ulcer healing. A trial of hydrocolloid dressing compared with povidone iodine gauze (Barrois, 1992) showed no statistically significant difference between the two groups for ulcer healing (relative risk for ulcer improvement with hydrocolloid 1.11; 95% confidence interval 0.51 to 2.42). Similarly, a semi-occlusive dressing was compared in one small trial (n=28) with saline-moistened gauze (Kraft, 1993) and no evidence of a difference between the two treatments was found (relative risk of ulcer healing with semi occlusive dressing 2.92; 95% confidence interval 0.74 to 11.45). A trial of 48 patients with 77 ulcers (Sebern, 1986) compared a polyurethane sterile dressing with saline gauze and found a large improvement in ulcer healing with the modern dressing (relative risk for ulcer healing with polyurethane dressing 16.39; 95% confidence interval 1.06 to 252.82). However the extremely wide confidence intervals for this result would suggest it was not a robust finding. One trial compared a hydrogel dressing with saline-soaked gauze (Thomas, 1998) and also found no evidence of improved ulcer healing rates (relative risk for ulcer healing with hydrogel 0.97; 95% confidence interval 0.56 to 1.68).

A newer dressing type, noncontact normothermic dressing, was compared with standard wound care in two trials (Kloth, 2002; Whitney, 2001). Wound healing results for these two trials showed no evidence of improved healing with the modern dressing (relative risk for ulcer healing with noncontact normothermic dressing 1.28; 95% confidence interval 0.76 to 2.16, see Figure 23).

Figure 23:



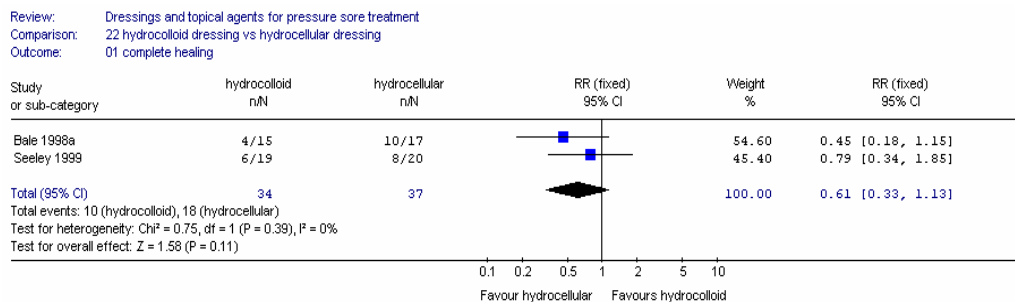
### Modern dressings versus modern dressings

There were 16 trials that compared different types of modern dressings (Belmin, 2002; Seeley, 1999; Bale, 1997,1998a,b; Thomas, 1997; Banks, 1994a,b,c,1996,1997; Seaman, 2000; Graumlich, 2003; Honde, 1994; Meaume, 2003; Price, 2000).

Hydrocellular dressings were assessed against hydrocolloid dressings in two trials (Seeley, 1999; Bale, 1998a). A meta-analysis of the results from these two trials did not show a significant difference in ulcer healing rates (relative risk for ulcer healing with hydrocolloid 0.61; 95% confidence interval 0.33 to 1.13 (see Figure 24).

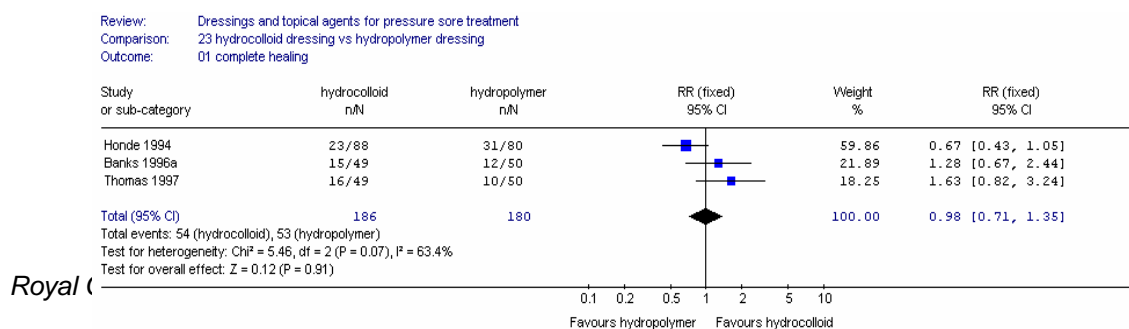
However, again these trials were small and it is likely there was insufficient power to detect real differences in treatment groups.

Figure 24:



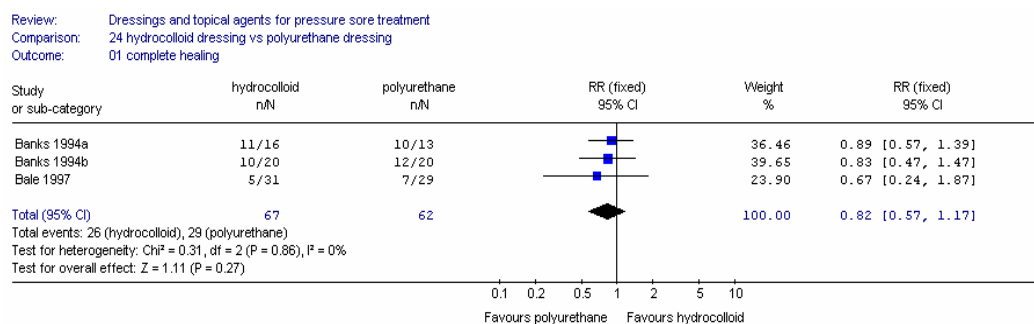
Meta-analysis of results from the three trials that examined hydropolymer versus hydrocolloid dressings (Banks, 1996; Thomas, 1997; Honde, 1994) showed no evidence of a significant difference in rates of wound healing (relative risk for ulcer healing with hydrocolloid 0.98; 95% confidence interval 0.71 to 1.35) (see Figure 25). As there was a moderate level of statistical heterogeneity (I<sup>2</sup> statistic = 63.4%), the meta-analysis was also run using a random effects model, but this made little difference to the results (relative risk for ulcer healing with hydrocolloid 1.07; 95% confidence interval 0.61 to 1.87, random effects).

Figure 25:



Three trials assessed hydrocolloid versus polyurethane foam dressings (Banks, 1994a,b; Bale, 1997). A meta-analysis showed no evidence of a significant difference in wound healing between these two types of dressings (relative risk for ulcer healing with hydrocolloid 0.82; 95% confidence interval 0.57 to 1.170 (see Figure 26).

Figure 26:



Several other comparisons between hydrocolloid dressings and other dressing types have been studied in randomised trials. A trial comparing hydrocolloid dressings with collagen dressings (Graumlich, 2003) found no evidence of a difference in wound healing (relative risk for ulcer healing with hydrocolloid 0.97; 95% confidence interval 0.60 to 1.57). The use of a calcium alginate dressing (UrgoSorb) for four weeks followed by a hydrocolloid dressing (Algoplaque) was compared with a standard hydrocolloid dressing (Duoderm E) for eight weeks in 100 patients (Belmin, 2002). A significant change in wound surface area at eight weeks was found for the sequential group with a reduction in mean surface area of 9.7cm<sup>2</sup> compared with the regular hydrocolloid dressing group whose mean surface area reduction was 5.2cm<sup>2</sup> (weighted mean difference 4.50; 95% confidence interval 1.83 to 7.17). A small (n=35) trial that compared a change indicator dressing (SIG) with a hydrocolloid dressing (Comfeel) (Seaman, 2000) saw an increase in wound healing with the change indicator dressings, but this was not statistically significant (relative risk for ulcer healing with hydrocolloid 0.16; 95% confidence interval 0.02 to 1.18). As most of these studies were small and have not been replicated, conclusive findings cannot be drawn from their results.

Similarly, there were a variety of single trial comparisons between several other dressing types. Hydrocellular and polyurethane dressings were compared in a trial of 20 patients (Banks, 1997) but although wound healing data were given for all patients, data were not presented for pressure ulcer patients alone. A recent trial of

38 patients compared the effect of hydropolymer and silicone dressings on wound healing (Meaume, 2003). This trial reported no evidence of a significant difference in ulcer healing rates between the two treatments (relative risk for ulcer healing with the hydropolymer dressing 1.13; 95% confidence interval 0.57 to 2.21). Polyurethane foam dressings (Lyof foam A) and low adherence dressings (Tegaderm) were compared in 50 patients (Banks, 1994c). Again, there was no evidence of a significant difference in wound healing between the two treatments (relative risk for ulcer healing with polyurethane 1.17; 95% confidence interval 0.79 to 1.72). When a radiant heat dressing was compared with an alginate dressing (Price, 2000), no evidence of a significant difference between the two groups was seen (relative risk for ulcer healing with radiant heat dressing 1.50; 95% confidence interval 0.27 to 8.22). Another study compared two types of hydrogel dressings (Sterigel and Intrasite) (Bale 1998b). This trial did not report wound healing data, only results for wound debridement. There was no evidence of a significant difference in this outcome between the two types of hydrogel (relative risk for wound debridement with Sterigel 1.44; 95% confidence interval 0.77 to 2.69). None of these fairly small trials showed significant or conclusive results favouring any of the new treatments, suggesting the need for further studies.

### **Modern dressings versus placebo**

One small trial (n=49) compared a wound closure system (Provant) with a placebo (Provant support surface transparently modified so that no treatment was given) (Ritz, 2002) and found no evidence of significant difference in wound closure rates for grade 2 pressure ulcers at six weeks (relative risk for ulcer healing with wound closure system 3.50; 95% confidence interval 0.50 to 24.41).

## **Discussion**

### **Quality of the studies**

Quality assessment suggests that methodological flaws are an issue affecting the validity of studies in chronic wound care. In general, the studies were too small to ensure that wounds of different sizes (and other prognostic variables) were evenly distributed across trial arms, resulting in a bias at baseline in most trials. The majority of studies also had a short follow-up and did not analyse the data by survival analysis, which would account for both whether and when a wound healed, and which would be a more efficient method for estimating the rate of healing. If future trials perpetuate many of the methodological flaws highlighted in this review, they are unlikely to

provide the necessary evidence to determine an effective wound management strategy. The variability between wounds at baseline for prognostic variables, including size, indicates that recruitment numbers need to be large and that trials should probably be multi-centred. If small single-centred trials are to be continued they could be improved by the use of matched or stratified randomisation to ensure a similar distribution of wound sizes between treatment groups at baseline, and the data should be analysed by matched pairs analysis where appropriate. However, even with this improved design a trial still needs to be large enough to ensure comparability for both unknown and known confounding factors.

### **Dressings and topical agents as treatments for pressure ulcers**

Studies that compare treatment with no treatment are very rare in the wound care literature because of concern over ethical issues associated with withholding treatment from a patient. In this review only a single trial was included that assessed the incremental benefit of topical insulin when given in addition to routine supportive care (not including direct management of the wound) for the treatment of pressure ulcers. This trial suggested that application of topical insulin did have a statistically significant benefit on wound healing. However, this requires further exploration and replication.

The alternative to withholding treatment from a patient is to use a placebo. Eleven trials were included in this review which assessed topical agents versus placebo or dressings versus placebo. In wound care trials such placebo treatments are unlikely to be inert as the application of the placebo or vehicle is likely to change the local environment of the wound, thereby modifying the biological processes associated with healing. A placebo is therefore not a substitute for withholding treatment in studies to determine the rationale for active treatment. The possible interaction between the vehicle and the healing process, together with small sample size, may provide some explanation for why trials do not show a statistically significant difference between an active treatment and a placebo.

Studies directly comparing topical agents for the treatment of pressure ulcers focused primarily on biologically active agents. Most of these trials were too small to provide conclusive results and their heterogeneity prevented pooling. At present the results are highly inconsistent both within and between trials, and further, better-designed studies with larger numbers are required.

## 6.4.1 Cost-effectiveness evaluation of dressings in the treatment of pressure ulcers

**Table 5: Overview of economic evaluations to assess dressings and topical agents**

Full or partial economic evaluation	Author	Country where study was conducted	Interventions compared
Partial	Aguilo Sanchez et al. (2001)	Spain	Hydrocolloid dressing vs. saline-moistened gauze dressing
Partial	Bale et al. (1998)	UK	Hydrocellular dressing vs. hydrocolloid dressing
Partial	Bergemann et al. (1999)	Germany	Gauze vs. impregnated gauze vs. calcium alginate vs. hydroactive wound dressing in combination with enzymatic wound cleaning collagenase vs. hydroactive wound dressing in combination with enzymatic wound cleaning collagenase during the first seven days of treatment
Full	Burgos et al. (2000)	Spain	Collagenase ointment vs. hydrocolloid occlusive dressing
Full	Capillas Perez et al. (2000)	Spain	Hydrocolloid dressing vs. saline gauze dressing
Partial	Colwell et al. (1993)	US	Hydrocolloid wafer dressing vs. sterile moist gauze dressing
Partial	Gorse et al. (1987)	US	Hydrocolloid dressing vs. Dakin's solution (chloramines-T) soaked wet-to-dry dressing

Partial	Graumlich et al. (2003)	US	Topical collagen vs. hydrocolloid dressing
Full	Harding et al. (2000/1)	UK	Saline-moistened gauze vs. hydrocolloid 1, hydrocolloid 2
Full	Kerstein et al. (2001)	US	Saline-moistened gauze vs. hydrocolloid 1, hydrocolloid 2
Partial	Kim et al. (1996)	Korea	Hydrocolloid occlusive dressing vs. wet-to-dry gauze dressing
Partial	Kraft et al. (1993)	US	Semi-permeable polyurethane foam dressing vs. moist saline gauze dressing
Partial	Mosher et al. (1999)	US	Autolysis vs. wet-to-dry saline vs. collagenase vs. fibrinolysin
Partial	Motta et al. (1999)	US	Synthetic polymer vs. hydrocolloid dressing
Full	Muller et al. (2001)	The Netherlands	Collagense containing ointment vs. hydrocolloid dressing
Full	Nasar et al. (1982)	UK	Debrisan vs. Eusol and paraffin dressings
Full	Ohura et al. (2004)	Japan	Hydrocolloid vs. traditional care with ointment and gauze with a standardised wound management algorithm vs. traditional care with ointment and gauze without a standardised wound management algorithm
Partial	Robson et al. (1999)	US	Recombinant human platelet-derived growth factor-BB: 100 µg rhPDGF-BB per day vs. 300 µg rhPDGF-BB per day vs. 100 µg rhPDGF-BB twice daily, vs.

			placebo
Partial	Robson et al. (2000)	US	Cytokine growth factors (2.0 µg/cm <sup>2</sup> GM-CSF) therapy topically applied daily for 35 days vs. 5.0 µg/cm <sup>2</sup> bFGF therapy applied daily for 35 days vs. 2.0 µg/cm <sup>2</sup> GM-CSF applied for 10 days followed sequentially by 25 days of topically applied 5.0 µg/cm <sup>2</sup> bFGF vs. Placebo applied daily for 35 days.
Partial	Sebern et al. (1986/9)	US	Transparent moisture vapour permeable dressing vs. gauze and tape
Partial	Xakellis et al. (1992)	US	Hydrocolloid dressing vs. non-sterile saline gauze dressing

### Dressing and topical agents including debridement

The majority (81%) of economic evaluations obtained for review assessed the costs and outcomes associated with dressings and topical agents. Table 5 (above) presents an overview of the treatments that were assessed in this area together with the country where the study was conducted.

**Table 6: Treatment comparisons**

	Treatment comparisons	Number of studies	References
1	Hydrocolloid dressing versus saline gauze dressing	9	Aguilo Sanchez et al. (2001)  Capillas Perez et al. (2000)  Colwell et al. (1993)

			Harding et al. (2000/1)  Kerstein et al. (2001)  Kim et al. (1996)  Ohura et al. (2004)  Xakellis et al. (1992)
<b>2</b>	Hydrocolloid dressing versus Dakin's solution (chloramines-T)-soaked wet-to-dry dressings	1	Gorse et al. (1987)
<b>3</b>	Hydrocolloid dressing versus hydrocellular dressing	1	Bale et al. (1982)
<b>4</b>	Gauze versus impregnated gauze versus calcium alginate versus hydroactive wound dressing in combination with enzymatic wound cleaning collagenase versus hydroactive wound dressing in combination with enzymatic wound cleaning collagenase during the first seven days of treatment	1	Bergemann et al. (1999)
<b>5</b>	Collagenase ointment versus hydrocolloid dressing	2	Burgos et al. (2000)  Muller et al. (2001)
<b>6</b>	Semi-permeable polyurethane foam dressing vs. moist saline	1	Kraft et al. (1993)

	gauze dressing		
7	Autolysis vs. wet-to-dry saline vs. collagenase vs. fibrinolysin	1	Mosher et al. (1999)
8	Synthetic polymer vs. hydrocolloid dressing	1	Motta et al. (1999)
9	Collagen vs. hydrocolloid dressing	1	Graumlich et al. (2003)
10	Debrisan vs. Eusol and paraffin dressings	1	Nasar et al., 1982
11	Growth factors versus placebo	2	Robson et al. (1999) Robson et al. (2000)
12	Transparent moisture vapour permeable dressing versus gauze tape	1	Sebern et al. (1986/9)

Seven (33%) full economic evaluations were reviewed together with 14 (67%) partial economic evaluations. Eleven studies (52%) were conducted in the US, three in the UK and three in Spain (14% each), and one in Germany, Korea, Japan and the Netherlands (5% each). Twelve different treatment comparisons were made and may be grouped as presented in Table 6. Companies who supply pressure ulcer treatments funded most studies. Reviews of the groups of different treatment comparisons follow.

#### **Hydrocolloid dressings versus moist gauze dressings**

Eight economic evaluations comparing hydrocolloid dressings to saline gauze dressings were reviewed including three full economic evaluations (Harding et al., 2000/1; Kerstein et al., 2001; Ohura et al., 2004) and six partial economic evaluations (Aguilo Sanchez, 2001; Capillas Perez et al., 2000; Colwell et al., 1993; Gorse et al., 1987; Kim et al., 1996; Xakellis et al., 1992).

Aguilo Sanchez et al. (2001)<sup>iii</sup> conducted a cost-consequence analysis based on data obtained from an RCT conducted in a hospital in Spain (see data extraction table 1, Appendix A). It is not clear from the abstract how long patient follow-up was. The effectiveness measure reported was the number of patients whose pressure ulcers were completely healed. Twenty (57%) pressure ulcers were completely healed in the hydrocolloid dressing compared to ten (29%) in the saline-moistened gauze group.

The daily cost of treatment, based on the cost of materials and nursing time, was Pta 180.50 (price year not stated) and Pta 209.36 for the hydrocolloid dressing compared to the saline-moistened gauze treatment. It is not clear how the daily cost of treatment was calculated since this could be the cost per day or the cost per day until complete heal of the ulcer. It appears that the hydrocolloid dressing is more effective and associated with lower costs (if indeed the daily cost of treatment takes length of time to heal into account). However, this needs verification before asserting that the hydrocolloid dressing was found to be more cost-effective. No statistical analyses or sensitivity analyses were conducted to assess uncertainty associated with the cost and effect estimates across the two groups.

Capillas Perez et al. (2000) also conducted a cost-effectiveness analysis based on an RCT conducted from the perspective of the district health authority in Spain (see data extraction table 5, Appendix A). The two effectiveness measures assessed were time to cicatrise an initial 1cm<sup>2</sup> wound and proportion of surface healed daily. The median nurse time to cicatrise an initial 1cm<sup>2</sup> pressure ulcer was 7.12 (first quartile 5.33 to third quartile 11.0) days compared to 12.18 (5.85 to 39.38) days for the hydrocolloid and saline gauze groups respectively. The median proportion of surface area healed daily was 1.42% (0.56% to 2.5%) versus 1.19% (0.59% to 1.55) for the hydrocolloid and saline gauze groups respectively. Neither difference was statistically significant.

Costs were calculated based on use of materials and nursing time. The median cost (1st and 3rd percentiles) of the cicatrisation of an initial 1cm<sup>2</sup> pressure ulcer was Pta 4,388 (1,808 to 7,539) (no price data available) compared to Pta 17,983 (6,521 to 87,798) and this difference was found to be statistically significant. Average cost-effectiveness rather than incremental cost-effectiveness was presented. However, it

---

<sup>iii</sup> *This review is based on an NHS EED abstract (NHS CRD, 2001). The original paper was written in Spanish.*

appears that hydrocolloid is cost-saving and is associated with better outcomes, dominating the saline gauze intervention.

It is worth noting that patients were allocated to intervention sequentially, which is not a truly random method of allocation. The effectiveness estimates were based on intermediate outcomes rather than final outcomes (pressure ulcer healed). Median costs were reported whereas, from the economics perspective, mean costs are the most appropriate and informative type of costs to report. The advantage of reporting the mean is the ability of parametric tests to make inferences about the arithmetic mean that is useful for budgetary purposes (Barber and Thompson, 1998)

Colwell et al. (1993) conducted a cost-consequence analysis based on an RCT conducted from the hospital perspective in the US (see data extraction table 6, Appendix A). Patients were followed up between six and 56 days (mean 17) and the outcome assessed was the proportion of pressure ulcers healed. Twenty-two percent (n=11) of pressure ulcers healed in the hydrocolloid group compared to two percent (n=1) in the moist gauze group. The total average cost (including cost of materials and nurse time) per patient was \$53.68 (no price date) versus \$176.90 for the hydrocolloid versus the gauze group. It appears that the hydrocolloid dressing costs less and is associated with better outcomes, dominating the moist gauze intervention.

A few caveats should be mentioned alongside the study results. The authors randomised by pressure ulcer rather than by patient and some patients had more than one pressure ulcer, both of which were included in the study. This method can introduce bias, for instance if the ulcers are allocated to different treatments then it may be difficult to remember to treat each differently. Also there may be something particular about the patient which impacts on the findings and this undermines the randomisation process. There were statistically significantly more grade 2 pressure ulcers allocated to the hydrocolloid treatment and these types of ulcers tend to have better healing characteristics than grade 3 pressure ulcers, potentially advantaging the hydrocolloid treatment.

Harding et al. (2000/1) conducted a cost-effectiveness analysis of saline-moistened gauze compared to two hydrocolloid dressings (Comfeel and Granuflex) (see data extraction table 9, Appendix A). The analysis was based on a probability based decision model, utilising data from the published literature and informed by expert opinion. The perspective of the analysis was the UK NHS. The effectiveness estimate was the proportion of pressure ulcers healed in 12 weeks and a meta-analysis was undertaken to pool data from 15 studies for use in the model. The proportion of pressure ulcers healed at 12 weeks in the saline-moistened gauze group was 51% compared to 48% in the hydrocolloid Comfeel group and 61% in the hydrocolloid Granuflex group. The average cost per patient healed (with costs including materials,

ancillary supplies, nursing and doctor debridement) was £2,663, £642 and £422 (1999 prices) for saline-moistened gauze, hydrocolloid Comfeel and hydrocolloid Granuflex respectively. Thus hydrocolloid Granuflex appears to be the most cost-effective option.

Although the unit cost of gauze treatment was lower than the unit cost of either hydrocolloid dressing, the total cost associated with the gauze treatment was highest due to higher nurse input. As the authors state, nurse time is the single most expensive cost for each treatment. The use of cost per wound healed does not take the length of time to healing into consideration. The assumptions and use of expert opinion on resource use and effectiveness were not described in a very transparent way. Incremental cost-effectiveness analysis was not undertaken.

Kerstein et al. (2001) also conducted a cost-effectiveness analysis, using a similar approach to Harding et al. (2000/1)<sup>iv</sup>, comparing saline-moistened gauze to two hydrocolloid dressings (Comfeel and DuoDERM<sup>v</sup>). It was based on a probability based decision model, utilising data from the published literature and informed by expert opinion. However, the perspective of the analysis was different since the Kerstein et al. (2001) study was based on a US hypothetical managed care plan setting. The effectiveness results were identical but the cost estimates were estimated using US resource use and costs. In terms of results, the average cost per patient healed (with costs including materials, ancillary supplies, nursing and doctor debridement) was \$2,179 (2000 prices), \$1,267 and \$910 for saline-moistened gauze, hydrocolloid Comfeel and hydrocolloid Granuflex respectively. The hydrocolloid DuoDerm dressing appeared to be the most cost-effective option. The same limitations as the Harding et al. (2000/1) study apply.

Kim et al. (1996) conducted a cost-consequence analysis based on an RCT undertaken in Japan (see data extraction table 11, Appendix A). The length of follow-up was not stated. Effectiveness measures included in the study were proportion of pressure ulcers completely healed, time to complete heal and rate of pressure ulcer heal. A total of 80.8% of pressure ulcers in the hydrocolloid group and 77.8% of pressure ulcers in the gauze group healed completely, and the difference between the two groups was not statistically significant. The time to complete heal was 18.9 days versus 24.3 days for the two comparators and the pressure ulcer healing speed was 9.1mm<sup>2</sup> per day and 7.9 mm<sup>2</sup>/day for the hydrocolloid and the gauze group respectively.

---

<sup>iv</sup> Based on the results it appears the Harding and the Kerstein study may be using the same data, however the perspective of the analysis differs.

<sup>v</sup> DuoDerm is the US brand name equivalent of the Granuflex UK brand name

The average cost of the interventions was Won 8,204 (+/-2,664) and Won 14,571 (+/-6,700) (no price date) for the two comparators respectively ( $P < 0.05$ ). It appears that the hydrocolloid dressing is more cost-effective than the gauze dressing with lower associated costs and better effects. However, in general, little detail was provided on methods used to conduct the evaluation so it is not clear as to the validity and reliability of the results. The costs calculated did not take the cost of staff into account, which seems an important omission based on results from the evaluations above.

Ohura et al. (2004) undertook a cost-effectiveness analysis of hydrocolloid DuoDERM dressing with a standardised wound management algorithm, traditional care of ointment and gauze with a standardised wound management algorithm and traditional care of ointment and gauze without a standardised wound management algorithm (see data extraction table 17, Appendix A). The study was based on a multi-centre, non-randomised trial in Japan and considered grade 2 and 3 pressure ulcers over a follow-up period of 12 weeks maximum. Effects were measured in terms of the Pressure Ulcer Status Tool (PSST), with greater reductions in PSST being associated with greater health benefits achieved, and costs were based on use of materials and labour time.

The hydrocolloid dressing was associated with a 11.1 point reduction in PSST compared to a 6.9 point reduction for gauze with standard management and a 9.0 reduction in PSST for the gauze without standard management comparator. The reduction was statistically different when comparing the first two of these interventions. In terms of costs across the three treatments, the average total cost was Yen 87,715, Yen 131,283 and Yen 200,584 (2001 prices). The difference in the cost of the hydrocolloid treatment compared to the gauze without the standardised wound management strategy was as statistically significantly different as when materials and total labour costs were analysed separately.

Across all pressure ulcers, the PSST unit difference per Yen was 0.127 for the hydrocolloid dressing compared to 0.045 for gauze without standardised wound management and 0.052 for gauze with standardised wound management. In terms of cost-effectiveness, based on these results the hydrocolloid dressing dominates with lower associated costs and higher associated outcomes.

The Ohura et al. study (2004) was based on a multi-centre clinical trial. No tests were undertaken to assess variation across study centres. Patient allocation to groups was non-random. Limited statistical testing was undertaken to explore uncertainty with no sensitivity analysis being conducted to assess the robustness of findings to variables included in the analysis. The generalisability of these results is unclear. Unlike the

large majority of other studies, the cost of doctors' time was included which was a high-cost input. Costs were not reported separately from resource use.

Xakellis et al. (1992) conducted a cost-consequence analysis of hydrocolloid dressings compared to non-sterile saline gauze dressings, based on an RCT in a long-term care setting in the US (see data extraction table 21, Appendix A). The study period was 21 months and study endpoints included pressure ulcer heal, progression to stage 4 pressure ulcer, doubling in pressure ulcer area, systemic infection from the pressure ulcer, no decrease in size of the pressure ulcer at two months and six months of treatment, patient discharge from the long-term care facility and death.

Effectiveness was measured in terms of proportions of pressure ulcers completely healed, time to healing and healing rates. Eighty-nine percent (n=16) of pressure ulcers were completely healed in the hydrocolloid group compared to 86% in the comparator group. The median time to healing after randomisation was nine days for hydrocolloid group and 11 days for the gauze group and this finding was not statistically significantly different. Seventy-five percent of pressure ulcers healed within 14 days in the hydrocolloid group compared to the 26 days in the gauze group. After adjusting for exudates present at baseline, healing rates were not statistically significantly different across groups although the trend was towards slower healing in the gauze group.

The cost of use of materials and nurse time was assessed and the median total cost per patient was \$15.58 (1990 prices) for the hydrocolloid group and \$22.65 for the gauze group if local nurse wages were used, and the difference was not statistically significant. If national nurse wages were used, the median total cost was \$15.90 and \$25.31 respectively ( $p=0.04$ ). Overall, the hydrocolloid was less costly and associated with greater health effects, hence it appears to be the more cost-effective option.

The authors reported median costs and conducted statistical tests based on non-parametric techniques, rather than mean costs and, as mentioned above (see review of Capillas Perez et al. (2000)), this makes findings difficult to interpret.

### **Overview of hydrocolloid dressings versus moist gauze dressings**

Although there were a number of limitations associated with all the economic evaluations comparing hydrocolloid dressings to moist gauze dressings, typically hydrocolloid dressings were found to be the more cost-effective option.

### **Hydrocolloid dressings versus Dakin's solution (chloramines-T)-soaked wet-to-dry dressings**

Gorse et al. (1987) (see data extraction table 7, Appendix A) conducted a cost-consequence analysis comparing hydrocolloid dressing with Dakin's solution (chloramines-T)-soaked wet-to-dry dressings in a hospital in the US. Patient follow-up was from initiation of conservative treatment until healing, hospital discharge or failure of the initial intervention. However, the time in days was not stated.

Effectiveness was measured in terms of the rate of healing for each pressure ulcer healed: that is the initial surface area divided by the number of days until complete healing. If patients died or were discharged before complete healing, the surface area at the last examination was subtracted from the initial surface area, and the results divided by the number of treatment days. In the hydrocolloid dressing group, 86.8% of pressure ulcers improved compared to 69.2% in the wet-to-dry dressing group. The number of days to complete heal for pressure ulcers that healed was 10.0 (+/-10.5) in the hydrocolloid group compared to 8.7 (+/-6.2) for the wet-to-dry dressing group. The rate of decrease (cm<sup>2</sup> per day) for pressure ulcers that healed was 0.72 (+/-1.22) compared to 0.55 (+/-0.59) for these groups respectively and this result was not statistically significantly different. Among the incompletely healed pressure ulcer group, the duration of follow-up was significantly longer for the wet-to-dry group but the rate of decrease in surface area was not significantly different. Among the pressure ulcers that worsened, a higher rate of increase in surface area was found in pressure ulcers treated in the hydrocolloid group compared to the wet-to-dry group.

Based on treatment costs alone, a cost of \$6.20 per week was estimated for treating each pressure ulcer in the hydrocolloid group compared to \$52.50 per week in the wet-to-dry dressing group. Costs associated with the hydrocolloid dressings were lower and more pressure ulcers healed in this group compared to those treated with wet-to-dry dressings, and on this basis the former appears to be the more cost-effective option, dominating wet-to-dry dressings.

