

The Cost-Effectiveness of Interventions for Preventing Pressure Ulcers

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Background: While there is scientific evidence to support the efficacy of preventive interventions for pressure ulcers, few empirical data are available on their cost-effectiveness. The aim of this study was to determine the cost-effectiveness of interventions to prevent pressure ulcers.

Methods: Costs of preventive interventions and days of ulcer-free survival were compared for two groups of patients. One group consisted of 250 patients from a geriatric unit of a British hospital (Norton sample). At the time of the study, no preventive measures were used. Data from the original report of the study were used to determine patients' attainment of one of three end points—ulcer formation, death, or discharge—from which a disease-free survival table was constructed. The second cohort of 420 patients consisted of residents of a long-term care facility in Iowa, where aggressive preventive measures were used (Iowa sample). Data were collected at the study onset and 3 months later. The types of preventive interventions used on each patient were assessed and their costs calculated. Cost of treatment for pressure ulcers was estimated from previous research performed at the Iowa facility. The cost-effectiveness of the preventive intervention was calculated by dividing the mean difference in cost between the two groups by mean difference in ulcer-free days.

Results: Survival analysis of days to ulcer development showed the Norton (no prevention) sample had a significantly shorter time to ulcer development than did the Iowa sample (patients receiving preventive measures) ($P < 0.0001$). The mean cost for prevention and treatment of an ulcer was $\$167 \pm \307 for the Norton sample and $\$245 \pm \379 for the Iowa sample. The mean number of ulcer-free days was 21.0 ± 17.4 for the Norton sample and 78.5 ± 11.0 for the Iowa sample. The cost per day of ulcer-free life gained was $\$1.36$.

Conclusion: The use of aggressive preventive measures in the long-term care setting is effective in reducing pressure ulcers and requires a relatively low level of institutional expenditures. (J Am Board Fam Pract 1996; 9:79-85.)

In the past 5 years pressure ulcers have been described as a common and costly condition in the elderly population.^{1,2} In an effort to control rapidly escalating health care costs, strategies for managing such common yet costly conditions as pressure ulcers are being reassessed. A number of authors have suggested that use of aggressive preventive interventions is the best strategy for controlling pressure ulcer costs.²⁻⁴

The most widely disseminated guideline for prevention of pressure ulcers was developed by a multidisciplinary, private-sector panel of experts and consumers convened by the Agency for Health Care Policy and Research of the US Department of Health and Human Services.² Their recommendations were formulated from an analysis of scientific evidence and a consideration of expert clinical judgment. They recommended regularly turning patients, using pressure-reducing mattresses and chair cushions, and using various site-specific devices to protect bony prominences from pressure.² Although the effectiveness of pressure-reducing devices and frequent patient repositioning is well established, there is little information on their cost-effectiveness.⁵ This need for information on cost-effectiveness has escalated as health care policy makers, payers, and providers consider how to implement these guideline strategies. Although

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fewer pressure ulcers are a desirable clinical outcome, the question remains, "How much does it cost to obtain this desired clinical outcome?"

Approaches to Cost-Effectiveness Analysis

Weinstein and Stason⁶ and Russell⁷ have described the methods for performing cost-effectiveness analysis of health care resources. Application of cost-effectiveness analysis to health care problems has been based on the premise that for any given level of resources, the objective is to maximize the total aggregate of health benefits conferred. To conduct such an analysis, three measures must be included: a measure of health benefits, a measure of costs of prevention, and a measure of the savings of disease treatment not needed. Typically, health resource costs are measured in dollars and are the net of the cost of prevention minus the reduction in medical treatment cost since disease is prevented. Health benefits are measured in "years of added life." Measurement of health benefits has been further refined into "years of added healthy life," which incorporates changes in mortality and morbidity into a single measure. Cost-effectiveness is the ratio of the net increase of health care costs to the net effectiveness in terms of enhanced life expectancy and quality of life.^{6,7} The formula for the cost-effectiveness ratio is as follows:

$$\text{Cost-effectiveness ratio} = \frac{\text{total increase in costs} + \text{total years of healthy life gained}}{\text{cost per healthy year gained}}$$

This model served as the basis for our analysis of the cost-effectiveness of interventions to prevent pressure ulcers. The aim of this study was to determine the cost-effectiveness of interventions to prevent pressure ulcers.

