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ORIGINAL ARTICLE

The cost-benefit of using soft silicone multilayered foam dressings to prevent sacral and heel pressure ulcers in trauma and critically ill patients: a within-trial analysis of the Border Trial

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Abstract

Little is known about the cost-benefit of soft silicone foam dressings in pressure ulcer (PU) prevention among critically ill patients in the emergency department (ED) and intensive care unit (ICU). A randomised controlled trial to assess the efficacy of soft silicone foam dressings in preventing sacral and heel PUs was undertaken among 440 critically ill patients in an acute care hospital. Participants were randomly allocated either to an intervention group with prophylactic dressings applied to the sacrum and heels in the ED and changed every 3 days in the ICU or to a control group with standard PU prevention care provided during their ED and ICU stay. The results showed a significant reduction of PU incidence rates in the intervention group ($P = 0{\cdot}001$). The intervention cost was estimated to be AU$36·61 per person based on an intention-to-treat analysis, but this was offset by lower downstream costs associated with PU treatment (AU$1103·52). Therefore, the average net cost of the intervention was lower than that of the control (AU$70·82 versus AU$144·56). We conclude that the use of soft silicone multilayered foam dressings to prevent sacral and heel PUs among critically ill patients results in cost savings in the acute care hospital.

Introduction

Pressure ulcers (PUs) are areas of localised damage to the skin and underlying tissue due to the combined mechanisms of pressure, shear and friction (1). Despite good clinical practice such as using support mattresses, regular repositioning, appropriate patient nutrition and incontinence management being implemented in hospitals, PUs remain common, especially among patients with neurological impairment and restricted mobility (2,3). Patients in the intensive care unit (ICU) are

Key Messages

- patients in the ICU and ED are known to be at high risk of PUs; studies show that using soft silicone multilayered foam dressings reduces the incidence of PUs among high-risk patients
- little is known about the cost-benefit of prophylactic dressings in PU prevention among critically ill patients

- 440 patients were recruited into a randomised controlled trial to assess the efficacy of soft silicone multilayered foam dressings in the prevention of sacral and heel PUs among critically ill ED and ICU patients
- the application of soft silicone foam dressings on the sacrum and heels of critically ill patients in the ED was highly efficacious and resulted in cost savings in the acute care hospital setting
- hospital policymakers should consider the use of soft silicone multilayered foam dressings among high-risk ED and ICU patients when developing new clinical protocols and initiatives for PU prevention

at high risk of developing PUs owing to the severity of their illness and pre-existing comorbidities (4). The risk of PUs in the ICU is even higher when the patients are transferred from the emergency department (ED), where they can lie on trolleys and standard hospital mattresses for considerable amount of time prior to their ICU transfer (5,6). For major trauma patients, prolonged surgical procedures in the operating theatre may also significantly increase the risk of PU development in ICU (7). Therefore, early detection and strategic management of patients who are at high risk of PUs in the ED is pivotal to reduce PU incidence in the ICU.

The financial burden of PUs to the health care system has been well described. The influential publication of Bennett *et al.* (8) in the UK raised worldwide awareness of the true costs associated with PUs. Using year 2000 UK prices, it was estimated that the cost of healing a stage I ulcer was £1064, whereas the cost increased to £10 551 for a stage IV ulcer. More recently, the same group of researchers (9) updated their earlier estimation of PU costs using UK prices in mid-2011. The updated report showed an increase of PU costs to healing, ranging from £1214 for a stage I ulcer to £14 108 for a stage IV ulcer. In Australia, PUs incur a median of 398 432 bed days lost, on average of AU$285 million per year (10). The cost estimates outlined in the literature support the investment in PU prevention. In Canada, Orsted (11) adapted the UK (8) cost model and showed potential annual savings from Can$240 000 to Can$1·2 million to a 100-bed health care facility when implementing a prevention programme to reduce the incidence of PUs by 35%. However, any cost-saving initiatives should be compared to the additional investments that are required in order to implement the prevention programme to reduce the PU incidence (10).