The cost analysis undertaken as part of this study was particularly weak. As noted above, the cost of nursing time can be substantial but these costs were omitted. Also, the cost was not examined until time to heal or according to any other effectiveness measure. Some patients had more than one pressure ulcer that was entered into the trial and this could bias the results. The allocation of patients to interventions was not random. The uncertainty associated with the estimates was only assessed statistically for the effectiveness dimension of the study.

### **Hydrocolloid dressings versus hydrocellular dressings**

Bale et al. (1998) conducted a cost-consequence analysis comparing hydrocolloid dressings to hydrocellular dressings (see data extraction table 2, Appendix A). The study was based on an RCT and the perspective of the analysis was the NHS. Patient follow-up was for a maximum of eight weeks. The effectiveness measure reported was the proportion of pressure ulcers healed completely at eight weeks. In this time, 59% of pressure ulcers healed in the hydrocolloid dressing group compared to 27% of the pressure ulcers in the hydrocellular dressing group.

Costs were based on materials and nursing time. The total cost of treatment per patient, whether their pressure ulcer had healed or not, was £50 in the hydrocolloid group and £76 in the hydrocellular group. A number of one-way sensitivity analyses were undertaken, including varying the costs applied if withdrawn before eight weeks, but did not alter the findings. Since more pressure ulcers healed in the hydrocolloid group and the daily cost of treatment was lower, it appears that hydrocolloid dressings may be the more cost-effective option.

There are a few study limitations that should be considered when interpreting the results. The cost of labour time, typically an important contributor to overall cost, was omitted. Some patients were withdrawn from the study (the authors do not say in which wound group they were). More patients were withdrawn from the hydrocellular group and this could bias results in favour of this group. Across all wounds, at seven weeks the numbers of wounds healed was very similar across groups but comparative data was not presented on pressure ulcers at seven weeks.

### **Gauze versus impregnated gauze versus calcium alginate versus hydroactive wound dressing in combination with enzymatic wound cleaning collagenase versus hydroactive wound dressing in combination with enzymatic wound cleaning collagenase during the first seven days of treatment**

Bergemann et al. (1999) conducted a cost-consequence analysis to compare five different interventions used in four hospitals in Germany (see data extraction table 3, Appendix A). A spreadsheet model was constructed, informed by an expert panel, and data to populate it were obtained using the hospital databases. The treatment of four sizes of pressure ulcers were considered: (i) 5cm x 8cm (ii) 8cm x 12cm (iii) 10cm x 15cm and (iv) 12cm x 20cm. It was assumed that the bigger the wound, the longer the treatment duration required. Equal efficacy was assumed or a decrease in the length of hospital stay of 10% for the two hydroactive treatments.

Resource use estimates were assumed to vary across wound surface areas, as informed by the expert panel. Costs were based on materials used and nurse time to

provide pressure ulcer care. Cost savings of between DM1,138 (DM538 to 1739) for the first hydroactive treatment compared to the impregnated gauze treatment and DM8,234 (DM4610 to DM 11,858) for the first hydroactive treatment compared to gauze only were found. Two-way sensitivity analysis was undertaken on the total costs associated with each intervention as well as the following parameters used to calculate costs (personnel costs per minute, time required to change a dressing, total number of wound dressing changes) and results remained fairly robust. Monte Carlo simulation was used to estimate the variation in inputs into the model (95% CI). The main finding was that, despite the higher material costs of the two hydroactive therapies, the reduced labour costs, due to quicker time to heal and reduced duration of treatment or time to inpatient discharge that were assumed, resulted in lower total costs relative to the three comparators.

The model assumed that use of the hydroactive treatments reduced inpatient stays by 10% but the evidence on this is not strong. Pressure ulcers were followed in the model not only until they had healed but sometimes, instead, until inpatient discharge: hence the pressure ulcer may remain unhealed and this does not fully take into account effectiveness. It is unlikely that all treatments are equally efficacious. Length of hospital stay was considered to be a proxy for health effect, however; this was incorporated within the cost estimates.

### **Collagenese ointment versus hydrocolloid dressings**

Burgos et al. (2000) conducted a cost-effectiveness analysis of collagenese ointment compared to hydrocolloid occlusive dressings (see data extraction table 4, Appendix A). The study was a multi-centre RCT conducted in Spanish hospitals. Patients were followed up for 12 weeks or until complete pressure ulcer heal, whichever occurred first. Reduction in pressure ulcer area was used as the measure of effect. The mean (standard deviation) reduction in pressure ulcer area in the collagenese group was 9.1 (1.2) cm<sup>2</sup> compared to 6.2 (9.8) cm<sup>2</sup> in the hydrocolloid group, an area reduction of 44% and 28% respectively. The pressure ulcer area decreased in 83% of cases in the collagenese group compared to 74% in the hydrocolloid group after twelve weeks of follow-up and these differences were not statistically significant. Pressure ulcers were completely healed for three patients in each group.

Resource use assessed were treatment supply, including ancillary supplies, and nurse time. Collagenese group pressure ulcers cost Pta 41,488 (95%CI: Pta 26,191-Pta 56,784) (price year 1998) compared to Pta 32,963 (95%CI: Pta 23,389-Pta 42,538) for the hydrocolloid dressing group and the difference was not statistically significant. The total cost per 1cm<sup>2</sup> reduction in pressure ulcer was Pta 4,559 for the collagenese group and Pta 5,310 for the hydrocolloid group. The cost per reduction in

pressure ulcer area was lower for the collagenese group, and on this basis it appears to be the more cost-effective option. Material costs were very similar but the total cost of collagenese tended to be higher than hydrocolloid dressings due to greater staff input. There was no allowance for across site differences.

Muller et al. (2001) also conducted a cost-effectiveness analysis comparing collagenese with hydrocolloid dressings (see data extraction table 15, Appendix A). The analysis was based on an RCT conducted in a hospital in the Netherlands. Effectiveness measures used included whether or not the ulcer was successfully treated (that is if the pressure ulcer was completely healed), the rate of complete wound healing and the average number of weeks required until pressure ulcer healing was achieved. In the collagenese group, 91.7% (11/12) patients were successfully treated compared to 63.6% (7/11) patients in the hydrocolloid group and this finding was statistically significant ( $p < 0.005$ ). The time to pressure ulcer heal was shorter for the collagenese group at, on average, 10 weeks compared to 14 weeks ( $P < 0.005$ ).

Resource use measured use of materials used and labour time, including doctor and nurse time. The average cost per patient of collagenese was NLG1,615.8 compared to NLG1,692.7 for the hydrocolloid dressings (price year 1998). The cost per successfully treated patient was NLG1,762.0 for collagenese compared to NLG2,661.4 for hydrocolloids, therefore the former appears to be more cost-effective with lower associated costs and better effects. A deterministic model and one-way sensitivity analysis and a probabilistic model using Monte Carlo simulation were conducted to explore uncertainty associated with the estimates. In all scenarios, collagenese remained the more cost-effective treatment. The assumption of the independency of model inputs is questionable. Average cost-effectiveness rather than incremental cost-effectiveness was reported. Two patients, one in each group, had two pressure ulcers (on the heel) but it was not mentioned which pressure ulcer (the pressure ulcers would be likely to differ) was included in the study.

### **Overview of collagenese ointment versus hydrocolloid dressings**

The two studies comparing collagenese ointment with hydrocolloid dressings were full economic evaluations based on RCTs and were of moderate quality. Both economic evaluations suggested that collagenese is more cost-effective than hydrocolloid dressings. Neither study was conducted in the UK and currently, collagenese is not licensed for use in the UK.

### **Semi-permeable polyurethane foam dressings versus moist saline gauze dressings**

Kraft et al. (1993) conducted a cost-consequence analysis comparing the use of semi-permeable polyurethane foam dressings to moist saline gauze dressings in stage 2 and 3 pressure ulcers (see data extraction table 12, Appendix A). The study was conducted in the US and was based on an RCT conducted in a long-term hospital care spinal cord injury centre. The effectiveness measure chosen was the proportion of patients with completely healed pressure ulcers. At 24 weeks, the follow-up duration, 42% (n=10) of pressure ulcers were healed in the semi-permeable polyurethane foam dressing group compared to 21% (n=3) in the gauze group. However this difference was not statistically significant. Treatment supply and nurse time was costed and the average total cost per week was \$20.48 for the foam dressing group and \$74.97 for the gauze dressing group.

Although costs and outcomes were not synthesised in the study more pressure ulcers were healed in the foam dressing group and the daily cost of treatment was lower, therefore this appears to be the more cost-effective option, dominating the gauze treatment option. The methods used to conduct the study were not written up in much detail so critical appraisal is a challenge. Some patients withdrew from treatment (two in the foam dressing group) but no reason for their withdrawal was provided. The cost analysis was not strong because only weekly costs per pressure ulcer treated were provided. The total cost of treatment to, say, time to complete heal, was not calculated. The length of time that the treatment is received can make a difference to the total cost of treatment.

### **Autolysis compared to either wet-to-dry saline, collagenase or fibrinolysin**

Mosher et al. (1999) conducted a cost-consequence analysis from the third party payer (Medicare) perspective in the US (see data extraction table 13, Appendix A). A decision analytic model was used and effectiveness data was obtained from the literature and expert opinion. Median values of experts gained were used as probabilities in the decision model.

The patient being studied was a hypothetical 78-year-old female in a long-term care facility who had not been hospitalised in the prior 12 months. She has a new full-thickness pressure ulcer on her trochanter with 50% necrotic tissue (eschar) covering the ulcer, mild odour, minimal draining, no undermining and intact peri-ulcer skin. A modified Delphi approach was used to reach consensus on critical treatment choices and possible outcomes. The effectiveness measure chosen was the probability of obtaining a clean wound bed for each 28-day treatment of the hypothetical treatment. Resource use measured included drugs, dressing and irrigation supply, doctor visits,

ancillary services (for example outpatient laboratory tests), hospitalisation and associated resource use.

The probability of a clean wound bed was estimated to be 0.887 (87%) for collagenase, 0.641 for autolysis, 0.376 for wet-to-dry saline and 0.449 for fibrinolysin. The total cost per patient for 28 days was \$610.96 (1995 prices) for collagenase, \$920.73 for autolysis, \$986.38 for fibrinolysin and \$1008.72 for wet-to-dry saline. Probabilistic sensitivity analysis was conducted to investigate parameter uncertainty and when all parameter inputs were varied by –10% and +10% the results remained robust. It appears that collagenase was the most cost-effective option for the management of pressure ulcers in long-term care based on the study findings.

The quality of the literature review process and the elicitation of expert opinion was not clear. The authors note that the probability data was non-normally distributed and non-random.

### **Synthetic polymer versus hydrocolloid dressings**

Motta et al. (1999) conducted a cost-consequence analysis based on pilot, RCT undertaken in the US and hence the sample size was small (n=10, 5 in each group) (see data extraction table 14, Appendix A). They compared a synthetic polymer dressing with a hydrocolloid dressing in home health care patients who were followed up for eight weeks.

Effectiveness measures included healing rates, adverse reactions and product performance (based on exudate performance, whether the dressing maintains a moist environment, promotes autolytic debridement and its overall clinical performance marked out of 1 to 5 with 1 being most favourable and 5 being least favourable). Two pressure ulcers in each group completely healed and all other pressure ulcers demonstrated substantial reductions in size. The overall healing rates were not statistically significantly different. No adverse reactions occurred and the overall performance of the interventions was assessed based on the average score obtained during dressing change for each parameter. No statistically significant differences were found.

Dressings and ancillary supplies and nurse time was costed. The total cost of treatment over eight weeks was \$57.76 (no price date was given) for the synthetic polymer group and \$91.48 for the hydrocolloid dressing group. Since the same number of pressure ulcers healed across groups, if this was taken as the measure of effect, then it appears that the synthetic polymer may be cost saving compared to the

hydrocolloid dressing. The sample size was small and it is questionable as to whether the results are generalisable to other settings.

### **Collagen versus hydrocolloid dressings**

Graumlich et al. (2003) conducted a cost-consequence analysis to compare topical collagen with hydrocolloid dressings (see data extraction table 8, Appendix A). The study was based on a multi-centre RCT of patients with grade 2 or 3 pressure ulcers in nursing homes in the US and the patients were followed up for eight weeks maximum (median of five weeks). Effects measured included the proportion of pressure ulcers completely healed within eight weeks and secondary outcomes including time to heal, ulcer area healed per day and linear healing of wound edge. Fifty-one percent of pressure ulcers were healed within eight weeks in the collagen group compared to 50% in the hydrocolloid group (95% CI: - 26% to 29%). The mean healing time in the topical collagen group was five weeks (95% CI: 4 to 6 weeks), and for the hydrocolloid group it was six weeks (95% CI: 5 to 7 weeks). The mean area healed per day was 6mm<sup>2</sup> in both groups and the mean linear healing of the wound edge was 3mm for both groups.

Treatment supply, including ancillary supplies and nurse time, was measured in order to calculate costs. The average cost per patient pressure ulcer over eight weeks was \$627.56 (no price date) for topical collagen and \$222.36 for the comparator.

Statistical tests to compare findings across groups were undertaken. There were no statistically significant differences in the healing outcome across groups. Topical collagen was considerably more expensive and offered no major benefits to patients otherwise eligible for hydrocolloid dressings. As the authors state, no analysis was undertaken to adjust for the heterogeneity in healing outcomes identified across nursing homes. The cost analysis was not strong and quantities of resources used was not reported separately from unit costs.

### **Debrisan versus Eusol and paraffin dressings**

Nasar et al. (1982) conducted a cost-effectiveness analysis based on an RCT in a hospital in the UK (see data extraction table 16, Appendix A). Patients were followed up until the pressure ulcer was clear and granulating, and appeared to be less than 25% of its original surface area. For the Debrisan group six out of eight pressure ulcers healed in approximately 39.3 days. One other patient died and one patient withdrew from treatment. For the Eusol group, five out of eight pressure ulcers healed in approximately 62 days. Three patients were switched to Debrisan. Resources measured to calculate costs included use of materials and ancillary supplies and hospital stay. The average cost of a pressure ulcer that healed was £1053.05 (price year not stated) for the Debrisan group and £1667.00 for Eusol group. Overall the

Debrisan cost less and was associated with a higher number of pressure ulcers healed compared to Eusol.

In summary, Debrisan appears to be more cost-effective than Eusol, costing less and being associated with a faster time to heal, for those pressure ulcers that healed. It is worth noting that some patients had more than one pressure ulcer entered into the trial, the actual length of patient follow-up was not stated and costs only related to those patients whose pressure ulcers had healed.

### **Growth factors versus placebo**

Robson et al. (1999) conducted a cost-consequence analysis, based on a 16-week long RCT in a hospital in the US (see data extraction table 18, Appendix A). They compared Recombinant human platelet-derived growth factor-BB. (1) 100 µg rhPDGF-BB per day with (2) 300 µg rhPDGF-BB per day, (3) 100 µg rhPDGF-BB twice daily and (4) placebo.

The effectiveness measure used to compare treatments was wound volume decrease over time. Four surgeons, who were blind to patients, assessed changes in the ease of surgical closure of pressure ulcers on a scale from 0 (no need to close, healed) to 13 (not possible to close) based on photographs of pressure ulcers which were taken from a set focal distance and which were obtained weekly. Ninety-four percent of the maximum number of photographs possible were available for rating. At the end of the trial, the pressure ulcers of patients in group one were rated to have improved by six points (mean) on the scale from beginning to end of treatment. For group 2 and 3 patients, the mean pressure score assigned was five points compared to four points assigned to pressure ulcers in the placebo group. All outcomes were statistically significantly improved from their respective starting ease of closure scores of 10 ( $p < 0.0001$ ).

In terms of cost, the change in difficulty of wound closure was studied in relation to the composite cost including surgeon's fee, anaesthesia fee and operating room cost. Costs were arrived at from charges to patients at two university centres. The range of costs was \$100 (no price date was stated) for a single-buttressed suture placed at the patient's bedside to \$12,000 for a difficult musculocutaneous or free flap. At the beginning of the trial, the mean and median cost of closure was estimated at \$8,000 per pressure ulcer as they were rated as requiring a somewhat easy pedicle flap procedure to close the wound. At the end of the trial, according to the raters, group 1 required a difficult direct wound application costing \$800 to \$1,000 (a cost saving of \$7,000 to \$7,200), compared to an easy skin graft for pressure ulcers in group 2 and 3 costing \$1,200 (a cost saving of \$6,800). For the placebo group a slightly more

difficult procedure was recommended costing \$1,700 (a cost saving of \$6,300). The cost savings were statistically significantly different even though 100% wound closure was not routinely achieved.

Based on the results, it appears that the growth factor received by group 1 was more cost-effective than that recommended to patients with pressure ulcers in groups 2 and 3 that, in turn, were more cost-effective than placebo. Statistical tests on effectiveness and costs were undertaken but the results of the latter were not reported. It is worth noting that the analysis assumes that pressure ulcers would have otherwise been closed via surgical techniques, a very costly intervention. The costs of the surgical interventions were given but no further details were provided. In an attempt to explore uncertainty, the authors tested the correlation between the ease of closure scale and the wound area, as photographs are only two-dimensional. Results of the clinical trial are provided in another paper.

Robson et al. (2000) also conducted another study using cost-consequence analysis (see data extraction table 19, Appendix A). The study was based on an RCT in a hospital in the US (see data extraction table 18, Appendix A). The interventions compared were cytokine growth factors: (1) 2.0 µg/cm<sup>2</sup> GM-CSF therapy topically applied daily for 35 days (2) 5.0 µg/cm<sup>2</sup> bFGF therapy applied daily for 35 days (3) 2.0 µg/cm<sup>2</sup> GM-CSF applied for 10 days followed sequentially by 25 days of topically applied 5.0 µg/cm<sup>2</sup> bFGF and (4) placebo applied daily for 35 days. Patients with grade 3 or 4 pressure ulcers were followed up for 35 days (five weeks). Effectiveness measures included the wound volume decrease over time. Surgeons rated changes in ease of surgical closure on a scale from (0) (no need to close, healed) to (13) (not possible to close) based on photographs of pressure ulcers at a set focal distance. An arbitrary response rate of at least 85% wound closure during 35 days of follow-up was chosen as indicative of a responder.

In terms of effectiveness, there were no differences in mean proportion of initial pressure ulcer volume remaining on day 36 across all interventions. However (2) had a trend toward greater pressure ulcer closure. The proportion of patients responding was statistically significantly higher for all cytokine therapies compared to placebo (4) ( $p=0.03$ ), with (2) patients doing best. The median ease of closure for all four groups was 11 on day 0. Group (2) patients' pressure ulcers had improved seven points on the ease of closure scale. Group (3) patients improved five points, group (1) patients improved four points and group (4) patients improved three points.

Resource use on the amount of topical substance each week of treatment was based on volumetrically-determined surface area at baseline and on study days 7, 14, 21,

28. The change in difficulty of pressure ulcer closure in relation to total cost (surgeon's fee, anaesthesia fee and operating room cost) was calculated. At the beginning of the trial, the median cost of closure was estimated at \$10,000 (no price date) per pressure ulcer. At the end of the trial, patients' pressure ulcers in group (2) were recommended to be healed by a difficult wound approximation costing \$800 to \$1,000 (a cost saving of \$9,000 to \$9,200). For patients' pressure ulcers in group (3), the rates recommended patients would require a somewhat easy skin graft costing \$1,700 (cost saving of 8,300). For group (1) a somewhat difficult procedure was required costing \$2,200 (cost saving of \$7,800). For group (4) pressure ulcers could be closed for \$3,000 (cost-saving of \$7,000). It appears that cytokine (1) was the most cost-effective strategy.

The cost analysis was not strong and the uncertainty around cost estimates for surgical procedures was not explored. A major assumption on which the analysis was based is the assumption that pressure ulcers would have otherwise been closed via surgical techniques. Assessment of inter-rater reliability, using the ease of closure scale, was not undertaken.

#### **Transparent moisture vapour permeable dressing versus gauze and tape**

Sebern et al. (1986/9) conducted a cost-consequence analysis to compare transparent moisture vapour permeable (TMVP) dressing to gauze and tape (see data extraction table 20). An RCT was conducted using a sample of patients using home care that was served by a metropolitan visiting nurse association in the US. Patients were followed up for eight weeks and effect measures used included their healing status at eight weeks (whether their pressure ulcer had healed, was progressing towards healing, was unchanged, they discontinued treatment or their ulcer deteriorated). Additionally, healing rates and patient comfort was considered. Of the grade 2 pressure ulcers in the TMVP group 64% (n=14) healed compared to none in the gauze and tape group. For grade 3 pressure ulcers there was no significant difference between the two groups and no further details were provided. In terms of healing rates, grade 2 pressure ulcers in the TMVP group had a 52% median decrease in area of the wound compared to 100% median decrease in the gauze group ( $P < 0.01$ , Wilcoxon). For grade 3 pressure ulcers, in the TMVP group, there was a 67% median decrease in pressure ulcer size compared to a 44% decrease in the gauze group but this finding was not statistically significant. Patients who had intact sensory input from their pressure ulcers reported less pain when the TMVP treatment was used.

Resource use assessed included treatments and nurse time. The mean eight-week treatment costs per grade 3 pressure ulcer was \$1470 for the TMVP group and \$1412 for the gauze group and this difference was not statistically significant. It appears that

TMVP was slightly more costly per pressure ulcer for the TMVP strategy; however, effects across the two interventions differed depending on the grade of the pressure ulcer and the effectiveness measure considered. There was no difference in outcome for grade 3 pressure ulcers; however, this may be due to type 2 error<sup>vi</sup>. Authors incorrectly re-graded pressure ulcers at the end of the study. The authors randomised by pressure ulcer rather than by patient and that can introduce bias. The variance associated with cost estimates was not reported and the statistical tests applied to costs were non-parametric when they should be parametric.

Level of evidence	Evidence statement
1++	There is insufficient evidence to indicate which dressing/s are the most effective in the treatment of pressure ulcers.
2-	<p><b>Economics evidence</b></p> <p>Although there were a number of limitations associated with all the economic evaluations comparing hydrocolloid dressings to moist gauze dressings, typically hydrocolloid dressings were found to be the more cost-effective option.</p>

## Recommendations: dressings and topical agents

Decisions about choice of dressing or topical agent for those with pressure ulcers should be made by registered health care professionals. **[D]**



<sup>vi</sup> The probability of failing to reject the null hypothesis when the latter is false. This probability becomes smaller with increasing sample size. The greater the probability of type 2 error, the weaker the power of the study to detect differences as statistically significant when such differences exist.

Choice of dressings or topical agents for the treatment of pressure ulcers should be based on: **[D]**

- ulcer assessment (condition of wound)
- general skin assessment
- treatment objective
- dressing characteristics
- previous positive effect of particular dressing
- manufacturer's indications for use and contraindications
- risk of adverse events, and
- patient preference (lifestyle, abilities and comfort).



There is insufficient research evidence to guide clinicians' decision making about which dressings are most effective in pressure ulcer management. **[A]** However professional consensus recommends:

Create the optimum wound healing environment by using modern dressings – e.g. hydrocolloids, hydrogels, hydrofibres, foams, films, alginates, soft silicones) in preference to basic dressing types – e.g. gauze, paraffin gauze and simple dressing pads. **[D]**



## **Debridement**

Clinicians should recognise the positive potential benefit of debridement in the management of pressure ulcers. Decisions about the method of debridement should be based on: **[D]**

- ulcer assessment (condition of wound)
- general skin assessment
- previous positive effect of debridement techniques
- manufacturer's indications for use and contraindications
- risk of adverse events
- patient preference (lifestyle, abilities and comfort)
- characteristic of dressing/technique, and
- treatment objective.



Decisions about debridement methods for patients with pressure ulcers should be made by registered health care professionals. **[D]**



	<b>Research recommendations</b>
	<p>The research concerning wound dressings and topical agents is of varied quality.</p> <p>In those trials reviewed, sample sizes were often not sufficient to detect clinically important effects, and poor baseline comparability of the groups introduced bias.</p> <p>Several important messages can be identified for future studies.</p> <ul style="list-style-type: none"> <li>• Recruitment numbers should be based on an <i>a priori</i> sample size calculation. In most trials the sample size is too small to find a statistically significant difference between treatment groups. Multi-centre trials should be considered to recruit sufficient patient numbers. These large trials have been undertaken in other areas of health care and, although the field of wound care presents its own difficulties, there is no reason why such trials should not be successful. If these trials are to be commissioned they will require a strong infrastructure to provide support, promote collaboration and establish a common knowledge base.</li> <li>• A truly objective outcome measure should be used – for example time to complete healing of the wound or wound healing should be expressed as both percentage and absolute change in area.</li> <li>• For each patient a single reference wound should be selected. Multiple wounds on a patient should not be included in the analysis as they are not independent unless specialised statistical analysis is performed to separate out the effects of the intervention – that is matched-pairs analysis.</li> <li>• Experimental groups should be comparable at baseline. In small RCTs, randomisation alone will not achieve comparability; in such situations patients should be paired</li> </ul>

	<p>by prognostically important baseline characteristics and then the individuals of each pair randomised to treatment. Such randomisation is particularly important if ulcers of different aetiologies are to be assessed in the same trial.</p> <ul style="list-style-type: none"><li>• Head-to-head comparisons of modern wound dressings are required and should use agents that are recommended for wounds of a similar nature.</li><li>• A complete and thorough description of concurrent treatments including secondary dressings should be given in trial reports.</li><li>• Assessment of outcomes should be blind to treatment.</li><li>• Survival rate analysis should be adopted for all studies that assess wound healing.</li><li>• Studies to determine the biological mechanisms involved in wound healing are needed. A better understanding of the healing process may lead to the development of validated outcome measures.</li><li>• All trials should be published where possible. Those involved in primary research should make their data available to those undertaking systematic reviews.</li><li>• Future trials should include cost-effectiveness and quality of life assessments, as well as objective measures of dressing performance. These measures would encapsulate those aspects of patient quality of life on which wounds most impact and would be sensitive to meaningful changes in quality of life generated by a change in the wound, including post healing of the wound.</li></ul>
--	--

## 6.5 Antimicrobial agents in the treatment of pressure

### ulcers

The methods described are those used to update the following systematic review:

O'Meara (2001) Systematic reviews of wound care management: (3) antimicrobial agents for chronic wounds; (4) diabetic foot ulceration, Volume 4, number 21.

The role of antimicrobial agents in the treatment of pressure ulcers remains unclear. The lack of clarity is due in part to uncertainty around the issues of whether bacterial presence is an important factor in wound healing. While the results from some studies indicate a positive association between higher bacterial counts and delayed wound healing (Lookingbill, 1978; Halbert, 1992), others show no such association (Eriksson, 1984; Gilchrist, 1989). Clinicians may use systemic antibiotics as a last resort when topical interventions have failed to produce healing (Huovinen, 1994).

Moist chronic pressure ulcers are an ideal medium for bacterial growth. Pressure ulcers may have a varied bacterial flora, with aerobic organisms cultured more frequently than anaerobes. *Staph. aureus*, *Streptococcus* species, *Proteus* species, *Escherichia coli*, *Pseudomonas*, *Klebsiella* and *Citrobacter* species are the most common isolates (Yarkony, 1994; Parish, 1983; Alvarez, 1991). In serious cases, infected pressure ulcers can lead to osteomyelitis and septicaemia (Yarkony, 1994).

#### Antimicrobials in current use

##### *Systemic agents*

Systemic agents fall into four main groups: penicillins, cephalosporins, aminoglycosides and quinolones. There are also several other drugs in use, including clindamycin, metronidazole and trimethoprim.

The penicillins work by interfering with the development of bacterial cell walls and cross-linkages. Broad spectrum agents such as ampicillin and amoxycillin are active against certain Gram-positive and Gram-negative organisms, but are inactivated by penicillinases produced by *Staph. aureus* and *E. coli* (BMA, 1999). Amoxycillin is sometimes used in combination with clavulanic acid (Chantelau, 1996). This combination produces an increased range of activity and is effective against both *Staph. aureus* and *E. coli* (BMA, 1999).

The cephalosporins have a similar action to the penicillins and have a wide range of

activity against both Gram-negative and Gram-positive organisms (BMA, 1999).

The aminoglycosides, such as gentamycin, act by interfering with normal protein synthesis. They have a wide range of action, but are potentially nephrotoxic and ototoxic, and serum levels should be monitored. They are active against the more resilient Gram-negative organisms. They are not absorbed from the gut and systemic administration is therefore by injection (BMA, 1999).

The quinolones, such as ciprofloxacin, prevent the formation of DNA within the cell nucleus. They are active against both Gram-positive and Gram-negative organisms. Ciprofloxacin is licensed for skin and soft-tissue infections, but there is a high incidence of staphylococcal resistance and it is recommended that its use is avoided in methicillin-resistant *Staph. aureus* (MRSA) infections (BMA, 1999).

Clindamycin is active against Gram-positive cocci, including penicillin-resistant staphylococci, and also against many anaerobes. It has an uncommon but serious and potentially fatal side effect, namely antibiotic-associated colitis. Current prescribing guidelines state that therapy should be withdrawn immediately in any patient developing diarrhoea (BMA, 1999). Metronidazole is active against anaerobic organisms (BMA, 1999), and has sometimes been used in combination with other agents, such as ampicillin (Lundhus, 1989). Trimethoprim is commonly used to treat urinary and respiratory tract infections (BMA, 1999), and has been shown to be active against *E. coli* when used to treat these conditions (Minassian, 1998).

### **Topical agents**

Topical agents include antibiotics, antiseptics and disinfectants. Although various definitions exist for these terms, there appears to be a lack of consensus within the literature as to the characteristics of each type of preparation. It has been suggested that both antiseptics and disinfectants destroy micro-organisms or limit their growth in the non-spore or vegetative state. However, antiseptics are usually applied solely to living tissues, while disinfectants may also be applied to equipment and surfaces (Morgan, 1993).

Topical preparations may be divided into two categories, according to their function. One group consists of lotions with antimicrobial properties, used to irrigate or cleanse wounds. These usually have only a brief contact time with the wound surface, unless they are used as a pack or soak. They include the hypochlorites (e.g. Eusol®), hexachlorophene (a constituent of some soaps and other skin cleansers), and substances such as potassium permanganate and gentian violet (both used in solution for skin cleansing).

The second group consists of preparations designed to stay in contact with the wound surface for a longer period of time, ideally until the next dressing change. These include creams, ointments and impregnated dressings. Most topical antibiotics come into this category, and include mupirocin (available as 2% ointment) which has a wide variety of activity, and fusidic acid (available as an impregnated dressing, or ointment, cream or gel, all 2%) for staphylococcal infections. Neomycin sulphate, available as a cream (0.5%) or ointment (0.25%), is used to treat bacterial skin infections. If large areas of skin are treated, ototoxicity is a possible adverse effect. Silver-based products, such as silver sulphadiazine (1% cream and impregnated dressing), have a broad-spectrum action against both Gram-positive and Gram-negative organisms, and also yeasts and fungi (Morison, 1997).

Some products that are available in different forms fall into both categories. These include povidone iodine (available as 10% solution, 10% ointment, 5% cream, 2.5% dry powder spray and impregnated dressing), chlorhexidine (available as 0.05% solution, 5% ointment and medicated tulle dressing; it is also a constituent of skin cleansers), benzoyl peroxide (available as lotions, creams and gels in various strengths) and hydrogen peroxide (available as 3% and 6% solutions and 1% cream) (BMA, 1999).

## **Objectives**

To systematically assess the evidence for the clinical effectiveness of systemic and topical antimicrobial agents in the treatment of existing pressure ulcers.

