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Economic Evaluations of Strategies to Prevent Hospital-Acquired Pressure Injuries



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GENERAL PURPOSE:

To provide information from a review of literature about economic evaluations of preventive strategies for pressure injuries (PIs).

TARGET AUDIENCE:

This continuing education activity is intended for physicians, physician assistants, nurse practitioners, and nurses with an interest in skin and wound care.

LEARNING OBJECTIVES/OUTCOMES:

After participating in this educational activity, the participant should be better able to:

1. Identify the purpose and methods used for this study.
2. Compare costs and effectiveness related to preventative strategies for PIs.

ABSTRACT

BACKGROUND: Pressure injuries (PIs) are a common and resource-intensive challenge for acute care hospitals worldwide. While a number of preventive strategies have the potential to reduce the cost of hospital-acquired PIs, it is unclear what approach is the most effective.

OBJECTIVE: The authors performed a narrative review of the literature on economic evaluations of preventive strategies to survey current findings and identify important factors in economic assessments.

DATA SOURCES: Ovid, MEDLINE, NHS Economic Evaluation Databases, and the Cochrane Database of Systematic Reviews

SELECTION CRITERIA: Potentially relevant original research articles and systematic reviews were considered.

DATA EXTRACTION: Selection criteria included articles that were written in English, provided data on cost or economic evaluations of preventive strategies of PIs in acute care, and published between January 2004 and September 2015. Data were abstracted from the articles using a standardized approach to evaluate how the items on the Consolidated Health Economic Evaluation Reporting Standards checklist were addressed.

DATA SYNTHESIS: The searches identified 192 references. Thirty-three original articles were chosen for full-text reviews. Nineteen of these articles provided clear descriptions of interventions, study methods, and outcomes considered.

CONCLUSIONS: Limitations in the available literature prevent firm conclusions from being reached about the relative economic merits of the various approaches to the prevention of PIs. The authors' review revealed a need for additional high-quality studies that adhere to commonly used standards of both currently utilized and emerging ways to prevent hospital-acquired PIs.

KEYWORDS: economic evaluation, hospital-acquired pressure injuries, prevention strategies, treatment costs

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INTRODUCTION

Hospital-acquired pressure injuries (HAPIs) are globally common, often preventable, costly, and associated with significant morbidity and mortality.¹ The point prevalence estimate for pressure injuries (PIs) in Canadian acute care facilities was 25.1% (95% confidence interval, 23.8%–26.3%) in a systematic review published in 2004.² The total net per-person adjusted cost of hospitalization for a HAPI was reported to be Can \$40,000 for a Stage II ulcer and Can \$90,000 for a Stage IV ulcer, based on data from the Ontario Case Costing Initiative database in 2013 using the European Pressure Ulcer Advisory Panel (EPUAP) staging system.³ The cost of dealing with PIs is increasing over time. For example, in the United Kingdom, the estimated annual total cost of managing PIs increased approximately 7-fold from 180 million to 321 million in 1993 to 1.4 billion to 2.1 billion in 2000.⁴ The financial burden of PIs on the United States healthcare system was estimated between \$6 and \$15 billion (USD) per year in 2012.⁵

There are many preventive strategies that have been implemented over the years for PIs. Frequent repositioning of patients and pressure redistribution surfaces (either alone or in combination) have attracted the most interest as preventive strategies.⁶ These approaches, though, appear to be only partially effective and can be costly to implement. It is unclear if any strategy offers financial advantages compared with others. The ability to gauge the likely benefits of the available preventive strategies and compare their cost-effectiveness is essential to making evidence-based decisions about the selection and implementation of preferred methods.⁴

The authors performed a narrative review of the literature published between 2004 and 2015 that reported on the costs of PIs and economic evaluations of prevention strategies in acute care. Their goals were to identify what prevention strategies had an economic evaluation, assess the relative strengths and weaknesses of the evaluations performed to date, and determine what future economic evaluations should incorporate.

METHODS

Search Strategy

In September 2015, the authors conducted searches on Ovid, MEDLINE, NHS Economic Evaluation Databases, and the Cochrane Database of Systematic Reviews to identify potentially relevant original research articles and systematic reviews on the topic. The search terms “pressure ulcer,” “pressure sore,” “bedsore,” “bed sore,” “decubitus ulcer,” and “decubitus sore” were combined with “cost-benefit analysis,” “cost-effective analysis,” “financial,” “dollar,” “expenditure,” “models,” “economic,” and “health care costs” to identify potentially relevant publications.

Selection Criteria

Two reviewers independently examined the titles and abstracts of identified articles to classify potentially eligible articles for inclusion in the review. These citations were selected for full-text reviews. Selection criteria included the following: written in English, provision of data on cost or economic evaluations of preventive strategies for PIs in acute care/primary healthcare centers, and publication between January 2004 and September 2015. Studies that provided both the original data and systematic reviews were considered.