Methods

The costs of preventive measures and the days of pressure-ulcer-free survival were compared for two groups of patients. One group received no preventive measures for pressure ulcers, the other group received aggressive preventive interventions. By comparing these two groups, the cost of gaining one pressure-ulcer-free day was calculated.

The no-prevention sample comprised the original 250 patients Norton⁸ used in 1960 to develop a scale for predicting the risk of developing pres-

sure ulcers. Patients in the Norton sample were older individuals admitted to the geriatric unit of a British hospital who were free of ulcers at the time of admission. In 1960 the standard nursing care was to nurse patients flat on their back on a regular hospital mattress. Norton collected baseline demographic information and primary medical diagnoses and categorized the patient's risk of developing a pressure ulcer using a scale of five clinical characteristics.⁸ These five clinical characteristics (physical condition, activity, mobility, continence, mental condition) were each rated on a scale from 1 (least function) to 4 (highest function). Patients with a Norton score of less than 12 were classified at very high risk for developing a pressure ulcer, those with a score of 12 to 14 were at high risk, those with a score of 15 to 17 were at low risk, and those with a score of 18 to 20 were at very low risk. Norton observed all patients until they reached one of three end points: ulcer formation, death, or discharge.

End points were defined to occur during one of five discrete time intervals. These five time intervals were less than 2 weeks, within 2 to less than 4 weeks, within 4 to less than 6 weeks, within 6 to less than 8 weeks, and within 8 to less than 12 weeks. The study was assumed to conclude after 12 weeks of observation. A summary of the distribution of end points was constructed from the nine tables presented in the original technical report (Table 1).⁸

Patients who reached an end point during a particular time interval were assumed to reach their end point at the midpoint of that interval: 7 days for less than 2 weeks, 21 days for 2 to less than 4 weeks, 35 days for 4 to less than 6 weeks, 49 days for 6 to less than 8 weeks, 70 days for 8 to less than 12 weeks. Patients who were assumed to be alive, ulcer-free, and still hospitalized at the study's conclusion ($n = 5$) were assigned an end point of 84 days.

The second cohort of patients were residents of a state-owned and -operated long-term care facility for aging veterans in Iowa.⁴ A description of the cost of preventive measures used with this population has been described previously.⁴ This sample will be called the Iowa sample. For the current analysis, only patients from the facility who were at least 65 years old were included. The Iowa patients received aggressive preventive measures. The major categories of preventive mea-

Table 1. Distribution of End Points for Patients in the Norton (No-Prevention) Sample (n = 250) by Norton Risk Scoring.*

Time Frame	< 12 (n = 42)	12-14 (n = 53)	15-17 (n = 92)	18-20 (n = 63)	Totals (n = 250)
< 2 weeks					
New ulcer	18	12	9	2	41
Died ulcer-free	13	7	3	0	23
Discharged ulcer-free	0	4	19	26	49
Total					113
2 - 4 weeks					
New ulcer	2	4	7	0	13
Died ulcer-free	2	1	1	2	6
Discharged ulcer-free	3	10	23	19	55
Total					74
4 - 6 weeks					
New ulcer	0	1	2	1	4
Died ulcer-free	1	1	0	0	2
Discharged-ulcer free	1	5	14	6	26
Total					32
6 - 8 weeks					
New ulcer	0	0	1	0	1
Died ulcer-free	0	0	1	1	2
Discharge ulcer-free	1	6	8	4	19
Total					22
8 + weeks					
New ulcer	0	0	0	0	0
Died ulcer-free	0	0	0	0	0
Discharged ulcer-free	1	2	4	2	9
Total					9

* < 12 = very high risk, 12-14 = high risk, 15-17 = low risk, 18-20 = very low risk.

asures were patient repositioning, pressure-reducing mattresses, wheelchair cushions, and miscellaneous site-specific devices such as heel and elbow protectors.⁴

