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Economic Evaluation of Pressure Ulcer Care: A Cost Minimization Analysis of Preventive Strategies

Executive Summary

- The purpose of this study was to determine the cost for prevention and treatment of pressure ulcers from a hospital perspective and to identify the least resource-intensive pressure ulcer prevention strategy.
- Cost analyses were examined from a hospital perspective using direct costs. The study was carried out alongside a prospective cohort study on the incidence and risk factors for pressure ulcers.
- Two large teaching hospitals in the Netherlands with (partly) opposing approaches in prevention, a technological versus a human approach, were analyzed.
- The main outcome measures were resource use, costs of preventive measures and treatment, and pressure ulcer incidence in both hospitals.
- Pressure ulcer prevention through a predominantly technical approach resulted in a similar incidence rate as prevention through a predominantly human approach.
- However, the technical approach was considerably less expensive.

Pressure ulcers are still a very common problem in hospitalized patients. In 2006, 8% of hospitalized patients in the Netherlands had a pressure ulcer grade II or worse (Halfens, Janssen, & Meijers, 2006). The proportion of newly hospitalized patients developing pressure ulcers varied from 2.7% to 29.5%, depending on the population studied (Schoonhoven, Bousema, & Buskens, 2007). In one study it was estimated that about 40% of patients hospitalized for more than 5 days qualified for preventive measures (Schoonhoven et al., 2006).

Pressure ulcers are caused by pressure and shearing forces (Defloor, 1999; Defloor et al., 2004). Clinical guidelines describe various measures for preventing and treating pressure ulcers (CBO Dutch Institute for Health Care Improvement, 2002; National Institute for Health and Clinical Excellence, 2003). Effective preventive measures reduce the intensity and/or the duration of pressure and shearing forces. For this a technical approach can be used in which the intensity of pressure and shearing forces are reduced by pressure-relieving mattresses, cushions, and postures (CBO, 2002). Alternatively, a more human resource intensive approach (turning, repositioning, and mobilization) can be used. In

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pressure ulcer care these interventions are used either as prevention or in addition to wound treatment, depending on the actual condition of the patient's skin.

Preventive measures and treatment for pressure ulcers are generally considered expensive and labor intensive. There have been few attempts to estimate the cost of pressure ulcer care (Bennet, Dealey, & Posnett, 2004; Haalboom, 1991; Severens, Habraken, Duivenvoorden, & Frederiks, 2002). The most recent study in the Dutch setting estimated the cost of illness of pressure ulcers between $362 million and $2.8 billion per year (Severens et al., 2002). All these estimates are, however, based on expert opinion and lack actual basis in terms of data.

To date, an economic evaluation recording the use of health care resources in hospitals for preventing or treating pressure ulcers is missing in the literature. We carried out an economic evaluation as part of a large pressure ulcer prediction rule validation study. The aim of this study was (a) to determine the cost for prevention and treatment of pressure ulcers from a hospital perspective, and (b) to establish the least resource-intensive pressure ulcer prevention strategy. Specifically, care with a predominant focus on a human resource approach and care with a predominant focus on a technical approach for preventing and treating pressure ulcers were examined.

Methods

Sample. This burden of disease and cost minimization study was carried out as an adjunct to the Purse Value study, an observational prospective cohort study for the validation of a newly developed pressure ulcer prediction rule. The cost study provided the data for the cost calculations. The Purse Value study provided the data on the incidence of pressure ulcers and the average number of days for preventive and treatment care necessary to extrapolate cost data to the hospital level. The data on prevention of these two studies were combined in the cost minimization analysis.

Purse Value study. The Purse Value study was an observational prospective cohort study carried out in two large teaching hospitals in the Netherlands (the Canisius Wilhelmina Hospital [CWZ] in Nijmegen and the St. Antonius Hospital [SAH] in Nieuwegein), with a capacity of 653 and 584 beds respectively.

Patients admitted to surgical, internal, and neurological wards, without pressure ulcers, older than 18 years, and with an expected admission of at least 5 days were eligible; a total of 11,000 fulfilled the criteria during the study period. Research nurses visited each ward twice a week and asked eligible patients admitted in the past 48 hours to participate. Approximately a quarter of all potentially eligible patients could be visited, of whom 1,807 (66%) agreed to participate. Eventually, 79.7% patients (1,440) had at least one followup visit before discharge; 618 patients at SAH between May 2001 and May 2002, and 822 patients at CWZ between May 2003 and March 2004.

Pressure ulcers were graded according to the classification of the European Pressure Ulcer Advisory Panel (1999). The outcome was defined as occurrence of a pressure ulcer grade 2 or worse. The nurses on the ward were blinded for the observations of the research nurse.

Data from this study were used to calculate the incidence of pressure ulcers and the average number of days for preventive care and treatment.

Patient characteristics for the two samples included in this study are shown in Table 1. The mean age in both samples does not differ significantly (64.8 vs. 66 years; p=0.09). However, significantly more patients were admitted to the surgical wards in SAH than in CWZ (87.4% and 36.9%, respectively), and the length of stay in CWZ was significantly longer than in SAH (2.8 and 2.3 weeks, respectively, $p \leq 0.0001$). Yet, a larger part of the SAH sample was at risk for pressure ulcer development according to the clinical prediction rule developed (Schoonhoven et al., 2006), compared to the CWZ sample (51% and 23.5%, respectively, $p \leq 0.0001$). Most of the other differences are related to the prevention and treatment approach which was compared in this study. Moreover, the incidence of pressure ulcers does not differ significantly between the two samples (5.5% and 4.9%, p=0.15). Therefore, we concluded that we could compare the two samples and present a cost minimization analysis.