A single individual performed the full-text reviews. Reviewed articles were selected for inclusion in the narrative review if they provided clear descriptions of interventions, methods used, and outcomes. Data were abstracted from the articles using a standardized approach to evaluate how the items on the CHEERS (Consolidated Health Economic Evaluation Reporting Standards) checklist were addressed.⁷ All prices were converted and adjusted to 2015 Canadian dollars.

RESULTS

The searches identified 192 citations. Review of titles and abstracts eliminated 149 of them. Thirty-three were chosen for full-text reviews. Nineteen of these articles provided original data with clear descriptions of interventions, study methods, and the economic outcomes considered and were included in the narrative review.^{3,4,8–24} They are summarized in Tables 1 and 2. Two systematic reviews were also identified.^{25,26} The remaining 12 articles were not retained because they did not provide either the original data/analyses or an explicit description of the methods used.

Nine studies reported on the cost of HAPIs.^{3,4,8–14} All of those studies originated from economically developed regions (Europe,^{4,8,11,12} North America,^{3,9,13} Australia^{10,14}), but heterogeneous approaches were taken to estimate and report costs. Notwithstanding these limitations, it was clear that the costs of

HAPIs reported were stage-dependent (ie, higher with increasing grade) and high in total.^{3,4} As indicated by Chan et al,³ the net cost of a Stage II HAPI was Can \$44,000 and Can \$90,000 for a Stage IV HAPI from 2002 to 2006.

Ten studies provided economic evaluations (5 cost-effectiveness, 3 cost-benefit, 2 both) of approaches to the prevention of PIs.^{15–24} Favorable outcomes from a bundle of PI prevention strategies were found in 2 studies that based cost estimates on statistical modeling using data from the literature.^{15,16} A combination of risk assessment, nutritional support, and repositioning resulted in an estimated net savings of Can \$55.12 per patient per day, a 9.3% decrease in PI incidence, and a 0.47% reduction in deaths in 2013.¹⁵ In the second study, pressure redistribution surfaces, nutritional support, repositioning, and moisture/incontinence control resulted in estimated net savings of Can \$3450.03 per hospitalization and a 1.90 increase in quality-adjusted life-years.¹⁶

Economic evaluations of single approaches also concluded that implementation of the intervention would result in cost savings. Pressure redistribution surfaces were the modality most commonly studied. These studies typically compared various types of pressure redistribution surfaces with an active control.^{17–20} In patients with spinal cord injuries requiring assistance with repositioning, a continuous computer-regulated mattress was found to be cost-effective if nurses were not able to frequently reposition patients.¹⁷

Mattress overlays were reported to be a cost-effective intervention compared with replacing mattresses,¹⁷ whereas another study indicated that alternating pressure mattresses offered an economic advantage compared with alternating pressure overlays.¹⁹ An inflated static overlay was found to be less costly and as effective as either a microfluid static overlay or a low-air-loss dynamic mattress with pulsation.¹⁹ Pressure redistribution surfaces may be less costly than frequent repositioning programs (Can \$23 vs \$42 mean cost of prevention per day per patient, respectively).²¹ Other single approaches to prevent PIs (ie, dressings and nutritional support) also showed apparent financial benefits.^{22–24} Some of these studies used statistical modeling for their economic evaluations,^{18,19} whereas others were at least partially based on collected data.^{17,20,21} The different methods used and the lack of a standard comparator made it impossible to compare across studies.

One of the identified systematic reviews examined the cost of preventing and treating PIs,²⁵ whereas the other assessed economic evaluations embedded in randomized controlled trials (RCTs) of interventions to prevent or treat PIs.²⁶ Both concluded that the cost of treating PIs was substantially higher than preventing them, but noted marked heterogeneity in the methods used in the published studies. For example, Demarre