The methods for the original data collection for the Iowa sample have been described previously but will be summarized here.⁴ Data collection occurred in two phases, once at the study onset and a second time approximately 3 months (12 weeks) later. The initial assessment consisted of documenting the preventive measures being used, assessing risk with the Norton score, and collecting baseline demographic and medical diagnostic information. Baseline Norton scores were obtained by a research nurse using the Norton risk assessment tool, and patients were categorized according to their risk level in the same manner as patients in the Norton sample had been. The use of prevention measures was estab-

lished by documentation of pressure-reducing devices applied to each patient and the frequency of turning as recorded on the nursing treatment form on the patient record. The medical conditions for each patient were coded according to the *International Classification of Diseases, 9th Revision, Clinical Modification (ICD-9-CM)*.⁹ The first medical condition listed on the problem list of the patient's medical record was defined as the primary medical diagnosis.

At their second assessment each patient in the Iowa sample was assigned an end point of ulcer formation, death, discharge, or end of study and ulcer-free. For 2 patients the exact date of their end-point occurrence (both had developed an ulcer) could not be determined, and the end point was defined as being the midpoint between their first and second assessment. For the purposes of this cost-effectiveness analysis, patients whose

Table 2. Pressure-Reducing Devices.

Type of Device	Frequency*	Cost/Unit (\$)
Mattresses (used by 184 patients)		
Egg crate foam overlays	137	7.83
6" all-in-one foam	31	39.00
Soft cell	12	216.00
Water mattress	5	39.00
Stryker	1	130.00
Sheepskin	1	7.50
Chair cushions (used by 259 patients)		
Sheepskin	8	7.50
Foam	212	15.00
Stryker pad	17	115.00
Jay cushion	36	363.00
Roho cushion	3	420.00
Site-specific devices		
Water pad	6	11.20
Foam boots	25	12.00
Foam elbow/heel protectors	17	6.25
Sheepskin	5	7.50

*Patients could have had more than one pressure-reducing device.

second assessment occurred after 12 weeks were defined as having reached an end point at 12 weeks (or 84 days) of observation, and their clinical outcomes were defined as their condition on day 84 of observation. It should be noted that no patient in the study developed pressure ulcers after day 84.

The cost of preventive measures for the Norton sample was assumed to be zero. For the Iowa sample, the cost of preventive interventions included the cost of nursing time for repositioning (turning) and the cost of pressure-reducing devices. Costs for nursing time to reposition patients were obtained from a workload measurement study (activity-based costing) that the facility had conducted previously to quantify the time required for a variety of nursing tasks. The average time to reposition a patient was 3.5 minutes. The nursing cost per minute was calculated using salary and benefits for a nursing assistant, the staff member who was usually responsible for repositioning patients. Salary and benefits for a nursing assistant at the Iowa facility were \$13.80 per hour or \$0.23 per minute. Patients who were being repositioned at the time of baseline assessment were assumed to continue being repositioned with the same fre-

quency interval throughout the study. The cost of repositioning was calculated as the cost of one repositioning multiplied by the number of repositionings performed on the patient during the study period.

The cost of pressure-reducing devices included the cost of mattresses, chair cushions, and miscellaneous site-specific devices (ie, foam heel and elbow protectors). Costs for the various types of devices used on patients were defined as the facility's purchase price (Table 2). The total cost of the equipment used by each patient was attributed entirely to that patient because pressure-reducing devices are typically used by a single patient in this facility. If patients had an item of durable medical equipment at baseline, the total cost of that device was included in the cost of prevention. Total aggregated cost for preventive interventions for the Iowa facility were calculated by summing the total cost for turning and for pressure-reducing devices for each patient for the total number of days of participation in the study.