Cost study. The cost study was performed in parallel with the Purse Value study. Due to specific sampling of patients who either received prevention or treatment for an existing pressure ulcer, this study enrolled other patients than the Purse Value study. Patients remained in the study until discontinuation of preventive measures, until the pressure ulcer was healed, or until discharge or death of the patient. Between October 2001 and February 2002, 120 (n=94 prevention group, n=26 treatment group) patients in SAH, and between November 2003 and January 2004, 130 (n=65 prevention group, n=65 treatment group) patients in the CWZ were included. In CWZ ten patients in the prevention group and seven in the treatment group were excluded from the final analysis because of incomplete data. Ultimately, 149 patients with complete data were available in the prevention group and 84 patients in the treatment group (see Table 2 & Figure 1).

Data collection. Individual patient characteristics and pressure ulcer related resource use were gathered on a standardized case report form (CRF). The nurs-

Table 1.
Characteristics Patient Groups in Purse Value Study per Hospital

	SAH (n=618 patients/ 9,912 patient days)	CWZ (n=822 patients/ 16,254 patient days)	Test Statistic	*p* Value
Age (mean, SD)	64.8 (12.6)	66 (14.8)	*t* -1.69	0.09
Female (n,%)	268 (43.4%)	428 (52.1%)	χ^2 10.69	0.001
Ward (n,%) Surgical Internal Neurology	 540 (87.4%) 59 (9.5%) 19 (3.1%)	 303 (36.9%) 457 (55.6%) 62 (7.5%)	χ^2 375.07	≤0.0001
Length of stay in days (mean, sd)	16.4 (6.8)	19.8 (10.6)	*t* -7.42	≤0.0001
Cumulative incidence PU grade II or worse (n, %)	34 (5.5%)	40 (4.9%)	χ^2 2.10	0.15
Incidence rate PU grade II or worse per patient week (mean, SD)	0.03 (0.16)	0.02 (0.13)	*t* 1.39	0.16
Number of patients receiving prevention	453	129	*U* -1.81	≤0.0001
Mean days (SD) of prevention	10.7 (4.6)	13.4 (9.4)	*t* -3.19	0.002
Score on prePURSE scale (mean, SD) *†	18.1 (8.7)	13.3 (7.5)	*t* 17.71	≤0.0001
At risk according to prePURSE scale (no of patient weeks,%) * †	650 (51%)	495 (23.5%)	χ^2 223.56	≤0.0001

* Calculated on total of 1,274 patient week records for St. Antonius Hospital (SAH) and 2,104 patient week records for Canisius Wilhelmina Hospital (CWZ).
† Score ranges from 0 to 41 points. ≥ 20 points is considered at risk.
PU = pressure ulcer
t=students t-test; χ^2 = Chi-square test; *U* = z-value Mann Whitney U test

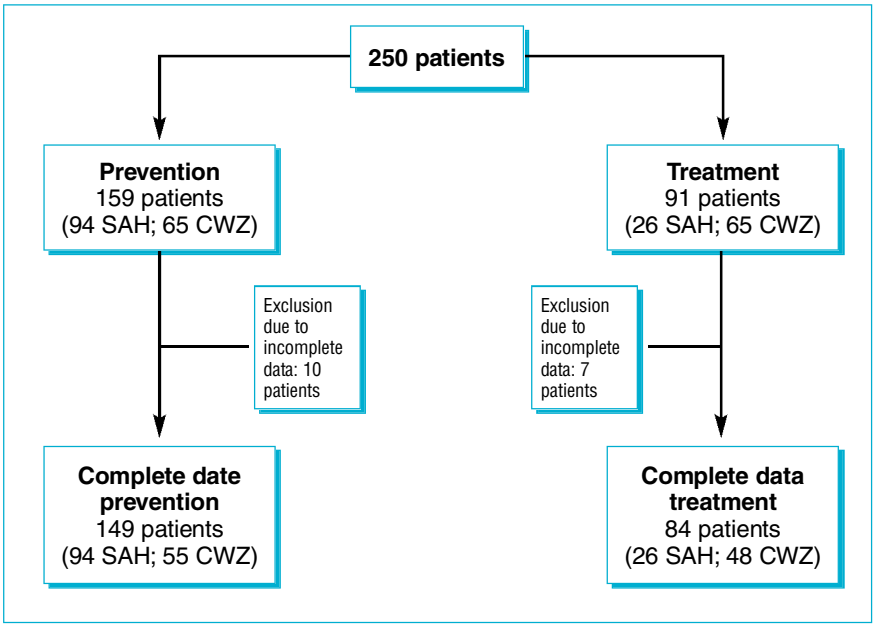
Table 2.
Characteristics of Patient Groups in Cost Study per Hospital