Table 1.
STUDIES ON COST OF HOSPITAL-ACQUIRED PRESSURE INJURIES

Reference	Settings, Location, and Population	Study Perspective and Time Horizon	Estimating Resources and Costs	Analytical Methods	Main Findings (Outcomes and Costs Converted to Can \$ in 2014)
Assadian et al ⁸	<ul style="list-style-type: none"> • 3 community hospitals (primary, secondary, and tertiary) • Germany • Inpatients and outpatients observed 	<ul style="list-style-type: none"> • Documented items and resources used, surgical procedures performed and personnel • December 1, 1999 to January 31, 2001, for all stages of pressure injuries (PIs) 	<ul style="list-style-type: none"> • Did not calculate facility maintenance and emergency provision costs • Costs based on hospital costs and health care workers incomes 	<ul style="list-style-type: none"> • Means compared using Wilcoxon rank sum test • Variables compared using a 2-sided chi-square test or Fisher exact test 	<ul style="list-style-type: none"> • 35 PIs included in analysis • Mean hospitalization duration was 18 ± 9 d (1–62 d) • Can \$2800 per patient (\$1147/d) spent on average (31% on staff, 63% on consumables, 6% on surgical procedures) • Mean cost (Can \$) per patient and annual incidence in UK by grade distribution and number of affected people. Stage 1: \$3,105 (\$2154–\$2631), 34.9%, 140K Stage 2: \$12,850 (\$11,566–\$14,135), 41.2%, 170K Stage 3: \$21,349 (\$19,211–\$23,482), 12.9%, 50K Stage 4: \$30,801 (\$27,722–\$33,881), 11.0%, 50K • Total cost in UK is \$4.1 billion to \$6.1 billion annually (mostly due to nurse time) for 410K patients
Bennett et al ⁴	<ul style="list-style-type: none"> • Acute and long-term care • United Kingdom (UK) • Patients developing PIs 	<ul style="list-style-type: none"> • Costs derived using bottom-up methodology based on protocols defined by European Pressure Ulcer Advisory Panel • 1999–2000 	<ul style="list-style-type: none"> • Costs of resources using representative UK NHS unit costs at 2000 prices • Costs include nurse time, dressings, antibiotics, diagnostics, support surfaces, and inpatient days • Costs did not include additional treatment of heel PIs of patients with peripheral vascular disease and diabetes, as well as infections with special precautions 	N/A	<ul style="list-style-type: none"> • Total cost in UK is \$4.1 billion to \$6.1 billion annually (mostly due to nurse time) for 410K patients

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Table 1.
STUDIES ON COST OF HOSPITAL-ACQUIRED PRESSURE INJURIES, CONTINUED

Reference	Settings, Location, and Population	Study Perspective and Time Horizon	Estimating Resources and Costs	Analytical Methods	Main Findings (Outcomes and Costs Converted to Can \$ in 2014)
Kerstein et al ⁹	<ul style="list-style-type: none"> • Acute- and long-term-care facilities in North America • United States • Patients with PIs 	<ul style="list-style-type: none"> • Literature review and expert opinion on protocol standards of care • 1999–2000 	<ul style="list-style-type: none"> • Supportive care (eg, pressure relief, nutritional support, incontinence management) not included in cost models • Costs from public resources and converted to US \$ and inflated to year 2000 using Medical Consumer Price Index • Costs included dressing changes, nursing time of dressing changes, surgical debridement, nonsurgical debridement, and infection 	<ul style="list-style-type: none"> • Meta-analysis using chi-square testing statistics 	<ul style="list-style-type: none"> • Based on 26 studies of 3 protocols (saline gauze and 2 different hydrocolloids) • 71% of patients with Stage II to 3% with Stage IV were treated with saline gauze • 54% of patients with Stage II to 6% with Stage IV were treated with hydrocolloid C • 46% of patients with Stage II to 0% with Stage IV were treated with hydrocolloid D • After 12 wk, 48% to 61% of ulcers healed and cost \$1754 to \$4198 per patient
Chan et al ³	<ul style="list-style-type: none"> • Acute care • Canada • Patients aged ≥65 y 	<ul style="list-style-type: none"> • Prevalence-based, cost-of-illness study • Included percentage of patients with PI stages • Did not include Stage I PIs • 2002–2006 	<ul style="list-style-type: none"> • Included overhead costs (administration, human resources and operations) in addition to direct costs (nursing, operating room, intensive care unit, diagnostics, and pharmacy) • Costs and cases identified using Ontario Case Costing Initiative data 	<ul style="list-style-type: none"> • Mean net costs (difference in hospital costs between PI and non-PI cohort) calculated using Bayesian linear mixed-models methods 	<ul style="list-style-type: none"> • HAPI cohort n=1637 • HAPI: Stage II = \$44,787 (48% of patients), Stage III = \$69,653 (9% of patients), Stage IV = \$92,093 (11% of patients), and unstageable = \$48,498 (32% of patients) • Can \$11,215 to \$18,861 for a preadmission PI (n = 2523) • Non-PI cohort n = 180,092
Graves et al ¹⁰	<ul style="list-style-type: none"> • Public hospitals • Australia • Inpatients 	<ul style="list-style-type: none"> • Considered incidence rate for PIs, length of stay, and opportunity cost of a bed day • 2001–2002 	<ul style="list-style-type: none"> • Data retrieved from Australian Institute of Health and Welfare 	<ul style="list-style-type: none"> • Developed a probabilistic model to predict costs of public hospitals 	<ul style="list-style-type: none"> • Median of 95,695 cases of PIs • Median of 398,432 bed days lost • Incurring median opportunity costs of Can \$291 million in 1 y for a public hospital in Australia

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Table 1.
STUDIES ON COST OF HOSPITAL-ACQUIRED PRESSURE INJURIES, CONTINUED