The sacrum and heel are the two most common locations for iatrogenic PUs, representing the greatest clinical challenge in prevention of PUs (12). To prevent the development of PUs on sacrum and heels, effective alleviation of pressure at these sites and daily inspection of the skin for early lesions are essential (2). The use of prophylactic dressings over bony prominences reduces pressure and friction and absorbs moisture from intact skin (4). In the USA, Brindle (4) used a soft silicone multilayered foam dressing to protect the sacrum from PUs in 41 ICU patients. In the 3-month study period, none of the patients developed ulcers while the sacral dressing was in use. In an Australian ED setting, the effectiveness of a soft silicone multilayered foam dressing in reducing the incidence of sacral PUs was tested by Cubit *et al.* (5), who noted a 8·4% difference in incidence of ulcers between the dressing group and the non-dressing group (1·9% versus 10·3%) over a 61-day period.

Although PU reduction can potentially lead to a huge cost saving to the health care system, there is a dearth of research explicitly evaluating the cost-benefit of prophylactic dressings that reduce the incidence of PUs. The only cost study on PU prevention with the application of dressing materials was conducted by Bou *et al.* (13) who compared the cost of a hydrocellular dressing versus a protective bandage in heel ulcer prevention among 130 patients from nursing homes and primary health care centres over an 8-week period. The results were in favour of the hydrocellular dressing versus the protective bandage in preventing heel ulcer development (3·3% versus 44%) and in saving nursing time for dressing changes (Can$12·24 versus Can$86·77). While the findings of Bou *et al.* (13) may be encouraging they cannot be applied to acute care settings. Compared with patients in nursing homes and primary care settings, prevention of PUs among inpatients can be complicated by physiological characteristics of the patients and environmental factors in the hospital (4).

This article aims to evaluate the cost-benefit of using soft silicone multilayered foam dressings in PU prevention. This was a substudy of a prospective randomised controlled trial (RCT) of the efficacy of soft silicone multilayered foam dressings in the prevention of sacral and heel PUs among critically ill ED and ICU patients (14).

Methods

Design

This cost-benefit analysis was based on a RCT that was undertaken in the ED and ICU of a large teaching hospital in Melbourne, Australia, from April 2011 to December 2012 (14). In order to be eligible for participation, participants had to be older than 18 years, and had to be admitted to the ED and subsequently transferred to the ICU for critical illness and/or major trauma. Patients with pre-existing sacral or heel PUs and trauma to sacral or heel areas were excluded.

Eligible ED patients were randomised either to a control group within which the standard PU prevention care (PU risk assessment, regular repositioning, nutritional support and incontinence management) was provided or to an intervention group within which a soft silicone multilayered foam dressing, a Mepilex® Border Sacrum (Mölnlycke Healthcare AB, Göteborg, Sweden), was applied to the patients' sacrum and a Mepilex Heel (Mölnlycke Healthcare AB) was applied to the patients' heels and retained with Tubifast® tubular bandage (Mölnlycke Healthcare AB). Patients in the intervention group also received the standard PU prevention care. Patients in both groups were assessed daily in the ICU by members of the research team to determine if any hospital-acquired PUs had developed. Patients in the intervention group were assessed by partially peeling off the dressings to visualise the skin for pressure-related injuries and then reapplying the dressings. Any PU that had developed in the ICU was staged

according to the 4-point staging system defined by the Australian Wound Management Association (15). The dressing in the intervention group was changed every 3 days or if soiled or dislodged. Dates of dressing changes were recorded in a standardised data sheet. This study was approved by the Human Research Ethics Committees at the participating hospital.

Outcome measures

The primary outcome measured in the RCT was the incidence rates of PUs in the ICU developed in both groups. The secondary outcomes included the marginal cost associated with the application of prophylactic dressings in the intervention group, the treatment costs of PUs in both groups and the average costs per person in both groups.

Cost-benefit analysis

The cost-benefit analysis was conducted from a health care sector's perspective (16). Only the within-trial cost including the hospital resources and time used to provide PU care by hospital health professionals was considered. Treatment costs associated with PUs following the patients transfer to rehabilitation services or discharge to the community were not included in the analysis. Only the marginal cost associated with the use of prophylactic dressings in the intervention group was calculated. The calculation of marginal cost was based on an intention-to-treat analysis (17) where all patients randomised to the intervention group were analysed regardless of death in the ED or transfer to another ward from the ED. The fixed cost of providing standard PU prevention care was not explicitly considered given that it was equal between the two groups. A bottom-up approach was used to calculate PU prevention and treatment costs by directly tracing actual use of personnel and resources (16). All costs were expressed in 2013 Australian dollars.