	SAH (n=120)	CWZ (n=113)	Total (n=233)	*p* Value
Age, mean (SD) in prevention group (n=149)	68 (14.8)	75 (11.9)	71 (14)	≤0.001
Age, mean (SD) in treatment group (n=84)	76 (13.1)	78 (10.9)	77 (12)	0.05
Pressure ulcers per grade*				
Grade I (n)	6	11		
Grade II (n)	16	22		
Grade III (n)	3	12		
Grade IV (n)	1	13		

* Figures do not represent prevalence or incidence because patients were selected based on presence of pressure ulcers.
SAH = St Antonius Hospital; CWZ = Canisius Wilhelmina Hospital

ing staff filled out the CRF at the start of prevention or treatment and subsequently once a week until prevention or treatment was discontinued or when the patient was discharged or died. If prevention or treatment changed during the observation period, the date of change was noted and a new CRF was filled out. The data from the CRF consisted of 180 items. The daily resource use recorded by the nursing staff using the CRF consisted of time spent by the nursing staff, use of materials, therapeutic interventions (e.g., necrotomy), enteral nutrition, and consultations of a specialized wound care

Figure 1.
Flowchart of Patient Inclusion Cost Study



SAH = St. Antonius Hospital; CWZ = Canisius Wilhelmina Hospital

nurse, dietician, or medical specialist. The 180 items were categorized into four main topics: costs for repositioning, costs for mobilization, costs for wound care, and costs for resources (special beds, mattresses, dressings, nutritional supplements, ointments).

Cost calculation methods. The hospital perspective used in this study compares direct costs (not charges or reimbursed amounts) of predominantly technical and predominantly human approaches to prevention and treatment of pressure ulcers (Oostenbrink, Buijs-Van der Woude, van Agthoven, Koopmanschap, & Rutten, 2003). The costs of the pressure ulcer interventions were determined using the bottom-up method, in which costs are calculated by directly tracing resources (Oostenbrink, Koopmanschap, & Rutten, 2002). The standard mattresses used in both hospitals were high-quality pressure-reducing foam mattresses (the Cliniplot mattress [Hill-Rom, U.S.] in the SAH and the Tempur-Pedic viscoelastic foam mattress [Tempur-Pedic, U.S.] in the CWZ). Table 3 gives an overview of the data that were collected for the calculation of the direct costs.

Cost outcomes include cost per intervention, cost of prevention, cost of treatment, cost per day, and cost per patient receiving prevention or treatment. Subsequently, we estimated the annual expenditures for the Dutch national health system by extrapolating from previously published national admission data and data on prevalence of pressure ulcers.

Cost per intervention. For the analysis of the average daily cost per intervention, the unit price per item scored on the CRF was established first (see Table 3). Hospital purchase prices of wound care products, enteral nutrition, special beds, and mattresses were obtained from the hospitals (unit prices reflect mean purchase cost after negotiation). The hour/minute wages of wound care nurses, dieticians, medical specialists, and nursing staff were in accordance with Dutch standards (Oostenbrink et al., 2003). These wages represent the total of the health care worker costs to the organization, including benefits.

The overall cost for each intervention was calculated using the following methodology. The time input of personnel was multiplied by the average wage costs per minute for each specific staff category. The costs of materials were calculated by multiplying the average volume per article by the unit price. This resulted in the cost per intervention (costs for repositioning, costs for mobilization, costs for wound care, and costs for resources [special beds, mattresses, dressings, nutritional supplements, ointments]).

Patients were not admitted to the hospital for treatment or prevention of pressure ulcers. Therefore the indirect costs (e.g., patient transport, central heating, and costs of basic health care such as the standard bed and mattress) were not taken into account. These costs do not seem attributable to pressure ulcer care.

Cost of prevention. The overall cost for prevention in each hospital was calculated by adding the costs of the different interventions used for prevention (repositioning, mobilization, and resources).

Cost of treatment. The overall cost for treatment in each hospital was the sum of the cost of the different interventions for treatment (repositioning, mobilization, wound care, and resources). As these costs increase with the severity of the pressure ulcer, cost per pressure ulcer grade was calculated separately.

Cost per day. For establishing the average *cost per day*, the total cost for prevention and treatment in the period of care calculated in the cost study was divided by the number of pressure ulcer prevention or treatment days observed in the cost study.

For establishing the average *cost per grade* per day, the total cost for treatment per grade in the

Table 3.
Information Was Gathered on the Direct Costs

Item	Description	Cost in €
Mattresses		**Cost per Day (min-max)***
	Standard mattress	-
	Foam mattress	2
	Gel overlay mattress	12
	Air mattress	6
	Low air loss mattress	18
	Alternating pressure mattress	11
	Continuous low pressure mattress	16 - 30
	Air fluidized	54
	Other	18
Cushions		**Cost per Day**
	Standard cushion	-
	Foam cushion	3
	Gel cushion	2
	Other	2
Wound care products		**Cost per Piece (min-max)***
	Gauze	0.03 - 0.52
	Hydrocolloid dressing	2.98 - 22.97
	Cleansing dressing	0.27 - 3.99
	Silicone dressing	0.85 - 6.32
	Absorbent dressing	0.07 - 0.33
	Transparent film dressing	0.33 - 4.82
	Bandage	0.36 - 3.10
	Gloves	0.10
	Catheter	0.14
	Syringe 50 ml	0.46
	NaCl fluid	0.01
	Sterile cup	0.95
	Tweezer	0.41
	Apron	0.60
	Scissor	0.49
	Ointment	0.03 - 0.15 per ml
Enteral nutrition		
	Supplements	1.45 - 6.14 per 200 ml
	Tube feeding	6.28 - 10.03 per 200 ml
Additional therapy	Vacuum-assisted closure therapy	45 per day
Salary costs		**Cost per Minute**
	Nurse daytime only	0.47
	Nurse including nightshift	0.58
	Dietician	0.58
	Specialized wound care nurse	0.52
	Medical specialist	2.40