Reference	Settings, Location, and Population	Study Perspective and Time Horizon	Estimating Resources and Costs	Analytical Methods	Main Findings (Outcomes and Costs Converted to Can \$ in 2014)
Silva et al ¹¹	<ul style="list-style-type: none"> • Acute and long-term care • Portugal • Patients in home care, hospital, or elderly homes 	<ul style="list-style-type: none"> • Reviewed broad scope of literature from national Portuguese database and international databases • 2006 	<ul style="list-style-type: none"> • Determined cost of PIs for the community of Azores, Portugal 	N/A	<ul style="list-style-type: none"> • Total annual cost of treatment for all PI stages in: home care, \$9.7 million; hospital, \$2.4 million; older adult homes, \$1.4 million
Filius et al ¹²	<ul style="list-style-type: none"> • One medical center • The Netherlands • Patients surgically treated for Stage III or IV pressure ulcers 	<ul style="list-style-type: none"> • Retrospective chart study • Categorized patients into 3 groups: <ul style="list-style-type: none"> Group 1: Patients with single pressure ulcer on one of the extremities Group 2: Patients with single pressure ulcer on the trunk Group 3: Patients with >1 pressure ulcer • 2007–2010 	<ul style="list-style-type: none"> • Costs for inpatient days, surgery, radiology examinations, wound therapy, costs for initial treatment and complications • Excluded extramural medical costs and nonmedical costs • Patient information obtained from patient records and the electronic hospital administration 	<ul style="list-style-type: none"> <i>t</i> Tests, analysis of variance, Mann-Whitney <i>U</i> test/ Kruskal-Wallis test, chi-square test, and Fisher exact test 	<ul style="list-style-type: none"> • Identified 40 patients in total with 52 cases of Stage III or IV pressure ulcers • Group 1: 5 cases; average cost of treatment = \$42,133 • Group 2: 32 cases; average cost of treatment = \$14,069 • Group 3: 15 cases; average cost of treatment = \$56,874 • <i>P</i> = .008 for groups stratified for number and location of pressure ulcers • Average cost = \$29,155 • Medical costs per patient varies from \$3792 to \$181,330 • Costs of hospitalization accounted for approximately 75% of total costs
Brem et al ¹³	<ul style="list-style-type: none"> • University-based, tertiary-care hospital • United States • Patients with Stage 4 PIs (hospital and community acquired) 	<ul style="list-style-type: none"> • Retrospective chart review • Obtained hospital records of patients over a maximum of 29 mo • Year not clearly indicated, but Medicare values were based on 2007 	<ul style="list-style-type: none"> • Charges related to treatment, complications, services, and hospital stay; inpatient ledger statements for total charge; physician costs excluded • Costs based on data collected 	N/A	<ul style="list-style-type: none"> • 19 patients with Stage 4 PIs 11 were hospital-acquired and 8 community-acquired • Average costs of treatment and complications \$169,489 for hospital-acquired (average of 1 admission) and \$163,035 for community-acquired (average of 4 admissions)

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Table 1.

STUDIES ON COST OF HOSPITAL-ACQUIRED PRESSURE INJURIES, CONTINUED

Reference	Settings, Location, and Population	Study Perspective and Time Horizon	Estimating Resources and Costs	Analytical Methods	Main Findings (Outcomes and Costs Converted to Can \$ in 2014)
Banks et al ¹⁴	<ul style="list-style-type: none"> Public hospitals in Queensland, Australia Inpatients 	<ul style="list-style-type: none"> Economic model with input parameters of relevant discharges, incidence rate, attributable fraction of malnutrition, independent effect of hospital length stay and cost of a patient bed/day 2002–2003 	<ul style="list-style-type: none"> Data collected from a health information service (discharge info), other literature (incidence, attributable fraction, and length of stay), and hospital statistics service (costs of patient bed/day) 	<ul style="list-style-type: none"> Probabilistic sensitivity analysis 	<ul style="list-style-type: none"> Mean 16,060 (SD, 5671) bed days lost Mean 3666 (SD, 555) of PI cases attributable to malnutrition Mean economic cost of \$13,804,578 (SD, \$5,241,550) for PIs

et al²⁵ commented on the differences in study design, perspective taken, cost components considered, and outcomes examined in the available studies. Both suggested standardizing PI economic studies to improve both quality and usability. A number of recommendations, such as enhancing quality of data collection and reporting, were suggested by Demarre et al²⁵ to improve study design and methods.

DISCUSSION

The available evidence validates that PIs are costly and prevention is preferable to treating them once they occur. Beyond that observation, few conclusions can be made. Ideally, economic evaluations should be done concurrently with efficacy trials,³ but unfortunately there are few high-quality RCTs of interventions to either prevent or manage PIs.²⁷ A common challenge to conducting high-quality RCTs as indicated by Palfreyman and Stone²⁶ is the cost of these studies, noting that medical devices, unlike pharmaceuticals, do not require RCTs before they are approved for marketing. In addition, the relevance of results and internal validity of the economic evaluations being done need improvement.^{28,29} The costs collected and used in studies to date have been inconsistent.^{25,26} Although direct costs associated with the intervention and the care of patients, such as nursing care and consumables, are commonly included,^{15–18,20–23} some studies did not specifically identify cost components¹⁹ or included only the costs of the intervention.²⁴ One included the cost of care outside the hospital,¹⁵ and another study incorporated unforeseen costs but did not specify them.¹⁶ Cost components of the intervention, such as cleaning and maintenance costs, were not consistently collected.¹⁸ What costs are included affects the outcomes of economic evaluations.²⁵

This variability makes it impossible to accurately compare the cost-effectiveness of different PI prevention approaches.