The marginal cost of PU prevention in the study was the sum of the dressing material cost and the labour cost for dressing application and changes in the intervention group. To calculate the material cost, we manually counted the frequencies of dressing application and changes in the intervention group. We then multiplied the frequencies by the unit prices of dressing materials. The labour cost was calculated by multiplying the time required for dressing application and changes by the average hourly wage cost of nurses. In Australia, the hourly pay rate for registered nurses (RNs) varies according to their years of experience, ranging from 1 to 10 years. For our analysis, we used the hourly rate of a RN with 5 years of experience as the basis for the labour cost.

To calculate the cost associated with PU treatment, we multiplied the incidence of PUs at each stage by the treatment cost specific to the ulcer stage. The total cost of treatment was calculated by adding the costs of treating PUs at all stages. The costs of ulcers at each stage were derived from a retrospective review of clinical notes of the patients who had developed PUs in the ICU. We first calculated the treatment cost per day and then multiplied the patients' average length of stay in the hospital since the development of PUs. Treatment costs were recorded for each patient covering the material cost (pressure alleviation devices, dressing materials and nutritional supplements for wound healing) and the labour cost (time spent on wound care by nurses, podiatrists, wound nurse consultants, dietitians and orthotists).

The average cost in the intervention group included the weighted average treatment cost of PUs and the average marginal cost of intervention. The average cost in the control group included only the weighted average treatment cost of PUs. For establishing the weighted average treatment cost of PUs, we initially calculated the average treatment cost per ulcer by adding the treatment costs of particular stage ulcer and then dividing by the number of ulcer stages observed in the study. The weighted average treatment cost of PUs in each group was the multiplication of the average treatment cost per ulcer by the incidence rate of PUs in the group.

Sensitivity and threshold analyses

To explore the uncertainty of our cost estimates for PU prevention, univariate sensitivity analyses were conducted by varying the key variables (frequencies of sacral and heel dressing changes in the intervention group, the time required for dressing changes in the intervention group and the marginal intervention cost). We used threshold analyses to determine at what point costs would no longer favour intervention over standard care.

Results

Initially, 440 patients (control, $n = 221$; intervention, $n = 219$) were recruited into the study. In the control group, 1 patient died in the ED prior to ICU admission, 29 patients were transferred to another ward or hospital from the ED and 39 patients were discharged from the ICU prior to the first PU assessment by the research team, leaving 152 patients in the final analysis. In the intervention group, 3 patients died in the ED prior to ICU admission, 17 patients were transferred to another ward or hospital from the ED and 38 patients were discharged from the ICU prior to the first PU assessment by the research team, leaving 161 patients in the final analysis. Our primary outcome analysis showed that 13·1% of patients ($n = 20$) in the control group developed a PU on the sacrum or heel compared with 3·1% of patients ($n = 5$) in the intervention group ($P = 0{\cdot}001$). The 'flow' of patients in the study was displayed in Figure 1 in the major report of the RCT (14).

Marginal cost of PU prevention

The marginal cost associated with intervention for PU prevention was \$8017·2, with an average cost of \$36·61 per person (Table 1). Most of the costs were attributable to the Mepilex Border and Tubifast bandage dressings. Our estimated time per dressing application or change was 2 minutes when the patient was turned over and kept ready by clinical staff for spinal examinations in the ED or skin inspections in the ICU. This estimation was based on the experiential knowledge of

Table 1 The marginal cost associated with the intervention group

	Intervention group ($n = 219$)
Frequencies of sacral dressing application/change	274
Unit price of Mepilex® Border Sacrum dressing	$11*
Frequencies of heel dressing application/change	465
Unit price of Mepilex Heel dressing	$9*
Tubifast tubular bandage (rolls)	10
Unit price of Tubifast tubular bandage	$9·9†
Material cost	$7298
Nursing time per dressing application/change	2 minutes
Nursing time for dressing application/change	24·63 hours‡
Labour cost	$719·2§
Total marginal cost	$8017·2
Average marginal cost	$36·61

*Unit price obtained from Mölnlycke Healthcare Pty Ltd.
†Unit price obtained from the hospital Supply and Logistic Department.
‡Multiplication of nursing time per dressing change by the total frequencies of sacral and heel dressing changes.
§Unit price obtained from the hospital Human Resources Department for Aus$29·2 per hour for a registered nurse with 5 years of experience.

members of the research team who performed dressing application and changes in the ED or ICU. The labour cost of clinical staff for turning over the patients was not considered because it was not an additional cost to our intervention. All patients in the study received regular repositioning as part of the standard care delivered in the hospital.