NOTE: Hospital purchase prices of wound care products, enteral nutrition, special beds, and mattresses were obtained from the hospitals (unit prices reflect mean purchase cost after negotiation).
* Price depends on brand, size or type of product, multiple brands, sizes, or types used.

period of care calculated in the cost study was divided by the number of pressure ulcer treatment days observed in the cost study.

Cost per patient per hospital receiving prevention or treatment. These costs per day were extrapolated to *mean cost per patient receiving prevention or treatment per hospitalization period* by multiplying them with the mean number of prevention or treatment days from the Purse Value study (see Table 1).

By multiplying the cost per grade per day with the mean days of treatment per grade, the *mean total cost for treatment per grade* was calculated. It was not possible to determine the length of hospitalization for grade IV pressure ulcers patients because grade IV pressure ulcer did not occur de novo in the Purse Value study. We assumed that the number of treatment days for grade IV pressure ulcers was equal to the number of treatment days for grade III pressure ulcers. Also, the effectiveness of the treatment could not be determined as we did not follow patients until the pressure ulcer healed.

Annual national cost. The currency used is Euros (€); 1 € equals $1.27 in U.S. dollars. Based on a previous study, it was hypothesized that 40% of patients hospitalized for more than 5 days are at risk according to the prePURSE risk assessment scale and therefore qualify for pressure ulcer prevention (Schoonhoven et al., 2006). This percentage was used as a basis for calculating prevention cost. To estimate the national annual cost associated with treating pressure ulcers, the data on hospitalization and prevalence of pressure ulcers from Dutch databases were used (Centraal Bureau voor de Statistiek [CBS], 2008; Halfens et al., 2006). Hospitalizations in psychiatric wards were not taken into account. We assumed that the mean length of stay of patients with a pressure ulcer is representative for all hospitals and used it as a basis for calculating treatment cost.

Table 4.
Prevention and Treatment of Pressure Ulcers in the Hospitals

	SAH	CWZ
	Applied n (%)	Applied n (%)
Prevention	n=94	n=55
Special mattress †	24 (26)	25 (46)
Repositioning	3 (3)	30 (55)
Mobilization	45 (48)	34 (62)
Dressing/Ointment †	42 (45)	14 (26)
Treatment	n=26	n=58
Special mattress †	22 (85)	31 (53)
Repositioning	6 (23)	36 (62)
Mobilization	19 (73)	44 (76)
Dressing/Ointment †	12 (46)	19 (33)

† Technical approach
SAH = St. Antonius Hospital; CWZ = Canisius Wilhelmina Hospital

Cost minimization analysis. As the incidence of pressure ulcers did not differ significantly between the two samples (the effect of the prevention approaches on pressure ulcer occurrence is equal), a cost minimization analysis was performed. Unfortunately, we do not have data on the effectiveness of treatment as this was not the focus of the Purse Value study. Therefore, we only performed a cost minimization analysis for prevention.

Scenario analysis. Nursing time is an important component in the cost of pressure ulcer care when a predominantly human approach is used. A scenario analyses was performed on the national costs in which we varied the cost of nursing time (from 0.5 to 1.5 times the real cost) to explore the effect of this variable on total cost.

Material costs are an important component in the cost of pressure ulcer care when a predominantly technical approach is used. Therefore, we also calculated different scenarios in which we varied these cost (50% more and 50% less than real cost) to explore the effect of this variable on total cost.

Finally, the number of patients who are considered at risk determine the cost of prevention. When using a validated pressure ulcer risk assessment scale, 40% of the patients are estimated to be at risk. However, in practice this percentage may be lower or higher depending on the risk assessment scale used (Schoonhoven et al., 2002; Vanderwee, Grypdonck, & Defloor, 2007). Therefore, we also calculated the national cost for the scenario in which 30% of the patients, comparable to the Braden scale, or 70% of the patients, comparable to the Waterlow scale, are considered at risk (Schoonhoven et al., 2002).

Statistical analysis. Student's *t* test or Mann-Whitney U-test were used for continuous data. The chi-square test or Fisher's exact test was used for categorical data. All data were analyzed using SPSS 13.0 (SPSS®, Inc., Chicago, IL).