## **Selection criteria**

### **Types of studies**

Both randomised controlled trials (RCTs) and prospective controlled clinical trials (CCTs) with concurrent controls were eligible for inclusion in this review. For both RCTs and CCTs, the units of allocation had to be patients or lesions. Studies, in which wards or clinics were the units of allocation, were excluded because of the possibility of non-comparability of standard care.

### **Types of participants**

Studies that recruited people with existing pressure ulcers, of any grade or severity,

were eligible for inclusion in the review. The study could be in any setting including hospital, clinic, community facilities or home.

### **Types of interventions**

Trials in which an antimicrobial was compared with another antimicrobial agent, or in which antimicrobial agent(s) were compared with a placebo, usual care, or no treatment, were eligible for inclusion in the review. Trials of antibiotics, antifungal and antiviral agents were all considered. Reports of antibiotic cover used with skin grafting of pressure ulcers and antimicrobials used in conjunction with debriding agents were excluded.

### **Types of outcome measures**

The primary outcome was wound healing. Since some measures of wound healing can be subjective, studies had to incorporate an objective assessment – such as change in ulcer size, rate of healing, frequency of complete healing or time to complete healing – to be included in the review.

Many evaluations of antimicrobial agents focus on microbiological outcomes such as wound cultures, sensitivities of micro-organisms, bacterial counts and bacterial eradication. Studies reporting only these types of results were excluded from this review since these intermediate (surrogate) outcomes have not been shown to be accurate and reliable indicators of healing. Where studies reported both wound healing and microbiological outcomes, only the former were incorporated in the review. Where available, data on adverse effects of interventions were to be included.

### **Search strategy**

Searches were carried out in April 2004 and an update search performed in June 2004. Full details of the search strategies can be found in Appendix B.

### **Methods of the review**

Full details are described in the methods section of this Guideline.

### **Description of studies**

Five eligible randomised trials were identified. Two of the included trials assessed antimicrobial agents on patients with other types of chronic wounds (Della Marchina, 1997; Worsley, 1991) but data relevant to patients with pressure ulcers were able to

be extracted separately and were thus included.

Most of the trials were conducted in either a hospital or an aged-care facility, resulting in most of the enrolled patients being elderly. There was a range of pressure ulcer severity requiring treatment in the included trials.

The period of either the interventions and/or follow-up assessments ranged from about two to 14 weeks. Three of the five included studies used photographic techniques as part of their objective measurement of wound healing.

No eligible trials were identified that assessed the effects of systemic antimicrobial agents in the treatment of pressure ulcers.

A variety of topical interventions were assessed in the included studies. One trial tested the effectiveness of an antiseptic spray (Della Marchina, 1997). Two trials assessed the effects of ointments: Gerding (1992) tested an oxyquinoline-based ointment, while Toba (1997) compared a gentian violet-based ointment with a povidone iodine ointment. Two trials assessed the effects of hydrocolloid dressings (Huchon, 1992; Worsley, 1991).

#### **Methodological quality of included studies**

The studies included in this review were small and generally of poor methodological quality. Details of the quality of each individual study are included in the Table of Included Studies [see Appendix A? ].

Sample size ranged from 14 to 137 patients per trial and *a priori* power calculations were not reported in any of the trials. In four of the five eligible trials, the method of random sequence generation was not stated. Only one trial (Toba, 1997) reported adequate allocation concealment. Blinding of treatment allocation and/or outcomes assessment was only reported in one trial (Gerding, 1992). Only one study reported withdrawal rates and reasons (Worsley, 1991).

In studies of pressure ulcer treatment it is extremely important for trialists to report on the baseline comparability of the treatment groups for important variables such as baseline risk. Risk of pressure ulcer development is usually reported as one of various risk scores such as Norton, Waterlow, Gosnell or Braden. Only one of the studies reviewed here (Huchon, 1992) presented such baseline data.

Even more importantly in pressure ulcer treatment trials it is essential to ensure baseline comparability for initial area of ulcers. A change in wound area is often

expressed as the percentage change which, unlike the absolute change in area, takes into account the initial size of the wound. For two wounds healing at the same linear rate (as measured by diameter reduction) percentage area calculations will show a larger change for a small wound than a big wound. The converse is true when the absolute change in area is measured, since for any unit reduction in wound radius a bigger area reduction will occur for a large wound.

This has important consequences for the validity of trial results where there is poor comparability in initial wound size at baseline between the treatment groups. In large trials, randomised allocation should ensure that the mean wound size and variance in each group is similar. In a small trial random allocation is unlikely to result in an even distribution of wound sizes. In a trial where there is poor comparability between groups for wound size at baseline, and the outcome is based on the change in area, the result can only be considered valid if it is obtained either: against the anticipated direction of the bias for wound size; or where percentage area change and absolute area change are in the same direction. If baseline data are not given then it is not possible to determine the direction of bias and the validity of the result cannot be determined. Three of the five trials included in this review presented data on baseline ulcer size (Gerding, 1992; Huchon, 1992; Toba, 1997).

Quality was not used to weight the studies in the analysis using any statistical technique. However methodological quality was drawn upon in the narrative interpretation of the results. Methodological flaws are discussed for each study in the Table of Included Studies (see Appendix A).

## **Results**

Five eligible trials were identified that assessed the effectiveness of antimicrobial agents in the treatment of existing pressure ulcers. All used topical antimicrobial agents; no trials were identified that assessed the effects of systemic agents.

Two trials (Huchon, 1992; Worsley, 1991) compared the use of a hydrocolloid dressing with one impregnated with povidone iodine. Neither trial individually, or when their results were combined in a meta-analysis, demonstrated a significant difference between the two treatments in terms of the number of pressure ulcers assessed as completely or partially healed at follow up between eight and 12 weeks (RR 1.19, 95% CI 0.92, 1.54). Worsley (1991) drew attention to the fact that fewer dressing changes per week were needed in the hydrocolloid group compared with the povidone iodine group (mean  $\pm$  SD:  $3 \pm 1.38$  versus  $4.9 \pm 1.69$ , respectively,  $p < 0.005$ ).

Two trials evaluated the effects of different ointments on the rate of pressure ulcer healing. A small trial (n=19) by Toba (1997) assessed the effects of GVCAMP ointment (gentian violet 0.1% blended with dibutyryl cAMP) in elderly women with pressure ulcers contaminated with MRSA. There was no statistically significant difference (mean difference -11.1%, 95% CI -27.86, 5.66) between the two groups in change in wound area at 14 weeks. The authors hypothesised that the lack of difference seen might be due to the fact that the two largest wounds (area greater than 50 cm<sup>2</sup>) were in the experimental group. However, an absence of power calculations makes assessment of this comment difficult.

The results of the trial by Gerding and colleagues (1992) are difficult to assess as although the unit of allocation was said to be patients, the unit of analysis was the number of lesions. From the results presented it is not clear how many of the 74 patients were randomised to each group. It is likely that some patients had more than one lesion. The results were presented and divided according to stage of lesion at enrolment which demonstrates that although the result for all lesions combined showed a significant increase in the number of ulcers either partially or completely healed with the oxyquinoline ointment (90%) compared to the povidone iodine ointment (63%) (RR 1.41, 95% CI 1.01, 1.91), when assessed by lesion stage subgroup no significant benefit was observed for either stage 1 or 2 lesions. Hence, these results should be interpreted with caution.

In a small RCT (n=19) by Della Marchina and colleagues (1997) no difference was found (RR 2.22, 95% CI 0.24, 20.57) in the rate of complete healing of pressure ulcers between an antiseptic spray containing eosin 2% and chloroxylenol 0.3% and an alternative spray.

No reliable or objective measures of secondary outcomes such as cost-effectiveness, adverse events, comfort, durability, reliability and acceptability of topical antimicrobial interventions were reported in any of the studies.

## **Discussion**

Despite the frequency of pressure ulcer incidence, the cost of the condition to the health care budget and the myriad of treatment modalities, this review demonstrates the paucity of good-quality evidence that guides current clinical practice on the use of antimicrobial agents in the treatment of existing pressure ulcers.

Oxyquinoline ointment may be more effective than a standard emollient for treating existing pressure ulcers (Gerding, 1992), but no significant differences were seen

when a hydrocolloid dressing was compared with povidone iodine ointment (Huchon, 1992; Worsley, 1991), or when a preparation based on gentian violet 0.1% was compared with a povidone iodine and sugar ointment (Toba, 1997). The trial which compared an antiseptic spray with an alternate spray (Della Marchina, 1997) was small and of poor methodological quality, precluding a reliable assessment of the effectiveness of this intervention.

These few interventions, tested in small trials of generally poor quality, were the only studies identified that assessed the effectiveness of antimicrobials in the treatment of existing pressure ulcers. There were no trials identified that assessed the effects of systemic antimicrobial agents in pressure ulcer management. The confidence with which we can draw firm conclusions from the few studies detailed in this review is greatly tempered by (a) the poor quality of many of the trials and (b) the lack of replication of most comparisons. Hence, much of the research into this subject requires replication on a larger scale. Attention should be paid to detailed baseline data collection and reporting, blinding of outcome assessors, reporting of withdrawals and the use of the intention-to-treat protocol. Rigorous methods of blinding for wound assessors are essential to establish the relationship between different types of products and changes in nurse labour time required. Finally, concurrent interventions should be described in detail, in particular pressure-relieving support surfaces, debridement techniques and forms of topical dressing application.

There are very few data on the cost-effectiveness of antimicrobial agents in pressure ulcer healing. Cost-effectiveness studies should be carried out in conjunction with rigorous evaluations of clinical effectiveness to determine the relative difference between cost per unit of the clinical effects of two or more treatments. A cost-effectiveness or cost-utility analysis should include both a measure of the clinical benefit from a non-biased study, and a measure of the net resources used (Drummond, 1994). Data should be collected relating to both short- and long-term patterns of wound healing and recurrence.

Information from two of the studies included in this review (Huchon, 1992; Worsley, 1991) suggests that certain treatments may be associated with reduced nurse labour time, but further research is required to establish this more reliably. Hydrocolloid dressings require significantly fewer changes than do dressings using conventional antiseptics and wound coverings. For the two studies which assessed this intervention (Huchon, 1992; Worsley, 1991) the effects on nursing time need to be assessed in relation to the equivalent results seen in terms of clinical effectiveness (wound healing).

	Evidence summary
1++	<p>There is insufficient evidence to indicate whether antimicrobials are effective in the treatment of pressure ulcers.</p> <p>No economic evaluations assessing antimicrobials for the treatment of pressure ulcers were found.</p>

	Research recommendations
	<p>The results summarised in this review are based on findings from small trials with methodological problems. Therefore, much of the required research needs replication in larger, well-designed studies using contemporary interventions for antimicrobial activity.</p>

### Recommendations: antimicrobial therapy

In the presence of systemic and clinical signs of infection in the patient with a pressure ulcer, systemic anti-microbial therapy should be considered. **D[GPP]**



## **6.6 Mobility and positioning in the treatment of pressure ulcers**

Mobility, or more precisely immobility, is reported as a significant risk factor for both the development of pressure ulcers as well as a contributory factor in delayed healing (Guralnik et al., 1988; Berlowitz and Wilking, 1989; Ek et al., 1991; Allman et al., 1995; Bergstrom et al., 1996; Schue and Langemo, 1998; Nixon et al., 2000 and Bergquist, 2003). Clinicians and carers engage in a range of activities to reduce the effects of immobility on the healing of pressure ulcers. Mobilising, positioning and repositioning patients (turning) to best promote healing by reducing pressure on the wound, and maintaining muscle mass and general tissue integrity are all central to the aims of this activity.

The literature suggests that both seated and bed bound individuals are at risk of delayed healing and many methods have been postulated to reduce this risk. Much of the research around positioning and re-positioning reports interface pressures for different sitting and lying positions with and without support surfaces. The effects of these interventions on the healing of pressure ulcers is not clear.

Limited sitting and lying times are seen as one aspect of reducing the risks for those with pressure ulcers. Another is posture and combining the sitting and lying regimes with appropriate support surfaces. Re-positioning patients every two or three hours is generally accepted as an effective method to prevent pressure ulcers in both patients with and without existing pressure ulcers (Defloor, 2000). The research evidence to support these interventions is not clear and is therefore the aim of this review. The literature reports a range of re-positioning times from two hourly to six hourly (Defloor, 2001) and, despite the possible effects on patients and the impact on resources, this evidence is limited with suggestion that re-positioning patients has no preventative effect on the development of grade 1 pressure ulcers (Defloor and Grypdonck, 2000).

### **Clinical question**

What is the evidence that mobility is effective in the treatment of pressure ulcers?

What is the evidence that re-positioning is effective in the treatment of pressure ulcers?

### **Objectives**

The objective is to undertake a systematic review of the evidence of mobility and positioning in the treatment of pressure ulcers to determine:

- What are the key mobility interventions/techniques used in pressure ulcer treatment?
- What are the key positioning techniques used in pressure ulcer treatment?
- What is the significance of these in pressure ulcer treatment?
- What are the priorities in pressure ulcer treatment?
- What is the existing evidence base for their use in the treatment of pressure ulcers?
- What is the empirical evidence that these processes are effective in the management of pressure ulcers?

## **Selection criteria**

### **Types of studies**

RCTs evaluating the effectiveness of mobility and or positioning interventions/techniques in the treatment of pressure ulcers. In the absence of any RCTs, evidence-controlled studies evaluating the effectiveness of mobility and positioning interventions in the treatment of pressure ulcers. Studies reporting interface pressure will not be included in this review because it is not clear how such outcomes relate to delayed healing and complications.

### **Types of participants**

All: adults and children, including those in primary and secondary care, residential homes, nursing homes, secure settings and the home.

### **Types of interventions**

Mobilising (exercise interventions) compared to standard care. Different positioning/re-positioning interventions compared and compared to standard care.

### **Types of outcome**

Healing rates, all objective measures of wound change over time.

## **Clinical evidence**

A total of 33 studies were identified from the sifting process and subsequently full papers ordered. This number also included those studies referenced with relevant titles but where the abstract was absent in the citation. After sifting full papers for relevance and duplicates at this stage, 26 papers were opinion pieces, editorials, anecdotal reports or fell outside the inclusion criterion for this review. Out of the six selected studies, five were excluded and one was included.

*Bates-Jensen et al.(2004)*

Bates-Jensen et al. (2004) undertook a randomised controlled trial with blinded assessment of outcomes at three points. A total of 190 incontinent nursing home residents were randomised to receive standard care or exercise and incontinence care every two hours between 8am and 4.30pm five days per week for 32 weeks. Skin health outcomes were the outcome measures of interest which included pressure ulcers. Assessors were blind to treatment group. *A priori* was performed. Intervention subjects had significantly better skin health outcomes than controls. However this was limited to the sacral and trochanter regions ( $p = <.001$ ).

Because this is a duel intervention trial it is not clear what proportion of the improved outcome is attributed to the exercise (mobilising) intervention. This trial included a range of skin conditions which included: maceration, papules, macules, blanching erythema, non blanching erythema, non pressure ulcers and pressure ulcers combined. The effects of the interventions on pressure ulcer healing are not clear from this study.

Due to the lack of evidence for mobility and positioning recommendations were sought from formal consensus methods.

## **Recommendations: mobility and positioning**

Mobilising, positioning and repositioning interventions should be considered for *all* individuals with pressure ulcers (including those in beds, chairs and wheelchairs). **[D]**

**[D]**

All patients with pressure ulcers should actively mobilise, change their position or be re-positioned frequently. **[D]**

Avoid positioning individuals directly on pressure ulcers or bony prominences (commonly the sites of pressure ulcer development). **[D]**

Mobilising, positioning and re-positioning interventions should be determined by: **[D]**

- general health status
- location of ulcer
- general skin assessment
- acceptability (including comfort) to the patient, and
- the needs of the carer.

Frequency of re-positioning should be determined by the patient's individual needs and recorded – e.g. a turning chart. **[D]**

Passive movements should be considered for patients with pressure ulcers who have compromised mobility. **[D]**

	<b>Research recommendations</b>
	There needs to be rigorous research to evaluate the effects of mobility interventions on the healing of pressure ulcers.



## 6.7 Nutrition in the treatment of pressure ulcers

The methods described in this review are those used to update the following systematic review:

Langer G, Schloemer G, Knerr A, Kuss O, Behrens J (2004) Nutritional interventions for preventing and treating pressure ulcers (Cochrane Review) in: *The Cochrane Library*, Issue 3, Chichester, UK: John Wiley & Sons, Ltd.

The treatment of pressure ulcers involves a number of strategies designed to address both extrinsic factors – e.g. reducing the pressure duration or magnitude at the skin surface by repositioning or using pressure-relieving cushions or mattresses – and intrinsic factors, which are concerned with providing the optimum tissue environment for wound healing – i.e. optimum hydration, circulation and nutrition.

It has been reported that malnutrition is positively correlated with pressure ulcer incidence and severity (Berlowitz, 1989; Bergstrom, 1992). Also that decreased calorie intake, dehydration, and a drop in serum albumin may decrease the tolerance of skin and underlying tissue to pressure, friction and shearing force, increasing the risk of skin breakdown and reducing wound healing (Mueller, 2001). Serum albumin is commonly used as a measure of the amount of protein in the blood for healing. However the effect of serum albumin level on wound healing is not clear – there is difference of opinion as to the relevance of such levels in pressure ulcer healing and thus it has limited value as an inclusion/exclusion criterion in controlled clinical trials (Hill et al., 1994). Low energy and low protein intake feature in reports of nutrition and wound healing. The combination of low energy and low protein intake is often described as protein-calorie or protein-energy malnutrition.

The Prinz (prevalence and incidence) study, which collected data from more than 45,000 patients in Austria between 1995 and 1999, reported that malnutrition – defined as a serum albumin less than 3.5 g/dl – was identified as a risk factor in 25% of patients (van Steelandt, 2000). Further studies suggest a correlation between protein-calorie malnutrition and pressure ulcers (Breslow, 1991; Finucane, 1995; Strauss, 1996).

The effectiveness of special diets in preventing and treating pressure ulcers has not yet been examined sufficiently despite the fact that risk assessment tools (for example Braden, 1994; Gosnell, 1989) include nutritional status as a part of the assessment process in the prevention of pressure ulcers. Nevertheless, there is a consensus that nutrition is an important factor in both the prevention and treatment of pressure ulcers.

This has been reiterated by the incorporation of nutritional factors in various guidelines – e.g. the EPUAP Pressure Ulcer Prevention Guidelines ("*There should be clarification of a full risk assessment in patients to include: [...] nutrition [...]*") or the EPUAP Pressure Ulcer Treatment Guidelines ("*Ensure adequate dietary intake to prevent malnutrition [...]*") (EPUAP 1998, EPUAP 2003). A systematic review is therefore required to summarise the best available research evidence and enable evidence-based guidance on the role of nutritional interventions in pressure ulcer prevention and treatment.

## **Objectives**

To evaluate the effect of nutritional support and supplementation in the treatment of pressure ulcers.

## **Selection criteria**

### **Types of studies**

Randomised controlled trials (RCTs) of parallel or crossover design evaluating the effect of enteral and/or parenteral nutrition in the treatment of pressure ulcers by measuring ulcer healing rates or changes in pressure ulcer severity. Controlled clinical trials (CCT) were only considered eligible for inclusion in the absence of RCTs.

### **Types of participants**

People of any age and sex with existing pressure ulcers, in any care setting, irrespective of primary diagnosis. A pressure ulcer was defined as an area of localised damage to the skin and underlying tissue caused by pressure, shear, friction and/or a combination of these.

### **Types of interventions**

Clearly described nutritional support (enteral or parenteral nutrition); supplementation or special diet. Comparisons between support or supplementary nutrition plus standard diet versus standard diet alone, and between different types of supplementary nutrition – e.g. enteral vs. parenteral – were eligible.

### **Types of outcome measures**

The primary outcome was:

- time to complete healing.

The following secondary outcomes were summarised:

- acceptability of supplements
- side effects
- costs
- rate of complete healing
- rate in change of size of ulcer (absolute and relative), and
- quality of life.

### **Main literature search**

Searches were undertaken to update the following Cochrane Review:  
Langer G, Schloemer G, Knerr A, Kuss O, Behrens J (2004) Nutritional interventions for preventing and treating pressure ulcers (Cochrane Review) in: *The Cochrane Library*, Issue 3, Chichester, UK: John Wiley & Sons, Ltd.

Databases were searched in August 2004.

Full search strategies are listed in Appendix B.

### **Appraisal of methodological quality**

Criteria for inclusion (methodological quality is reported in the evidence tables).

No economic evaluations assessing nutritional support in the treatment of pressure ulcers were found.

## **Clinical evidence**

### **Ascorbic acid (Vitamin C), two trials**

Taylor (1974) carried out a double-blind, RCT with 20 surgical patients with pressure ulcers. Patients in the treatment group received an additional 500mg ascorbic acid twice daily for four weeks.

ter Riet (1995) conducted a multi-centre blinded RCT with 88 patients with pressure ulcers in 11 nursing homes and one hospital. Patients in the intervention group received 500mg ascorbic acid twice daily with or without ultrasound for a period of 12 weeks. Patients in the control group received 10mg ascorbic acid twice daily with or without ultrasound. Most patients had nutritional deficiencies on admission.

### **Protein, one trial**

Chernoff (1990) undertook a RCT with 12 institutionalised tube-fed patients with pressure ulcers. Patients were randomised to a high-protein or a very high-protein dietary formula and monitored for eight weeks to assess pressure ulcer healing.

### **Zinc, two trials**

Norris (1971) performed a randomised, double-blind, crossover study with 14 patients with pressure ulcers. Patients received either 3 x 200mg zinc sulphate per day or placebo for a period of 24 weeks. After 12 weeks the patients switched groups.

Brewer (1967) conducted a randomised, double-blinded, placebo-controlled trial with 14 spinal cord injury patients. Patients received either zinc sulphate 220mg, or a placebo capsule, three times a day for two to three months.

### **Multinutrient supplementation, one trial**

Ek (1991) performed a randomised, controlled trial of 501 patients newly admitted to a long-term medical ward. Patients in the standard care group received the standard hospital diet containing 2200 kcal/day. The intervention group received 200ml liquid supplement, twice daily for the duration of their hospital stay or for 26 weeks, whichever was the shorter. Each 100ml of the liquid supplement contained 4g protein, 4g fat, 11.8g carbohydrates, 419 kJ, and minerals and vitamins.

### **Methodological quality of included studies**

The included studies were small (average sample size was 33, with a range from 12 to 88 patients) and of poor methodological quality. None of the included studies reported a power calculation.

### **Ascorbic acid (Vitamin C), two trials**

The RCT by Taylor (1974) with 20 surgical patients was placebo-controlled, and patients were allocated to the treatment groups according to their year of birth, indicating that they were likely to be aware of the allocation. Patients were comparable at baseline, and no dropouts were reported. Outcome assessors were blinded to treatment.

ter Riet (1995) carried out a multi-centre RCT in 88 patients where investigators, nursing staff, physiotherapists and patients were blinded as to treatment allocation but allocation concealment was not described. They performed an intention-to-treat and a per-protocol analysis.

### **Protein, one trial**

Chernoff (1990) undertook a RCT with 12 patients. Follow up was for eight weeks. They published no information about randomisation and allocation method, blinding, baseline characteristics or follow up.

### **Zinc, two trials**

The trial by Norris (1971) was a randomised crossover study, which was described as double-blind but the method of allocation was not specified. Only three of 14 patients (21%) completed the study after 24 weeks. Pressure ulcer volumes have been measured in four-week intervals. No intention-to-treat analysis was given.

The trial by Brewer (1967) was a randomised, double-blinded, placebo-controlled trial, although the methods of random allocation and blinding are not described. Thirteen of the fourteen enrolled patients completed the trial after two to three months of treatment. Pressure ulcer healing was described as complete, definite improvement or no change, but the method of outcome assessment was not described.

### **Multinutrient supplementation, one trial**

Ek (1991) was a randomised controlled trial but the method of allocation was not specified. The numbers of patients who completed the treatment (to discharge or 26 weeks, whichever was shorter) was not stated. Methods of assessing pressure ulcer

healing were not reported but methods of assessing several other outcome measures, such as serum protein analyses, anthropometry, skin testing, malnutrition and the modified Norton Scale score, were reported in detail.

## **Results**

The included trials were heterogeneous in terms of patients – for example some surgical, some critically ill, some residents in nursing homes – and to interventions, including, for example, type, application form, timing, dose and duration of nutritional supplementation. Furthermore different primary outcomes have been evaluated in the studies; therefore it was considered inappropriate to perform a meta-analysis.

### **Ascorbic acid (Vitamin C)**

Taylor (1974): 20 people in surgical wards were followed up and data reported at one month. In the group treated with ascorbic acid there was a statistically significant mean reduction in pressure ulcer area of 84% (SE 7.60) after one month compared with 42.7% (SE 7.41) in the placebo group WMD 41.30 (95% CI 34.72 to 47.88  $p < 0.005$ ) (see Figure 27). Complete healing of pressure ulcers occurred in six patients in the nutritional intervention group versus three patients in the placebo group. Relative risk for healing with supplement was 2 (95% CI 0.68 to 5.85) (see Figure 28). The mean healing rate was 2.47cm<sup>2</sup>/week in the intervention group compared with 1.45cm<sup>2</sup>/week in the control group.

ter Riet (1995): The mean absolute healing rate in the intervention group (n=43) was 0.21cm<sup>2</sup>/week and 0.27cm<sup>2</sup>/week in the control group (n=45)(difference - 0.06cm<sup>2</sup>/week; no standard deviations were reported). The mean volume reduction was 0ml/week in the intervention group and 0.20ml/week in the control group (difference -0.20ml/week). The mean clinical change where improvements – i.e. surface reduction, healing velocity, volume reduction – were scored on a scale from -100 to +100% was 17.89%/week in the intervention group and 26.08%/week in the control group (difference -8.19%/week).

ter Reit displayed the healing survival curves for both groups and there was no difference in the hazard of healing. From Figure 28 the proportion healed at 84 days was 17/43 in the treatment group and 22/45 in the control group (RR 0.81 95%CI 0.50 to 1.30 – calculated by the reviewers).

Figure 27:

Review: Nutritional interventions for preventing and treating pressure ulcers  
 Comparison: 02 Ascorbic Acid (Treatment)  
 Outcome: 01 Mean Surface Reduction (%)

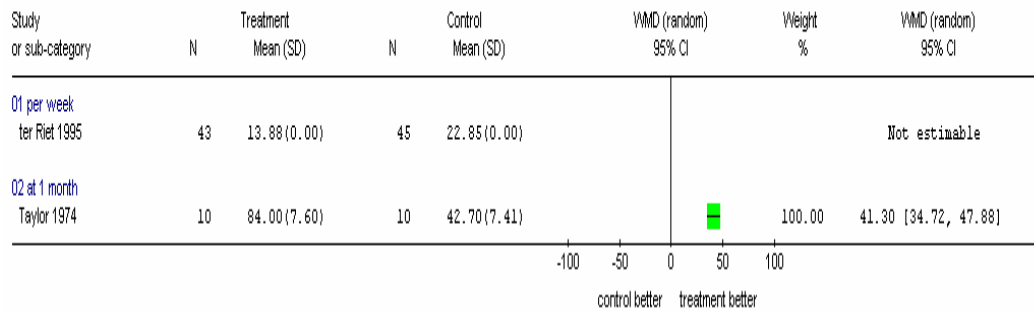
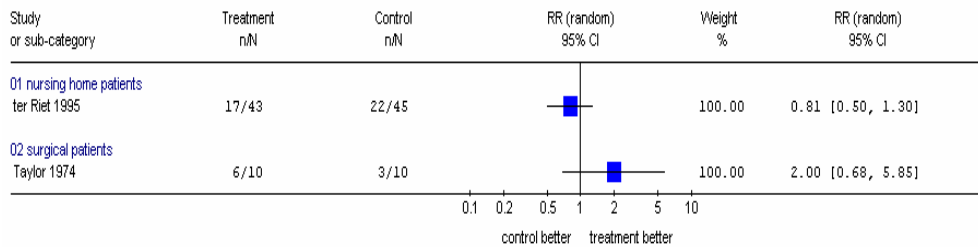


Figure 28:

Review: Nutritional interventions for preventing and treating pressure ulcers  
 Comparison: 02 Ascorbic Acid (Treatment)  
 Outcome: 02 Number of people healed

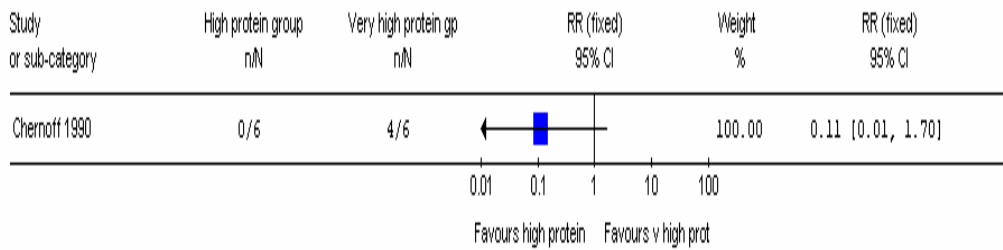


### Protein

Chernoff (1990): At the start of the study, pressure ulcers ranged in size from 1.6cm<sup>2</sup> to 63.8cm<sup>2</sup> in the high-protein group and from 1.0cm<sup>2</sup> to 46.4cm<sup>2</sup> in the very high-protein group. On both diets ulcer size decreased, but the improvement was greater in the very high-protein group. None of the patients in the high-protein group and four patients in the very high-protein group had complete healing of their ulcer. This gives a relative risk of healing of 0.11 (95%CI 0.01 to 1.70) which is not statistically significant (see Figure 29). The average decrease in ulcer size was 42% in the high-protein group compared with 73% in the very high-protein group.

Figure 29:

Review: Nutritional interventions for preventing and treating pressure ulcers  
 Comparison: 03 Protein (Treatment)  
 Outcome: 02 Number of people healed

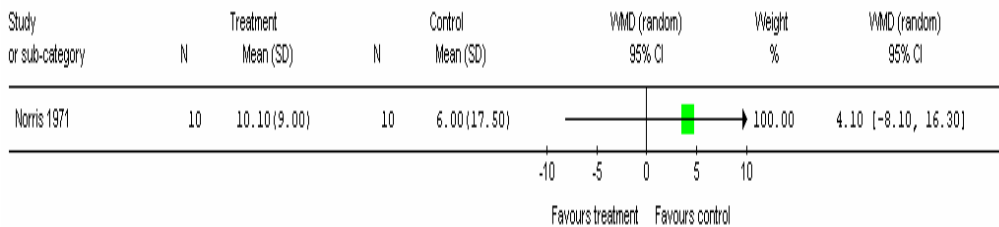


### Zinc

Norris (1971): 14 patients treated with zinc sulphate had pressure ulcers with a mean net change in volume of 10ml (SD 9ml), 14 patients receiving placebo had pressure ulcers with a mean net change in volume of 6.0ml (SD 17.5ml), which is not statistically significant (weighted mean difference (WMD) 4.1ml; CI 95% -8.10 to 16.30; p=0.5).

Figure 30:

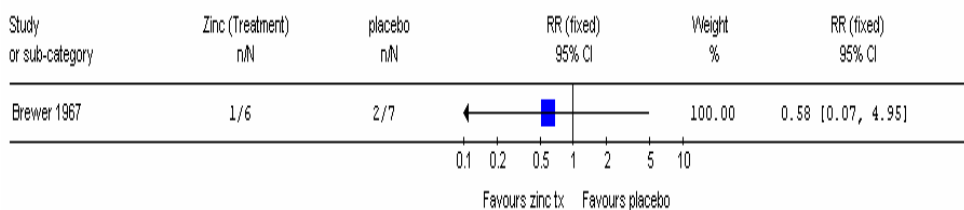
Review: Nutritional interventions for preventing and treating pressure ulcers  
 Comparison: 04 Zinc (Treatment)  
 Outcome: 01 PU Volume (ml)



Brewer (1967): This early and small (n=14) trial reported no significant difference in the rate of pressure ulcer healing in spinal cord injury patients treated with zinc sulphate 220mg, three times a day for two to three months (one of six patients had complete ulcer healing), compared with patients receiving placebo capsules (two of seven patients).