Another challenge is that a number of the interventions for prevention are complex in nature and involve multiple components, such as training, nursing care, nutritional support, and/or use of technology. This complexity, especially if interventions are individually tailored to deal with identified risk factors, will raise challenges in their economic evaluation.

The authors acknowledge a number of limitations to their narrative review. Their focus was limited to economic evaluations performed to date on the prevention of PI in acute care, not on what approach should be taken to prevent PIs. The authors acknowledge that multicomponent interventions implemented by interdisciplinary teams are viewed as the standard of practice in the prevention in PIs.^{30,31} Comparing different preventive strategies, especially in isolation, across settings in various patient populations would be counter to the concept of customizing PI prevention interventions. Nearly all of the economic evaluations of PI prevention strategies come from more economically developed nations. One of the few available reports dealing with economically developing nations was a literature review of the prevalence, risks, costs, and solutions to PIs among spinal cord injury patients that did not meet the authors' inclusion criteria.³² Although the prevalence was high, the authors had difficulty obtaining accurate information, especially economic data. One of few published studies from a less economically developed region dealt with a cardiac hospital in Bangalore, India.³³ A quality improvement strategy that included raising awareness, educating staff, improving documentation and communication, and implementing preventive practices, including

Table 2.

STUDIES ON ECONOMIC EVALUATIONS OF PRESSURE INJURY PREVENTION STRATEGIES

Reference	Setting, Location and Population	Comparators (Intervention and Control)	Economic Evaluation (Measurement of Effectiveness)	Study Perspective and Time Horizon	Estimating Resources and Costs	Model and Analytical Methods	Main Findings (Outcomes and Costs Converted to Can \$ in 2014)
Catz et al ¹⁷	<ul style="list-style-type: none"> • Hospital (Spinal Rehabilitation Department) • Israel • Patients with spinal cord injuries 	<ul style="list-style-type: none"> • Intervention: Mattress with continuous computerized regulation • Control: Foam mattress or low-air-loss bed system 	<ul style="list-style-type: none"> • Cost-effectiveness and benefit 	<ul style="list-style-type: none"> • Comparing a continuous computerized regulation mattress to foam mattress and low-air-loss bed system • Year of study not clearly indicated, but costs were based on 1999 	<ul style="list-style-type: none"> • Calculated costs of mattress systems and nursing care (repositioning) using 1999 prices • Calculated cost-benefit ratio (cost of advanced system – cost of foam mattress / labor cost of advanced system – labor cost of foam mattress) 	N/A	<ul style="list-style-type: none"> • Cost to achieve 1 d without signs of impending PI • A mattress with continuous computerized regulation is least expensive and a low-air-loss bed is most expensive (\$36 for continuous computerized regulation, \$43 for foam, and \$50 for low-air-loss bed) • Cost-benefit ratio of the continuous computerize regulation is 0.43 for tetraplegia and 0.73 for paraplegia • Cost-benefit ratio for low air loss bed is 1.1 for tetraplegia and 1.9 for paraplegia
Vermette et al ²⁰	<ul style="list-style-type: none"> • Acute care hospital • Canada • Adults admitted to medical, surgical, active geriatric, or intensive care unit wards 	<ul style="list-style-type: none"> • Intervention: air-inflated static overlay (ISO) • Control group: microfluid static overlay or low-air-loss dynamic mattress with pulsation 	<ul style="list-style-type: none"> • Cost-benefit 	<ul style="list-style-type: none"> • Prospective, randomized controlled trial (RCT) • Randomized 110 patients • Patients were observed 3 times per week for up to 14 d • Sep 2009 to Mar 2010 	<ul style="list-style-type: none"> • Costs associated with the surfaces and patient comfort 	<ul style="list-style-type: none"> • No model used • Fisher tests were used to assess categorical data, and the Mann-Whitney test was used to compare variables 	<ul style="list-style-type: none"> • No significant difference in the incidences of pressure injuries (PIs) between the 2 groups • Prices varied as the average prevention cost using the ISO was \$3590 vs the \$14,521 for the control methods used • ISO is a cost-effective option for prevention of PIs

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Table 2.