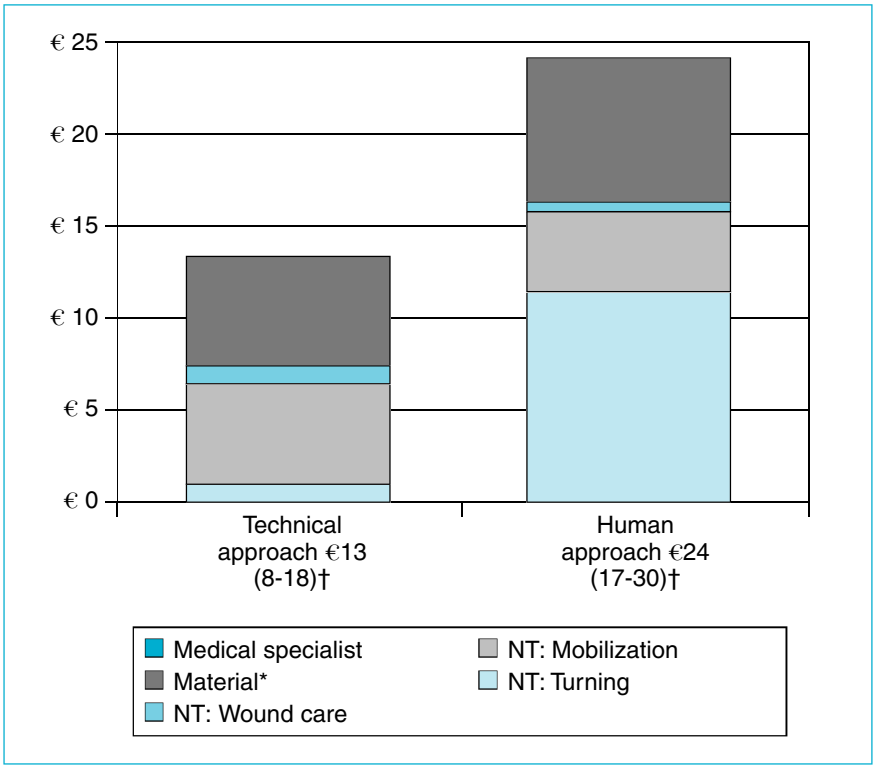
Ethical issues. Ethical approval was obtained from the ethical committees of both hospitals. Individual informed consent was

Table 5.
Mean Cost per Intervention (Prevention)

	Mean Nursing Time in Minutes (95% CI)	Mean Cost per Minute in € *	Mean Cost per Intervention in €
Repositioning	7.9 (7.3-8.6)	0.58	4.60
Mobilization	8.0 (7.1-8.9)	0.47	3.75
Ointment	2.5 (2.2-2.7)	0.47	1.16
Mattresses	NA	NA	5.67

* Cost of repositioning is higher due to higher nurse salary during night shift.
NA = not applicable

Figure 2.
Distribution of Cost by Preventive Measures per Prevention Approach in Euros



* Mattress, pillow, special bed, ointment, bandages, extra nutrition, enteral nutrition, heel prevention
† Mean cost per day in Euros (95% CI)
NT = nursing time

obtained from all study participants who volunteered to take part in the study. Anonymity and confidentiality were maintained throughout the study.

Results

Incidence of pressure ulcers. Seventy-four patients developed a pressure ulcer grade II or worse in the Purse Value study. The incidence figures did not differ significantly between the two hospitals: 5.5% in SAH and 4.9% in CWZ (χ^2=2.10, *df*=1; *p*=0.15) (see Table 1).

Pressure ulcer prevention and treatment. Table 4 shows the application of different measures of pressure ulcer prevention and treatment in the two hospitals. Although both hospitals applied prevention according to the Dutch guidelines (CBO, 2002), the preventive approach differed between the hospitals. The CWZ placed most emphasis on repositioning and mobilization (human approach), while the SAH most frequently used special dressings and ointments (technical approach). The same difference was observed in the *treatment* of pressure ulcers. The SAH placed most emphasis on special mattresses, while the CWZ placed more emphasis on repositioning. Both hospitals also frequently mobilized their patients.

Cost of prevention. The mean cost for the technical approach of prevention per day was €13 (95% CI: €8-€18, range €0.54-€103) and €24 (95% CI: €17-€30; range €0.13-€166) for the human approach (see Table 5 & Figure 2). The minimum values represent cases in which only ointment was applied. The maximum values represent patients who where extensively mobilized and repositioned. Figure 2 shows that the largest part of the costs in the human approach was composed of cost for nursing time (€16.27 [67.9%]) (turning, mobilization, and wound care). In contrast, the part of the cost for nursing time in the technical approach was €7.25 (55.9%).

Cost of treatment. The same intervention (repositioning, mobi-

Table 6.
Mean Cost per Intervention (Treatment)

	Mean Nursing Time in Minutes (95% CI)	Mean Cost per Minute in € *	Mean Cost per Intervention in € (95% CI)
Repositioning	10.4 (9.6 - 11.1)	0.58	6.00
Mobilization	13.5 (11.9 - 5)	0.47	6.32
Ointment	2.6 (2.1 - 3.1)	0.47	1.22
Wound care	12.6 (10.4 - 14.8)	0.47	5.93
Wound care products	NA	NA	9.65
Mattresses	NA	NA	11.20

* Cost of repositioning is higher due to higher nurse salary during night shift.
NA = not applicable