Cost of PU treatment within the trial

The within-trial PU treatment cost was categorised into two major aspects: the material cost and the labour cost. Table 2 provides an overview of the unit prices used for the calculation of direct daily costs of PU treatment.

We identified 34 PUs in the ICU at different anatomical sites. PUs detected in the study comprised stage I, II and IV ulcers (Table 3). This study was conducted among a group of major trauma and critically ill patients. Some of our participants died soon after the development of PUs in the ICU owing to their underlying illness. Our retrospective review of clinical records also identified some patients being transferred to rehabilitation services or referred to the Royal District Nursing Service with ongoing wound management due to continuous progression of PUs. Therefore, it was difficult to calculate the exact ulcer healing time in the study population. We therefore undertook a conservative approach for this cost analysis by focussing only on the treatment cost incurred during the patients' hospital stay. On the basis of the retrospective review of clinical notes, we calculated an average length of stay of 20 days in the hospital since the patients' development of PUs.

Table 4 shows the estimated treatment cost for each PU stage at different anatomical sites. The daily treatment costs of stage II ulcers varied slightly between the sacrum ($57·14) and heel ($58·85), which was attributable to the labour cost associated with ulcer management at different sites. In the study, most of the heel ulcers were reviewed by a podiatrist for ongoing foot care and by an orthotist for fitting a pressure-alleviation boot, whereas only one sacral ulcer was reviewed by a wound nurse consultant. The time spent on PU management by nurses and other health professionals was a major driver of the treatment costs. The daily treatment costs also increased with ulcer severity, owing to the need for more frequent dressing changes, expensive air mattresses and nutritional supplements. Daily costs ranged from $43·22 for stage I sacral ulcers to $73·45 for stage IV heel ulcers. The cost per episode of acute care was $864·4 for a stage I sacral ulcer, whereas the cost per episode of acute care increased to $1469 for a stage IV heel ulcer.

Table 5 shows the estimated total treatment costs in the intervention and control groups. The total treatment cost in the control group ($25173·2) was 3·6 times higher than that in the intervention group ($6920·2), because of the high incidence of PUs in the control group.

Table 2 Information collected for the calculation of direct treatment costs of pressure ulcers

Items	Description	Unit price
Material cost*	Air mattress (BI-WAVE/TRINOVA/CAIRWAVE)	$11·88–$18·75 (min–max)†
	Air chair (ROHO)	$2·14†
	Orthotics boots	$32
	Silicone dressing (Mepilex Border)	$8·4
	Hydrocolloid dressing (Comfeel plus)	$5·07
	Transparent dressing (Tegaderm)	$2·62
	Fixation dressing (Bandage, Mefix, Tubifast)	$0·53–10·9 (min–max)
	Dressing pack	$0·43
	Sodium chloride irrigation	$0·2
	Gloves	$0·47
	Gauze	$0·27
	Nutritional supplements (Resource, Arginaid)	$1·8–$3·7 (min–max)
Labour cost‡	Registered nurse (RN)	$29·2§
	Wound nurse consultant	$39·8¶
	Podiatrist	$34·5¶
	Dietitian	$34·5¶
	Orthotist	$34·5¶

*All material cost information except for the air mattress/chair obtained from the hospital Supply and Logistic Department.
†Information about daily rental cost for the air mattress/chair obtained from the mattress company that provided rental service to the hospital.
‡Labour cost information obtained from the hospital Human Resources Department.
§The hourly rate of a RN with 5 years of experience.
¶The mean hourly rate of health professionals with different classifications.