STUDIES ON ECONOMIC EVALUATIONS OF PRESSURE INJURY PREVENTION STRATEGIES, CONTINUED

Reference	Setting, Location and Population	Comparators (Intervention and Control)	Economic Evaluation (Measurement of Effectiveness)	Study Perspective and Time Horizon	Estimating Resources and Costs	Model and Analytical Methods	Main Findings (Outcomes and Costs Converted to Can \$ in 2014)
Schuurman et al ²¹	<ul style="list-style-type: none"> • Two teaching hospitals • The Netherlands • Adults admitted to surgical, internal, and neurological wards 	<ul style="list-style-type: none"> • Intervention: Technical approach (pressure redistribution mattress, cushion, and posture) • Control: Human approach (turning, repositioning, and mobilization) 	<ul style="list-style-type: none"> • Cost-benefit 	<ul style="list-style-type: none"> • Observational prospective cohort study (Purse Value study) used to determine incidence of PIs and average number of days for preventive care and treatment • Cost study ran parallel with Purse Value study and provided data for cost calculations • May 2001 to March 2004 	<ul style="list-style-type: none"> • Data collected was based on recorded information • Calculated costs for repositioning, costs for mobilization, costs for wound care and costs for resources • Cost outcomes: cost per intervention, cost of prevention, cost of treatment, cost per day, cost per patient receiving prevention or treatment, and annual expenditures 	<ul style="list-style-type: none"> • No model used • Bottom-up cost calculations 	<ul style="list-style-type: none"> • 149 patients in prevention group and 84 patients in treatment group • Mean costs of prevention per d per patient for the technical and human approaches to intervention were \$23 (\$0.93–\$182) and \$42 (\$0.22–\$294), respectively • Minimum value applied to ointment only, maximum applied to those who were moved and mobilized as much as possible • Mean cost for entire length of stay per patient for technical and human approaches of prevention were \$246 and \$570, respectively • Treatment cost for human approach was \$624 (grade 1) to \$3048 (grade 4) • Treatment cost for technical approach was \$750 (grade 1) to \$2282 (grade 4). • Mean length of stay for one hospital was 16.4 d and 19.8 d for the other hospital

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Table 2.

STUDIES ON ECONOMIC EVALUATIONS OF PRESSURE INJURY PREVENTION STRATEGIES, CONTINUED

Reference	Setting, Location and Population	Comparators (Intervention and Control)	Economic Evaluation (Measurement of Effectiveness)	Study Perspective and Time Horizon	Estimating Resources and Costs	Model and Analytical Methods	Main Findings (Outcomes and Costs Converted to Can \$ in 2014)
Santamaria and Santamaria ²⁴	<ul style="list-style-type: none"> Multiple public hospitals (acute care) Australia Patients at high risk of PIs 	<ul style="list-style-type: none"> Intervention: Prophylactic dressings Control: No prophylactic dressings 	<ul style="list-style-type: none"> Cost-benefit 	<ul style="list-style-type: none"> Economic estimation based on RCT (Border Trial) cost benefit analysis Border Trial tested the dressings applied to the sacrum and heel of critically ill intensive care unit patients Apr 2011 to Dec 2012 	<ul style="list-style-type: none"> Annualized data for 2012–2013 from national database in the form of patient days 	<ul style="list-style-type: none"> No model used Extrapolated results from Border trial to entire Australian patient population 	<ul style="list-style-type: none"> 71,000 patients expected annually to develop a PI Costs \$812,872,194 Use of dressing can result in annual savings of \$36,359,884 Cost-benefit of 55% to Australian healthcare system
Banks et al ²²	<ul style="list-style-type: none"> Single public hospital Australia 	<ul style="list-style-type: none"> Intervention: nutrition Control: standard care 	<ul style="list-style-type: none"> Cost-effectiveness 	<ul style="list-style-type: none"> Used statistical models to predict: <ul style="list-style-type: none"> “Cases of pressure ulcers avoided” “Number of bed days gained” “Changes to economic costs” 2002–2003 	<ul style="list-style-type: none"> Costs for intensive nutrition support include: staffing, food/nutritional supplements Costs estimated based on proportion of malnourished patients requiring nutrition support with subset of malnourished patients already receiving nutrition support 	<ul style="list-style-type: none"> Economic model using data from a meta-analysis on nutrition support Probabilistic sensitivity analysis 	<ul style="list-style-type: none"> Mean 2896 (SD, 632) prevented PI cases in 1 y Mean 12,397 (SD, 4491) bed days avoided in 1 y Mean savings of \$5,507,661 (SD, \$2,989,809) in 1 y

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Table 2.