Table 7.
Estimated Mean Cost of Pressure Ulcers in Euros per Grade per Hospital

	Cost per Day (95% CI)		Mean Days of Treatment *		Mean Treatment Cost per Grade (95% CI)	
	SAH	CWZ	SAH	CWZ	SAH	CWZ
Grade I	€ 47 (18 - 75)	€ 32 (17 - 48)	9	11	€ 423 (162 - 675)	€ 352 (187 - 528)
Grade II	€ 58 (35 - 80)	€ 50 (36 - 63)	12	10	€ 696 (420 - 960)	€ 500 (360 - 630)
Grade III	€ 63 (32 - 90)	€ 88 (64 - 110)	13	14	€ 819 (416 - 1,170)	€ 1,232 (896 - 1,540)
Grade IV	€ 99 (74 - 123)	€ 123 (75 - 171)	13 †	14 †	€ 1,287 (962 - 1,599)	€ 1,722 (1,050 - 2,394)

* Based on data from Purse Value study. † In this study no grade IV ulcers occurred. We assumed that the number of treatment days for grade IV is equal to the number of treatment days for grade III.
SAH = St. Antonius Hospital; CWZ = Canisius Wilhelmina Hospital

lization) is more expensive in the treatment group than in the prevention group as it takes more nursing time to perform the intervention in patients with pressure ulcers (see Table 6).

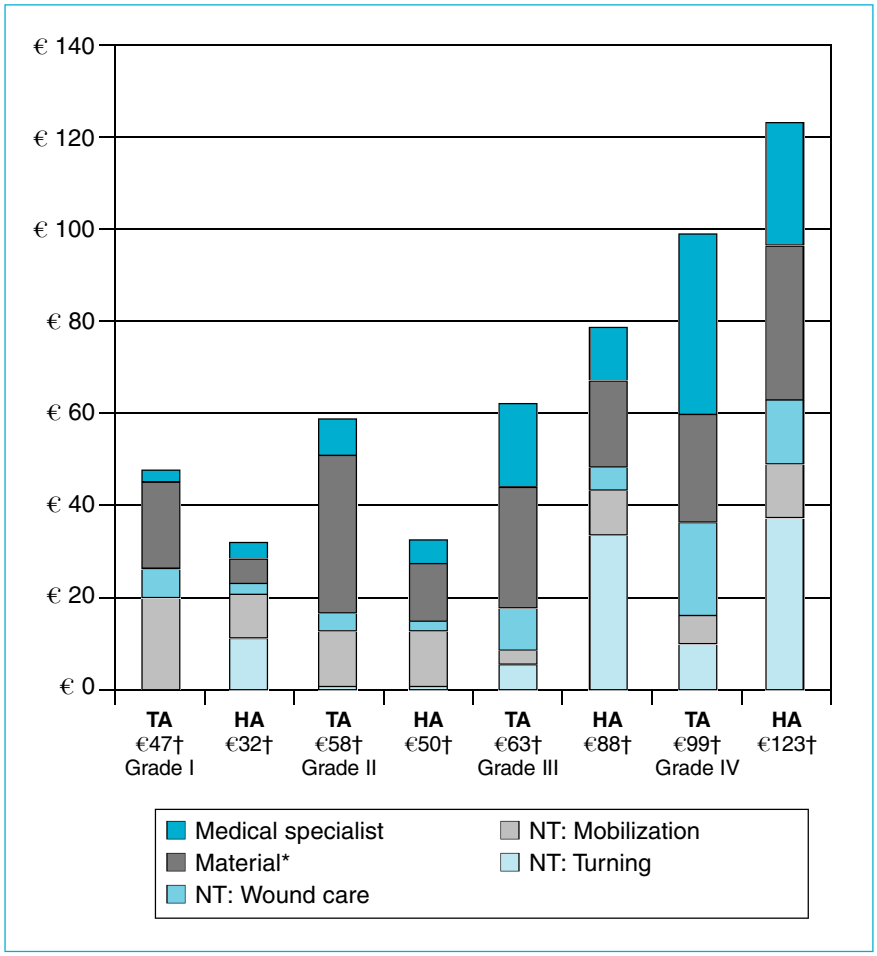
The cost per day for pressure ulcer treatment is directly related to the severity of the skin disorder. Table 7 shows the estimated budget impact per pressure ulcer grade for the SAH with the predominantly technical approach and the CWZ with the predominantly human approach. Figure 3 shows that in the human approach the major part of the cost for treatment per grade consisted of cost for nursing time, where in the technical approach the majority consisted of cost for resources.

Cost per patient by hospital. Although the length of stay in the CWZ was significantly longer than in the SAH (19.8 days vs. 16.4 days, respectively), the patients in the SAH had a higher risk for pressure ulcer development (see Table 1). Also the mean number of days of prevention was significantly higher in the CWZ than in the SAH (13.4 days vs. 10.7 days, respectively).

Since the mean length of preventive care in the SAH is €10.7 days, budget impact for giving preventive care with a predominant focus on the technical approach rather than the human approach is estimated at €139 (95% CI: €86-€193) per patient receiving prevention. The costs associated with prevention with a predominant focus on the human approach rather than the technical approach were estimated at €321 (95% CI: €228-€402) per patient receiving prevention (mean length of preventive care in CWZ: 13.4 days).

