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The studies in this thesis were set up to investigate the prevalence of (infected) chronic wounds in Dutch nursing homes, and to answer the question whether a swab is a valid and reliable method for the assessment of infection of a chronic wound. At the end the results of a cost analysis of the Knowledge Centre of Wound Care in Venray are provided.

Wound healing normally occurs in a predictable sequence (coagulation, inflammation, proliferation, remodelling). When the anatomic and functional integrity of the skin is not reached within 3 weeks, a wound is considered chronic or hard-to-heal.

Chronic wounds, including pressure ulcers, leg ulcers and diabetic foot ulcers are often painful and debilitating for patients, resulting in a reduction of quality of life. Moreover, chronic wounds are associated with high costs accounting for more than 2-4% of health care expenses worldwide. Within the next 40 years, the cost burden of treating chronic wounds is expected to grow progressively due to an aging population and in particular a sharp rise in the incidence of both obesity and diabetes.

To create awareness in caregivers, managers, policymakers and politicians of the scale of the problem, there is a need for prevalence data of chronic (infected) wounds. Up until now, no data have been published in the Netherlands.

Chronic wounds may become complicated by infection. Wound infection leads to a multiplication of micro-organisms, a prolonged (and excessive) inflammatory response, a delay in the collagen synthesis, and a retarded epithelialisation. It ultimately results in tissue damage. Efficient management and careful antimicrobial treatment of these wounds is essential. This leads to earlier wound healing and costs less. However, the clinical assessment of a chronic wound infection is challenging. In comparison with the clinical assessment of infection of acute wounds, the clinical signs and symptoms of infection of chronic wounds are more difficult to interpret.

The clinical assessment of chronic infected wounds is often accompanied by the identification and the assessment of the number of present isolated microorganisms. It has been claimed that bacterial quantification supports the clinical assessment of wound infection supports and is useful for a focused treatment of the wound.

Following her 'Exploration of Dutch wound care', van Mierlo-van den Broek (2011) recommended an innovative organization of chronic wound care in the Netherlands. The key elements of this innovative way of organizing wound care involved the possibility of a quick referral of a patient with a chronic wound to a genuine wound care specialist team/ wound care centre in which a comprehensive multidisciplinary wound assessment is performed, followed by a strictly monitored and targeted intervention targeted and strictly monitored wound treatment plan. In succession of several cost effective examples of community based leg ulcer clinics in the UK at the end of last century an outpatient wound clinic, the Knowledge Centre in Wound Care (KCWC) was founded in Venray, the Netherlands in 2009. Although the phenomenon of an outpatient wound clinic meets the substantive argument for an innovative organization of chronic wound care in the Netherlands, it is not clear whether such an approach is cost-effective.
**Chapter 1** The general introduction addresses background information on the knowledge of chronic wounds and wound infection. In addition, the aims and outline of the thesis are presented.

In **chapter 2**, using a cross-sectional descriptive survey, a first explorative study was conducted to investigate the number and types of chronic wounds treated by Dutch Elderly care physicians (former Nursing Home Physicians or NHPs). The study was also aimed to identify how many of the treated chronic wounds the NHPs considered infected. 361 NHPs were sent a questionnaire to select and rank their top five criteria for chronic wound infection from a list that was provided. The signs and symptoms on the provided list were the same as those indicated by the European Wound Management Association’s position document in 2005. 139 of the NHPs returned the questionnaire and 121 were valid to use in the analysis. Then their ranking was compared with the selections made by an international multidisciplinary Delphi group of wound experts in 2005. It showed that at the time of the survey, 73.5% of the responding NHPs treated at least one chronic pressure ulcer (PU). 31.6% of the NHPs treated at least one, but no more than two chronic post-operative wounds. Chronic venous leg ulcers (VLUs), arterial ulcers and diabetic ulcers were being treated less frequently than PUs and post-operative wounds. Of the PUs, 53% were considered to be infected. The other chronic wounds were considered to be infected far less frequently. In comparison to the group of international wound experts, Dutch NHPs appeared to use more ‘traditional’ criteria such as ‘puss/abscess’ and ‘malodour’ to identify chronic wound infection.

In **chapter 3**, the prevalence of (infected) chronic wounds was described more extensively. It was also explored which signs and symptoms were used to diagnose infected chronic wounds. In April 2012, as part of the annual National Prevalence Measurement of Care Problems of Maastricht University (LPZ), a multi-centre cross-sectional point-prevalence measurement was carried out together with an assessment of relevant care quality indicators. The results showed that in 21 participating nursing homes with 61 wards and 1514 patients, 63 patients had together 72 chronic wounds, resulting in an overall prevalence of 4.2%. Almost half (46%) of these wounds were pressure ulcers (PUs) followed by post-surgical wounds (9.5%). 22% (n=16) of these 72 chronic wounds were clinically assessed to be infected. Increase of exudate (81.3%; n=13), erythema (68.8% ; n=11), pain (56.3%; n=9) and wound recalcitrance (56.3%; n=9) were considered to be diagnostic signs and symptoms of infection. It showed that at institutional level most quality indicators were fulfilled. In all the nursing homes the number of chronic wounds were centrally registered and every two years a specific training was organized. However, at ward level the same quality indicators were fulfilled less.