STUDIES ON ECONOMIC EVALUATIONS OF PRESSURE INJURY PREVENTION STRATEGIES, CONTINUED

Reference	Setting, Location and Population	Comparators (Intervention and Control)	Economic Evaluation (Measurement of Effectiveness)	Study Perspective and Time Horizon	Estimating Resources and Costs	Model and Analytical Methods	Main Findings (Outcomes and Costs Converted to Can \$ in 2014)
Iglesias et al ¹⁹	<ul style="list-style-type: none"> • 11 hospitals • UK Patients aged ≥55 y with existing Grade 2 pressure ulcer 	<ul style="list-style-type: none"> • Comparing alternating pressure mattresses vs. alternating pressure overlays 	<ul style="list-style-type: none"> • Cost-effectiveness 	<ul style="list-style-type: none"> • Cost-effectiveness analysis that ran alongside multicenter pragmatic RCT • 2002–2003 	<ul style="list-style-type: none"> • Estimated mean health benefits and mean total costs 	<ul style="list-style-type: none"> • Gamma distribution of a generalized linear model with an identity link function • Nonparametric bootstrapping techniques • Sensitivity analysis 	<ul style="list-style-type: none"> • Alternating pressure mattresses showed lower overall costs (\$825.32 per patient on average; ulceration delay time of 10.64-d average) • Cost-effectiveness acceptability curve showed that on average alternating pressure mattresses were associated with 80% probability of being cost saving
Fleurence ¹⁸	<ul style="list-style-type: none"> • Hospital • UK • Patients in 3 scenarios: <ul style="list-style-type: none"> - Adm. without a PI - Adm. with or risk of superficial PIs - Adm. with or risk of severe ulcers 	<ul style="list-style-type: none"> • Comparing mattress overlay and pressure mattress replacement 	<ul style="list-style-type: none"> • Cost-effectiveness 	<ul style="list-style-type: none"> • Obtained costs, PI-free days, and quality-adjusted life-years (QALYs) for each pressure redistribution device for 1, 4, and 12 wk 	<ul style="list-style-type: none"> • Data obtained from literature and a health professional specialist in wound care • Costs adjusted to 2003 values using the Retail Price Index 	<ul style="list-style-type: none"> • Used a decision-analytic model to evaluate prevention strategies, treatment of superficial ulcers, and treatment of severe ulcers 	<ul style="list-style-type: none"> • Wound care specialists cutoff point was \$83,427/QALY per 1000 patients admitted for PIs; ceiling ratio was \$13,905/QALY to \$278,091/QALY • Alternating pressure mattress overlays may be cost-effective for the prevention of PIs • Alternating pressure mattress replacements are cost-effective in treatment of superficial and severe PIs

(continues)

Table 2.

STUDIES ON ECONOMIC EVALUATIONS OF PRESSURE INJURY PREVENTION STRATEGIES, CONTINUED

Reference	Setting, Location and Population	Comparators (Intervention and Control)	Economic Evaluation (Measurement of Effectiveness)	Study Perspective and Time Horizon	Estimating Resources and Costs	Model and Analytical Methods	Main Findings (Outcomes and Costs Converted to Can \$ in 2014)
Torra I Bou et al ²³	<ul style="list-style-type: none"> • Economic study based on 2006 Canadian material and labor costs using efficacy data from open, randomized, multi-center, comparative study done in Spain. • High-risk patients for developing PIs 	<ul style="list-style-type: none"> • Protective bandage vs polyurethane foam, hydrocellular dressing 	<ul style="list-style-type: none"> • Cost-effectiveness 	<ul style="list-style-type: none"> • Comparing cost-effectiveness between: <ul style="list-style-type: none"> • Group A: normal prevention measures with protective heel bandage • Group B: normal prevention measures with hydrocellular dressing • Patients received intervention for 8 wk 	<ul style="list-style-type: none"> • Unit costs based on manufacturer's price list for Canada in 2006 	<ul style="list-style-type: none"> • Efficacy analyzed using chi-square testing • Economic profile comparison 	<ul style="list-style-type: none"> • 130 Patients in study • Cost of dressing changes and nursing costs (Can \$): \$197.71 for group A and \$211.11 for group B • Incremental cost per ulcer avoided for group B (Can \$): \$32.93
Mathiesen et al ¹⁵	<ul style="list-style-type: none"> • Hospital • Denmark patients with hospital-acquired PIs (HAPIs) 	<ul style="list-style-type: none"> • Pressure Ulcer Bundle (PUB): guidelines for using and structuring existing preventive initiatives (assessment, nutrition, and repositioning) vs standard care 	<ul style="list-style-type: none"> • Cost-effectiveness 	<ul style="list-style-type: none"> • Used a decision analytic model to determine cost-effectiveness ratio of PUB • Time not clearly indicated 	<ul style="list-style-type: none"> • Collected data from literature and local cost and effectiveness data from hospital • Currency was converted from the Danish Krone to Euros for the year 2011 • Costs included both care during hospital admission and care outside the hospital (documentation labor, repositioning, complications, healing) 	<ul style="list-style-type: none"> • Used a decision tree with a time frame of the maximum length of healing time 	<ul style="list-style-type: none"> • PUB caused a net savings of \$55.12 per patient (\$169.05 to treat, but \$113.93 to prevent) • 9.3% decrease in PIs occurring • 0.47% reduction in deaths

(continues)

Table 2.