The cost of treatment for an ulcer was estimated from a previous study performed on the cost of treatment at this Iowa facility.³ Included in computing costs were nursing time and supplies used to treat the ulcers, diagnostic tests, and antibiotics used to treat complications. The reported average cost per day for treating pressure ulcers, including cost of complications that were treated in the long-term care facility, was used to generate an estimate of expected cost. This expected cost of treatment was applied to ulcers that developed in both samples. The cost to treat an ulcer was assumed to be the mean cost for treating an ulcer of a particular stage. Pressure ulcers in the Norton sample were reported to be superficial or deep. The superficial ulcers were assumed to cost the average per day of treating stage 2 ulcers (\$3.65), and the deep ulcers were assumed to cost the average per day of treating stage 3 ulcers (\$4.46) and stage 4 ulcers (\$6.03) weighted in proportion to their occurrence. The total cost of treatment was calculated for each ulcer by multiplying the average cost per day based on stage times the number of days to end point. For the patients in both samples who were not previously receiving preventive interventions, the cost of a 6-inch foam mattress and a wheelchair cushion were added to treatment costs, as these would typically be included in management of an ulcer.

The total cost of treatment for each patient who developed an ulcer was added to the total cost of prevention for each patient to obtain a total cost for managing a pressure ulcer.

The length of time to pressure ulcer development between the two samples was compared using survival analysis techniques. Survival time was defined as the time to ulcer development. Survival analysis between the two samples was performed using a life-table analysis with the interval for the life table defined as 14 days. Cost-effectiveness was calculated by a two-step process. First, the mean cost of prevention and treatment of patients in the Iowa sample was subtracted from that of the Norton sample. This difference in mean cost was then divided by the mean difference in disease-free days between the two samples. This cost-effectiveness calculation produced a mean cost for each day of ulcer-free life gained as a result of the preventive program. Both the survival and the cost-effectiveness analyses were repeated for each subgroup of patients within a Norton risk category.

Results

The Norton sample of 250 patients averaged 79.9 years of age, and slightly fewer than one half were male. The Iowa sample of 420 patients averaged 77.4 ± 8.4 years of age. Twenty percent of the Iowa sample were 85 years of age or older compared with 23 percent older than 85 years in the Norton sample. The Iowa sample was 80 percent male, reflective of the predominately veteran population of the facility from which the sample was drawn. The primary medical condition for patients in each sample is presented in Table 3. The distribution of risk level according to the Norton score for the

Table 3. Comparison of Primary Medical Conditions for Patients in the Norton (No-Prevention) and Iowa (Aggressive-Prevention) Groups.

Disease Category	Norton Sample (n = 2500) No. (%)	Iowa Sample (n = 420) No. (%)
Cerebrovascular	65 (26)	72 (17)
Parkinsonism and other neurologic (paraplegia)	19 (8)	108 (26)*
Heart disease	39 (16)	69 (16)
Respiratory†	47 (19)	26 (6)
Gastrointestinal†	12 (5)	6 (1)
Malignancy	16 (6)	4 (1)
Skeletal‡	32 (13)	23 (5)
Miscellaneous§	20 (8)	112 (27)

*Includes dementia.

†Excludes cancer.

‡Includes arthritis, osteoporosis, deformities from old fractures.

§Includes peripheral vascular disease, diabetes, hypertension, phlebitis.

two samples is shown in Table 4. There was a trend toward a greater proportion of patients in the Iowa sample being in the high-risk group (Norton score ≤ 14); however, the difference did not reach statistical significance ($\chi^2 = 3.14$, $df = 1$, $P = 0.08$).

The patients in the Norton sample achieved the following end points: 59 developed ulcers, 33 died ulcer-free, and 153 were discharged ulcer-free, and 5 were still hospitalized and ulcer-free at study conclusion. In the Iowa sample 8 developed ulcers, 15 died ulcer-free, and 397 were still institutionalized and ulcer-free at the study conclusion. The mean number of days to end point for the Norton sample was 21.0 ± 17.4 days and for the Iowa sample was 78.5 ± 11.0 days. Of the 59 patients in the Norton sample who developed ul-

Table 4. Characteristics of the Norton and Iowa Samples.