Figure 31:

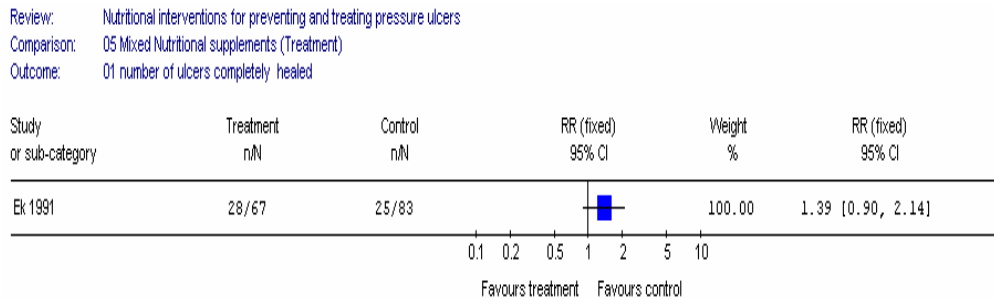
Review: Nutritional interventions for preventing and treating pressure ulcers  
 Comparison: 04 Zinc (Treatment)  
 Outcome: 02 Complete ulcer healing



### Multinutrient supplementation

Ek (1991): The total number of sores that developed in the experimental group was 67 and in the control group 83. This was from a total of 495 patients on whom data was available (of the 501 patients randomised). However, it is not known how many patients were in each treatment group. Of the 67 sores that developed in the experimental group, 41.8% (28/67) healed completely compared with 30.3% (25) of the 83 pressure sores in the control group. These results were reported as not reaching statistical significance.

Figure 32:



### Discussion

Studies of nutritional support/supplementation vary in terms of interventions, outcome measurements and follow up. Interpretation of these findings should be made with caution. Studies included too few patients and had a high drop-out rate. Furthermore, follow-up time was found to be very short. Hence trials are not likely to detect the true effects of the intervention. Some trialists reported that laboratory markers of malnutrition improved during treatment but the clinical effects of protein, calories, and vitamin or zinc supplementation on the healing of existing sores is unclear.

### Ascorbic acid

The Taylor (1974) trial included a small number of participants (n=20). The method of randomisation (by year of birth) is open to the researchers, and there is the potential that people were recruited into the trial according to clinical judgment rather than truly randomly. They found significant effects on the reduction of pressure sore area with the intervention (500mg ascorbic acid twice daily up to 12 weeks for surgical patients) but the clinical relevance of a reduction in area (rather than complete healing) is not known.

In the trial by ter Riet (1995) most patients were based in nursing homes (n=88) and had nutritional deficiencies on admission. The control group received 10mg ascorbic acid, and the experimental group received 500mg. Patients in the control group had better clinical outcomes at 12 weeks. This study used a reasonable control intervention and a larger sample size, which would suggest that the effect of ascorbic acid on the treatment of pressure ulcers seems to be at least unclear.

### **Protein**

Chernoff (1990) had a small number of institutionalised tube-fed patients (n=12), and the lack of information about randomisation and allocation method, blinding, baseline characteristics and follow up contribute to the poor trial quality. They reported an average decrease in ulcer size which was better in the very high-protein group (73% vs. 42%). There is only weak evidence on the effect of very high-protein supplementation rather than regular protein supplements for the treatment of pressure ulcers in tube-fed patients.

### **Zinc**

The RCT of Norris (1971) is limited by the small number of patients (n=14). Only three patients completed the study after 12 weeks. They found no significant effects of zinc for pressure ulcers, but the trial is far too small to detect clinically important effects as statistically significant.

The trial by Brewer (1967) was also small (n=14) but had a good treatment completion rate (13 of the 14 patients). Again, although not significant, differences were not found in the effect of zinc on pressure ulcer healing. The small sample size did not permit the detection of statistically significant or clinically important treatment effects.

### **Multinutrient supplementation**

The trial by Ek (1991) was poorly reported in terms of results by treatment group allocation. It is not known how many of the 501 patients randomised were allocated to each group, making an assessment of the effects of the treatment on either pressure sore prevention or healing difficult. Many secondary analyses were reported, including results on the patients' state of malnourishment, functional level of activity, mobility, food intake, albumin levels and other measures, but there were very limited data on pressure ulcer healing rates.

Most treatment studies have short trial periods. Therefore, improvement or healing of pressure ulcer wounds is unlikely to be detected.

Most patients in the studies described above seem to have laboratory defined and confirmed nutritional deficiencies, which improved throughout treatment with additional nutritional supplements. Whether this has an effect on clinically relevant outcomes, such as pressure ulcer healing, remains unclear.

	Evidence summaries
1++	There is no evidence to support the routine administration of nutritional support/supplementation included in this review to promote the healing of pressure ulcers.
1+	In patients who have detected deficiencies, supplementation to correct the deficiency according to the daily recommended amounts may be indicated following a nutritional evaluation.
1++	The effect of corrective nutritional supplementation on pressure ulcer healing remains unclear however.

### Recommendations: nutritional support

† Nutritional support should be given to patients with an identified nutritional deficiency. **[C]**



Nutritional support/supplementation for the treatment of patients with pressure ulcers should be based on: **[D]**

† The link between correcting this deficiency and its causal relationship with pressure ulcer healing has not been clearly established.

- nutritional assessment (using a recognised tool, e.g. "MUST" Tool)
- general health status
- patient preference, and
- expert input supporting decision-making (dietician or specialists).



	<b>Research recommendations</b>
	<p>Further research with larger numbers of patients and sound methodology is required to procure evidence on the impact of nutrition on pressure ulcers.</p> <p>Consideration should be given to the constituents of the supplement and method of administration, as studies have reported low tolerance of nasogastric tube feeding.</p>

## **6.8 Surgery for the treatment of pressure ulcers**

Surgery has been indicated for the treatment of pressure ulcers since the early part of the 20th century. As early as 1950, in a review of 59 ischial pressure ulcers, surgery was the method of treatment described, and an evaluation of complications and short-term outcomes reported (Cannon et al., 1950).

Surgery may be indicated:

- when conservative measures have failed to heal the pressure ulcer
- to accelerate debridement to expedite spontaneous healing
- to provide a quick by-pass to conservative measures for reasons of comfort, economy or achievement of a superior repair, and
- to achieve a more robust repair than could be achieved by conservative treatment.

Identifying candidates for surgical interventions is based on a thorough assessment of the individual including:

- aetiology of the pressure ulcer
- anatomical site, staging
- infection status
- any underlying medical condition
- nutritional status
- neurological status
- psychosocial status, and
- social factors.

(Foster et al., 1997; Margara et al., 2003).

Surgery is not usually indicated in patients who have grade 1 or 2 pressure ulcers (apart from minor debridement). It is usually used as an intervention in those with grade 3 or 4 pressure ulcers (Henderson, 2004).

The current surgical management of pressure ulcers broadly consists of debridement, which can be superficial and may or may not include the removal of bone tissue followed by flap coverage. There is a plethora of different techniques, which have been described in the literature. Pressure ulcers can be surgically debrided and left as an open wound to heal conservatively, surgically closed with or without debridement, or repaired using a range of myocutaneous flaps or skin

grafting.

### **Types of surgery**

Surgery can be subdivided into:

- emergency (drainage or abscess)
- urgent (debridement of necrotic eschar), or
- elective (further debridement followed by closure).

Which techniques are currently considered to be the most effective is not clear. How clinicians reach decisions about which technique to use is also not clear. Indications about choice of technique from the available literature depends on the assessment of the patient and the site of the ulcer (a flap which is specifically indicated for the area involved and the ability of that chosen flap to be re-harvested if the ulcer reoccurs).

Methods of wound closure can be divided into:

- direct closure of the wound margins
- skin grafting
- preservation of the walls of the ulcer to conserve tissue, followed by direct closure or flap closure over this retained tissue, and
- radical excision of the walls of the pressure ulcer followed by flap closure.

This review aims to consider the contribution of surgery in the treatment of pressure ulcers and its effect on wound healing.

### **Clinical question**

What is the evidence that surgery is effective in the treatment of pressure ulcers?

#### **OBJECTIVES**

The objective was to undertake a systematic review of the evidence of surgical interventions for individuals with pressure ulcers to determine:

- What are the surgical techniques and interventions used?
- In which populations are these techniques and interventions used?

- What are the safety implications?
- What is the empirical evidence that surgery is effective in the management of pressure ulcers?

## **Selection criteria**

### **Types of studies**

RCTs comparing surgery versus conservative treatment, surgical technique versus surgical technique, surgery versus other interventions (that do not come under the definition of conservative) for the treatment of pressure ulcers.

### **Types of participants**

All: adults and children.

### **Types of outcome**

Time to heal, time to wound closure, all objective healing measures. Mortality rates, safety information, quality of life measures.

## **Search strategy**

### **Main literature search**

This involved searching a range of medical, nursing, psychological and grey literature databases. All databases were searched from inception date and searches were not limited by study design. The searches were limited to retrieve literature published in English, and to omit animal studies and letters, comments and editorial publication types.

Databases were searched in February 2004 and an update search was performed in August 2004.

The strategies are listed in Appendix B.

### **DATA ABSTRACTION**

Papers were screened for relevance and study design. The methodological quality of the papers was assessed using pre-defined principles as outlined in Appendix E. Data were extracted by a single reviewer and the evidence tables compiled.

### **Appraisal of methodological quality**

No RCTs were identified from the search strategy and so the decision was taken to follow a narrative review with an open study design criteria. The body of evidence for this review was found to be case series.

Case series and case reports consist either of collections of reports on the treatment of individual patients, or of reports on a single patient. Case series and case reports have limited or no use in a review of an effectiveness of an intervention. However they have an important role in alerting to the potential rare harms or the benefits of an effective treatment (Vandenbrouke, 2001).

Case series and case reports have no control group with which to compare outcomes and therefore have no statistical validity.

Case series studies were assessed against eight quality variables to provide a guide of the extent to which the findings or reporting of each study could be relied upon, and to highlight any methodological flaws. The eight variables were:

- case series collected in more than one centre (multi-centre study)
- aims of case series clearly stated
- case definition clearly reported
- explicit statement that patients were recruited consecutively
- prospective data collection
- reporting of confidence intervals or other estimate of random variability
- reporting of mortality/recurrences/complications, and
- baseline data for ulcers.

Quality criteria for case reports and case series are not well established. This is an adaptation of criteria used in other systematic reviews of case series (Vardulaki et al., 2000 ).

### **Search results**

Initial search results	530
N screened for relevance following sift	53
N included	24
N excluded	11

### **Clinical evidence**

A total of 53 studies were identified from the sifting process and subsequently full papers ordered. This number also included those studies referenced with relevant titles but where the abstract was absent in the citation. After sifting full papers for relevance and duplicates at this stage, 18 papers were opinion pieces, editorials, anecdotal reports or fell outside the inclusion criterion for this review. Out of the selected studies 11 were excluded, 24 included.

The majority of the included studies were case reports, case series and retrospective chart reviews of variable quality.

Total study population for this review is 1,085 cases represented in both individual case reports and case series. Case series number of participants ranged from two to 297. Less than 10 participants were included in this review. However a further 16 studies could have been excluded if this criterion was to have been used.

The reported locations of ulcers were:

- sacral area
- trochanteric area
- ischial area

- heel
- malleolar, and
- plantar.

The age range from reported studies was 5-83 years although not all studies reported full demographic details. The grade or stage of ulcer was only described in five studies (Aggarwal et al., 1996; Gusenoff, 2002; Higinis et al., 2002; Margara et al., 2002; Tizian et al., 1986) and a range of grading systems was used. Grades ranged from grade 3 to 7 indicating that, despite the grade or staging system, it was the higher grades that were indicated for surgical interventions. However surgical intervention in lower grades cannot be ruled out due to the grading and staging systems not adequately being described. Baseline data for ulcer size was only given in seven studies (Aggarwal et al., 1996; Akan et al., 2001; Aydan et al., 2003; Benito; Forster et al., 1997; Gusenoff, 2002; Higinis et al., 2002; Hiroyuki et al., 1995; Little et al., 1982; Margara et al., 2002; Tizian et al., 1986) either as a range, or largest and smallest ulcer.

Follow-up period varied greatly from less than one month to 60 months.

Complications as a result of surgery were reported in 21 studies with rates of up to 60% reported on one study (Klien, 1988).

Reported complications were:

- wound dehiscence
- flap necrosis
- wound infection
- osteomyelitis
- sepsis
- seroma
- muscle atrophy
- blisters
- suture sinuses
- haematoma
- abscess
- recurrent ulcer
- death
- aspiration pneumonia
- intraoperative myocardial infarction, and

- deep venous thrombosis.

Generally co-interventions were poorly described in the included studies. Studies that did report on co-interventions were Bocchi et al. (2004), Margara et al. (2002), Rubayi (1999), Waiter et al. (1999), and Tizian et al. (1986).

Reported co-interventions were:

- two-hourly position changes
- water mattresses
- air mattresses
- vacuum-assisted closure
- oral fluids 30ml/kg/24 hours
- vitamins/minerals
- no smoking
- nutrition 30-35cal/kg/body weight
- protein of 1-2g/kg/24 hours
- physiotherapy
- compliance interventions, and
- sitting programme.

## **Conclusions**

The lack of any randomised studies means that reporting on the effectiveness of surgical interventions is not possible given the available evidence.

There is no evidence to indicate whether surgery is effective in the treatment of pressure ulcers and consequently no evidence to indicate which technique is the most effective in the treatment of pressure ulcers. However surgery is clearly indicated as a treatment option. Its use is mainly indicated in those with spinal cord injury, the elderly and in children, although the latter is less frequently reported. Recurrence rates are variable in the limited evidence but reports indicate that they can be as high as 50%.

	Evidence summary
3	Surgical management of pressure ulcers should be based on an overall assessment of the individual with everyone involved in the patient's care. With high reported recurrence rates, risk factors for delayed healing and pressure ulcer development need to be minimised.
	No economic evaluations assessing surgical interventions for the treatment of pressure ulcers were found.

Recommendations for this area of the guideline have been made using formal consensus methods.

### Recommendations: surgery

Referral for surgical interventions for patients with pressure ulcers should be based on: **[D]**

- level of risk (anaesthetic and surgical intervention; recurrence)
- patient preference (lifestyle, abilities and comfort)
- ulcer assessment
- general skin assessment
- general health status
- competing care needs
- assessment of psychosocial factors for the risk of recurrence
- practitioner's experience
- previous positive effect of surgical techniques, and
- failure of previous conservative management interventions.

## 6.9 Topical negative pressure, electrotherapy and electromagnetic therapy, and therapeutic ultrasound in the treatment of pressure ulcers

The methods described in this review are those used to update the following systematic review:

Cullum N, Nelson EA, Flemming K, Sheldon TA (2000) Systematic reviews of wound care management: (5) beds; (6) compression; (7) laser therapy, therapeutic ultrasound, electrotherapy and electromagnetic therapy. *Health Technology Assessment*, 4(21).

The treatment of pressure ulcers can be broken down into four main areas:

- local treatment of the wound using wound dressings and other topical applications
- pressure relief using beds, mattresses or cushions, and repositioning of the patient
- treatment of concurrent conditions which may be delaying healing – for example poor nutrition, infection, and
- the use of adjunct therapies such as electrical stimulation, ultrasound, laser therapy and negative pressure.

**Adjunct therapies are being used increasingly to assist the healing of pressure ulcers (Lyder, 2003; Hess, 2003), usually when conventional therapy has failed to make significant improvements in wound healing. The clinical and cost-effectiveness of many of these treatments have not been rigorously assessed.**

## **Description of adjunct therapies to be included in the review**

### **Topical negative pressure**

One way of manipulating the wound environment in order to promote healing is to apply a topical negative pressure (TNP) (measured in mmHg) across the wound surface via a dressing (Davydov, 1992; Davydov, 1994; Fleischmann, 1993; Fleischmann, 1995; Argenta, 1997). The concept of negative pressure to create a suction force, enabling the drainage of surgical wounds and the promotion of wound healing is well documented (Fox, 1976; Fay, 1987). It has been suggested that if excess fluid is not adequately removed from a wound following surgery, its components may serve as both physical and chemical deterrents to wound healing (Fay, 1987). The basic concept that mechanical forces influence the shape and growth of tissues is also well documented (Ovington, 1999).

TNP is reported to do both, that is remove excess interstitial fluid, and transmit mechanical forces to surrounding tissues with resultant deformation of the extracellular matrix and cells (Morykwas, 1998). Both factors are thought to result in increased wound healing through a variety of mechanisms (Banwell, 1999). The transparent adhesive used to secure the dressing may also help maintain a moist wound environment (Mendez-Eastman, 1998; Banwell, 1999).

There are a number of names to describe the treatment of a wound with TNP – including sub-atmospheric pressure therapy or dressing, vacuum sealing technique, vacuum-assisted wound closure, vacuum-assisted closure, negative pressure therapy or dressing, foam suction dressing, vacuum compression, vacuum pack, sealed surface wound suction (Banwell, 1999; Banwell, 2003), or sealing aspirative therapy. For the purposes of this review this intervention will be referred to as TNP.

TNP requires an open cell dressing (e.g. foam) to pack the wound, tubing to connect the dressing to a suction pump via a cannister which collects any exudate, and an air-tight seal around the dressing (Baxandall, 1997). All non-viable tissue is removed beforehand (Argenta, 1997). TNP is generally viewed as contraindicated if the wound or surrounding tissues are cancerous, if there are fistulas to organs or body cavities, there is necrotic tissue, or if there is untreated osteomyelitis (Mendez-Eastman, 1998).

Laboratory evidence of the effectiveness of TNP on the wound environment has been obtained from several animal studies (Morykwas, 1993; Morykwas, 1997; Fabian,

2000).

The use of TNP in chronic human wounds has been described by a number of clinicians (Morykwas, 1995; Das Gupta, 1996; Argenta, 1997; Mullner, 1997; Banwell, 1998; Holmich, 1998; Genecov, 1998; Deva, 2000; Ladin, 2000; Lange, 2000 ; Mooney, 2000; Wu, 2000; Thomas, 2001 ; Heath, 2002). The use of TNP for the in-home treatment of chronic wounds has been reviewed (Weinberg Group, 1999) by referring to trials using non concurrent/historical control groups. This review examines the impact of TNP on chronic human wounds by referring to trials where the patients have been randomised to concurrent control groups. In 2001, a group of Canadian wound care opinion leaders was convened (with the financial assistance of a TNP support surface manufacturer) to assess the potential role of TNP in the treatment of chronic wounds (Sibbald, 2003). They noted that there was a gap between the evidence base and current practice with regard to this form of adjunct therapy.

#### **Therapeutic ultrasound**

The mechanisms by which ultrasound may affect wound healing have been reviewed by Dyson (1982). The cellular effects of ultrasound can be divided into thermal and non-thermal (Dyson, 1982); the lower intensities used therapeutically mean that any beneficial effects are likely to be due to non-thermal mechanisms (Dyson, 1987). Non-thermal effects include the production of standing waves, acoustic streaming, microstreaming and cavitation. Some of these effects may be beneficial while others are potentially harmful; standing waves may cause the arrest of blood flow, while cavitation may cause bubble formation within the blood stream (Dyson, 1987). Careful choice of exposure time, intensity, and continuous movement of the ultrasound applicator should minimise these effects. Therapeutic ultrasound has been evaluated in a number of different regimens: varying pulse duration, power output and frequency.

#### **Electrotherapy and electromagnetic therapy**

Electrical stimulation has been used for decades as a treatment for chronic wounds (Hewitt, 1956) and is often applied by physical therapists. However, its role in promoting pressure ulcer healing as an adjunct to or in the absence of other proven therapies is unclear.

Research into the role of electricity in wound healing has been undertaken since at least the 1940s (Burr, 1940). Experimental animal studies have shown that electrical potentials over the wound during healing are initially positive, becoming negative after

the fourth day of healing (Weiss, 1990). It has been concluded that the proliferative phase of healing is related to a negative electrical potential over the wound; however, some studies have experimented with positive wound electrodes, and others by reversing the electrode during healing. It is hypothesised that electrical stimulation influences the migratory, proliferative and synthetic functions of fibroblasts, and also results in increased expression of growth factors (Weiss, 1990). It seems likely that a moist wound environment is essential to maintain endogenous or applied current flow.

There are several types of electric treatment modalities including: low-voltage direct current (LVDC), high-voltage pulsed direct current (PDC), low-voltage alternating current (LVAC) and pulsed electromagnetic field (PEMF) (Sheffet, 2000; Unger, 2000). All have different administration regimes and equipment required.

Electromagnetic therapy is distinct from most other forms of electrotherapy in that it is a field effect, and not a direct electrical effect or a form of radiation. The terminology Pulsed Electromagnetic Field (PEMF) is used to distinguish it from short-wave diathermy, which uses either capacitance or induction to produce indirect heating of tissues and can be thought of as a field effect (Stiller, 1992).

### **Objective**

To systematically assess the evidence for the effectiveness of adjunct therapies in the treatment of existing pressure ulcers.

### **Selection criteria**

#### **Types of studies**

Only randomised controlled trials (RCTs) were included in this review. Studies that did not employ true random allocation of participants to treatment groups, such as quasi-experimental designs, were excluded. The units of allocation had to be patients or lesions. Studies in which wards, clinics or physicians were the units of allocation were excluded because of the possibility of non-comparability of standard care. Both published and unpublished studies were included, with no restriction on date or language.

### **Types of participants**

Studies that recruited people with existing pressure ulcers, of any grade or severity, were eligible for inclusion in the review. The study could be in any setting including hospital, clinic, community facilities, or home.

### **Types of interventions**

Trials in which an adjunct therapy or therapies were compared with a placebo, usual care, or no treatment were eligible for inclusion in the review. All modes of delivery/administration/dose for the named adjunct therapies were considered for the review. It was anticipated that, where appropriate, similar regimens would be grouped and subjected to sub-group analyses.

### **Types of outcome measures**

The primary outcome was wound healing. Since some measures of wound healing can be subjective, studies had to incorporate at least one objective assessment – such as change in ulcer size, rate of healing, frequency of complete healing or time to complete healing – to be included in the review. Change in ulcer size may have been presented as a percentage or absolute change over a period of time. Objective methods of measuring changes on wound size included tracing the ulcer outline followed by counting grids on graph paper, weighing uniform-density tracing paper, planimetry or computerised image analysis.

A single standard outcome measure for wound healing does not exist. Both objective and subjective measures are widely used by researchers, but little effort has been made to determine the validity of many of these measurements. Comfort, ease of application, ease of removal, exudate and handling are frequently-used measures of dressing performance, but they are not validated outcomes on which to base decisions of effectiveness. In this review the most commonly validated outcome measures encountered were based on wound healing. The non-ambiguity of complete healing, and its importance to clinicians and patients alike (because of its potential impact on quality of life and burden of care), make it the preferred outcome measure with which to compare studies of clinical effectiveness.

Objective measures of healing are usually based on wound area. Planimetry, often aided by computer analysis, is the most frequently used method of calculating wound area, though other methods, such as the measurement of wound diameter or weight of a tracing drawn around the area of the wound, are also used. Measurements of

wound volume are infrequently reported in the literature; these methods are often cumbersome and their accuracy has not been proven. Computerised image analysis may in the future, as the equipment becomes more affordable and portable, prove to be a useful technique for the assessment of wound volume.

Even though objective measures reduce or eliminate subjective biases and reduce random measurement errors, they have certain inherent biases if the patients being compared have wounds with different baseline size. A change in wound area is often expressed as the percentage change which, unlike the absolute change in area, takes into account the initial size of the wound. For two wounds healing at the same linear rate (as measured by diameter reduction) percentage area calculations will show a larger change for a small wound than for a big wound. The converse is true when the absolute change in area is measured, as for any unit reduction in wound radius, a bigger area reduction will occur for a large wound.

This has important consequences for the validity of trial results where there is poor comparability in initial wound size at baseline between the treatment groups. In large trials, randomised allocation should ensure that the mean wound size and variance in each group is similar. In a small trial random allocation is unlikely to result in an even distribution of wound sizes. In a trial where there is poor comparability between groups for wound size at baseline, and the outcome is based on the change in area, the result can only be considered valid if it is obtained either: against the anticipated direction of the bias for wound size; or where percentage area change and absolute area change are in the same direction. If baseline data are not given then it is not possible to determine the direction of bias and the validity of the results cannot be determined. Despite the potential for objective outcomes to be biased by differences in wound size at baseline, they remain the most reliable assessment of wound healing as, unlike subjective measures, they reduce the biases of the assessor which cannot be estimated.

Secondary outcomes such as costs, quality of life, pain and acceptability of the adjunct therapy were assessed where possible.

## **Search strategy**

## **Clinical effectiveness searching**

### **Main literature search**

Searches were undertaken to update the following Cochrane review:

Cullum N, Nelson EA, Flemming K, Sheldon TA (2000) Systematic reviews of wound care management: (5) beds; (6) compression; (7) laser therapy, therapeutic ultrasound, electrotherapy and electromagnetic therapy. *Health Technology Assessment*,4(21).

Searches were limited by study design to retrieve randomised controlled trials. Searches were also limited to retrieve literature published in English, and to omit animal studies and letters, comments and editorial publication types.

Databases were searched in February 2004 and update searches were carried out in June 2004:

The strategies are listed in Appendix B.

### **Description of included studies**

Ten eligible randomised trials were identified for inclusion in the review. One trial (Joseph, 2000) assessed the effect of topical negative pressure on a variety of chronic wounds including pressure ulcers. Three RCTs examined the effect of therapeutic ultrasound in the treatment of pressure ulcers (McDiarmid, 1985; ter Riet, 1995; Nussbaum, 1994). Four trials compared electrotherapy to sham therapy for the treatment of pressure ulcers (Gentzkow, 1991; Griffin, 1991; Wood, 1993; Ritz, 2002). A further two trials assessed the effect of electromagnetic therapy for the treatment of pressure ulcers (Comorosan, 1993 ; Salzburg, 1995).

### **Included studies for topical negative pressure**

Joseph and colleagues (2000) assessed 24 patients with 36 chronic wounds (resulting from pressure, wound dehiscence, trauma, venous stasis or radiation), defined as present for greater than one month, in a randomised parallel group study. Eighteen wounds received TNP (open cell foam dressing with continuous suction (125 mmHg) changed every 48 hours. Eighteen wounds received normal saline wet-to-moist gauze dressings (with an occlusive dressing used to secure the gauze) changed three times a day. If patients had multiple wounds, it appears that the

individual wounds were treated during randomisation and data analysis as if they were independent from each other.

At three and six weeks the percent change in wound volume was measured by volume displacement of alginate impression moulds. Additional outcome measures were given by Joseph, such as histology and culture, but they did not fulfil the selection criteria of this review. The trial used a commercially available therapy unit and integral dressing (VAC Therapy, KCI, OXON, UK) to apply the negative pressure.

A total of twenty-one studies reporting the effects of TNP on pressure ulcer healing were excluded from the review (see Table of Excluded Studies, Appendix D). The main reason for exclusion was that they were not RCTs. Patients were either not randomly allocated to the two concurrent treatment groups, or the control group was non concurrent/historical, or, as in the majority of studies, there was no control or comparison group at all. Some of the studies were prospective RCTs, but on animals not humans, and some assessed the effect of TNP on types of chronic wounds other than pressure ulcers. Those prospective RCTs on humans were reporting the effects of TNP on acute wounds.

A further seven studies are still awaiting assessment. This is mainly due to publication as abstracts only without a subsequent full publication, and thus insufficient information to assess inclusion criteria or to extract results data, or the primary paper is yet to be sourced and assessed for inclusion. The citations and reasons for not yet being assessed are detailed in the Table of Studies Awaiting Assessment

#### **Included studies for therapeutic ultrasound**

Three RCTs were identified that examined the effectiveness of ultrasound treatment in the healing of pressure ulcers. The studies all contained small numbers of patients with group sizes varying from 20 patients in three arms to 88 patients in two arms. Two trials (McDiarmid, 1985; ter Riet, 1995) compared ultrasound therapy delivered at approximately 3MHz to sham therapy. A third (Nussbaum, 1994) compared a combination of ultrasound and ultraviolet with laser treatment (820nm laser diode) with standard wound care. McDiarmid (1985) and Nussbaum (1994) studied patients with superficial pressure ulcers. ter Riet (1995) studied patients with stage 2 pressure ulcers (partial skin thickness or worse).

The first of these studies (McDiarmid, 1985) compared 3MHz of ultrasound with sham treatment for patients with pressure ulcers. Treatment was for a minimum of five

minutes (timing dependent on wound size), three times per week. The duration of follow up for the study was unclear.

ter Riet (1995) randomised 88 nursing home patients with pressure ulcers to receive either ultrasound or sham treatment five times a week over a 12-week period. The ultrasound was at a frequency of 3.28MHz with a pulse duration of 2ms.

Nussbaum (1994) compared a combination of ultrasound and ultraviolet treatment (given alternately for five days a week) with laser treatment (820nm laser diode), and with standard wound care twice daily (cleansing with 0.05% chlorine solution, paraffin tulle dressing and pressure relief). Treatment continued until healing occurred.

Two trials were excluded from the review as they were not RCTs (see Table of Excluded Studies, Appendix D).

#### **Included studies for electrotherapy and electromagnetic therapy**

Four trials comparing electrotherapy to sham therapy for the treatment of pressure ulcers were suitable for inclusion in this review (Gentzkow, 1991; Griffin, 1991; Wood, 1993; Ritz, 2002). These four studies contained a total of 137 patients.

The first of these RCTs (Gentzkow, 1991) recruited both hospital and community patients with stage 2, 3 or 4 pressure ulcers who were randomised to receive either electrical stimulation twice daily for four weeks or sham stimulation. Patients with more than one pressure ulcer could have all ulcers randomised into the study. Both groups received standard treatment of cleansing with normal saline, a wound dressing (type not stated), and turning to relieve pressure on the affected area in addition to the electrotherapy or sham electrotherapy. The grading of ulcers was described by the authors as stage 2: full thickness skin defect to subcutaneous tissue; stage 3 to muscle; stage 4 to bone/joint.

The second study (Griffin, 1991) examined 17 male patients with spinal cord injury and a pressure ulcer graded between 2 and 4 on the Delisa system. Participants were randomised to receive electrotherapy and standard treatment or sham therapy plus standard treatment. The standard treatment consisted of wound cleansing and dressing – pressure ulcers were cleansed using Cara-Klenz application of Carrington gel (dermal wound cleanser) and dressed using a dry dressing. Mechanical debridement was as necessary. There was no change of mattress for any patient during the study.

The third study (Wood, 1993) compared electrotherapy with sham therapy for the treatment of chronic stage 2 or 3 pressure ulcers which had shown no improvement with standard nursing care over the preceding five weeks. Both groups received standard treatment of wound cleansing, simple moist dressings and whirlpool baths. No hydrocolloids, films or foam dressings were used. There was no description of the system for grading pressure ulcers in the study.