The mean duration of treatment per grade in the SAH varied between 9 and 13 days, and in the CWZ between 10 and 14 days (see Table 7). The mean cost per grade for giving treatment with a predominant focus on the technical approach rather than the human approach increased from €423

Figure 3.
Distribution of Treatment Cost by Grade per Treatment Approach in Euros



* Mattress, pillow, special bed, ointment, bandages, extra nutrition, enteral nutrition, heel prevention
† Mean cost per day in Euros
NT = nursing time; TA = technical approach; HA = human approach

(95% CI: €162-€675) per patient with a grade 1 pressure ulcer to €1,287 (95% CI: €962-€1,599) per patient with a grade 4 pressure ulcer. The mean cost per grade for giving treatment with a predominant focus on the human approach rather than the technical approach increases from €352 (95% CI: €187-€528) per patient with a grade 1 pressure ulcer to €1,722 (95% CI: €1,050-€2,394) per patient with a grade 4 pressure ulcer (see Table 7).

The estimated budget impact of treatment per hospital cannot be calculated as we did not have data on the prevalence per grade from the Purse Value study.

National costs. The annual number of hospital admissions in the Netherlands in 2005 excluding same day care admissions (<24-hour stay) amounted to approximately 1,650,000. About 30% of these admissions (495,000) lasted more than 5 days (CBS, 2008). When using a validated risk assessment scale, 40% of these patients (198,000) were assessed to be in need of preventive measures. This number multiplied by the average cost for prevention per patient resulted in an estimate of the annual burden for the Dutch national health system of €27.5 million per year when the focus would primarily remain on a technical prevention approach, and an estimated €63.6 million per year if the focus was primarily on a human prevention approach.

The annual Dutch prevalence study showed a prevalence of 18% of pressure ulcers in Dutch hospitals in 2006, with a subdivision of 10.3% for grade I pressure ulcers, 5% for grade II, 2.4% for grade III, and grade 0.8% for grade IV (Halfens et al., 2006). A proportional cost calculation for treatment resulted in an estimation of €178.8 million per year when the focus would primarily be on a technical approach and an estimate of €174.5 million per year if the focus would primarily be on a human approach. Adding prevention and treatment together leads to an estimated national annual expenditure between €206.3 million and €238.1 million for pressure ulcer care in Dutch hospitals.

Cost minimization analysis. The national cost for pressure ulcer prevention when the focus is primarily on a technical prevention approach is significantly lower than the national cost for pressure ulcer prevention when the focus is primarily on a human prevention approach (€27.5 million [95% CI: €17.0 million-€38.2 million] vs. €63.6 million [95% CI: €45.1 million-€79.6 million], p=0.0001).

We do not have data on the effectiveness of the treatment on pressure ulcer healing. This makes it impossible to do a cost minimization analysis on the treatment data.

Scenario analyses. Table 8 shows the variation in cost in the different scenarios. The effect of increasing or decreasing the cost of nursing has the largest impact on the human approach (+/- 35%). Increasing or decreasing the cost of material has the largest impact on the technical approach (+/- 22%).

Table 8.
Scenario Analyses Based on National Cost

	Current Cost (95% CI)	Cost When Salary Is 1.5 Times Higher (95% CI)	Cost When Salary Is 0.5 Times Lower (95% CI)	Cost When Material Cost Are 50% Higher (95% CI)	Cost When Material Cost Are 50% Lower (95% CI)	Cost When Prevention Is Given to 30% of the Patients (95% CI)	Cost When Prevention Is Given to 70% of the Patients (95% CI)
TA prevention	27.5 (17.0 - 38.2)	35.3 (21.2 - 49.5) +28%	19.8 (12.9 - 27.7) -28%	33.6 (21.8 - 45.4) +22%	21.5 (12.4 - 30.6) -22%	20.6 (12.8-28.7)	48.2 (29./8 - 66.9)
HA prevention	63.6 (45.1 - 79.6)	87.8 (62.1 - 113.6) +35%	41.5 (30.8 - 52.3) -35%	74.4 (54.7 - 94) +15%	55.0 (38.2 - 71.8) -15%	47.7 (33.8 - 59.7)	111.2 (79 - 139.3)
TA treatment	178.8 (93.4 - 264.2)	229.1 (113.6 - 344.7) +28%	128.4 (69.6 - 178.0) -28%	217.2 (117.8 - 316.6) +21%	140.4 (66.1 - 212.7) -21%	NA	NA
HA treatment	174.5 (111.9 - 237.1)	235.8 (147.7 - 323.7) +35%	113.6 (73.8 - 152.6) -35%	197.4 (129.9 - 264.9) +13%	151.5 (92.5 - 210.6) -13%	NA	NA

Cost in million Euros; TA = technical approach; HA = human approach; NA = not applicable

Discussion

Both the technical and human pressure ulcer prevention strategy resulted in an incidence which did not differ significantly. However, a technical approach in pressure ulcer prevention is associated with lower cost than a human approach.