Characteristics	Norton Score Category				Total
	< 12	12-14	15-17	18-20	
Iowa sample (n = 420)					
Number of patients	110	79	112	119	420
Ulcer-free days (mean No.)	75.4 ± 16.2	78.5 ± 11.0	79.9 ± 7.0	79.9 ± 7.5	78.5 ± 11.0
Mean cost (\$)	595 ± 401	329 ± 431	91 ± 211	11 ± 35	245 ± 379
Norton sample (n = 250)					
Number of patients	42	533	92	63	250
Ulcer-free days (mean No.)	13.5 ± 14.7	22.0 ± 18.0	24.2 ± 17.0	20.3 ± 16.6	21.0 ± 17.4
Mean cost (\$)	350 ± 384	236 ± 357	137 ± 275	29 ± 133	167 ± 307
Cost per ulcer-free day (\$)	3.97	1.62	-0.83	-0.31	1.36

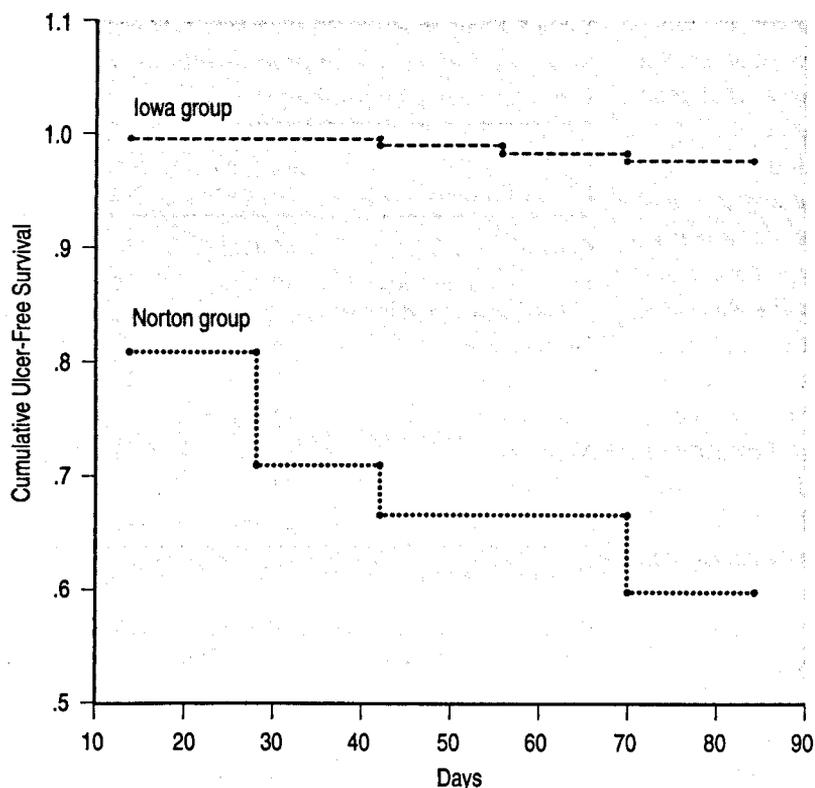


Figure 1. Survival analysis (using life tables) of days to ulcer development for Norton (no-prevention) versus Iowa (aggressive-prevention) groups. (Wilcoxon = 104.7, $df = 1$, $P < 0.0001$.)

cers, 18 developed deep ulcers, and 41 developed superficial ulcers. In the Iowa sample 2 developed deep ulcers, and 6 developed superficial ulcers.

The survival analysis comparing days to ulcer development for the Norton versus the Iowa samples is presented in Figure 1. The Norton sample had a significantly shorter time to ulcer development than did the Iowa sample (Wilcoxon statistic = 104.1, $df = 1$, $P < 0.0001$). This finding of significantly reduced time to ulcer development in the Norton sample compared with the Iowa sample persisted for all subgroups of Norton risk: for patients with a Norton score less than 12, Wilcoxon = 56.3, $df = 1$, $P < 0.0001$; for patients with a Norton score of 12 to 14, Wilcoxon = 24.2, $df = 1$, $P < 0.0001$; for patients with a Norton score of 15 to 17, Wilcoxon = 27.8, $df = 1$, $P < 0.0001$; and for patients with a Norton score of 18 to 20, Wilcoxon = 6.8, $df = 1$, $P = 0.01$.