The final study (Ritz, 2002) compared the Provant wound closure system (which uses radiofrequency stimuli to induce fibroblast and epithelial cell proliferation) twice daily with sham treatment in high-risk patients with grade 2 to 4 pressure ulcers. This treatment was in addition to standard care. Patients treated with concurrent adjunct therapy support surfaces – e.g. hyperbaric oxygenation, electrical stimulation – were excluded.

Two studies of electromagnetic therapy for the treatment of pressure ulcers were included in the review (Comorosan, 1993; Salzburg, 1995). These two studies contained a total of 60 patients. The first study (Comorosan, 1993) was a three-arm study comparing electromagnetic therapy, a combination of sham electromagnetic therapy and standard therapy, and standard therapy alone, over a two-week treatment and follow-up period. Treatment was given for 30 minutes, twice a day. The participants were all patients in an elderly care unit with grade 2 or 3 pressure ulcers. The grading system for the ulcers was not described.

The second study (Salzburg, 1995) compared electromagnetic therapy with sham electromagnetic therapy over a 12-week period. The patients included in the study were all male hospital inpatients with a spinal cord injury. This study also gave treatment for 30 minutes twice a day, although the electromagnetic therapy regimen differed from the Comorosan study.

The pressure ulcers were graded as 2 or 3 with an even distribution of each between the groups. A clear definition of the grading of the ulcers was provided by the authors. Grade 2 ulcers were defined as partial-thickness skin loss involving epidermis or dermis, superficial, and clinically presenting as a deep crater, abrasion, blister or shallow crater. Stage 3 was defined as full-thickness skin loss involving damage or necrosis of subcutaneous tissue extending down to, but not through, underlying fascia, clinically presenting as a deep crater with or without undermining of adjacent tissue.

Two trials that assessed either electrotherapy or electromagnetic therapy were excluded from the review as they were not RCTs (see Table of Excluded Studies, Appendix D)

### **Methodological quality of included studies**

Details of the quality assessment of each study are outlined in the Table of Included Studies (Appendix, A). The key components of quality that were assessed included *a priori* sample size calculations, allocation concealment, masking of outcome assessment and reporting of withdrawals by treatment group. Quality was not used to weight the studies in the analysis using any statistical technique; however methodological quality was drawn upon in the narrative interpretation of the results.

### **Methodological quality of included topical negative pressure studies**

In Joseph (2000), of the 24 patients recruited to the study, 12 patients had multiple wounds resulting in a total of 36 wounds. It is not clear how many patients in each arm of the study had multiple wounds and if these patients were evenly distributed across groups. This could potentially impact on baseline comparability of groups. Baseline comparability was reported for age, sex, initial wound volume, ethnicity, smoking status and wound duration. Each wound was randomised to either TNP or saline gauze dressings. Of the 12 patients with multiple wounds, three patients were randomised to both therapies.

It is inappropriate to randomise and analyse multiple wounds as if they were independent from each other unless using a within subjects design. The preferable way of dealing with multiple wounds using a between patients design is to have a single reference wound. Random assignment of wounds to treatments was achieved using files, marked with silver or black labels on the inside panel that were randomly organised in a locked cabinet. It is not clear if these files were sealed so the adequacy of allocation concealment is unclear.

Neither the patient nor the providers were blind to the treatment used. The outcome assessors were blinded as they were not involved in the daily care of the study patients and they only assessed the wounds once the dressings had been removed. Appropriate outcome measures were used, for example percent change in wound volume over time, but also extraneous ones which would be reflected in the change in volume. The authors stated that follow up beyond the six-week study period continued until complete wound closure was shown for each patient but unfortunately

this time to complete healing data was not reported. It was not reported if there were any withdrawals. It is unclear whether intention-to-treat analysis was performed.

### **Methodological quality of included therapeutic ultrasound studies**

None of the three included trials that assessed therapeutic ultrasound (McDiarmid, 1985; Nussbaum, 1994; ter Riet, 1995) included information on the method of randomisation although ter Riet (1995) stated that the method of allocation was concealed – that is the person randomising the patient to the trial was unaware of which group they would enter before randomisation. The two trials that evaluated only ultrasound (McDiarmid, 1985; ter Riet, 1995) attempted to mask the patients to which group they were in by using a sham therapy group. All three trials used blinded outcome assessment. None of the trials used intention-to-treat analysis. Concurrent interventions, such as support surfaces, were described in two of the three studies (ter Riet, 1995; Nussbaum, 1994).

### **Methodological quality of included electrotherapy and electromagnetic therapy studies**

It was difficult to extract some of the details on methodological quality due to poor reporting in the five studies that assessed either electrotherapy or electromagnetic therapy (Comoroson, 1993; Salzberg, 1995). Attempts to contact the authors for clarification were unsuccessful.

None of the studies that assessed electrotherapy (Gentzkow, 1991; Griffin, 1991; Wood, 1993; Ritz, 2002) provided information about the method of randomisation used for their trials, and none incorporated an intention-to-treat analysis. However all four studies did provide information about the baseline features of the pressure ulcer area which enables more accurate interpretation of the results. While all three studies reported the type of wound dressing used during the trials, none reported other concurrent interventions such as support surfaces (beds, mattresses and cushions) used.

Neither study that assessed electromagnetic therapy (Comoroson, 1993; Salzberg, 1995) stated the method of randomisation, nor conducted an intention-to-treat analysis. Both studies however used blinded outcome assessment. While both studies reported the types of wound dressings used during the study, neither reported other concurrent interventions such as support surfaces (bed, mattresses and cushions) used. The study by Comorosan (1993) did not provide information on the

strategies used for randomisation and so there is no rationale as to why the three arms in the study contain an uneven distribution of patients.

## **Results**

### **Results for topical negative pressure studies**

Synthesis of results using statistical pooling methods was not appropriate, as only one trial fulfilled the selection criteria.

Joseph (2000) reported a significantly greater reduction in wound volume (expressed as a percentage of the initial volume at six weeks) in favour of TNP dressings when compared with standard wet-to-moist saline gauze dressings (78% vs 30%  $p=0.038$ ). It was not clear whether mean or median values were provided. No standard deviations, ranges or confidence intervals were provided. The trialists stated that follow up beyond the six-week study period continued until complete wound closure and that all patients were offered operative wound closure for any remaining open wounds. Unfortunately these time-to-healing data were not reported. Adverse outcomes were three out of eighteen wounds with TNP had osteomyelitis and/or calcaneal fractures. Two of the patients suffered calcaneal fractures while ambulating on the TNP dressing, which Joseph (2000) states is against the manufacturer's recommendations and medical advice. Both patients eventually required amputation. Eight out of eighteen wounds with control dressing had osteomyelitis, other wound infections or fistulas ( $p=0.0028$ ).

There were no RCTs evaluating the effectiveness of TNP on cost, quality of life, pain or comfort and there were no RCTs evaluating the effectiveness of different TNP regimens.

### **Results for therapeutic ultrasound studies**

Two trials compared therapeutic ultrasound with sham ultrasound (McDiarmid, 1985; ter Riet, 1995). The third trial compared a combination of ultrasound and ultraviolet light with laser therapy and standard treatment (Nussbaum, 1999).

#### **Ultrasound therapy versus sham therapy**

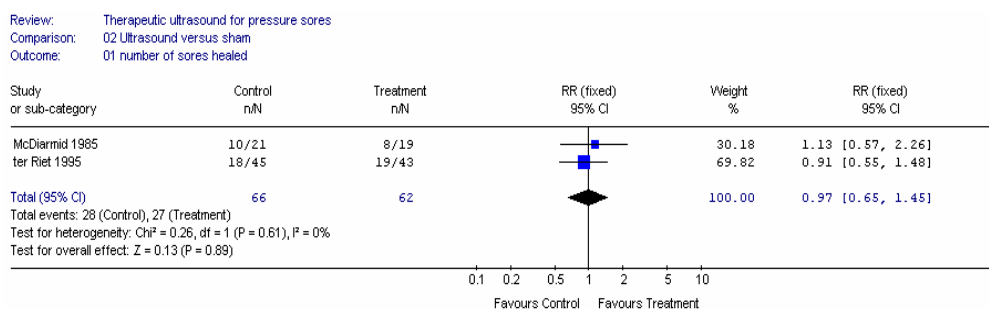
McDiarmid (1985): 10/21 (48%) pressure ulcers healed in the ultrasound group compared with 8/19 (42%) in the sham group (RR 1.13, 95% CI 0.57, 2.26).

Treatment was delivered three times a week for an unspecified period of time.

ter Riet (1995): 18/45 (40%) of pressure ulcers healed in the intervention group compared with 19/43 (44%) in the control group (RR 0.91, 95% CI 0.55, 1.48). Treatment was given five times a week for 12 weeks or until healing had occurred.

The trials by McDiarmid (1985) and ter Riet (1995) were considered sufficiently similar to pool (chi-squared = 0.26,  $I^2=0\%$ ), giving a pooled relative risk of 0.97 (95% CI 0.65, 1.45;  $p=0.89$ ). Thus two studies involving only 128 patients in total found no evidence of a benefit of ultrasound on the healing rates of pressure ulcers (see Figure 33).

Figure 33:



### Ultrasound and ultraviolet therapy versus laser therapy versus standard treatment

Ultrasound combined with ultraviolet (UV) therapy was compared with laser alone and standard therapy in 20 patients with spinal cord injury and pressure ulcers up to 1cm in depth (Nussbaum, 1994). Groups were broadly similar in terms of area and depth of ulcers. Four patients dropped out leaving 16 patients with 18 wounds. After 12 weeks all ulcers (6/6) had healed in the combined ultrasound/ultraviolet treatment group. In the laser treatment group 4/6 (66%) ulcers healed, and in the standard wound care group 5/6 (83%) ulcers healed. There was no statistically significant difference between the groups due to the extremely small sample size, and the consequent lack of power, as shown below:

- ultrasound/UV therapy versus laser therapy: RR 1.5, 95% CI 0.85, 2.64
- ultrasound/UV therapy versus standard treatment: RR 1.2, 95% CI 0.84, 1.72
- laser therapy versus standard therapy: RR 0.8, 95% CI 0.41, 1.56

No secondary outcome measures, including costs, quality of life, pain and acceptability, were measured in any of the RCTs included.

## Results for electrotherapy and electromagnetic therapy studies

### Electrotherapy versus sham electrotherapy

Four trials compared electrotherapy with sham electrotherapy.

Gentzkow (1991): After four weeks there was a mean percentage ulcer healing of 49.8% (SD 30.9) in the electrotherapy group and a 23.4% (SD 47.4) mean percentage ulcer healing in the sham group ( $p=0.042$ ). The baseline ulcer areas given demonstrated larger ulcers in the intervention group. Thus the result is against the direction of bias, as the outcome of percentage healing favoured the control group.

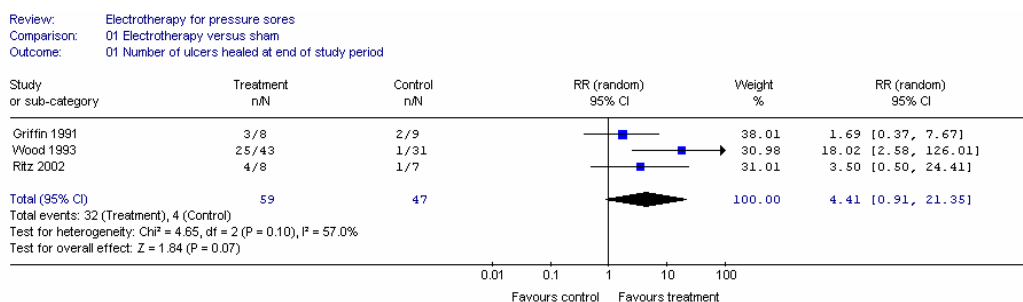
Griffin (1991): 3/8 (37.5%) ulcers healed in the electrotherapy group compared with 2/9 (22%) in the control group (RR 1.69, 95% CI 0.37-7.67).

Wood (1993): 25/43 (58%) of electrotherapy group ulcers healed, compared to only 1/31 (3%) in the sham therapy group (RR 18.02, 95% CI 2.58-126.01). As the ulcers were larger at baseline in the intervention group, this result is against the direction of bias.

Ritz (2002): 4/8 (50%) ulcers in the electrotherapy group healed completely, compared with only 1/7 (14%) in the sham therapy group (RR 3.50, 95% CI 0.50, 24.41). This was a very small, industry-sponsored study.

Three studies had outcomes on the numbers of ulcers healed and were considered sufficiently similar to pool (Griffin, 1991; Wood, 1993; Ritz 2002) (Chi-square 4.69,  $I^2=57%$ ). This resulted in a pooled relative risk of 4.41 (95% CI 0.9-21.35;  $p=0.07$ ) (see Figure 34). This shows no evidence of improved healing of pressure ulcers treated with electrotherapy compared with sham therapy. Again, however, as this result is drawn from three small studies with a total of 106 patients, the results should be interpreted with caution.

Figure 34:



### **Electromagnetic therapy versus sham therapy**

Two trials compared electromagnetic therapy with sham therapy, although the trial by Comorosan included a third arm in which only standard therapy was applied.

Comorosan (1993): 17/20 (85%) ulcers healed in the electromagnetic therapy group within two weeks compared with no ulcers healing in either of the other two groups (0/5 and 0/5) (RR 10, 95% CI 0.7-143.7).

Salzburg (1995): For grade 3 pressure ulcers, 3/5 (60%) healed in the electromagnetic therapy group compared with no ulcers healing in the sham electrotherapy group (0/5) at 12 weeks (RR 7, 95% CI 0.45-108.26). For grade 2 pressure ulcers, there was a median of 84% healing in the electromagnetic therapy group at one week compared with 40% in the sham therapy group (p=0.01). Groups could not be combined due to the different timings and outcome measures between the grade 2 and grade 3 pressure ulcers.

Secondary outcome measures, such as financial costs, quality of life, pain and acceptability, were not measured in either of the RCTs included.

## **Discussion**

### **Quality of the included studies**

Quality assessment suggests that methodological flaws are an issue affecting the validity of most studies in chronic wound care. In general, the studies were too small to ensure that wounds of different sizes (and other prognostic variables) were evenly distributed across trial arms, resulting in a bias at baseline in most trials. The majority of studies also had a short follow-up and did not analyse the data by survival analysis, which would account for both whether and when a wound healed and which would be a more efficient method for estimating the rate of healing.

If future trials perpetuate many of the methodological flaws highlighted in this review, they are unlikely to provide the evidence needed to determine an effective wound management strategy. The variability between wounds at baseline for prognostic variables, including size, indicates that recruitment numbers need to be large and that trials should probably be multi-centred. If small single-centred trials are to be

continued they could be improved by the use of matched or stratified randomisation to ensure a similar distribution of wound sizes between treatment groups at baseline, and the data should be analysed by matched pairs analysis where appropriate. However, even with this improved design a trial still needs to be large enough to ensure comparability for both unknown and known confounding factors.

It is important to ensure, when conducting an RCT, that systematic differences in comparison groups (selection bias), care provided apart from the intervention being evaluated (performance bias), outcome assessment (detection bias), and withdrawals from the trial (attrition bias) are avoided (or made explicit) (Clarke, 2003). The logical basis for this being that any differences in group outcomes could be due to these systematic differences. Differences in group outcomes could then be wrongly attributed to the intervention being evaluated.

Selection bias can be eliminated by assembling comparison groups in such a way that the process is impervious to any subconscious influence by the individuals making the allocation. This is most securely achieved if an assignment schedule generated using true randomisation is concealed. Allocation concealment can always be implemented (Clarke, 2003). Performance and detection biases can occur if there are unintended differences in the way the treatment and placebo groups are treated, either while receiving the intervention or being assessed at follow up. The best way to avoid these potential biases is for those providing and receiving care, and those undertaking the outcome assessments, to be blinded so that they do not know the group to which the recipients of care have been allocated (Clarke, 2003). There is limited empirical evidence of a relationship between parameters thought to measure validity and actual trial outcomes. More research is needed to establish which criteria for assessing validity are important determinants of study results and when (Clarke, 2003).

When critically appraising the validity of the studies, the reviewers had to rely on adequate reporting of the trials. Assuming that if something was not reported it was not done is not necessarily correct. The reviewers relied on the good will of experts in the field to provide information on completed, or ongoing, published or unpublished studies.

The reviewers did attempt to obtain additional clarifying data from investigators; however no response was received.

The alternative to withholding treatment from a patient is to employ a placebo. In wound care trials such placebo treatments are unlikely to be inert, as the application of the placebo or vehicle is likely to change the local environment of the wound, thereby modifying the biological processes associated with healing. A placebo is therefore not a substitute for withholding treatment in studies to determine the rationale for active treatment. The possible interaction between the vehicle and the healing process, together with small sample size, may provide some explanation for why so few of the trials included in this review showed a statistically significant difference between an active treatment and a placebo.

Generally, the methodological quality and sample size of the trials included in this review was only fair. Very few trials reported their methods of randomisation or allocation concealment, and few calculated *a priori* sample size estimates. However, several studies used sham therapy in order to maintain blinding of treatment allocation to the patients, clinicians and outcomes assessors.

#### **Topical negative pressure as an adjunct treatment for pressure ulcers**

In the study by Joseph (Joseph 2000) the assignment schedule appeared to be generated using true randomisation but the adequacy of allocation concealment was unclear, hence risking selection bias. The study was also at risk of performance bias as the experimental group received TNP delivered via a foam dressing whereas the control groups had saline gauze dressings so it was impossible to blind those providing and receiving care. However, outcome assessors were blind on treatment allocation thereby reducing the risk of detection bias. It is uncertain whether the Joseph (2000) study was at risk of attrition bias. In this study it was not clear whether intention-to-treat analysis was used, if exclusions were made, and, if they were, the reasons for these (protocol deviations, withdrawals, dropouts and losses to follow up).

Due to the poor reporting of this study, precise effects measures cannot be calculated. This, coupled with the small sample size and methodological flaws, means that this trial does not provide any evidence of benefit on the use of topical negative pressure as an adjunct therapy for pressure ulcer treatment. Further controlled trials are needed to address this question.

#### **Therapeutic ultrasound as an adjunct treatment for pressure ulcers**

The results of the two included trials in this review (McDiarmid, 1985; ter Riet, 1995) do not suggest a benefit associated with therapeutic ultrasound in the healing of

pressure ulcers. Again however, as the numbers of randomised patients are small and methodological quality relatively poor, the results should be viewed with caution. Further randomised trials are warranted.

### **Electrotherapy or electromagnetic therapy as an adjunct treatment for pressure ulcers**

The four trials identified that assessed these interventions (Getzkow, 1991; Griffin, 1991; Wood, 1993; Ritz, 2002) all suggested a trend toward benefit associated with using electrotherapy to treat pressure ulcers. However this suggestion is drawn from a total of only 186 patients.

The three studies whose results were pooled (Griffin, 1991; Wood, 1993; Ritz, 2002) all had unmatched groups for ulcer size at baseline. Griffin (1991) had larger ulcers in the control group. The result (RR 1.69, 95% CI 0.37-7.67), while not statistically significant, favours electrotherapy, and is therefore with the direction of bias. There were only small numbers of patients in each group in this study.

Wood (1993) included patients whose ulcers were larger in the intervention group. The result of this study (RR 18.02, 95% CI 2.58-126.01) is statistically significant while being against the direction of bias. Overall, there was no evidence of a statistically significant benefit in pressure ulcer healing with the use of electrotherapy. The extent to which electrotherapy contributes to healing in patients who are otherwise receiving pressure relief and moist wound-healing strategies needs to be explored further using rigorous methodology.

While the two trials (Comorosan, 1993; Salzburg, 1995) that assessed the effect of electromagnetic therapy are both suggest a benefit for the healing of pressure ulcers, neither reaches statistical significance and the evidence is rather unreliable. Both trials contained small numbers of patients, and had differing regimens of treatment over varying time scales. The extent to which electromagnetic therapy contributes to healing in patients who are otherwise receiving pressure relief and moist wound-healing strategies should be explored further. The trials do not adequately report the severity of pressure ulcers and baseline comparisons. As such the results should be viewed as unreliable and further research is needed involving larger numbers of patients.

### **6.9.1 Cost-effectiveness of adjunct therapies (topical negative pressure, therapeutic ultrasound, electrotherapy and electromagnetic therapy)**

One full economic evaluation and one partial economic evaluation of adjunct therapies were identified for review (Macario et al., 2002; Philbeck et al., 1999 respectively).

Macario et al. (2002) conducted a cost-utility analysis comparing noncontact normothermic wound therapy to current standard care (see data extraction table 22, Appendix A). The study was conducted in a long-term care institution in the US. The authors reported that the perspective of the analysis was societal. The analysis included societal-based utilities, however the costing was undertaken from the perspective of the health care payer (see data extraction table 22, Appendix A). The study was based on a decision-analytic model. The base case analysis involved a hypothetical 72-year-old patient with a two-month old, ischial grade 3 pressure ulcer who was living in a nursing home. The secondary analysis involved a grade 4 pressure ulcer. Monte Carlo simulation was undertaken to resample from the data to estimate results for 10,000 hypothetical patients.

Data to populate the model were obtained from national statistics, the literature and author opinion. A Markov model was used which comprised of six mutually exclusive health states including: (i) grade 3 pressure ulcer, (ii) grade 4 pressure ulcer, (iii) healing wound, (iv) closed wound healed back to normal, (v) complications requiring hospitalisation, and (vi) death. Patient progression through the model was divided into eight-week cycles over 40 months.

Utility estimates were based on author assumption, informed by the literature. The quality of life of a patient with a pressure ulcer was determined by assigning levels of disability and distress to each health state. The authors used the Rosser-Kind index, which includes disability and distress dimensions to attach utilities to each of the six health states (above). The change in utility attached to patients' health status as they progressed through the model was combined with life expectancy to calculate QALY estimates. The resources measured and costed included nurse and doctor time, use of supplies and equipment, and the cost of complications.

Over the 40-month timeframe, it was estimated that for grade 3 pressure ulcers 0.10 (SE<sup>vii</sup> = 0.0005) QALYs were gained per patient using noncontact normothermic wound therapy over current standard care. For grade 4 pressure ulcers the gain in QALYs was 0.14 (SE = 0.0010) per patient. In terms of costs, for grade 3 pressure ulcers it was estimated that noncontact normothermic wound therapy cost \$6,3340 (SE = \$98) (price year 2000) less than current standard care and for grade 4 pressure ulcers the cost was estimated to be \$15,216 (SE = \$186) less. Thus noncontact normothermic wound therapy was identified as the dominant strategy in treating grade 3 and 4 pressure ulcers.

Probabilistic sensitivity analysis was undertaken to test the robustness of the results by simultaneously considering uncertainty associated with all probabilities, utilities and costs included in the model. Results were most sensitive to the following model inputs: daily treatment costs and the probability of healing to a normal closed wound with standard care; the cost of the complication state; and the acquisition cost of noncontact normothermic wound therapy. If the cost of the latter increased to \$421 its use increased overall costs. The Monte Carlo simulations showed that noncontact normothermic wound therapy is likely to reduce costs and increase quality of life for at least 75% (SE=0.4%) of patients with stage 3 pressure ulcers and to reduce costs by around 81% (SE=0.4%) for patients with stage 4 pressure ulcers.

These results should be considered in the light of a number of assumptions that underpin the Macario et al. (2002) model. As the authors mention, their assumption that transition probabilities remain constant over time may be questioned. For instance, in practice the probability of healing after the first eight-week cycle may not be equal to the probability of healing after the fourth eight-week cycle. Utilities were attached to health states indirectly, that is the patients themselves did not value health states as this data was not available. The model assumed that reduction in wound size directly improved the probability of wound healing. Data to populate the model was obtained from numerous sources, based on controlled and randomised trials. There was much variability due to differences in the delivery of care across settings (standard care varies in particular), confounding comorbidities, variability in types, sizes and locations of pressure ulcers.

Philbeck et al. (1999) conducted a cost-consequence analysis comparing negative pressure wound therapy (TNP) to saline-soaked gauze dressing applied to patients

---

<sup>vii</sup> SE = Standard Error. This statistic indicates the degree of uncertainty in calculating an estimate from a sample

placed on either a low air loss mattress or a foam mattress bed for grade 3 or 4 pressure ulcers (see data extraction table 23, Appendix A). The analysis was conducted from the perspective of the health care payer although this was not stated.

For the negative pressure wound therapy group a Medicare observational dataset was used which covered a 180-day follow-up period. For the comparator, data from the Ferrell et al. study (1993) were used (see Appendix A data extraction table 25, which presents an economic evaluation by Ferrell et al. ((1995)) which was also based on this trial). The study was excluded from the clinical effectiveness review because it was based on retrospective, observational data for the negative pressure wound therapy and a historical control (Ferrell et al., 1993) for the comparator.

Effectiveness measures from both studies included healing rates as a reduction in wound area and volume over 30 days, and time to heal. The reduction in cm<sup>2</sup> per day of the wound was faster for negative pressure wound therapy at 0.230cm<sup>2</sup> per day compared to 0.090cm<sup>2</sup> for the comparator. Time to heal, based on wound healing rates, was expected to be 97 days for negative pressure wound therapy compared to 247 days for the comparator. The total cost of negative pressure wound therapy per day, including the cost of materials and nursing visits was \$149.96 versus \$95.00 (the price year was not stated). However, due to a faster expected healing rate, the expected total cost to complete heal was lower on average for each patient in the negative pressure wound therapy group (\$14,546 versus \$23,465).

It appears that negative pressure wound therapy dominates saline-soaked gauze dressings applied to patients placed on either a low air loss mattress or a foam mattress bed for grade 3 or 4 pressure ulcers. However, there are a number of substantial limitations associated with the study that cast doubts on the validity and reliability of the results. While the authors aimed to closely match patients from either study, the potential variability and uncertainty introduced into the study as a result of the study design was not explored. The authors state that the Medicare dataset did not contain data on the duration of previous interventions, medical history and laboratory values relevant to wound healing, and the homogeneity of the patients across the two groups, apart from the treatment received, is questionable. The initial surface area of the wounds was very different (22.2cm<sup>2</sup> versus 4.3cm<sup>2</sup> for the negative pressure and comparator treatments respectively). However this may be expected to favour the latter.

**Overview of adjunct therapies**

	<b>Research evidence</b>
1-	<p>Topical negative pressure treatment was only assessed in one trial with a small sample size and methodological limitations. While the trial results suggested that topical negative pressure treatment may increase healing rates of pressure ulcers compared with saline gauze dressings, the findings must be viewed with extreme caution. Practitioners ought to make patients aware of the limited trial-based evidence for the effectiveness of topical negative pressure for pressure ulcer healing and that further research is required to validate the preliminary findings.</p>
1+	<p>There is no evidence of a benefit of using ultrasound therapy in the treatment of pressure ulcers. The possibility of a beneficial or a harmful effect cannot be ruled out, however, due to the small number of trials with methodological limitations and small numbers of participants.</p>
1+	<p>The meta-analysis of the results of three trials which assessed the effect of electrotherapy on pressure ulcer healing showed no evidence of benefit for this treatment. However this suggestion is drawn from three studies with a total of only 137 patients. Therefore the results should be viewed with caution as it is difficult to determine clinically important effects from such small samples. Further research is required into this potentially beneficial treatment before definitive recommendations for practice can be made.</p>
1+	<p>There is no reliable evidence of benefit of using electromagnetic therapy in the treatment of pressure ulcers. The possibility of benefit or harm cannot be ruled out due to the small number of trials with methodological limitations and small numbers of participants.</p>

1++	<p>Overall, while adjunct therapies are increasingly being used in clinical practice, there is currently little good-quality evidence to support their use.</p> <p><b>Cost-effectiveness</b></p> <p>The effectiveness evidence on which the two economic evaluations were based was moderate to low, primarily due to lack of data. The two studies compare different treatments so it was not appropriate to synthesise the data. The economic evaluation presented by Macario et al. is the stronger of the two studies and it appears that noncontact normothermic wound therapy may be more cost-effective than current standard care. Although the Philbeck et al. (1999) study suggests that negative pressure wound therapy might be a more cost-effective option than saline-soaked gauze dressings applied to patients placed on either a low air loss mattress or a foam mattress bed for grade 3 or 4 pressure ulcers, the internal validity and generalisability of the findings is questionable.</p> <p>One partial economic evaluation compared (TNP) to standard care and found that TNP was more cost-effective.</p>
-----	--

## Recommendations: adjunct therapies

The use of adjunct therapies (electro-therapy technologies and topical negative pressure therapy) for the treatment of pressure ulcers should be based on: **[D]**

- ulcer assessment
- level of risk from holistic assessment
- general skin assessment
- general health status
- previous positive effects of the technology/therapy
- patient preference (lifestyle, abilities and comfort), and
- practitioner's competence.



	<b>Research recommendations</b>
	<p>There is a need for well-designed, adequately powered, multi-centre RCTs to evaluate the contribution of adjunct therapies to the healing of pressure ulcers.</p> <p>Evidence for the relative effectiveness of adjunct therapies compared to other treatment modalities in pressure ulcer management is likely to be provided by trials in which the comparison is an adjunct therapy against a background of standard care (preferably treatments based on the best available evidence), or adjunct therapies compared with sham therapies.</p> <p>Well-designed, multi-centre RCTs evaluating the effectiveness of adjunct therapies on healing rates, healing times, cost, quality of life, pain and comfort, and whether there are optimal regimes for patients with existing pressure ulcers of varying degrees of severity, are thus required.</p>

## **7. RECOMMENDATIONS FOR RESEARCH**

The following research gaps were identified by the GDG. Following NICE requirements, the first five are those that were prioritised by the GDG using a group consensus process, in which every research recommendation was ranked by each group member.

### **Risk of delayed healing/complications to healing**

Well designed, large-scale prospective cohort studies including those with pressure ulcers, and including relevant identified risk factors to show how the identified risk factors lead to more severe ulcers or delayed healing or complications.

### **Pressure ulcer assessment**

Pressure ulcer assessment is a fundamental activity for both evaluating treatment interventions and communicating that information. Research needs to focus on which methods of measurement and which parameters are of use to clinicians to allow accurate wound evaluation.

### **Support surfaces for pressure support**

Independent, well-designed, multi-centre, randomised, controlled trials are needed to compare the clinical and cost-effectiveness of different types of pressure-relieving support surfaces to treat existing pressure ulcers for patients in a variety of settings. In particular, this research should aim to compare, for example:

- different types of high-specification foam mattresses and other constant low-pressure devices, and
- alternating pressure, air fluidised and low air loss devices.

The studies should also evaluate the cost-benefit trade off of pressure ulcer treatment alternatives.

Positioning and repositioning should be investigated in those with existing pressure ulcers to determine:

- the need for repositioning with pressure-relieving devices
- methods of repositioning on different devices with frequency, and
- practitioner time involved in repositioning.

Future research must address the methodological deficiencies associated with much of the research described in the reviews. Particular attention should be paid to:

- description of inclusion and exclusion criteria used to derive the sample from the target population
- evidence of an a priori sample size calculation
- evidence of allocation concealment at randomisation
- description of baseline comparability of treatment groups
- evidence of blinded outcome assessment
- clear description of main interventions
- adequate description of associated care, and
- withdrawals reported by the treatment group with reasons.

Attention should also be paid to:

- true randomisation (with concealed allocation)
- a sample of sufficient size to detect clinically important differences, and clear criteria for measuring outcomes
- blinded interventions and assessment
- adequate follow up
- appropriate statistical analysis
- measuring patient experiences of pressure-relieving equipment
- comfort
- pain
- ease of use (for devices)
- appropriateness for users and settings, and
- durability of equipment.