The two hospitals differed in their preventive strategies. The main focus of SAH appeared to be on technical support (e.g., mattresses and dressings and ointments), while the main focus of CWZ appeared to be on human support (e.g., repositioning and mobilization). Both approaches are in accordance with the national pressure ulcer guidelines (CBO, 2002), and appear equally effective in preventing pressure ulcers as the incidence of pressure ulcers is low and does not differ. These results are consistent with other studies. Vanderwee, Grypdonck, and Defloor (2005) reported that patients who were placed on an alternating mattress (technical approach) did not develop pressure ulcers grade II or worse more frequently than patients who underwent position change every 4 hours on a visco-elastic foam mattress (human approach). Bennett et al. (2004) also found that most of the costs incurred for pressure ulcers were due to nursing time. While the CWZ also combined repositioning with the use of special mattresses in their prevention strategy, the differences in costs between the two approaches in this study are striking. The daily cost of the human approach is two times higher than the cost of the technical approach. Therefore, we assume that in prevention of pressure ulcers a technical approach (a less labor-intensive approach) is probably cost saving.

Since we did not ascertain followup on the patients that actually underwent treatment for pressure ulcers, we have no data on the effectiveness of the treatment and therefore, we cannot draw concrete conclusions regarding the cost effectiveness of treatment strategies. However, the treatment cost for more serious pressure ulcers via the technical approach also appeared less expensive than the human approach. Conversely, this is not true for the less serious pressure ulcers (grade I and grade II). In the less serious pressure ulcers the material used in the predominantly technical approach is expensive compared to the nursing time used in the predominantly human approach.

It should be emphasized that the calculated costs represent non-complicated pressure ulcers. The annual figures mentioned are based on calculations of the mean. It is obvious that the costs for patients who need specialized treatment for complicated pressure ulcers (e.g., necrotomy or flap surgery), will be much higher than the mean figures. These treatments are indicated for the more serious wounds (grade III and grade IV pressure ulcers). We recognize that the cost of treatment of these wounds is under-represented and therefore underestimated in this study. However, the vast majority of pressure ulcers remain below grade IV and this study therefore adequately reflects the overall budget impacts of in-hospital pressure ulcers.

Notably, the calculations are limited to Dutch hospitals. In fact, the pressure ulcer problem is far more extended, as it

is not limited to hospitals alone (Health Council of the Netherlands, 1999). Home care and nursing home care costs were not taken into account.

In this study, we calculated the amount of prevention days using data from the Purse Value study. This study was based on patients who were expected to stay in the hospital for more than 5 days. One may argue that this leads to an overestimation of the cost, especially prevention cost. However, in practice a risk assessment scale is not used selectively (only for patients who will be admitted for a longer period of time). The risk assessment will be made for all patients. It is, however, not likely that this will result in more patients at risk as the patients who are admitted for less than 5 days are generally in a better condition or admitted for less severe treatments than patients who need to stay more than 5 days. Therefore, we believe that this selection did not result in a major overestimation of the cost of prevention when performed according to the guideline. However, in practice the nurses may have concerns about the validity of the outcome on the risk assessment scale and provide care based on their clinical judgement. This will result in patients at risk according to the risk assessment scale not receiving preventive care, but also in patients not at risk according to the risk assessment scale receiving preventive care. This will most probably result in fewer patients receiving preventive care. The estimated cost of pressure ulcer prevention may therefore be an overestimation of the true cost due to nonadherence to the guideline.

In clinical practice several risk assessment scales are in use. The scenario analysis based on the percentage of patients at risk shows that the costs differ considerably based on the risk assessment scale used. Unfortunately these risk assessment scales also differ in their ability to detect patients at risk for pressure ulcers (Schoonhoven et al., 2002). Thus it is reasonable to assume that the incidence of pressure ulcers will also vary depending on the risk assessment scale used. As these data are not available, this could not be taken into account in the various scenarios.

Finally, one may argue that the patient population in the two hospitals is different. Although both are large teaching hospitals, the length of stay and risk profile are significantly different. SAH has a strong focus on cardiothoracic surgery, which may explain why more patients are considered at risk. Whether the differences in patient population can explain the differences in preventive approach is currently not known.

Using a validated risk assessment as an indicator for starting prevention (Schoonhoven et al., 2006) will result in identifying approximately 40% of the patients as being at risk for pressure ulcer development and thus in need of preventive measures. Despite the fact that the technical approach may decrease daily costs, almost half of the patients will be in need of prevention. Interestingly, Vanderwee et al. (2005) found that postponing prevention until nonblanchable erythema occurred did not lead to a higher incidence of pressure ulcers grade II or worse. This selective approach may further decrease the cost of preventive strategies.

Assuming that prevention would be implemented according to the guideline would imply annual expenditures between €206.3 million to €238.1 million for pressure ulcers. Clearly, this disorder is a major burden in terms of utilization of health care resources and personnel. The total health care expenditure in the Netherlands for hospital care in 2005 was approximately €17 billion (CBS, 2008), which means that between 1.21% and 1.41% of the total budget is spent on pressure ulcer care in hospitals alone. This is more than previous estimates (Severens et al., 2002).

Conclusion

Pressure ulcers have a considerable budget impact. The daily cost of a technical approach in prevention and treatment appears to be lower than the cost of a human approach, specifically for higher-grade pressure ulcers. Changing risk assessment and treatment strategies may further improve cost effectiveness. However, there is an urgent need for large experimental studies to further examine health outcomes and cost effectiveness of prevention and treatment of pressure ulcers. **$**

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