Table 3 The number of pressure ulcers (PUs) in the intervention and control groups, by stage of ulcer and by anatomical site of ulcer

	Intervention ($n = 161$)		Control ($n = 152$)	
	Sacral PU	Heel PU	Sacral PU	Heel PU
Stage I	–	4	8	15
Stage II	2	1	–	2
Stage IV	–	–	–	2

Table 4 Estimated treatment cost per day and per episode of acute care, by stage of ulcer and by anatomical site of ulcer

	Sacrum	Heel
Stage I		
Cost per day	$43·22	$43·22
Cost per episode of acute care*	$864·4	$864·4
Stage II		
Cost per day	$57·14	$58·85
Cost per episode of acute care*	$1142·8	$1177
Stage IV		
Cost per day	–	$73·45
Cost per episode of acute care*	–	$1469

*An episode of acute care was the patients' average length of stay in the hospital since the development of pressure ulcers in the intensive care unit (20 days).

Table 5 Estimated cost of treating pressure ulcers in the intervention and control groups

	Intervention ($n=161$)		Control ($n=152$)	
	Sacral ulcers ($n=2$ stage II)	Heel ulcers ($n=4$ stage I and 1 stage II)	Sacral ulcers ($n=8$ stage I)	Heel ulcers ($n=15$ stage I, 2 stage II and 2 stage IV)
Stage I	$3457·6		$19881·2	
Stage II	$3462·6		$2354	
Stage IV	–		$2938	
Total	$6920·2		$25173·2	

Average cost in each group

Table 6 shows that even after including the marginal cost associated with dressing application, the average cost per person in the intervention group remained lower than that in the control group ($70·82 versus $144·56).

Sensitivity and threshold analyses

We performed a univariate sensitivity analysis using the least-favourable estimates of key variables. The results showed that the standard care would be less expensive, if: (i) the sacral dressing had to be changed 1204 times (compared with 274 times in the study); (ii) the heel dressing had to be changed 1605 times (compared with 465 times in the study); (iii) nurses had to spend 376·63 hours (compared with 24·63 hours in the study) for dressing application and change; (iv) intervention costs were increased by more than twofold ($18267·2 versus $8017·2); and (v) treatment costs associated with PUs were decreased more than two-thirds ($366·1 versus 1103·52).

Discussion

Based on an intention-to-treat analysis, the results of this study show that the application of prophylactic Mepilex Border Sacrum and Mepilex Heel dressings to the sacrum and heels of critically ill patients at the point of their ED admission leads to cost savings in the hospital. The results are robust to examinations of uncertainty surrounding key variables.

Table 6 Average cost in the intervention and control groups

	Intervention ($n=161$)	Control ($n=152$)
Average treatment cost per ulcer*	$1103·52	$1103·52
Weighted average treatment cost	$34·21†	$144·56‡
Average marginal cost	$36·61	–
Total average cost	$70·82§	$144·56

*The average cost of treating stage I, II and IV sacral and heel ulcers per episode of acute care.
†Multiplication of the average treatment cost per ulcer by the incidence rate of PUs in the intervention group (3·1%).
‡Multiplication of the average treatment cost per ulcer by the incidence rate of PUs in the intervention group (13·1%).
§The sum of the weighted average treatment cost and the average marginal cost.

Our results are supportive of the cost analysis by Bou *et al.* (13) which studied using hydrocellular dressings versus protective bandage in reducing heel ulcer incidences in nursing homes and primary care settings. In the study by Bou *et al.*, despite the nursing cost of dressing changes being lower in the dressing group when compared with the bandage group (Can$12·24 versus Can$86·77), the overall nursing cost was slightly higher in the dressing group (Can$183·84 versus Can$172·17), because of the high number of skin inspections performed in this group. Therefore, there was a slight incremental cost of Can$28·68 associated with every ulcer avoided in the dressing group, whereas in our study, there was little difference with respect to the cost of nursing time required for skin inspections between the two groups. Regular skin inspections as a standard PU care strategy were performed among all high-risk patients during their hospital stay.

In our analysis, the daily treatment cost ranged from $43 to $59 for a stage I sacral PU to a stage II heel PU, and $73 for a stage IV heel PU. Our treatment costs are lower than the latest UK estimates of the costs of treating a stage I/II ulcer at £43–47 per day, and a stage III/IV ulcer at £57 per day (9). The differences may be attributable to our approach of calculating costs using retrospective clinical data, whereas the UK estimates are based on daily resources required to deliver best clinical practice. In addition, we did not include inpatient bed-day costs as a resource for our study population as was done in the UK study. Based on the retrospective review of clinical notes, the development of PUs did not appear to change the length of stay in the hospital for critically ill patients.