### **Antimicrobials/nutrition**

The results summarised in this review are based on findings from small trials with methodological problems. Therefore, much of the required research needs replication in larger, well-designed studies using contemporary interventions for antimicrobial activity, and nutritional support/supplementation.

### **Surgery**

Research needs to focus on the effectiveness of different types of surgery, and surgery compared to conventional treatments, in those with pressure ulcers.

## **Combined Quick Reference Guide**

## **8. AUDIT CRITERIA**

The audit criteria below are to assist with implementation of the Guideline recommendations. The criteria presented are considered to be the key criteria associated with the Guideline recommendations. They are suitable for use in primary and secondary care, and for all patients with pressure ulcers.

Caveats for Guideline users

- Objectives for an audit.
- Individuals to be included in an audit.
- Data sources and documentation of audit.

Systems for recording the necessary information, which will provide data sources for audit, should be agreed by trusts.

Whatever method is used for documentation, it should be accessible to all members of the multidisciplinary team.

Documentation of the factors taken into consideration when deciding the most appropriate intervention should occur.

The fact that carers and patients have been informed about pressure ulcers should be documented. Patients and carers should be directly questioned about their satisfaction with, and the adequacy of, the information provided. This should be documented in either the patient's notes or in another source as agreed by the trust.

Trusts should establish a system of recording when staff have been educated in the management of pressure ulcers and should implement a process for reviewing pertinent education needs.

	Criterion	Exception	Definition of terms
1.	The individual's plan of care contains a classification/grade for all pressure ulcers using the European Pressure Ulcer Advisory Panel (EPUAP) classification system.	None	The grade of ulcers should be clearly documented in the plan of care to be available to the inter-disciplinary team. Pressure ulcers should be given a grade of 1-4. Pressure ulcers should not be reverse graded in that a healing grade 4 pressure ulcer should be described as such and not as a grade 3 pressure ulcer.
2.	A pressure ulcer that is identified as a grade 2 or above is documented as a clinical incident.	None	The reporting should follow trust procedure for reporting of clinical incidents.
3.	Individuals with pressure ulcers have their ulcer assessed initially (within six hours) and the assessment is ongoing. The assessment is supported by tracings and or a photograph of the ulcer.	None	The ulcer is assessed for cause, site/location, dimensions, stage/grade, exudates (amount and type), local signs of infection, pain, wound appearance, appearance of surrounding skin, undermining/tracking (sinus or fistula), and odour. Clinical experts are involved as appropriate – e.g. tissue viability nurse.
4.	Individuals with pressure ulcers have access to appropriate pressure-relieving support surfaces or strategies throughout a 24-hour period. This includes all surfaces used by the individual, including mattresses and cushions.	None	Support surfaces include all surfaces used by an individual, which will include mattresses for beds (including theatre trollies), and cushions for chairs and wheelchairs. Strategies include the use of repositioning to minimise prolonged pressure on the body.
5.	Individuals with grade 1-2 pressure ulcers have a high-specification foam mattress/cushion as a minimum and are very closely observed for deteriorations. Individuals have a documented repositioning regime.	Those in whom this is contraindicated. Those with perceived or further deterioration. <i>Need input from clinician.</i>	Repositioning is documented in the plan of care.
6.	Individuals with grade 3-4 pressure ulcers have alternating pressure	Those in whom this is contraindicated – i.e due to patient weight	Repositioning is documented in the plan of care.

	overlay or sophisticated low pressure support as a minimum and are closely observed.	or issues of safety. Where a replacement system or alternative support may be indicated.	
7.	Individuals with pressure ulcers have their ulcers dressed with modern wound dressings to create the optimum wound healing environment.	Those individuals in whom these dressings are contraindicated.  Patient informed choice.	The dressing should be documented in the plan of care with rationale for its use. Choice of dressings should be based on the ulcer assessment, general skin assessment, treatment objective, risk of adverse events, patient preference, dressing characteristics, and manufacturer's indications for use. Decisions about choice should be made by registered health care professionals. Examples of modern dressings are: hydrocolloids, hydrogels, hydrofibres, foams, films, alginates and soft silicones.

## **9. DISSEMINATION OF GUIDELINES**

The Guideline will be produced in a full and summary format, and a version for the public (*Information for the public*).

Full copies of the Guideline will be available through the NICE website (<http://www.nice.org.uk>) in PDF format and the summary through the National Electronic Library for Health (NeLH) (<http://www.nelh.nhs.uk/>) and National Guideline Clearinghouse (<http://www.guidelines.gov>).

## **10. VALIDATION**

The Guideline has been validated through two stakeholder consultation processes. The first and second drafts were submitted in December 2004 and March 2005 to NICE, who obtained and collated stakeholders' comments for consideration by the GDG.

## **11. SCHEDULED REVIEW OF GUIDELINE**

The process of reviewing the evidence is expected to begin four years after the date of issue of this Guideline. Reviewing may begin earlier than four years if significant evidence that affects the Guideline recommendations is identified sooner. The updated Guideline will be available within two years of the start of the review process.

## References

- Adeoke BOA and Badmos KA (2001) Acceleration of pressure ulcer healing in spinal cord injured patients using interrupted direct current. *Afr J Med Sci*,30,pp.195-197.
- Agren MS and Stromberg HE (1985) Topical treatment of pressure ulcers. A randomized comparative trial of Varidase and zinc oxide. *Scand J Plast Reconstr Surg*,19,pp.97-100.
- Aguilo Sanchez S, Figueiras Mareque L, Quintilla Gatnau A and Veiga Bogos L. (2001) Traditional dressings or cures in a moist environment? (Spanish). *Revista Rol de Enfermeria*,24,pp.50-54.
- AHCPR (1994) *Treatment of pressure ulcers, clinical practice guideline No 15*. USA Department of Health and Human Services, Rockville: USA.
- Alarcon T, Barcena A et al. (1999).Factors predictive of outcome on admission to an acute geriatric ward. *Age & Ageing*,28(5),pp.429-32.
- Allman RM, Walker JM, Hart MK, Laprade CA, Noel LB and Smith CR (1987) Air-fluidized beds or conventional therapy for pressure sores. A randomized trial. *Annals of Internal Medicine*,107(5),pp.641-8.
- Allman RM, Goode P, Patrick M, Burst N and Bartolucci AA (1995) Pressure ulcer risk factors among hospitalised patients with activity limitation. *Journal of the American Medical Association*,273(11),pp.865-70.
- Allman RM (1997) Pressure ulcer prevalence, incidence, risk factors, and impact. *Clinical Geriatric Medicine*,13,pp.421-36.
- Alm A, Hornmark AM, Fall PA, et al. (1989) Care of pressure sores: a controlled study of the use of a hydrocolloid dressing compared with wet saline gauze compresses. *Acta Derm Venereol Suppl (Stockh)*,149,pp.1-10.
- Altman DG, Schulz KF, Moher D, et al. (2001) The revised CONSORT statement for reporting randomized trials: explanation and elaboration. *Annals of Internal Medicine*,134,pp.663-694.
- Alvarez OM and Childs EJ (1991) Pressure ulcers. Physical, supportive and local aspects of management. *Clin Podiatr Med Surg*,8,pp.869-90.
- Alvarez OM, Fernandez-Obregon A, Rogers RS, Bergamo L, Masso J and Black M. (2002) A prospective, randomized, comparative study of collagenase and papain-urea for pressure ulcer debridement. *Wounds-A Compendium of Clinical Research & Practice*,14(8),pp.:293-301.
- Amundson J A, Sherbondy A et al. (1994) Early identification and treatment necessary to prevent malnutrition in children and adolescents with severe disabilities. *Journal of the American Dietetic Association*,94(8),pp.880-883.
- Andersen KE and Kvorning SA (1982) Medical aspects of the decubitus ulcer. *International Journal of Dermatology*,21(5),pp.265-270.
- Andrychuk MA (1998) Orthopaedic essentials. Pressure ulcers: causes, risk factors, assessment, and intervention. *Orthopaedic Nursing*,17(4),pp.65-83.

- Andrychuk MA (1998) Pressure ulcers: causes, risk factors, assessment, and intervention. *Orthopaedic Nursing*,17(4),pp.65-81;quiz 82-3.
- Argenta LC and Morykwas MJ (1997) Vacuum-assisted closure: a new method for wound control and treatment: clinical experience. *Annals of Plastic Surgery*, 38,pp.563-576.
- Avanzi A, Martinelli R, Accardi S, et al. (2000) Adhesive hydrocellular dressing vs hydrocolloid dressing in the treatment of pressure sores. First World Wound Healing Congress 2000,p.90.
- Ayello E (1992) Teaching the assessment of patients with pressure ulcers. *Decubitus*,5(7),pp.53-4.
- Ayello E (1996) Keeping pressure ulcers in check. (Assessment tool). *Nursing*,26(10),pp.62-3.
- Ayello EA (1997) Assessment of pressure ulcer healing. *Advances in Wound Care*, 10(5),p.10.
- Ayello EA, Mezey M et al. (1997) Educational assessment and teaching of older clients with pressure ulcers. *Clinics in Geriatric Medicine*,13(3),pp.483-96.
- Ayello EA, Thomas DR et al. (1999) Nutritional aspects of wound healing. *Home Healthcare Nurse*,17(11),pp.719-29;quiz 730.
- Azad S and Nishokawa H (2002) Topical negative pressure may help chronic wound healing. *Bmj*,3247,pp.345,1100.
- Baggerly J and DiBlasi M (1996) Pressure sores and pressure sore prevention in a rehabilitation setting: building information for improving outcomes and allocating resources. *Rehabilitation Nursing*,21(6),pp.321-5.
- Baker P and Haig G (1981) Metronidazole in the treatment of chronic pressure sores and ulcers: a comparison with standard treatments in general practice. *Practitioner*,225,pp.569-73.
- Bale S, Banks V and Harding KG (1996) A 100 patient cost-effectiveness trial of a hydrocellular and hydrocolloid dressing. Proceedings of the 5th European Conference on Advances in Wound Management, 21-24 Nov 1995. Harrogate, London, UK: Macmillan Magazines,p294.
- Bale S, Squires D, Varnon T, Walker A, Benbow M and Harding KG. (1997) A comparison of two dressings in pressure sore management. *Journal of Wound Care*,6,pp.463-6.
- Bale S, Banks V, Haglestein S and Harding KG (1998) A comparison of two amorphous hydrogels in the debridement of pressure sores. *Journal of Wound Care*,7,pp.65-8.
- Bale S, Hagelstein S, Banks V and Harding KG (1998) Costs of dressings in the community. *Journal of Wound Care*,7,pp.327-30.
- Bale S (1999) The preliminary results of a comparative study of performance characteristics and safety of a foam dressing Biatain Adhesive versus Tielle on pressure sores. 9th European Conference on Advances in Wound Management. Harrogate, UK,8.
- Banks V, Bale S and Harding K (1994) The use of two dressings for moderately exuding pressure sores. *J Wound Care*,3,pp.132-4.

Banks V, Bale S and Harding KG (1994) Superficial pressure sores: comparing two regimes. *J Wound Care*,3,pp.8-10.

Banks V, Bale S and Harding KG (1994) Comparing two dressings for exuding pressure sores in community patients. *J Wound Care*,4,pp.175-178.

Banks V, Riggs R, Bale S and Harding K (1994) Comparison of an absorbent semi-permeable polyurethane dressing (Spyrosorb/Mitraflex) and a hydrocolloid dressing (Granuflex E) for the treatment of moderately exuding pressure sores in community patients. In: Harding Kg DCCGGF (ed.) Proceedings of the 3rd European Conference on Advances in Wound Management, 19-22 Oct 1993, Harrogate, London, UK: Macmillan Magazines,p.159.

Banks V, Fear M, Orpin J, et al. (1996) A comparative open multi-centre trial of hydroplolymer dressing and hydrocolloid. Proceedings of the symposium on Advanced Wound Care and Medical Research Forum on Wound Repair, 20-24 Apr 1996, Atlanta GA. Wayne GA: Health Management Publication,p.113.

Banks V, Hagelstein S, Bale S and Harding KG (1996) A comparison of a new polyurethane dressing versus a hydrocellular dressing in the treatment of moderate to heavily exudating wounds. Proceedings of Symposium on Advanced Wound Care & Medical Research Forum on Wound Repair,p.113.

Banks V, Bale S, Harding K and Harding EF (1997) Evaluation of a new polyurethane foam dressing. *Journal of Wound Care*,6,pp.266-9.

Banks V (1998) Nutrition and pressure area management. *Journal of Wound Care*,7(6),pp.318-9.

Banwell PE, Holten IW and Martin DL (1998) Negative pressure therapy: clinical applications and experiences with 200 cases. *Wound Repair and Regeneration*,8, 6,p.A460.

Banwell PE (1999) Topical negative pressure therapy in wound care. *Journal of Wound Care*,8,pp.79-84.

Banwell PE and Teot L (2003) Topical negative pressure (TNP): the evolution of a novel wound therapy. *J Wound Care*,12,pp.22-28.

Baranoski S and Thimsen K (2003) OASIS skin and wound integumentary assessment items: applying the WOCN guidance document. *Home Healthcare Nurse*, suppl:3-13.

Barbenel JC (1981) *A technique for the routine assessment of elderly patients while in bed. 1st annual report.* Bioengineering Unit, Glasgow: University of Strathclyde.

Barbenel JC (1982) *A technique for the routine assessment of the mobility of elderly patients while in bed. Final report.* Bioengineering Unit, Glasgow: University of Strathclyde.

Barrois B (1992) Comparison of Granuflex and medicated paraffin gauze in pressure sores. Proceedings of the 2nd European Conference on Advances in Wound Management, 20-23 Oct 1992. Harrogate, London, UK: Macmillan Magazines,p.209.

Barton AA and Barton M (1973) The clinical and thermographical evaluation of pressure sores. *Age & Ageing*,2(1),pp.55-9.

Bates-Jensen BM (1994) The Pressure Sore Status Tool: An outcome measure for pressure sores. *Topics in Geriatric Rehabilitation*,9(4),pp.17-34.

Bates-Jensen B and McNeess P (1996) The Wound Intelligence System: early issues and findings from multi-site tests. *Ostomy Wound Management*,42(10A Suppl),pp.53S-61S.

Bates-Jensen BM (1995) Indices to include in wound healing assessment. *Advances in Wound Care*,8(4),suppl 25-33.

Bates-Jensen BM and McNeess P (1995) Toward an intelligent wound assessment system. *Ostomy Wound Management*,41(7A Suppl),80S-86S,discussion 87S.

Bates-Jensen BM, Alessi CA et al. (2003) The effects of an exercise and incontinence intervention on skin health outcomes in nursing home residents. *Journal of the American Geriatrics Society*, 51(3),pp.348-55.

Baxandall T (1997) Healing cavity wounds with negative pressure. *Elderly Care*,9,pp.20-22.

Baumgarten M, Margolis D, Berlin JS et al. (2003) Risk factors for pressure ulcers among elderly hip fracture patients. *Wound Repair and Regeneration*,11,pp.96-103.

Bedi A (1993) A tool to fill the gap. Developing a wound risk assessment chart for children. *Professional Nurse*,9(2),pp.112-20.

Begg C et al. (1996) Improving the quality of reporting of randomised controlled trials: the CONSORT statement. *Jama*,276,pp.637-9.

Belmin J, Meaume S, Rabus MT and Bohbot S (2002) Investigators of the sequential treatment of the elderly with pressure sores T. Sequential treatment with calcium alginate dressings and hydrocolloid dressings accelerates pressure ulcer healing in older subjects: a multicenter randomized trial of sequential versus nonsequential treatment with hydrocolloid dressings alone. *Journal of the American Geriatrics Society*,50,pp.269-74.

Benati G, Delvecchio S, Cilla D and Pedone V (2001) Impact on pressure ulcer healing of an arginine-enriched nutritional solution in patients with severe cognitive impairment. *Arch Gerontol Geriatr*,Jan,33 Suppl 1,pp.43-7.

Benbo M (1996) Pressure sore guidelines: patient/carer involvement and education. *British Journal of Nursing*,5(3),pp.182,184-7.

Bendy R, Nuccio P, Wolfe E, Collins B, Tamburro C, Glass W et al. (1964) Relationship of quantitative wound bacterial counts to healing decubiti: effect of topical gentamycin. *Antimicrob Agents Chemother*,4,pp.147-55.

Bennett G and Moody M (1995) *Wound care for health professionals*, London: Chapman and Hall.

Bennett G, Dealey C and Posnett J (2004) The cost of pressure ulcers in the UK. *Age and Aging*,33,pp.230-235.

Bennett RG, Baran PJ, DeVone LV, Bacetti H, Kristo B, Tayback M and Greenough WB. (1998) Low air loss hydrotherapy versus standard care for incontinent hospitalized patients. *J Am Ger Soc*,46(5),pp.569-76.

Belmin J, Meaume S, Rabus MT and Bohbot S (2002) Investigators of the sequential treatment of the elderly with pressure sores T. Sequential treatment with calcium alginate dressings and hydrocolloid dressings accelerates pressure ulcer healing in older subjects: a multicenter randomized trial of sequential versus nonsequential treatment with hydrocolloid dressings alone. *Journal of the American Geriatrics Society*,50,pp.269-74.

Bergemann R et al. (1999) Economic evaluation of the treatment of chronic wounds: hydroactive wound dressings in combination with enzymatic ointment versus gauze dressings in patients with pressure ulcer and venous leg ulcer in Germany. *PharmacoEconomics*,16,pp.367-77.

Bergquist S (2003) Pressure ulcer prediction in older adults receiving home health care: implications for use with the OASIS. *Advances in Skin and Wound Care*,16(3),pp.132-139.

Bergstrom N, Braden B and Milne D (1987) Are dietary and serum zinc and copper factors in the development of pressure sores in institutionalized elderly. *Federation Proceedings*,46,p:902.

Bergstrom N and Braden B (1992) A prospective study of pressure sore risk among institutionalized elderly. *Journal of the American Geriatrics Society*,40(8),pp.747-758.

Bergstrom N, Allman RM et al. (1995) Pressure ulcer treatment: quick reference guide for clinicians. *Advances in Wound Care*, 8(2 part 1),pp.22.

Bergstrom N, Braden B, Kemp M et al. (1996) Multi-site study of incidence of pressure ulcers and the relationship between risk level, demographic characteristics, diagnosis and prescription of preventive interventions. *Journal of American Geriatrics Society*,44,pp.22-30

Bergstrom N, Demuth PJ and Braden BJ [1998] A clinical trial of the Braden scale for predicting pressure sore risk. *Nursing Clinics of North America*,22,pp417-428.

Berlowitz DR and Wilkin SVB (1990) Risk factors for pressure sores: a comparison of cross-sectional and cohort derived data. *Journal of American Geriatrics Society*, 37(11),pp.1043-1050.

Berlowitz DR and Wilkin SV (1990) The short-term outcome of pressure sores. *Journal of the American Geriatrics Society*,38(7),pp.748-52.

Berlowitz DR, Brandeis GH et al. (1997) Predictors of pressure ulcer healing among long-term care residents. *Journal of the American Geriatrics Society*,45(1),pp.30-4.

Berlowitz DR, Brandeis GH et al. (1997) Effect of pressure ulcers on the survival of long-term care residents. *Journals of Gerontology Series A-Biological Sciences & Medical Sciences*,52(2),pp.M106-10.

Bianchetti A, Zanetti O et al. (1993) Risk factors for the development of pressure sores in hospitalized elderly patients: results of a prospective study. *Archives of Gerontology & Geriatrics*,16(3),pp.225-232.

- Bo M, Massaia M et al. (2003) Predictive factors of in-hospital mortality in older patients admitted to a medical intensive care unit. *Journal of the American Geriatrics Society*,51(4):529-33.
- Bohanannon RW and Pfaller BA (1983) Documentation of wound surface area from tracings of wound perimeter: clinical report on three techniques. *Physical Therapy*, 63(10),pp.1622-1624.
- Bonnefoy M, Coulon L et al. (1995) Implication of cytokines in the aggravation of malnutrition and hypercatabolism in elderly patients with severe pressure sores. *Age & Ageing*,24(1),pp.37-42.
- Bourdel-Marchasson I, Dumas F, Pinganaud G, Emeriau JP and Decamps A. (1997) Audit of percutaneous endoscopic gastrostomy in long-term enteral feeding in a nursing home. *Int J Qual Health Care*,Aug,9(4),pp.297-302.
- Bourdel-Marchasson I, Barateau M, Rondeau V, Dequae-Merchadou L, Salles-Montaudon N, Emeriau JP, Manciet G and Dartigues JF (2000) A multi-center trial of the effects of oral nutritional supplementation in critically ill older inpatients. GAGE Group. Groupe Aquitain Geriatrique d'Evaluation. *Nutrition*,Jan,16(1),pp.1-5.
- Boyle M and Green M (2001) Pressure sores in intensive care: defining their incidence and associated factors and assessing the utility of two pressure sore risk assessment tools. *Australian Critical Care*,14(1),pp.24-30.
- Boynton PR and Paustian C (1996) Wound assessment and decision-making options. *Critical Care Nursing Clinics of North America*,8(2),pp.125-39.
- Bradley M, Cullum N and Sheldon T (1999a) The debridement of chronic wounds: a systematic review. *Health Technology Assessment*,no.17(pt 1).
- Bradley M, Cullum N, Nelson E et al. (1999b) Systematic reviews of wound care management: (2) dressings and topical agents use in the healing of chronic wounds. *Health Technology Assessment*,3,no.17(pt2).
- Brandeis GH, Ooi WL, Hossain M et al. (1994) A longitudinal study of risk factors associated with the formation of pressure ulcers in nursing homes. *Journal of the American Geriatrics Society*,42(4),pp.388-393.
- Breslow RA, Hallfrisch J and Goldberg AP (1991) Malnutrition in tubefed nursing home patients with pressure sores. *J Parenter Enteral Nutr*,Nov-Dec,15(6),pp.663-8.
- Breslow RA, Hallfrisch J, Guy DG, Crawley B and Goldberg AP (1993) The importance of dietary protein in healing pressure ulcers. *J Am Geriatr Soc*,Apr,41(4),pp.357-62.
- Brewer Jr RD, Mihaldzic N and Dietz A (1967) The effect of oral zinc sulfate on the healing of decubitus ulcers in spinal cord injured patients. Proceedings of the Annual Clinical-Spinal Cord Injury Conference,pp.70-2.
- British Medical Association (BMA) (1999) *Royal Pharmaceutical Society of Great Britain. British National Formulary*, London: BMA and The Pharmaceutical Press.

- Brod M, McHenry E, Plasse TF, Fedorczyk D and Trout JR (1990) A randomized comparison of polyhema and hydrocolloid dressings for treatment of pressure sores [letter]. *Arch Dermatol*,126,pp.969-70.
- Brooks R and Semylen A (1997) Economic appraisal in pressure sore management. *Journal of Wound Care*,6,10,pp.491-494.
- Brown-Etris M, Fowler E, Papen J, et al.(1996) Comparison and evaluation of the performance characteristics, usability and effectiveness on wound healing of Transorbent versus Duoderm CGF. In: Negus DJG (ed.) Proceedings of 5th European Conference on Advances in Wound Management, 21-24 Nov 1995, Harrogate, UK: Macmillan Magazines,pp.151-5.
- Brown-Etris M, Bateman D, Shields D, et al. [1992] Final report of a clinical study designed to evaluate and compare a collagen alginate dressing and a calcium-sodium alginate dressing in pressure ulcers. In: Proceedings of European Wound Conference.
- Bulstrode CJK et al (1987) Measurement and prediction of progress in delayed wound healing. *Journal of the Royal Society of Medicine*,80,pp.210-212.
- Burgos A, Gimenez J, Moreno E et al. (2000) Collagenase ointment application at 24- versus 48-hour intervals in the treatment of pressure ulcers. A randomised multi-centre study. *Clinical Drug Investigation*,19,pp.399-407.
- Burgos A, Gimenez J, Moreno E et al. (2000) Cost, efficacy, efficiency and tolerability of collagenase ointment versus hydrocolloid occlusive dressing in the treatment of pressure ulcers. A comparative, randomised, multicentre study. *Clinical Drug Investigation*,19,pp.357-365.
- Burr RG and Rajan KT (1972) Leucocyte ascorbic acid and pressure sores in paraplegia. *British Journal of Nutrition*,28(2),pp.275-81.
- Burr HS, Taffel M and Harvey SC (1940) An electrometric study of the healing wound in man. *Yale J Biol Med*,12,pp.483-5.
- Caley L, Jones S, Freer J et al. (1994) Randomised prospective trial of two types of low air loss therapy.
- Capillas PR, Cabre AV, Gil CAM, Gaitano GAG and Torra iBJE (2000) A comparison of the effectiveness and cost of moist environment dressings treatment as compared to traditional dressings treatment: randomized clinical trial on patients suffering venous leg ulcers or pressure ulcers treated by primary health care nurses. *Revista Rol de Enfermeria*,23,pp.17-24.
- Capillas Perez R, Cabre Aguilar V, Gil Canedo-Dorantes L, Garcia-Cantu R, Barrera R, Mendez-Ramirez I, Navarro VH and Serrano G (2002) Healing of chronic arterial and venous leg ulcers with systemic electromagnetic fields. *Arch Med Res*,33,pp.281-289.
- Casey G (1997) Nutrition helps wound healing. *Nursing New Zealand (Wellington)*, 3(11),p.19.
- Casey G (1998a) Three steps to effective wound care. *Nursing Standard*,12(49),pp. 43-4.
- Casey G (1998b) Tissue viability supplement. The importance of nutrition in wound healing. *Nursing Standard*,13(3),pp.51-2.
- Cassino R, Veroni C, Ricci E, Carusone A and Mercanti A (1997) Vacuum assisted closure therapy in pressure ulcer management. *European Wound Management*

Association Conference 1997. London: European Wound Management Association,p.39.

Chang KW, Alsagoff S, Ong KT and Sim PH (1998) Pressure ulcers – randomised controlled trial comparing hydrocolloid and saline gauze dressings. *Medical Journal of Malaysia*,53,pp.428-31.

Chantelau E, Tanudjaja T, Altenhofer F, Ersanli Z, Lacigova S and Metzger C. (1996) Antibiotic treatment for uncomplicated neuropathic forefoot ulcers in diabetes: a controlled trial. *Diabetic Med*,13,pp.156-9.

Cheneworth CC, Hagglund KH, Valmassoi B and Brannon C (1994) Portrait of practice: healing heel ulcers. *Adv Wound Care*,7,pp.44-48.

Chernoff RS, Milton KY and Lipschitz DA (1990) The effect of a very high-protein liquid formula on decubitus ulcers healing in long-term tube-fed institutionalized patients. *J Am Diet Assoc*,90,pp.A-130.

Clark M and Donald IP (1999) A randomised controlled trial comparing the healing of pressure sores upon two pressure-redistributing seat cushions. In: Proceedings of the 7th European Conference on Advances in Wound Management. London: Macmillan Magazines Ltd.,pp.122-125.

Clark M and Kadhon HM (1988) The nursing prevention of pressure sores in hospital and community patients. *Journal of Advanced Nursing*,13(3),pp.365-373.

Clark M and Watts S (1994) The incidence of pressure sores in a National Health Service Trust hospital during 1991. *Journal of Advanced Nursing*,20,pp.33-36.

Clarke M and Oxman AD (2003) (editors) *Cochrane reviewers' handbook version 4.2.0 in Review Manager (RevMan 4.2.2)*. Oxford, UK: Update Software.

Clough N P (1994) The cost of pressure area management in an intensive care unit. *Journal of Wound Care*,3,pp.33-35.

Coggrave M et al (2002) Topical negative pressure for pressure ulcer management. *Br J Nurs*,116,suppl.S29-36.

Colome AM, Gaitano Garcia A and Torra i Bou JE (2000) [Comparison of the effectiveness and cost of treatment with humid environment as compared to traditional cure. Clinical trial on primary care patients with venous leg ulcers and pressure ulcers]. [Spanish]. *Revista de Enfermeria*,23,pp.17-24.

Cooper DM (1995) Indices to include in wound assessment. *Adv Wound Care*,8:15s.

Colin D, Kurring PA, Quinlan D and Yvon C (1996) Managing sloughy pressure sores. *J Wound Care*,5,pp.444-6.

Collier J (1992) A moist, odour-less environment. A multicentered trial of a foamed gel and a hydrocolloid dressing. *Professional Nurse*,7,pp.804-808.

Collier M E (1999) Pressure ulcer development and principles for prevention. In Miller M and Glover D *Wound management theory and practice*. London: NTBooks Emap.

Colwell JC, Foreman MD and Trotter JP (1993) A comparison of the efficacy and cost-effectiveness of two methods of managing pressure ulcers. *Decubitus*,6,pp.28-36.

Coutts P, Sibbald RG, Inman K and Maltby-Stephens N (2000) The use of an adhesive hydrocellular foam compared to a hydrocolloid dressing for the treatment of Stage II and III pressure ulcers. The 13th Annual Symposium on Advanced Wound Care & 10th Annual Medical Research Forum on Wound Repair,D7.

Crim JR and Seeger LL (1994) Imaging evaluation of osteomyelitis. *Critical Reviews in Diagnostic Imaging*,35(3),pp.201-56.

Cruse J M, Lewis RE et al. (2000) Review of immune function, healing of pressure ulcers, and nutritional status in patients with spinal cord injury. *Journal of Spinal Cord Medicine*,23(2),pp.129-35.

Cruse JM, Lewis RE et al. (2000) Facilitation of immune function, healing of pressure ulcers, and nutritional status in spinal cord injury patients. *Experimental & Molecular Pathology*,68(1),pp.38-54.

Cruse JM, Wang H et al. (2002) Cellular and molecular alterations in spinal cord injury patients with pressure ulcers: a preliminary report. *Experimental & Molecular Pathology*,72(2),pp.124-31.

Culley F (1998) Clinical. Nursing aspects of pressure sore prevention and therapy. *British Journal of Nursing*,7(15),pp.879-80.

Cullum N A, Deeks J J and Fletcher A W et al (1995) Preventing and treating pressure sore. *Quality in Health Care*,4,pp.289-297.

Cullum N A (2001) Pressure ulcer prevention and treatment: A synopsis of the current evidence. *Critical Care Nursing Clinics of North America*,13(4),pp.547-554.

Cullum N, Nelson E, Flemming K et al. (2001) Systematic review of wound care management: (5) beds; (6) compression; (7) laser therapy, therapeutic ultrasound, electrotherapy and electromagnetic therapy. *Health Technology Assessment*,5,9.

Cullum N, Nelson EA and Nixon J (2003) Pressure sores. Clinical Evidence. BMJ Publishing Group.

Cullum N, Deeks J, Sheldon, TA, Song F and Fletcher AW (2004) Beds, mattresses and cushions for pressure sore prevention and treatment (Cochrane Review) in: *The Cochrane Library*, Issue 1, Chichester, UK: John Wiley & Sons, Ltd.

Cutler NR et al. (1993) Comparison of quantitative methodologies to define chronic pressure ulcer measurement. *Decubitus*,6(6),pp.22-30.

Dallam L, Smyth C et al. (1995) Pressure ulcer pain: assessment and quantification. *Journal of Wound, Ostomy, & Continence Nursing*,22(5),pp.211-5,discussion pp.217-8.

Danielson JR and Tasche C (1990) Pressure sores: evaluating quality of care. *QA Review*,2(9),p.5.

Darkovich SL, Brown E and Spencer M (1990) Biofilm hydrogel dressing: a clinical evaluation in the treatment of pressure sores. *Ostomy Wound Manag*,29,pp.47-60.