Mean costs (total cost) for prevention were \$0.00 per patient (\$0.00 total) for the Norton sample and \$235±372 (\$98,786 total) for the Iowa sample. Individual components of the prevention cost were pressure-reducing devices and turning.

In the Iowa sample, a total of 300 patients had 516 pressure-reducing devices, which accounted for \$26,324 (26.6 percent) of the prevention cost. The frequency of utilization of the various devices is described in Table 2. Turning was used as a preventive measure on 107 patients in the Iowa sample, which totaled \$72,462 (73.4 percent of prevention costs). Expected costs for treatment of pressure ulcers were based on treatment costs from Frantz et al¹⁰ and were calculated to be \$743 for patients who developed deep ulcers (stage 3 and 4) and \$459 for patients who developed superficial ulcers (stage 2). Based on this expected cost of treatment, the mean cost for prevention and treatment was \$167 ± \$307 for patients in the Norton sample and \$245 ± \$379 for patients in the Iowa sample. Thus, the mean increase in costs with the use of

preventive measures was \$78.

The mean numbers of disease-free days were 21.0 ± 17.4 for patients in the Norton sample and 78.5 ± 11.0 for patients in the Iowa sample. Therefore, the mean increase in ulcer-free days with the use of preventive measures was 57.5. The cost per day of ulcer-free life gained for the entire sample was \$1.36. The mean cost and mean number of disease-free days for risk subgroups of the Norton and Iowa samples are described in Table 4. When calculated for each risk subgroup, the cost per day of ulcer-free life gained increased as risk level escalated. The cost per day of ulcer-free life gained according to risk subgroup is reported in Table 4.

Discussion

The findings of the study suggest that interventions to prevent pressure ulcers are effective and relatively inexpensive. The outcome measure of days of ulcer-free life was significantly greater for patients in the Iowa sample, and this clinical outcome was achieved for \$1.36 per day of ulcer-free life gained. Clearly the preventive strategy is cost-

effective as well as effective in preventing pressure ulcers.

As a consequence of the individualized approach to implementing prevention, institutional expenditures were low. Usually with prevention, all at-risk patients receive the same preventive intervention. Under this traditional prevention scenario, cost effectiveness improves as risk increases. In this long-term care facility the nurses individualized the interventions using more costly preventive interventions for the higher risk patients and less costly interventions for the lower risk patients. Using this progressively more aggressive approach to prevention, the total costs became more expensive as the patient risk for developing ulcers increased. The higher cost of \$3.97 per day of ulcer-free life gained for patients in the very high risk group was partly offset, however, by a savings of \$0.31 per day of ulcer-free life gained for patients in the very low risk group. As a consequence, the overall strategy was quite cost-effective at only \$1.36 per day of ulcer-free life gained. This daily cost can represent a considerable portion of the daily profit in the long-term care setting. As a consequence, stratification of patients and targeted applications of preventive measures would be important.

There were several limitations to this study. First, patients from a geriatric hospital in London in 1960 were compared with patients in a veteran's nursing home in Iowa in 1991. It appears that the patients in the Norton sample had more acute disease and the Iowa sample had more chronic disease. Nevertheless, the patients in the Norton and Iowa samples were comparable on proportions of patients at-risk for pressure ulcers. A second limitation arose from the need to estimate the time to the late end points in the Norton sample. Because it is now ethically impossible to do a trial with a nonintervention arm, some form of estimation is necessary to determine the days of ulcer-free survival associated with no preventive measures. An additional limitation of the study was the assumption that preventive measures were used throughout the study, and that the risk level of patients did not change during the course of the study. Given the predominance of stable, chronic disease in the Iowa sample,

it is unlikely that dramatic shifts occurred in patient risk level or use of preventive measures.

The use of prevention in the long-term care setting is clearly effective in reducing pressure ulcer occurrence. It is also relatively inexpensive, costing only \$1.36 per day of ulcer-free life gained. Effective intervention for pressure ulcer prevention need not be expensive. By matching the intensity of preventive interventions with the level of patient risk, the cost incurred for preventing pressure ulcers can be minimized.

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