Despite the implementation of standard PU prevention strategies in the study, the incidence rate of hospital-acquired PUs among control patients remains striking (13·1%). This finding suggests a huge potential for improvement in the prevention of PUs among critically ill ED and ICU patients. The application of prophylactic dressings results in a 10% reduction in the incidence rate of sacral and heel PUs in the intervention group (3·1%). The hospital where the study was undertaken has 24 ICU beds with 2000 new admissions annually, which suggests that an estimate of 260 patients (with the current incidence rate of 13·1%) may develop a PU during

their stay in the ICU. A 10% PU reduction with the use of prophylactic dressings in the ICU could render an annual cost saving anywhere from $172 880 to $293 800 for the hospital, depending on the stage and the location of PUs.

Our estimates of treatment costs are built upon the stage and the location of PUs. We are not aware of any other cost studies that differentiate treatment costs between sacral and heel PUs, although most of previous studies analysed treatment costs by ulcer stages (3,18,19). We believe that, similar to the stage of PUs, PU locations should also be considered to provide an accurate reflection of treatment costs. This is because ulcers at different locations involve different labour and material costs. Our initial assumption was that the treatment cost of sacral PUs should be higher than that of heel PUs because more nurses were required to reposition the patients during sacral dressing changes versus heel dressing changes, whereas the additional costs of podiatrists and pressure-relieving boots in heel ulcer management offset the increased cost for repositioning in sacral ulcer management.

Our study has some limitations. First, we did not follow-up on the patients who had developed PUs in the ICU. The treatment cost information was collected retrospectively from the patients' clinical notes. It is likely that the treatment costs of PUs are underestimated because of the incompleteness of documentation on PU management. Second, we did not specifically measure the healing time of sacral and heel PUs for our patients. It was not possible to calculate the expected time of healing PUs in our study population. We calculated the treatment costs per episode of acute care based on the patients' average length of stay in the hospital. It is very likely that the costs of PU treatment are significantly underestimated in this analysis. Severe PUs rarely heal completely in acute care settings (3). The costs in rehabilitation services and the community following the patient hospital discharge would substantially increase the overall cost of PU treatment. Third, we calculated only the within-trial cost, and our cost analysis is confined to the health care sector's perspective. We did not consider the societal cost of PUs, such as the patients' production loss due to the morbidity resulting from PUs, and the impact on the patients' families. Therefore, our estimated treatment cost of PUs is very conservative. Fourth, the results of this cost-benefit analysis can only be interpreted in the context of critically ill patients in the ED and ICU environments. The results cannot be generalised to hospital inpatients.

Conclusion

This study provides evidence for the cost-benefit of applying Mepilex Border Sacrum and Mepilex Heel dressings on the sacrum and heels of critically ill patients when they arrive in the ED. The intervention costs of dressings and time necessary for dressing application can be easily offset by the huge treatment savings accruing through the reduction of PUs in the ICU. The implications for policy changes are evident. The hospital policymakers should consider the use of prophylactic dressings among high-risk ED or ICU patients when developing new clinical protocols and initiatives for PU prevention. Nevertheless, it will not be appropriate to advocate the replacement of bedside nursing care with prophylactic dressings. Instead, we encourage nurses to proactively engage in early identification and intervention of high-risk patients to prevent occurrence of pressure injuries. By doing so, nurses can be saved from labour-intensive PU treatment that involves dressing the wound and monitoring the wound progress. We believe that nursing time spent in PU treatment is an opportunity cost because a release of nursing time from wound management can potentially improve the overall quality of patient care. For the hospital, the initial marginal cost of prophylactic dressings to prevent PUs in critically ill patients could save more than a quarter of a million of dollars in treatment costs per year.

This study also highlights the implications for future research. It will be more accurate to calculate treatment costs by following up patients who undergo PU treatments. Future studies are required to determine the substantial treatment cost of PUs across all health care settings including acute care, rehabilitation and primary care. In addition to collecting data on costs and clinical outcomes, further work is required to evaluate the effectiveness of using prophylactic dressings in PU prevention to improve the patients' quality of life in the long term. Quantifying the quality of life makes it possible to measure all health effects and changes resulting from the intervention, not only those costs and effects limited to the health care sector.