STUDIES ON ECONOMIC EVALUATIONS OF PRESSURE INJURY PREVENTION STRATEGIES, CONTINUED

Reference	Setting, Location and Population	Comparators (Intervention and Control)	Economic Evaluation (Measurement of Effectiveness)	Study Perspective and Time Horizon	Estimating Resources and Costs	Model and Analytical Methods	Main Findings (Outcomes and Costs Converted to Can \$ in 2014)
Padula et al ¹⁶	<ul style="list-style-type: none"> • Hospital • United States • Patients followed through a single hospitalization at risk of developing a HAPI 	<ul style="list-style-type: none"> • Compare prevention plan with standard care 	<ul style="list-style-type: none"> • Cost-effectiveness and benefit 	<ul style="list-style-type: none"> • Compared cost-effectiveness of prevention plan with standard care of treating HAPIs • 1-y time frame 	<ul style="list-style-type: none"> • Used data obtained from literature to calculate costs and probabilities • Costs adjusted to 2009 US \$ 	<ul style="list-style-type: none"> • Semi-Markov model used to stimulate admission of patients 	<ul style="list-style-type: none"> • Prevention costs were \$9037.89/hospitalization, with an expected 11.241 QALYs • Standard care costs were \$12,487.92/hospitalization with 9.342 QALYs. • Cost prevention was \$72.70 per d per person

those in operating rooms, led to a reduction in prevalence from 6% to zero over a 5-month period.³³ No economic evaluation was done. Differences in patient populations (and inherent risk for PIs), available resources, labor costs, and other factors emphasize the need for caution in extrapolating results from one setting or country to another.

There are emerging approaches to the prevention of PIs that have not been studied from a cost perspective and may offer advantages. An example of this was continuous monitoring with feedback of interface pressure distribution. This type of technology monitors the interface pressure of patients and could alert caregivers on the need for repositioning a patient and guide how it is done.^{34–36}

Based on the authors' review of the literature, a number of recommendations (Table 3)^{7,25,26,37} to improve on the economic evaluations of approaches to prevent HAPIs were made. The authors believe this information is needed to support rational decisions about PI prevention.

CONCLUSIONS

In summary, HAPIs are a common and costly challenge for healthcare systems. Various PI prevention approaches, including pressure redistribution mattresses or overlays, specialized bandages, and nutrition, whether used as single interventions or in a combined manner, have been reported to be cost-effective in at least some studies. However, methodologic limitations including study design heterogeneity, differences in cost components, and intervention complexity

undermine our ability to make firm conclusions about the extent of their cost-effectiveness. In addition, the lack of a common methodology prevents the confirmation of promising results found in 1 study or comparing approaches and/or results across studies. The authors suggest that economic evaluation of strategies to prevent HAPIs should be done concurrently with RCTs and conducted in less, as well as more, economically developed nations.

In addition, future economic evaluations of approaches to the prevention of PIs should use explicit, standardized, and appropriate methodology that will allow comparisons of the consequences of alternative courses of action.³⁸

PRACTICE PEARLS

- To date, the economic evaluations of PI prevention strategies used as a single or combined intervention are methodologically limited.
- A lack of an explicit and standardized approach in conducting economic evaluations makes it difficult to compare approaches and results across studies. Few evidence-based conclusions can be made from the current literature.
- Standardized and methodologically sound economic evaluations of strategies to prevent HAPIs should be conducted concurrently with efficacy trials.
- Future economic evaluations of PI prevention strategies should allow for comparisons of alternative courses of action in terms of the cost of preventing PIs.

Table 3.**RECOMMENDATIONS FOR FUTURE ECONOMIC EVALUATIONS OF APPROACHES TO THE PREVENTION OF HOSPITAL-ACQUIRED PRESSURE INJURIES^{7,25,26}**

Recommendation	
1	Economic evaluations of approaches to the prevention of pressure injuries that allow comparative analyses of alternative courses of action in terms of both costs and the incidence of pressure injuries ³⁷ are required and should be prioritized by funders
2	Studies should report (with justification for certain items) on <ul style="list-style-type: none"> ○ Broader context of the study ○ Study population and subgroups (if applicable) ○ Setting and location ○ Study perspective ○ Intervention and comparator(s) ○ Time horizon ○ Discount rate ○ Health outcomes ○ Measure of effectiveness ○ Methods used to estimate resources and costs <ul style="list-style-type: none"> ▪ Description of cost items (and how they were assessed) ▪ Description of how costs were calculated ○ Currency ○ Decision-analytical model used ○ Analytical methods <ul style="list-style-type: none"> ▪ Mean (with measures of variance) costs ▪ Separate reporting of labor and material costs ▪ Sensitivity analyses to examine the influence of variances in labor and material costs ▪ Cost per patient per day with information on length of stay (to facilitate comparisons) ▪ Incremental cost-effectiveness ratios ▪ Effects of uncertainty and assumptions ▪ Subgroup analyses (if applicable)

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