Darouiche RO, Landon GC et al. (1994) Osteomyelitis associated with pressure sores. *Archives of Internal Medicine*,154(7),pp.753-758.

Das Gupta R, Twyman L, Morgan B and McGrouther DA (1996) An introduction to VAC therapy in the treatment of chronic wounds. *European Tissue Repair Society*,3.

David JA, Chapman RG et al. (1983) An Investigation of the current methods used in nursing for the care of patients with established pressure sores. Funded by the DHSS. DOH Stationary Office London.

Day A and Leonards F (1993) Seeking quality care for patients with pressure ulcers. *Decubitus*,6(1),pp.32-43.

Davidson M (2002) Sharpen your wound assessment skills: learn how impeccable assessment and documentation can help your patient heal. *Nursing, 32(10): Hospital Nursing*:32hn1-2.

Davydov Iu A, Larichev AB and Abramov A (1992) Wound healing after vacuum drainage. *Khirurgiia Mosk*,7,pp.21-26.

Davydov Iu A, Abramov A and Darichev AB (1994) Regulation of wound process by the method of vacuum therapy in middle-aged and aged patients. *Khirurgiia Mosk*, 9,pp.7-10.

Day A and Leonard F (1993) Seeking quality care for patients with pressure ulcers. *Decubitus*,6(1),pp.32-8.

De Lange MY, Schasfoort RA, Obdeijn MC, Van der Werff JFA and Nicolai JPA (2000) Vacuum-assisted closure: indications and clinical experience. *European Journal of Plastic Surgery*,23,pp.178-182.

Dealey C (1994) *The care of wounds*, Oxford: Blackwell Scientific Publications.

Dealey C and Keogh A (1997) A randomized, controlled, parallel-group clinical trial of a new polyurethane foam island dressing versus a hydrocolloid island dressing in the treatment of grade II and III pressure sores. 6th European Conference on Advances in Wound Management,pp.94-95.

Dealey C (1999) *The care of wounds – a guide for nurses*, Oxford: Blackwell Science.

Deeks JJ (1996) Pressure sore prevention: Using and evaluating risk assessment tools, *British Journal of Nursing*,5,pp.313-20.

Deeks J (1998) Odds ratios should be used only in case control studies and logistic regression analyses. *BMJ*,317,pp.1155-1156.

Defloor T (2000) Do pressure relief cushions really relieve pressure? *Western Journal of Nursing Research*,22(3),pp.335-350.

Defloor T (2000) *Does turning patients really prevent pressure ulcers?* PhD Thesis, Ghent University. Ghent.

Defloor T (2000) The effects of position and mattress on interface pressure. *Applied Nursing Research*,13,1,pp 2-11.

- Defloor T (2001) Manual repositioning of patients. *Journal of Tissue Viability*,11,3, p.117.
- Defloor T (2001) Wisselhouding, Minder frequent en toch minder decubitus. *Tijdschrift Gerontol Geriatr*,32,pp.174-7.
- Defloor T and Grypdonck MHF (1999) Sitting posture and prevention of pressure ulcers. *Applied Nursing research*,12,3,pp.136-142.
- Department of Health (1993) *Pressure sores: a key quality indicator*. London: Department of Health.
- Della Marchina M and Renzi G. (1997) Disinfezione di piaghe e ferite del paziente anziano con un nuovo preparato antisettico. *Chron Dermatol*,7,pp.873-885.
- Delmi M, Rapin CH, Bengoa JM, Delmas PD, Vasey H and Bonjour JP (1990) Dietary supplementation in elderly patients with fractured neck of the femur. *Lancet*,Apr 28,335(8696),pp.1013-6.
- Dennis M (1989) Poor nutritional status on admission predicts poor outcomes after stroke observational data from the food trial. *Stroke*,34(6),pp.1450-1455.
- Deva AK, Buckland GH, Fisher E et al. (2000) Topical negative pressure in wound management. *Medical Journal of Australia*,173,pp.128-131.
- Devine B. (1995) Alternating pressure air mattresses in the management of established pressure sores. *Journal of Tissue Viability*,5,pp.94-98.
- Drummond M (1994) *Economic analysis alongside controlled trials: an introduction for clinical researchers*. London: Department of Health.
- Drummond MF and Jefferson TO (1996) Guidelines for authors and peer reviewers of economic submissions to the BMJ. *British Medical Journal*,313,pp.275-283.
- Drummond M, O'Brien B, Stoddart G and Torrance G. (1997) *Methods for the economic evaluation of health care programmes. 2<sup>nd</sup> Edition*. Oxford University Press:Oxford.
- Dyson M (1982) Non-thermal cellular effects of ultrasound. *British Journal of Cancer Supplement*,45,165-71.
- Dyson M (1987) Mechanisms involved in therapeutic ultrasound. *Physiotherapy*,73,116-20.
- Dzwierzynski WW and Spitz K et al. (1998) Improvement in resource utilization after development of a clinical pathway for patients with pressure ulcers. *Plastic & Reconstructive Surgery*,102(6),pp.2006-11.
- Eccles M and Mason J (2001) How to develop cost conscious guidelines, *Health Technology Assessment*,5,16.
- Edsberg LE, Brogan MS, Jaynes D and Fries K (2002) Topical hyperbaric oxygen and electrical stimulation: exploring possible synergy. *Ostomy Wound Management*,48,pp.42-50.
- Ek AC, Unosson M et al. (1989) The modified Norton scale and the nutritional state. *Scandinavian Journal of Caring Sciences*,3(4),pp.183-7.

- Ek AC, Larsson J et al. (1990) The correlation between energy, malnutrition and clinical outcome in an elderly hospital population. *Clinical Nutrition*,9(4),pp.185-189.
- Ek AC, Unosson M et al. (1991) The development and healing of pressure sores related to the nutritional state. *Clinical Nutrition*,10(5),pp.245-250.
- Elliott TR (1999) Social problem-solving abilities and adjustment to recent-onset spinal cord injury. *Rehabilitation Psychology*,44(4),pp.315-332.
- Elliott TR, Shewchuk RM et al. (1999) Caregiver social problem-solving abilities and family member adjustment to recent-onset physical disability. *Rehabilitation Psychology*,44(1),pp.104-123.
- Emflorgo CA (1999) The assessment and treatment of wound pain. *Journal of Wound Care*,8(8),pp.384-5.
- Eriksson G. (1984) Bacterial growth in venous leg ulcers – its clinical significance in the healing process. In: *An environment for healing: the role of occlusion*. Royal Society of Medicine International Congress and Symposium Series,vol. 88, London:Royal Society of Medicine,pp.45-9.
- Evans D, Land L and Geary A. (2000) A clinical evaluation of the Nimbus 3 alternating pressure mattress replacement system. *Journal of Wound Care*,9(4),pp.181-186.
- Evans D and Land L (2001) Topical negative pressure for treating chronic wounds. *The Cochrane Database of Systematic Reviews*, Issue 1.
- Evans D and Land L (2001) Topical negative pressure for treating chronic wounds: a systematic review. *British Journal of Plastic Surgery*,54,pp.238-242.
- Ewing MR, Garrow C, Presley TA, Ashley C and Kinsella NM (1964) Further experiences in the use of sheep skins as an aid in nursing. *The Australian Nurses' Journal*,Sept,pp.215-219.
- Fabian TS, Kaufman HJ, Lett ED et al. (2000) The evaluation of subatmospheric pressure and hyperbaric oxygen in ischemic full thickness wound healing. *The American Surgeon*,66,pp.1136-1143.
- Fader M, Clarke-O'Neill S et al. (2003) Management of night-time urinary incontinence in residential settings for older people: an investigation into the effects of different pad changing regimes on skin health. *Journal of Clinical Nursing*,2(3),pp. 374-86.
- Fay MF (1987) Drainage systems. Their role in wound healing. *Aornj*,46,pp.442-455.
- Ferguson M, Cook A et al. (2000) Pressure ulcer management: the importance of nutrition. *MEDSURG Nursing*,9(4),pp.163-75,quiz 176-7.
- Ferrell BA, Osterweil D and Christenson P (1993) A randomised trial of low air loss beds for treatment of pressure ulcers. *JAMA*,269,pp.494-497.
- Ferrell BA, Artinian BM et al. (1995) The Sessing scale for assessment of pressure ulcer healing. *Journal of the American Geriatrics Society*,43(1),pp.37-40.

- Fischer H, Gilliet F, Hornemann M et al.(1984) Enzymatische Wundreinigung beim venösen Ulcus cruris. Bericht über eine multizentrische klinische Vergleichsstudie mit verschiedenen Enzympräparaten. *Fortschr Med*,102,pp.281-283.
- Fishman T D (1999) Wound assessment and evaluation. *Dermatology Nursing*,11(3),pp.201-2.
- Fishman TD (1999) Wound assessment and evaluation. Unstageable pressure ulcer due to eschar formation. *Dermatology Nursing*,11(3),pp.201-2.
- Fleischmann W, Becker U, Bischoff M and Hoekstra H (1995) Vacuum sealing: indication, technique and results. *Eur J Orthop Surg Traumatol*,5,pp.37-40.
- Fishman T D (2001) Wound assessment and evaluation... pressure ulcer. *Dermatology Nursing*,13(1),pp.59-60.
- Fleischmann W, Strecker W, Bombelli M and Kinzl L. (1993) Vacuum sealing as treatment of soft tissue damage in open fractures. *Unfallchirurg*,96,pp.488-492.
- Flemming K and Cullum N (2000) Therapeutic ultrasound for pressure sores. *The Cochrane Database of Systematic Reviews*, Issue 4.
- Flemming K and Cullum N (2001) Electromagnetic therapy for treating pressure sores. *The Cochrane Database of Systematic Reviews*, Issue 1.
- Flock P (2003) Pilot study to determine the effectiveness of diamorphine gel to control pressure ulcer pain. *Journal of Pain & Symptom Management*,25(6),pp.547-54.
- Ford CN, Reinhard ER, Yeh D et al (2002) Interim analysis of a prospective, randomized trial of vacuum-assisted closure versus the healthpoint system in the management of pressure ulcers. *Ann Plast Surg*,491,pp.55-61,discussion 61.
- Fowler EM (1983) New, once-daily pressure sore dressing speeds healing. *Registered Nurse*,46,pp.56-57.
- Fox JW and Golden GT (1976) The use of drains in subcutaneous surgical procedures. *Am J Surg*,132,pp.673-674.
- Franks PJ and Moffatt CJ (1999) Focus on wound management. Quality of life issues in chronic wound management. *British Journal of Community Nursing*,4(6),pp. 283-4.
- Franks PJ, Winterberg H et al. (2002) Health-related quality of life and pressure ulceration assessment in patients treated in the community. *Wound Repair & Regeneration*,10(3),pp.133-40.
- Freeman K, Smyth C et al. (2001) Pain measurement scales: a comparison of the visual analogue and faces rating scales in measuring pressure ulcer pain.[comment]. *Journal of Wound, Ostomy, & Continence Nursing*,28(6),pp.290-6.
- Fu X, Shen Z, Guo Z, Zhang M and Sheng Z (2002) Healing of chronic cutaneous wounds by topical treatment with basic fibroblast growth factor. *Chinese Medical Journal*,115,pp.331-5.
- Gallagher SM (1997) Morbid obesity: a chronic disease with an impact on wounds and related problems. *Ostomy Wound Management*,43(5),pp.18-24,26-7.
- Gallagher J and Gray M. (2003) Is aloe vera effective for healing chronic wounds? *J WOCN*,30,pp.68-71.

- Gardner SE, Frantz RA and Schmidt FL (1999) Effect of electrical stimulation on chronic wound healing: a meta-analysis. *Wound Repair and Regeneration*,7(6),pp. 495-503.
- Gardner SE, Frantz RA et al. (2001) A tool to assess clinical signs and symptoms of localized infection in chronic wounds: development and reliability. *Ostomy Wound Management*,47(1),pp.40-7.
- Garrigues NN (1987) Pressure ulcers: current concepts in wound care,10(1),p4. *Journal of Wound Care*.
- Genecov DG, Schneider AM, Morykwas MJ, Parker D, White WL and Argenta LC. A controlled subatmospheric pressure dressing increases the rate of skin graft donor site reepithelialisation. *Annals of Plastic Surgery*,1998,40,pp.219-225.
- Gentzkow GD, Pollack SV, Kloth LC and Stubbs HA (1991) *Wounds: A Compendium Of Clinical Research And Practice*,3,pp.158-170
- Gerding GA and Browning JS (1992) Oxyquinoline-containing ointment vs standard therapy for stage I and stage II lesions. *Dermatol Nurs*,4,pp.389-398.
- Gilchrist B and Reed C (1989) The bacteriology of chronic venous ulcers treated with occlusive hydrocolloid dressings. *Br J Dermatol*,121,pp.337-44.
- Gilmore SA, Robinson G et al. (1995) Clinical indicators associated with unintentional weight loss and pressure ulcers in elderly residents of nursing facilities. *Journal of the American Dietetic Association*,95(9),pp.984-92.
- Giovannini UM, DeMaria R, Chaptal PA and Teot L (2000) The role of aspiration therapy for the non healing wounds in cardiac surgery. First World Wound Healing Congress 2000: Australian Wound Management Association,p.114.
- Gorse GJ and Messner RL (1987) Improved pressure sore healing with hydrocolloid dressings. *Arch Dermatol*,123,pp.766-71.
- Gosnell DJ (1987) Assessment and evaluation of pressure sore. *Nursing Clinics of North America*,22,pp.399-416.
- Granick MS, McGowan E et al. (1998) Outcome assessment of an in-hospital cross-functional wound care team. *Plastic & Reconstructive Surgery*,101(5),pp.1243-7.
- Graumlich JF, Blough LS and McLaughlin RG et al. (2003) Healing pressure ulcers with collagen or hydrocolloid: a randomized, controlled trial. *Journal of the American Geriatrics Society*,51,pp.147-54.
- Gray M (2003) Does oral supplementation with vitamins A or E promote healing of chronic wounds? *Journal of Wound, Ostomy & Continence Nursing*,30(6),pp.290-4.
- Gray M (2003) Does oral zinc supplementation promote healing of chronic wounds? (Review) (36 refs) *Journal of Wound, Ostomy & Continence Nursing*,Nov;30(6).

Does vitamin C supplementation promote pressure ulcer healing? *Journal of Wound, Ostomy & Continence Nursing*,30(5),pp.245- 247

Greer SE, Longaker MT and Margiotta M (1999) Preliminary results from a multicentre randomised controlled study of the use of subatmospheric pressure dressing for pressure ulcer healing. *Wound Repair and Regeneration*,7,p.A255.

Greer SE (2000) Whither sub-atmospheric pressure dressing. *Annals of Plastic Surgery*,45,pp.332-4.

Griffin JW, Tooms RE, Mendius RA, Clifft JK, Vander Zwaag R and el-Zeky F (1991) Efficacy of high voltage pulsed current for healing of pressure ulcers in patients with spinal cord injury. *Physical Therapy*,71,pp.433-442,discussion 442-4.

Griffin et al (1993) Comparison of photographic and transparency-based methods for measuring wound surface area. *Physical Therapy*,73(2),pp.117-122.

Groen HW, Groenier KH and Schuling J (1999) Comparative study of a foam mattress and a water mattress. *Journal of Wound Care*,8(7),pp.333-335.

Gunningberg L, Lindholm C et al. (2001) Risk, prevention and treatment of pressure ulcers – nursing staff knowledge and documentation. *Scandinavian Journal of Caring Sciences*,15(3),pp.257-263.

Guralnik JM, Harris TB , White LR et al. (1988) Occurrence and prediction of pressure sores in the national health and nutrition examination survey follow-up. *Journal of the American Geriatrics Society*,36(9),pp.807.

Hagelstein SM and Banks V (1995) Maintaining quality of life for elderly patients in residential care. *Journal of Wound Care*,4(8),pp.347-8.

Halbert AR, Stacey MC, Rohr JB and Jopp-McKay A (1992) The effect of bacterial colonization on venous ulcer healing. *Australas J Dermatol*,33,pp.75-80.

Halfens RJG, Van Achterberg T and Bal RM (2000) Validity and reliability of the Braden scale and the influence of other risk factors: a multi-centre prospective study. *International Journal of Nursing Studies*,37(4),pp.313-319.

Halfens RJ, Bours GJ et al. (2001) Relevance of the diagnosis 'stage 1 pressure ulcer': an empirical study of the clinical course of stage 1 ulcers in acute care and long-term care hospital populations. *Journal of Clinical Nursing*,10(6),pp.748-57.

Hanan K and Scheele L (1991) Albumin vs. weight as a predictor of nutritional status and pressure ulcer development. *Ostomy Wound Management*,33,pp.22-7.

Harding K, Cutting K and Price P (2000) The cost-effectiveness of wound management protocols of care. *British Journal of Nursing*,9,S6,S8,S10-S20.

Harding K, Cutting K and Price P (2001) Wound management protocols of care. *British Journal of Health Care Management*,7,pp.191-197.

Hardy MA (1989) Biology of scar formation. *Physical Therapy*,69,pp.1014-1024.

Hartgrink HH, Wille J, Konig P, Hermans J and Breslau PJ. (1998) Pressure sores and tube feeding in patients with a fracture of the hip: a randomized clinical trial. *Clin Nutr*,Dec,17(6),p.287-

Hartmann D (1977) Considerations in the choice of inter-observer reliability estimates. *J Appl Behav Anal*,10,pp.103-116.

- Hartman D and Coetzee JC (2002) Two US practitioners' experience of using essential oils for wound care. *J Wound Care*,11(8),pp.317-20.
- Healy M (2003) Wound care and pain. *World of Irish Nursing*,11(5),pp39-40.
- Heath T, Moisisidis E and Deva A (2002) A prospective controlled trial of vacuum assisted closure (VAC) in the treatment of acute surgical wounds requiring split skin grafting. Fourth Australian Wound Management Association Conference 2002. Adelaide, South Australia.
- Hefley ML and Radcliffe J (1990) The 1988-1989 decubitus study. Can a standardization of treatment be set for the elderly patient with decubiti ulcers stage III? *Hawaii Medical Journal*,49(9),346,pp.349-50.
- Heissing R, Kirschner P and Romer H (1995) Wound drainage with continuous high vacuum vs variable vacuum suction drainage. *Unfallchirurg*,98,p.525.
- Hewitt GK (1956) Chronic leg ulcers. *Physiotherapy*,42,pp.43-45.
- Hess CL, Howard MA and Attinger CE (2003) A review of mechanical adjuncts in wound healing: hydrotherapy, ultrasound, negative pressure therapy, hyperbaric oxygen, and electrostimulation. *Ann Plast Surg*,51,pp.210-218.
- Holmich LR, Sim E, Krag C, Dahlfeldt H and Norden A (1998) Vacuum assisted wound closure clinical experience. *Wound Repair and Regeneration*,6,A470.
- Honde C, Derks C and Tudor D (1994) Local treatment of pressure sores in the elderly: amino acid copolymer membrane versus hydrocolloid dressing. *J Am Geriatr Soc*,42,pp.1180-3.
- Hoshowsky and Schramm CA (1994) Intraoperative pressure prevention: an analysis of bedding materials. *Research in Nursing in Health*,17(5),pp.333-339.
- Houghton PE et al (2000) Photographic assessment of the appearance of pressure and leg ulcers. *Ostomy Wound Management*,46(4),pp.20-30.
- House A, House B and Campbell M (1981) Measures of inter-observer agreement. *Journal of Behavioural Assessment*,3,1,pp.37-57.
- Houwing R, Rozendaal M, Wouters-Wesseling W, Beulens JWJ, Buskens E and Haalboom J (2003) A randomised, double-blind assessment of the effect of nutritional supplementation on the prevention of pressure ulcers in hip-fracture patients. *Clinical Nutrition*,22(4),pp.401-405.
- Huchon D (1992) Comparison between granuflex and paraffin-impregnated medical gauze in the treatment of pressure sores. *Eurosci Commun*,pp.23-26.
- Huck SW and Cormier WH (1996) *Reading Statistics and Research*, New York:Harper Collins.
- Huovinen S, Kotilainen P, Jarvinen H, Malanin K, Sarna S, Helander I et al. (1994) Comparison of ciprofloxacin or trimethoprim therapy for venous leg ulcers: results of a pilot study. *J Am Acad Dermatol*,31,pp.279-81.
- Isago T, Nozaki M, Kikuchi Y, Honda T and Nakazawa H (2003) Negative-pressure dressings in the treatment of pressure ulcers. *Journal of Dermatology*,30,pp.299-305.

- Jackobs MK (1999) The cost of medical nutrition therapy in healing pressure ulcers. *Topics in Clinical Nutrition*,14(2),pp.41-7.
- Jones I, Tweed C et al. (2001) Pressure area care in infants and children: Nimbus Paediatric System. *British Journal of Nursing*,10(12),pp.789-95.
- Joseph E, Hamori CA, Bergman S, Roaf E, Swann NF and Anastasi GW (2000) A prospective randomised trial of vacuum assisted closure versus standard therapy of chronic nonhealing wounds. *Wounds*,12,pp.60-67.
- Karba R, Semarov D, Vodovnik L, Benko H and Savrin R (1997) DC electrical stimulation for chronic wound healing enhancement. Part 1. Clinical study and determination of electrical field distribution in the numerical wound model. *Bioelectrochemistry and Bioenergetics*,43,pp.265-270.
- Kartes SK (1996) A team approach for risk assessment, prevention, and treatment of pressure ulcers in nursing home patients. *Journal of Nursing Care Quality*, 10(3): 34-45.
- Keogh A and Dealey C (2001) Profiling beds versus standard hospital beds: effects on pressure ulcer incidence outcomes. *Journal of Wound Care*,10(2),pp.15-19.
- Kemp MG, Keithley JK, Smith DW et al. (1990) Factors that contribute to pressure sores in surgical patients. *Research in Nursing and Health*,13(5),pp.293-301.
- Kerstein MD, Gemmen E, Van Rijswijk L, Lyder CH, Phillips T, Xakellis G et al. (2001) Cost and cost-effectiveness of venous and pressure ulcer protocols of care. *Disease Management & Health Outcomes*,9,pp.651-663.
- Kim YC, Shin JC, Park CI, Oh SH, Choi SM and Kim YS (1996) Efficacy of hydrocolloid occlusive dressing technique in decubitus ulcer treatment: a comparative study. *Yonsei Medical Journal*,37,pp.181-5.
- Kloth L and Feedar J (1988) Acceleration of wound healing with high voltage, monophasic, pulsed current. *Phys Ther*,68,pp.503-508.
- Kloth LC, Berman JE, Dumit-Minkel S, Sutton CH, Papanek PE and Wurzel J. (2000) Effects of a normothermic dressing on pressure ulcer healing. *Advances in Skin & Wound Care*,13,pp.69-74.
- Kloth LC, Berman JE, Nett M, Papanek PE and Dumit-Minkel S (2002) A randomized controlled clinical trial to evaluate the effects of noncontact normothermic wound therapy on chronic full-thickness pressure ulcers. *Advances in Skin & Wound Care*,15,pp.270-6.
- Kraft MR, Lawson L, Pohlmann B, Reid-Lokos C and Barder L (1993) A comparison of Epi-Lock and saline dressings on the treatment of pressure ulcers. *Decubitus*,6,pp.42-8.
- Krainski MM (1992) Pressure ulcers and the elderly. *Ostomy Wound Management*, 38(5),p.22.
- Krasner D (1997) Wound healing scale, version 1.0: a proposal. *Advances in Wound Care*,10(5),pp.82-85.
- Krause JS (1997) Skin sores after spinal cord injury: relationship to life adjustment. *Spinal Cord*,36(1),pp 51-6.
- Kucan JO, Robson MC, Hegggers JP and Ko F (1981) Comparison of silver sulfadiazine, povidone-iodine and physiologic saline in the treatment of chronic pressure ulcers. *J Am Geriatr Soc*,29,pp.232-5.

- Ladin D, Hou Z and Philbeck TE (2000) Vacuum assisted closure in the management of lower-extremity wounds. *Advances in Wound Care* (submitted).
- Lamond DFS (1998) The treatment of pressure sores: a comparison of novice and expert nurses' knowledge, information use and decision accuracy. *J Advanced Nursing*,27(2),pp.280-6.
- Landi F, Aloe L, Russo A et al. (2003) Topical treatment of pressure ulcers with nerve growth factor: a randomized clinical trial. *Annals of Internal Medicine*,139,pp.635-41.
- Langer G, Schloemer G, Knerr A, Kuss O and Behrens J (2004) Nutritional interventions for preventing and treating pressure ulcers (Cochrane Review) in: *The Cochrane Library*, Issue 3, Chichester, UK: John Wiley & Sons, Ltd.
- Langkamp-Henken B, Herrlinger-Garcia KA, Stechmiller JK, Nickerson-Troy JA, Lewis B and Moffatt L (2000) Arginine supplementation is well tolerated but does not enhance mitogen-induced lymphocyte proliferation in elderly nursing home residents with pressure ulcers. *J Parenter Enteral Nutr*,Sep-Oct,24(5),pp.280-7.
- Larsson J, Unosson M, Ek AC and Nilsson L (1990) Effect of dietary supplement on nutritional status and clinical outcome in 501 geriatric patients: a randomized study. *Clinical Nutrition*,9,pp.179-84.
- Lazzara DJ and Buschmann MBT (1991) Prevention of pressure ulcers in elderly nursing home residents: are special support surfaces the answer? *Decubitus*,4,pp.42-26.
- Lee LK and Ambrus JL (1975) Collagenous therapy for decubitus ulcers. *Geriatrics*,30,pp.91-8.
- LeVasseur SA and Helme RD (1991) A double-blind clinical trial to compare the efficacy of an active based cream F14001 against a placebo non-active based cream for the treatment of pressure ulcers in a population of elderly subjects. *J Adv Nurs*,16,pp.952-6.
- Lewis B (1996) Protein levels and the aetiology of pressure sores. *Journal of Wound Care*,5(10),pp.479-82.
- Ljungberg S (1998) Comparison of dextranomer paste and saline dressings for management of decubital ulcers. *Clinical Therapeutics*,20,pp.737-43.
- Lookingbill DP, Miller SH and Knowles RC (1978) Bacteriology of chronic leg ulcers. *Arch Dermatol*,114,pp.1765-8.
- Lucas C, Coenen CHM and de Haan RJ (2000) The effect of low level laser therapy (LLLT) on Stage III decubitus ulcers (pressure ulcers); a prospective randomised single blind, multicentre pilot study. *Lasers Med Sci*,14,pp.94-100.
- Lum CC, Cheung W, Chow PM, Woo J, Hui E and Or KH (1996) Use of a hydrogel in pressure sore management. A randomised controlled clinical trial. Proceedings of the 5th European Conference on Advances in Wound Management,vol. 5., London: Macmillan Ltd,p.283.
- Lundhus E, Gjode F, Holm CN and Terpling S (1989) Bacterial antimicrobial cover in primary suture of perianal or pilonidal abscess. A prospective, randomized, double-blind clinical trial. *Acta Chirurg Scand*,155,pp.351-4.
- Lyder CH (2003) Pressure ulcer prevention and management. *Jama*,289,pp.223-226.
- Maas-Irslinger R, Hensby CN and Farley KL (2003) Efficacy and safety of XENADERM ointment: a novel formulation for treatment of injured skin due to pressure ulcers. *Wounds: A Compendium of Clinical Research & Practice*,15(3),suppl:2S-8S.

Macario A and Dexter F (2002) Is noncontact normothermic wound therapy cost-effective for the treatment of stages 3 and 4 pressure ulcers? *Wounds-A Compendium of Clinical Research & Practice*,14(3),pp.93-106.

Maklebust J (1987) Pressure ulcers: aetiology and prevention. *Nursing Clinics of North America*,22(2),pp.359-377.

Maklebust J (1997) Policy implications of using reverse staging to monitor pressure ulcer status. *Advances in Wound Care*,10(5),pp.32-5.

Maklebust J (1997) Pressure ulcer assessment. *Clinics in Geriatric Medicine*,13(3),pp.455-81.

Maklebust J and Magnan MA (1992) Approaches to patient and family education for pressure ulcer management. *Decubitus*,5(7),pp.18-20,24,26passim.

Maklebust J and Magnan MA (1994) Risk factors associated with having a pressure ulcer: a secondary data analysis. *Advances in Wound Care*,7(6),pp.25, 27-8,31-4passim.

Maklebust J and Margolis D (1995) Session I: pressure ulcers: definition and assessment parameters. *Advances in Wound Care*,8(4),pp.28/6-28/7.

Maklebust J and Sieggreen MY (1996) Attacking on all fronts: how to conquer pressure ulcers. *Nursing*,26(12),pp.34-40.

Malone C (2000) Pressure sores in the labour ward. *RCM Midwives Journal*,3(1),pp.20-3.

Malone ML, Rosen LB et al. (1998) Complications of acute myocardial infarction in patients. *American Journal of Cardiology*,81(5),pp.638-41.

Manfredi PL, Breuer B et al. (2003) Pain assessment in elderly patients with severe dementia. *Journal of Pain & Symptom Management*,25(1),pp.48-52.

Marchand AC and Lidowski H (1993) Reassessment of the use of genuine sheepskin for pressure ulcer prevention and treatment. *Decubitus*,6(1),pp.44-47.

Marchette L, Arnell I and Redick E (1991) Skin ulcers of elderly surgical patients in critical care units. *Dimensions of Critical Care Nursing*,10(6),pp.321-329.

Matthews Kirk P (1996) Pressure ulcer management following spinal cord injury. *Topics in Spinal Cord Injury Rehabilitation*,2(1),pp.9-20.

Matzen S, Peschardt A and Alsbjorn B (1999) A new amorphous hydrocolloid for the treatment of pressure sores: a randomised controlled study. *Scandinavian Journal of Plastic & Reconstructive Surgery & Hand Surgery*,33,pp.13-5.

- McCallon SK, Knight CA, Valiulus JP, Cunningham MW, McCulloch JM and Farinas LP. (2000) Vacuum assisted closure vs saline-moistened gauze in the healing of postoperative diabetic foot wounds. *Ostomy/Wound Management*,46,pp28-32,34.
- McDiarmid T, Burns PN, Lewith GT and Machin D (1985) Ultrasound in the treatment of pressure ulcers. *Physiotherapy*,71,pp.66-70.
- Meaume S (1999) A randomized controlled study to compare a sequential treatment using alginate-CMC and hydrocolloid dressing or hydrocolloid dressing alone in decubitus ulcer management. 9th European Conference on Advances in Wound Management. Harrogate, UK, 9-11 Nov, 1999,p.11.
- Meaume S, Van de Looverbosch D, Heyman H, Romanelli M, Ciangherotti A and Charpin S (2003) A study to compare a new self-adherent soft silicone dressing with a self-adherent polymer dressing in stage II pressure ulcers. *Ostomy Wound Management*,49,pp.44-51.
- Melhuish et al. (1994) Circumference, area and volume of the healing wound. *Journal of Wound Care*,3(8),pp.380-384.
- Mendez-Eastman S (1998) When wounds won't heal. *Rn*,61,pp.20-24.
- Meraviglia M, Becker H et al. (2002) Maintenance of skin integrity as a clinical indicator of nursing care. *Advances in Skin & Wound Care*,15(1),pp.24-9.
- Milward P, Siddle H and Bridgewater A (1995) A user evaluation on the Triple Care cleanser and cream system examining impact on pressure ulcer incidence in a long term care centre. In Proceedings of 5th European Conference on Advances in Wound Management, Nov21-24. Harrogate, UK, 1995.
- Minassian M, Lewis D, Chattopadhyay D, Bovill B, Duckworth G and Williams J (1998) A comparison between single-dose fosfomycin trometamol (Monuril) and a five day course of trimethoprim in the treatment of uncomplicated lower urinary tract infection in women. *Int J Antimicrob Agents*,10,pp.39-47.
- Moberg S, Hoffman L, Grennert ML and Holst A (1983) A randomized trial of cadexomer iodine in decubitus ulcers. *J Am Geriatr Soc*,31,pp.462-5.
- Mooney JF, Argenta LC, Marks MW, Morykwas MJ and DeFranzo AJ (2000) Treatment of soft tissue defects in pediatric patients using the V.A.C. system. *Clinical Orthopaedics and Related Research*,376,pp.26-31.
- Morgan D (1993) Is there still a role for antiseptics? *J Tissue Viability*,3:80-4.
- Morison M, Moffatt C, Bridel-Nixon J and Bale S (1997) *Nursing management of chronic wounds*. 2nd edition. London: Mosby.