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References

1. National Pressure Ulcer Advisory Panel and European Pressure Ulcer Advisory Panel. *Prevention and treatment of pressure ulcers: clinical practice guideline*. Washington, DC: National Pressure Ulcer Advisory Panel, 2009:21–50.
2. Legood R, McInnes E. Pressure ulcers: guideline development and economic modelling. *J Adv Nurs* 2005;**50**:307–14.
3. Brem H, Maggi J, Nierman D, Rolnitzky L, Bell D, Rennert R, Golinko M, Yan A, Lyder C, Vladeck B. High cost of stage IV pressure ulcers. *Am J Surg* 2010;**200**:473–7.
4. Brindle CT. Outliers to the Braden Scale: identifying high-risk ICU patients and the results of prophylactic dressing use. *WCET J* 2010;**30**:11–8.
5. Cubit KB, McNally B, Lopez V. Taking the pressure off in the Emergency Department: evaluation of the prophylactic application of a low shear, soft silicon sacral dressing on high risk medical patients. *Int Wound J* 2012; doi: 10.1111/j.1742-481X.2012.01025.x.
6. Pham B, Teague L, Mahoney J, Goodman L, Paulden M, Poss J, Li J, Ieraci L, Carcone S, Krahn M. Early prevention of pressure ulcers among elderly patients admitted through emergency departments: a cost-effectiveness analysis. *Ann Emerg Med* 2011;**58**:468–78.

7. Pham B, Teague L, Mahoney J, Goodman L, Paulden M. Support surfaces for intraoperative prevention of pressure ulcers in patients undergoing surgery: a cost-effectiveness analysis. *Surgery* 2011;**50**:122–32.
8. Bennett G, Dealey C, Posnett J. The cost of pressure ulcers in the UK. *Age Ageing* 2004;**33**:230–5.
9. Dealey C, Posnett J, Walker A. The cost of pressure ulcers in the United Kingdom. *J Wound Care* 2012;**21**:261–4.
10. Graves N, Birrell FA, Whitby M. Modeling the economic losses from pressure ulcers among hospitalized patients in Australia. *Wound Repair Regen* 2005;**13**:462–7.
11. Orsted H. Innovations in pressure ulcer prevention and management: targeted interventions that reduce prevalence. *Wounds Int* 2009;**1**:1–8 URL http://www.woundsinternational.com/pdf/content_227.pdf [accessed on 7 February 2013]
12. Santamaria N, Carville K, Prentice J. Woundswest: identifying the prevalence of wounds within western Australia's public health system. *Eur Wound Manage Assoc J* 2009;**9**:13–8.
13. Bou J-ETI, López JR, Camañes G, Narváez EH, Blanco JB, Torralba JB, Martinez-Esparza EH, García LSM, Soriano JV. Preventing pressure ulcers on the heel: a Canadian cost study. *Dermatol Nurs* 2009;**21**:268–72.
14. Santamaria N, Gerdtz M, Sage S, McCann J, Freeman A, Vassiliou T, De Vincentis S, Ng AW, Manias E, Liu W, Knott J. A randomised controlled trial of the effectiveness of soft silicone multi-layered foam dressings in the prevention of sacral and heel pressure ulcers in trauma and critically ill patients: the Border Trial. *Int Wound J* 2013; doi: 10.1111/iwj.12101.
15. Australian Wound Management Association. *Clinical practice guidelines for the prevention and management of pressure ulcers*. West Leederville: Cambridge Publishing, 2001.
16. Oostenbrink JB, Koopmanschap MA, Rutten FFH. Standardisation of costs: the Dutch manual for costing in economic evaluations. *Pharmacoeconomics* 2002;**20**:443–54.
17. Schulz KF, Altman DG, Moher D, for the CONSORT Group. CONSORT 2010 statement: updated guidelines for reporting parallel group randomised trials. *Ann Intern Med* 2010;**152**:726–32.
18. Padula WV, Mishra MK, Makic MB, Sullivan PW. Improving the quality of pressure ulcer care with prevention: a cost-effectiveness analysis. *Med Care* 2011;**49**:385–92.
19. Payne W, Posnett J, Alvarez O, Brown Etris M, Jameson G. A prospective, randomized clinical trial to assess the cost-effectiveness of a modern foam dressing versus a traditional saline gauze dressing in the treatment of stage ii pressure ulcers. *Ostomy Wound Manage* 2009;**55**:50–5.