It was the aim in **chapter 4** by reviewing the literature to investigate the usefulness of a wound swab (using the Levine or Z-technique) in comparison to a biopsy as a reliable method for the diagnosis of a chronic wound infection.
The electronic databases PubMed, the Cumulative Index of Nursing and Allied Health Literature (CINAHL) and Medline were searched by strategy. Only 6 articles fulfilled the inclusion criteria. The Levine technique detects more organisms in acute wounds as well as in chronic wounds. At a threshold of $3.7 \times 10^4$ micro-organisms per swab, the Levine technique had a sensitivity of 0.90 and a specificity of 57%, and a positive predictive value and negative predictive value of 0.77 and 0.91 respectively. Compared both with the biopsy as golden standard, the diagnostic accuracy to diagnose a chronic wound infection by the Levine's technique was higher in comparison to the Z-technique. From the international literature it became clear that the method of swab taking varied and was not uniformly described.

In chapter 5 in a prospective study the Levine swab technique was used to assess whether bacteriological analysis of a wound swab is supportive in the clinical assessment of infection of a chronic wound. Patients attending an outpatient wound clinic who had endured a chronic wound for more than three weeks were clinically assessed for infection. The 13 signs and symptoms of chronic wound infection, mentioned in the international consensus document on wound infection of the World Union of Wound Healing Societies (WUWHS) were used (2008). Standardized wound swabs were taken by the Levine technique. The microbiological findings of the swabs were compared with the clinical assessment of the wounds. The results showed that the clinical assessments were not significantly correlated with the bacteriological results of the swabs taken. This applied for all types of chronic wounds, including for those of patients with a known diagnosis of diabetes mellitus or peripheral arterial disease (PAD). The conclusion was that in our study microbiological analysis of swabs taken from chronic wounds do not support the clinical assessment, and in fact is waste of time and money.

Chapter 6 described the results of a cost analysis of one of the first outpatient community wound care clinics in the Netherlands, the Knowledge Centre in Wound Care (KCWC) at Venray. An observational cohort study was conducted with a one-year pre-admission and a one-year post-admission comparison of costs. Patients were included after their initial admission at the outpatient wound care clinic. Only patients insured by the health insurance company Coöperatie Volksgezondheidszorg (VGZ) were included. A standard six-step procedure for performing cost studies was used to calculate the costs. Given the skewed data, non-parametric bootstrapping was used to test for statistical differences. The results showed that wound care at the KCWC for chronic wounds of patients was not only therapeutically effective (complete healing in 106 out of 172 patients) but also cost-efficient. The differences in costs related to wound care between the year before and the year after initial admission to the wound clinic resulted in a reduction of €2,533 per patient, per year in the base case analysis. This study was a first attempt of a cost analysis of an equipped outpatient wound clinic in the Netherlands. The organization of more outpatient wound clinics may be an adequate solution to meet the expected growth of chronic wounds in the Netherlands.
Chapter 7 provides an overview and discussion of the main results presented in this thesis. Theoretical and methodological considerations were addressed. The implications for daily wound care practice and future research are described. Furthermore, the following recommendations are made:

1) Conduct a regular prevalence measurement of chronic wounds. This may create more awareness and focus among managers and caregivers and will support the actual daily wound care activities, a better registration of these wounds in the resident’s files, the multidisciplinary discussions as well as other improvement activities in the care for residents with chronic wounds.

By applying a methodology approach like the National Prevalence Measurement of care problems of Maastricht University (LPZ-Landelijke Prevalentiemeting Zorgproblemen) it is ensured that the data obtained can be used for benchmarking within and between health care settings.

2) Validate the signs and symptoms further that are provided by the consensus document ‘Wound infection in clinical practice’ of the World Union of Wound Healing Societies (WUWHS) in 2008.

Regarding the issue of diagnosing infection of chronic wounds and knowing that there is currently no better diagnostic strategy than the clinical assessment itself, there is need of research into innovative objective diagnostic solutions. A promising advance is the use of DNA sequencing techniques. However related high costs and the complicated feasibility of these techniques to use in for instance nursing home settings, do not allow extensive use yet.
Prevalence and assessment of (infected) chronic wounds