Morykwas MJ (1995) Effect of VAC therapy on total charge and length of stay of patients in DRG 263: a 21 month analysis. 27th Annual Conference, Wound, Ostomy and Continence Nurses 1995.

Morykwas MJ and Argenta LC (1993) Use of negative pressure to increase the rate of granulation tissue formation in chronic open wounds. Annual Meeting: Federation of American Societies for Experimental Biology 1993.

Morykwas MJ, Argenta LC, Shelton-Brown EI and Wyman McGuirt W (1997) Vacuum-assisted closure: a new method for wound control and treatment: animal studies and basic foundation. *Annals of Plastic Surgery*,38,pp.553-562.

Morykwas MJ (1998) External application of sub-atmospheric pressure and healing: mechanisms of action. *Wound Healing Society Newsletter*,8.

Mosher BA, Cuddigan J, Thomas DR and Boudreau DM (1999) Outcomes of 4 methods of debridement using a decision analysis methodology. *Advances in Wound Care*,12,pp.81-8.

Motta G, Dunham L, Dye T, Mentz J, O'Connell-Gifford E and Smith E (1999) Clinical efficacy and cost-effectiveness of a new synthetic polymer sheet wound dressing. *Ostomy/Wound Management*,45,pp.41-49.

Mulder GD, Altman M, Seeley JE and Tintle T (1993) Prospective randomized study of the efficacy of hydrogel, hydrocolloid, and saline solution-moistened dressings on the management of pressure ulcers. *Wound Repair Regen*,1,pp.213-18.

Mulder GD, Taro N, Seeley J and Andrews K (1994) A study of pressure ulcer response to low air loss beds vs. conventional treatment. *J Geriatr Dermatol*,2(3),pp.87-91.

Muller E, van Leen MWF and Bergemann R (2001) Economic evaluation collagenase-containing ointment and hydrocolloid dressing in the treatment of pressure ulcers. *PharmacoEconomics*,19,pp.1209-16.

Mullner T, Mrkonjic O and Vecsei V (1997) The use of negative pressure to promote the healing of tissue defects: a clinical trial using the vacuum sealing technique. *British Journal of Plastic Surgery*,50,pp.194-199.

Munro BH, Brown L and Heitman BB (1989) Pressure ulcers: one bed or another? *Geriatric Nursing*,10,pp.190-2.

Murdoch V (2002) Pressure care in the paediatric intensive care unit. *Nursing Standard*,17(6),pp.71-6.

Mustoe TA, Cutler NR, Allman RM et al. (1994) A phase II study to evaluate recombinant platelet-derived growth factor-BB in the treatment of stage 3 and 4 pressure ulcers. *Arch Surg*,129,pp.213-19.

Myers SA, Takiguchi S, Slavish S and Rose CL (1990) Consistent wound care and nutritional support in treatment. *Decubitus*,Aug,3(3),pp.16-28.

Nasar MA and Morley R (1982) Cost-effectiveness in treating deep pressure sores and ulcers. *Practitioner*,226,pp.307-10.

National Institute for Clinical Excellence (2003) *Clinical Guideline 7; Pressure ulcer prevention*.NICE 2003.

Naylor IL (1999) Ulcer care in the Middle Ages. *Journal of Wound Care*,8,4,pp.208-212.

Nelson M (2001) Pressure ulcer assessment and documentation: the beginning of a plan of care. *Journal of Legal Nurse Consultants*,12(4),pp.22-5.

Nesselroth SM and Gahtan V (2000) Management of pressure ulcers in the home care setting. *Home Healthcare Consultant*,7(4),pp.34-42.

Newton C (1993) On-line assessment. *Nursing Times*,89(25),Wound Care:62.

NHS Centre for Reviews and Dissemination (2001) *Improving access to cost-effectiveness information for health care decision-making*. CRD6 Report, 2<sup>nd</sup> edition.

Nixon J, Smye S et al. (1999) The diagnosis of early pressure sores: report of the pilot study. *Journal of Tissue Viability*,9(2),pp.62-6.

Nixon J, Brown J and McElvenny D et al. (2000) Prognostic factors associated with pressure sore development in the immediate post-operative period. *International Journal of Nursing Studies*,37(4),pp.279-289.

Norris JR and Reynolds RE (1971) The effect of oral zinc sulfate therapy on decubitus ulcers. *J Am Geriatr Soc*,19,pp.793-7.

North G and Booth A (1999) Why appraise the evidence? A case study of vitamin C and the healing of pressure sores. *Journal of Human Nutrition & Dietetics*,12(3),pp. 237-244.

Norton D, McLaren R and Exon-Smith A (1962) *An investigation of geriatric nursing problems in hospital*. 1<sup>st</sup> edition. London:Churchill Livingstone.

Nussbaum EL, Biemann I and Mustard B (1994) Comparison of ultrasound/ultraviolet-C and laser for treatment of pressure ulcers in patients with spinal cord injury. *Physical Therapy*,74,pp.812-825.

Ohura T, Sanada H and Mino Y (2004) Clinical activity-based cost-effectiveness of traditional versus modern wound management in patients with pressure ulcers. *Wounds – A Compendium of Clinical Research & Practice*,pp.157-163.

Oke S and Davies S (1995) A holistic approach to pressure sore management. *British Journal of Nursing*,4(6),pp.319-20,322,339-40.

Oleske DM, Smith XP, White P, Pottage J and Donovan MI (1986) A randomized clinical trial of two dressing methods for the treatment of low-grade pressure ulcers. *J Enterostomal Ther*,13,pp90-8.

O'Meara S, Cullum N, Majid M and Sheldon T (2000) Systematic reviews of wound care management: (3) antimicrobial agents for chronic wounds. *Health Technology Assessment*,4(21),pp.3-107.

Oppenheim AN (1984) *Questionnaire Design and Attitude Measurement*. London, Heinemen.

Orlando PL (1998) Pressure ulcer management in the geriatric patient. *Annals of Pharmacotherapy*,32(11),pp.1221-7.

Ovington LG (1999) 1, 2, 3, s-t-r-e-t-c-h; vacuum enhances wound closure. *Advances in Wound Care*, the 1999 Edition Source Book, pp.125-127.

Palmieri, B. (1992) Heterologous collagen in wound healing: a clinical study. Dextranomer vs lyophilized collagen sponge. *Int J Tissue React*,14(Suppl),pp.21-5.

Papanikolaou P, Lyne P A and Lycett E (2003) Pressure ulcer risk assessment: application of logistic analysis. *Journal of Advanced Nursing*,44(2),pp.128-36.

Parish LC and Collins E (1979) Decubitus ulcers: a comparative study. *Cutis*,23,pp.106-10.

Parish LC and Joseph AW (1983) Decubitus ulcer: how to intervene effectively. *Drug Therapy Hospital Education*,1983,8,pp.95-8.

Pase MN and Hoffman RG (1998) Selection and use of pressure ulcer risk-assessment tools and treatment protocols in extended-care facilities in the southwest. *Journal of Wound, Ostomy, & Continence Nursing*,25(1),pp.44-50.

Payne JF (1896) On an unpublished English anatomical treatise of the fourteenth century. *BMJ*,1,pp.200-203.

Pedley G (1998) Prevention and management of pressure sores. *Journal of Community Nursing*,12(11),pp.4.

Perier C, Granouillet R et al. (2002) Nutritional markers, acute phase reactants and tissue inhibitor of matrix metalloproteinase 1 in elderly patients with pressure sores. *Gerontology*,48(5),pp.298-301.

Peschardt A, Alsbjorn B and Gottrup F (1997) A comparative randomized study on performance characteristics of a new hydrogel versus saline gauze for the treatment of pressure sores. 6th European Conference on Advances in Wound Management,p.283.

Philbeck TE, Whittington KT, Millsap MH, Briones RB, Wight DG and Schroeder WJ (1999) The clinical and cost-effectiveness of externally applied negative pressure wound therapy in the treatment of wounds in home healthcare medicare patients. *Ostomy/Wound Management. The Journal for Extended Patient Care Management*,45,pp.41-50.

Phillips L (2000) Cost-effective strategy for managing pressure ulcers in critical care: a prospective, non-randomised, cohort study. *Journal of Tissue Viability*,10(3 su),pp.2-6.

Pierce GF, Tarpley JE, Allman RMG, P.S., Serdar CM and Morris B (1994) Tissue repair processes in healing chronic pressure ulcers treated with recombinant platelet-derived growth factor BB. RPDGF-BB 100 micrograms/ml x rPDGF-BB 300 micrograms/ml x placebo. *Am J Pathol*,145,pp.1399-1410.

Pittl G, Milnes M, McMackin S, Boughey F and Fako W [1998] A multi-phase, open label, randomized, parallel comparative study of two hydrocolloid dressings on patients with stage II and stage III exudating pressure ulcers. Comfeel Plus dressing vs Duoderm CGF. Poster presented at the Wound Ostomy and Continence Nurses Annual Conference.

Plassmann P and Jones TD (1998) MAVIS: a non invasive instrument to measure area and volume of wounds. *Medical Engineering & Physics*,20,pp.332-338.

Pontieri-Lewis V (1995) Focus on wound care. Pressure ulcers: assessment to evaluation. *MEDSURG Nursing*,4(3),pp.220-1.

Pontieri-Lewis V (1995) Pressure ulcers: assessment to evaluation. *MEDSURG Nursing*,4(3),pp.220-1.

Prescott Jr WA and Regal RE (2003) Pressure ulcers: what to think when giving zinc. *P & T*,28(7),pp.473-474.

Preston KM (1987) Dermal ulcers: simplifying a complex problem of pressure sores. *Journal of Gerontological Nursing*,12(7),pp.11-16.

Price P, Bale S, Crook H and Harding KG (2000) The effect of a radiant heat dressing on pressure ulcers. *Journal of Wound Care*,9,pp.201-5.

Prior J (2002) The pressure is on: midwives and decubitus ulcers. *RCM Midwives Journal*,5(5),pp.196-200.

Pullen R, Popp R, Volkens P and Fusgen I (2002) Prospective randomized double-blind study of the wound-debriding effects of collagenase and fibrinolysin/deoxyribonuclease in pressure ulcers. *Age & Ageing*,31,126-130.

Ratliff CR and Rodeheaver GT (1999) Pressure ulcer assessment and management. *Lippincott's Primary Care Practice*, 3(2),pp.242-58.

Rawcliffe C (1995) *Medicine and Society in Later Medieval England*. Stroud: Sutton.

Reed RL, Hepburn K, Adelson R et al. (2003) Low serum albumin levels, confusion and fecal incontinence: are these risk factors for pressure ulcers in mobility-impaired hospitalized adults? *Gerontology*,49,pp.255-259.

Rees RS, Robson MC, Smiell JM and Perry BH (1999) Becaplermin gel in the treatment of pressure ulcers: a phase II randomized, double-blind, placebo-controlled study. *Wound Repair & Regeneration*,7,pp.141-7.

Rhodes RS, Heyneman CA, Culbertson VL, Wilson SE and Phatak HM (2001) Topical phenytoin treatment of stage II decubitus ulcers in the elderly. *Annals of Pharmacotherapy*,35,pp.675-81.

Ribbons RM and McKenna LG (1997) Facilitating higher order thinking skills in nurse education: a prototype database for teaching wound assessment and management skills. *Studies in Health Technology & Informatics*,46,pp.389-92.

Richardson G, Wonderling D, Simon J, Wailoo A, Douglas H-R, Culyer A, Tsuchiya A, Roberts J and Drummond MF, on behalf of Health Economists in Guidelines. In National Institute for Clinical Excellence (2004) *Guideline Development Methods. Information for National Collaborating Centres and Guideline Developers*. London.

Riet ter G, van Houtem H and Knipschild P (1992) Health care professionals views of the effectiveness of pressure ulcer treatments. A survey amongst nursing home physicians, dermatologists, and nursing staff in the Netherlands. *Clinical Exp Dermatology*,17,pp.328-31.

Rippon MG, Springett K and Walmsley R (1999) Ultrasound evaluation of acute experimental and chronic clinical wounds. *Skin Research and Technology*,5,pp.228-236.

Ritz MC, Gallegos R, Canham MB, Eskalai M and George FR (2002) PROVANT Wound-Closure System accelerates closure of pressure wounds in a randomized, double-blind, placebo-controlled trial. *Annals of the New York Academy of Sciences*,961,pp.356-9.

Robson MC, Phillips LG, Hegggers JP, McPherson MA and Heiner LS (1991) Clinical studies on growth factors in pressure sores: preliminary report. *Prog Clin Biol Res*,365,pp.95-102.

Robson MC, Phillips LG, Thomason A et al. (1992) Recombinant human platelet-derived growth factor-BB for the treatment of chronic pressure ulcers. *Ann Plast Surg*,1992,29,pp.193-201.

Robson MC, Phillips LG, Lawrence WT et al. (1992) The safety and effect of topically applied recombinant basic fibroblast growth factor on the healing of chronic pressure sores. *Ann Surg*,216,pp.401-6.

Robson MC, Abdullah A, Burns BF et al. (1994) Safety and effect of topical recombinant human interleukin-1 beta in the management of pressure sores. *Wound Repair Regen*,2,pp.177-81.

Robson MC, Maggi SP, Smith PD, Wassermann RJ, Mosiello GC, Hill DP et al. (1999) Original articles: ease of wound closure as an endpoint of treatment efficacy.[comment]. *Wound Repair & Regeneration*,7,pp.90-6.

Robson MC, Hill DP, Smith PD et al. (2000) Sequential cytokine therapy for pressure ulcers: clinical and mechanistic response. *Annals of Surgery*,231,pp.600-11.

Ronda L and Falce RL (2002) Skin care in older people. *Primary Health Care*,12(7),pp.51-7.

Rook J L (1996) Wound care pain management. *Advances in Wound Care*,9(6),pp. 24-31.

Rook JL (1997) Wound care pain management. *Nurse Practitioner*,22(3),pp.122-6,131,134-6.

Rosenthal MJ, Felton RM, Hileman DL, Lee M and Friedman M (1996) A wheelchair cushion designed to redistribute sites of sitting pressure. *Arch Phys Med Rehabil*,77,pp.278-82.

Russell L, Taylor J et al. (1998) Development and validation of the Burton Score: a tool for nutritional assessment. *Journal of Tissue Viability*,8(4),pp.16-22.

Russell L (2000) Malnutrition and pressure ulcers: nutrition assessment tools. (37 refs). *Br J Nursing*,9(4),pp.194-204.

Russell L, Reynolds TM, Carr J, Evans A and Holmes M (2000) Randomised controlled trial of two pressure-relieving systems. *Journal of Wound Care*,9(2),pp.52-55.

- Russell L, Reynolds TM, Towns A, Worth W, Greenman A and Turner R (2003) Randomized comparison trial of the RIK and the Nimbus 3 mattresses. *British Journal of Nursing*,12(4),pp.254-259.
- Russell L, Nebbioso G, Munter KC, Beele H and Basse PB (2004) The CONTOP study: a hydro-activated silver-containing foam dressing versus standard care, WUWHS meeting, Paris, July 2004.
- Rycroft-Malone J and McInnes E (2000) Pressure ulcer risk assessment and prevention. *Technical Report*. RCN: London.
- Sae-Sia W and Wipke-Tevis D (2002) Pressure ulcer prevention and treatment practices in inpatient rehabilitation facilities. *Rehabilitation Nursing*,27(5),pp.192-8.
- Sayag J, Meaume S and Bohbot S (1996) Healing properties of calcium alginate dressings. *J Wound Care*,5,pp.357-62.
- Saydak SJ (1990) A pilot test of two methods for the treatment of pressure ulcers. *J Enterostomal Ther*,17,pp.140-2.
- Schnelle JF, Ouslander JG et al. (1993) Nighttime sleep and bed mobility among incontinent nursing home residents. *Journal of the American Geriatrics Society*,41(9),pp.903-9.
- Schnelle JF, Adamson GM, Cruise PA et al (1997) Skin disorder and moisture in incontinent nursing home residents: intervention implications. *Journal of the American Geriatric Society*,45(10),pp.1182-1188.
- Schnelle JF, Cruise PA et al. (1998) Individualizing nighttime incontinence care in nursing home residents. *Nursing Research*,47(4),pp.197-204.
- Schoonhoven L, Defloor T, van der Tweel I et al (2002) Risk indicators for pressure ulcers during surgery. *Applied Nursing Research*,16(1),pp.163-173.
- Schubert V, Perbeck L et al. (1994) Skin microcirculatory and thermal changes in elderly subjects with early stage of pressure sores. *Clinical Physiology*,14(1),pp1-13.
- Schue RM and Langemo DK (1998) Pressure ulcer prevalence and incidence and modifications of the Braden scale for rehabilitation unit. *Journal of Wound Ostomy and Continence NURSE*,25(1),pp.36-43.
- Schulz KF, Chalmers I, Hayes RJ and Altman DG (1995) Empirical evidence of bias – dimensions of methodological quality associated with estimates of treatment effects in controlled trials. *Jama*,273,pp.408-412.
- Schwarzl F, Moshammer H and Haas F (1998) Treatment of pressure ulcers with V.A.C. *Acta Chir Austriaca*,150,pp.:8-9.
- Scott F and Newens A (1999) Hospital monitoring of pressure ulcers in the UK. *Journal of Wound Care*, 8(5),pp.221-4.
- Scotts A. et al (2001) An instrument to measure healing in pressure ulcers: development and validation of the pressure ulcer scale for healing (PUSH). *Journal of Gerontology*,56A,12,pp.795-799.

- Seaman S, Herbster S, Muglia J, Murray M and Rick C (2000) Simplifying modern wound management for nonprofessional caregivers. *Ostomy Wound Management*,46,pp.18-27.
- Sebern MD (1986) Pressure ulcer management in home health care: efficacy and cost-effectiveness of moisture vapor permeable dressing. *Med Rehabil*,67,pp.726-9.
- Sebern MD (1989) Cost and efficacy of pressure ulcer management in a metropolitan visiting nurse association. *Decubitus*,2,pp.58-9.
- Seeley J, Jensen JL and Hutcherson J (1999) A randomized clinical study comparing a hydrocellular dressing to a hydrocolloid dressing in the management of pressure ulcers. *Ostomy Wound Management*,45,pp.39-44, 46-7.
- Seiler WO and Stahelin HB (1985) Decubitus ulcers: treatment through five therapeutic principles. *Geriatrics*,40(9),pp.30-44.
- Selkowitz DM, Cameron MH, Mainzer A and Wolfe R (2002) Efficacy of pulsed low-intensity ultrasound in wound healing: a single-case design. *Ostomy/Wound Management*,48,pp.40-50.
- Senapati, AG, Jenner G and Thompson RPH (1989) Zinc in the elderly. *Quarterly Journal of Medicine*,70(261),pp.81-7.
- Shea JD(1975) Pressure sores: classification and management. *Clinical Orthop*,112,pp.89-100.
- Sheffet A, Cytryn AS and Louria DB (2000) Applying electric and electromagnetic energy as adjunctive treatment for pressure ulcers: a critical review. *Ostomy/Wound Management*,46,pp.28-44.
- Shiraishi T, Oka R and Nakagawa Y. (1997) Pharmaceutical and bacteriological study on povidone-iodine sugar ointment. *Dermatology*,195,pp.100-3.
- Shubert V (1997) Measuring the area of chronic ulcers for consistent documentation in clinical practice. *Wounds – A Compendium Of Clinical Research & Practice*,9(5),pp.153-9.
- Shutler S, Stock J, Bale S, Harding KG, Squires D and Wilson I (1995) A multi-centre comparison of a hydrocellular adhesive dressing (Allevyn Adhesive) and a hydrocolloid dressing (Granuflex) in the management of stage 2 and 3 pressure sores. In Conference Proceedings of 5th European Conference on Advances in Wound Management, Nov 21-24. Harrogate, UK, 1995.
- Smith DB and Lekan-Rutledge D (1997) Continence management and wound care for a patient in a residential facility. *Journal of Wocn*,24(3),172-8.
- Smith DM, Winsemius DK and Besdine RW (1991) Pressure sores in the elderly: can this outcome be improved? *J Gen Intern Med*,6:81-93.
- Smith LN (1996) Managing surgical wounds: a study report. *Nursing Standard*,10.
- Smith-Temple J and Johnson JY (1998) Hospital extra. Clinical procedures. Pressure ulcer management. *AJN, American Journal of Nursing*,98(2),Contin Care Extra Ed:16D.

Song C and Tan KC (2000) Vacuum dressings in chronic wounds. First World Wound Healing Congress: Australian Wound Management Association,p113.

Sopata M, Luczak J et al (2002) Effect of bacteriological status on pressure ulcer healing in patients with advanced cancer. *Journal of Wound Care*,11(3),pp.107-10.

Specht JP, Bergquist S et al. (1995) Adoption of a research-based practice for treatment of pressure ulcers. *Nursing Clinics of North America*,30(3),pp.553-63.

Spoelhof GD (2000) Management of pressure ulcers in the nursing home. *Annals of Long Term Care*,8(8),pp.69-77.

Spooner R (1993) Managing a patient's multiple pressure sores. (Care of an elderly demented woman with little mobility). *Journal of Wound Care*,2(3),pp.139-141.

Sprigle S, Linden M et al. (2001) Clinical skin temperature measurement to predict incipient pressure ulcers. *Advances in Skin & Wound Care*,14(3),pp133-7.

Sprigle S, Linden M et al. (2003) Analysis of localized erythema using clinical indicators and spectroscopy. *Ostomy Wound Management*,49(3),pp.42-52.

Standards Of Reporting Trials Group. (1994) A proposal for structured reporting of randomised controlled trials. *JAMA*,272,pp.1926-1931.

Stiller MJ, Pak GH, Shupack JL, Thaler S, Kenny C and Jondreau L (1992) A portable pulsed electromagnetic field (PEMF) device to enhance healing of recalcitrant venous ulcers: a double-blind, placebo controlled trial. *British J Dermatol*,127,pp.147-154.

Stoneberg C, Pitcock N and Myton C (1986) Pressure sores in the homebound: one solution. *American Journal of Nursing*,April,pp.426-8.

Strauss MJ, Gong J, Gary BD et al. (1991) The cost of home air-fluidized therapy for pressure sores. A randomized controlled trial. *Journal of Family Practice*,33,pp.52-59.

Subramanian T, Vijayarathinam P, Sathyavan V, Navaneethakrishnan S, Anugraham S, Anbalagan K et al. (1990) Effects of placental dressings in indolent ulcers. *J Ind Med Assoc*,88,pp.314-16.

Sugarman B, Hawes S et al. (1983) Osteomyelitis beneath pressure sores. *Archives of Internal Medicine*,143(4),pp.683-8.

Sugarman B (1987) Pressure sores and underlying bone infection. *Archives of Internal Medicine*,147(3),pp.553-5.

Taylor A (2000) *Managing pressure ulcers: the need for pain assessment*. *Community Outlook*,6(3),pp.45-6.

Taylor TV, Rimmer S, Day B, Butcher J, Dymock IW (1974) Ascorbic acid supplementation in the treatment of pressure-sores. *Lancet*,Sep 7,2(7880),pp.544-6.

ter Riet G, Kessels AG and Knipschild PG (1995) Randomized clinical trial of ascorbic acid in the treatment of pressure ulcers. *J Clin Epidemiol*,Dec,48(12),pp.1453-60.

ter Riet G, Kessels AGH and Knipschild P (1995) A randomized clinical trial of ultrasound treatment for pressure ulcers. *British Medical Journal*,310,pp.1040-1.

The Weinberg Group (1999) *Technology assessment of the V.A.C for in-home treatment of chronic wounds*. Washington, USA, The Weinberg Group Inc.

Theaker C, Mannan M, Ives N et al (2000) Risk factors for pressure sores in the critically ill. *Anaesthesia*,55,pp.221-224.

Thomas DR, Goode PS, Tarquine PH , Allman RM (1996) Hospital acquired pressure ulcers and risk of death. *Journal of American Geriatric Society*,44,pp.1435-40.

Thomas DR, Goode PS, LaMaster K and Tennyson T (1998) Acemannan hydrogel dressing versus saline dressing for pressure ulcers. A randomized, controlled trial. *Advances in Wound Care*,11,pp.273-6.

Thomas DR (2001) Improving outcomes of pressure ulcers with nutritional interventions: a review of the evidence. *Nutrition*,17,pp.121-125.

Thomas DR (2001) Age-related changes in wound healing. *Drugs & Aging*,18(8),pp.607-20.

Thomas S and Fear M (1993) Comparing two dressings for wound debridement. *J Wound Care*,2,pp.272-4.

Thomas S, Fear M et al. (1994) Assessment of patients with chronic wounds. *Journal of Wound Care*,3(3),pp.151-4.

Thomas S, Banks V, Bale S et al. (1997) A comparison of two dressings in the management of chronic wounds. *Journal of Wound Care*,6,pp.383-6.

Thomas S (2000) Alginate dressings in surgery and wound management - part 1. *J Wound Care*,9,pp.56-60.

Thomas S (2000) Alginate dressings in surgery and wound management - part 2. *J Wound Care*,9,pp.115-119.

Thornhill-Joyne M, Gonzales F et al. (1986) Osteomyelitis associated with pressure ulcers. *Archives of Physical Medicine & Rehabilitation*,67(5),pp.314-8.

Toba K, Sudoh N, Nagano K, Eto M, Mizuno Y, Nakagawa H et al. (1997) Randomised prospective trial of gentian violet with dibutyl cAMP and povidone iodine with sugar as treatment for pressure sores infected with methicillin-resistant *Staphylococcus aureus* in elderly patients. *Jpn J Geriatr*,34,pp.577-585.

Torrance C (1983) *Pressure sores: aetiology, treatment and prevention*. Croom Helm, London.

Touche Ross (1993) *The cost of pressure sores*. Touché Ross & Company: London.

Tytgat H and Van Asch H (1988) Topical ketanserine in the treatment of decubitus ulcers: a double blind study with 2% Ketanserine ointment against placebo. *Adv Ther*,5,pp.143-52.

Unger PG and Raimastery S (1991) A controlled study of the effect of high voltage pulse current on wound healing. *Phys Ther*,71,S119.

Unger PG (2000) Update on high-voltage pulsed. Current research and application. *Top Geriatr Rehabil*,16,pp.35-46.

van de Berg JS, Robson MC and Mikhail RJ (1995) Extension of the life span of pressure ulcer fibroblasts with recombinant human interleukin-1beta. *Am J Pathol*,146,pp.1273-1282.

van Ort SR and Gerber RM (1976) Topical application of insulin in the treatment of decubitus ulcers: a pilot study. *Nurs Res*,25,pp.9-12.

van Rijswijk L (1993) Full-thickness pressure ulcers: patient and wound healing characteristics. *Decubitus*, 6(1),pp.16-21.

van Rijswijk L and Polansky M (1994) Predictors of time to healing deep pressure ulcers. *Ostomy Wound Management*,40(8),40-2,44,46-8 passim.

Verhonick R (1961) Decubitus ulcers observations measured objectively. *Nursing Research*,10(4),p.211.

Vesmarovich S, Walker T et al. (1999) Innovations in practice. Use of telerehabilitation to manage pressure ulcers in persons with spinal cord injuries. *Advances in Wound Care*,12(5),pp.264-9.

Viehbeck M, McGlynn J et al. (1995) Pressure ulcers and wound healing: educating the spinal cord injured individual on the effects of cigarette smoking. *Sci Nursing*, 12(3),pp.73-6.

Walker P (2001) Management of pressure ulcers. *Oncology* (Huntington),15(11),1499-508,1511;discussion1511,1515-6.

Walker TL, Kreutz D et al. (2002) On mobility. Planning for comfort: pressure ulcers are a problem for people who use wheelchairs. *Advance for Directors in Rehabilitation*,11(8),pp.21-2.

Waltman NL, Bergstrom N et al. (1991) Nutritional status, pressure sores, and mortality in elderly patients with cancer. *Oncology Nursing Forum*,18(5),pp.867-73.

Weiss DS, Kirsner R and Eaglstein WH (1990) Electrical stimulation and wound healing. *Arch Dermatol*,126,pp.222-25.

Wellard SJ (2001) An Australian experience of managing pressure ulcers in persons with SCI. *Sci Nursing*,18(1),pp.11-7.

Whitney JD, Salvadalena G, Higa L and Mich M (2001) Treatment of pressure ulcers with noncontact normothermic wound therapy: healing and warming effects. *Journal of Wound, Ostomy, & Continence Nursing*,28,pp.244-52.

Williams DF, Stotts NA et al. (2000) Patients with existing pressure ulcers admitted to acute care. *Journal of Wound, Ostomy, & Continence Nursing*,27(4),pp.216-26.

Willock J, Hughes J, Tickle S, Rossiter G, Johnson C and Pye H (1999) Pressure sores in children – the acute hospital perspective. *Journal of Tissue Viability*,10(2),pp.59-65.

- Willock J, Hughes J et al. (2000) Pressure sores in children – the acute hospital perspective. *Journal of Tissue Viability*,10(2),59-62.
- Winter GD (1962) Formation of the scab and the rate of epithelialisation of superficial wounds in the skin of the domestic pig. *Nature*,193,p.293.
- Wollina U (1997) A hydropolymer dressing for chronic wounds: Clinical experiences with 478 patients in an open multicenter trial. *Anais Brasileiros de Dermatologia*,72,pp.527-532.
- Wood JM, Evans PEd, Schallreuter KU et al. (1993) A multicentre study on the use of pulsed low-intensity direct current for healing chronic stage II and stage III decubitus ulcers. *Archives of Dermatology*,pp.999-1009.
- Wongworawat MD, Schnall SB, Holtom PD, Moon C and Schiller F (2003) Negative pressure dressings as an alternative technique for the treatment of infected wounds. *Clinical Orthopaedics & Related Research*,414.
- Worsley M and Buchanan L (1991) Comparing efficacies. This study compared two products used in the treatment of leg ulcers and pressure sores. *Nurs Stand*,5,pp.4-6.
- Wu SH, Zecha PJ, Feitz R and Hovius SER (2000) Vacuum therapy as an intermediate phase in wound closure: a clinical experience. *European Journal of Plastic Surgery*,23,pp.174-177.
- Wysocki AB (1996) Wound fluids and the pathogenesis of chronic wounds. *Journal of Wound Ostomy and Continence Nursing*,23,pp.238-290.
- Xakellis GC and Chrischilles EA (1992) Hydrocolloid versus saline-gauze dressings in treating pressure ulcers: a cost-effectiveness analysis. *Arch Phys Med Rehabil*,73,pp.463-9.
- Yarkony GM (1994) Pressure ulcers: a review. *Arch Phys Med Rehab*,75,pp.908-1.