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Assessing the Cost-effectiveness of Pressure Injury Prevention Strategies in a Quasi-experimental Design

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ABSTRACT

OBJECTIVE: Pressure injuries (PIs) remain a significant challenge in healthcare, causing patient discomfort, prolonging hospital stays, and imposing substantial financial burdens on healthcare systems. Despite advancements in prevention strategies, determining the most cost-effective interventions remains paramount for healthcare providers and policymakers. The study authors aimed to assess the cost-effectiveness of various PI prevention strategies within a quasi-experimental design framework.

METHODS: A quasi-experimental study with 2 arms was conducted between September 2022 and February 2023 in a hospital in Saudi Arabia: the routine care for the PI group, group 1, and the PI prevention bundle group, group 2. Data on PI incidence, severity, and associated costs were collected to compare outcomes between group 1 and group 2.

RESULTS: A total of 368 patients were enrolled in the study: 218 patients in group 1 and 150 in group 2. Mortality was higher in the routine care group. The mean PI-free day in the prevention bundle group was 298.8 days compared with 19.7 days in the routine care group. Overall, the mean total cost for the bundle care group was ~$9600 lower than that of the routine care group.

CONCLUSIONS: This quasi-experimental study confirmed that PI prevention is cost-effective. Hospitals should invest in interdisciplinary teams and prevention bundles to improve patient outcomes and resource utilization.

KEYWORDS: assessment, bundles of care, cost, pressure injury, prevention, standard care

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INTRODUCTION

Pressure injuries (PIs) are characterized as areas of lesion or trauma in the skin and/or underlying structures due to pressure or a combination of pressure with shear and friction.[1,2] Pressure injuries are usually found at bony prominences or in a localized area related to a medical device or other object. They are classified according to the severity and level of tissue injury from Stage 1, "non-blanchable erythema of intact skin," to Stage 4, "full-thickness and tissue loss." Two other stages, unstageable and deep tissue pressure injury, are now acknowledged.[2] The etiology of PIs is multifactorial, involving a balance of patient and environmental conditions. Coleman et al[3] reviewed the literature and classified the relevant risk factors for PI into 2 groups: mechanical conditions (magnitude and duration of the mechanical forces applied and their mode of action) and the individual's susceptibility or tolerance. The latest identified risk factors include individuals' internal anatomy, such as the prominence of bone structures, tissue morphology, mechanical and thermal properties of tissues, and tissue repair and transport capacity.[3,4] The risk factors described as associated with mechanical conditions are immobility and poor sensory perception and response. On the other hand, skin status, poor perfusion, poor nutrition, diabetes, moisture, and low albumin are risk factors associated with individual susceptibility and tolerance.[5]

Hospital-acquired pressure injuries (HAPIs) are preventable conditions that affect all age groups and may occur across all medical specialties, interfering with patients' recovery and causing pain and infection.[6] Therefore, HAPIs are associated with increased length of stay in the hospital, reduced quality of life, and increased mortality (OR = 1.4 after adjusting for risk factors).[6,7] Healthcare professionals can prevent most HAPIs by consistently adopting measures to minimize and/or eliminate PI risk factors. The National Pressure Injury Advisory Panel; the European Pressure Ulcer Advisory Panel; the Pan Pacific Pressure Injury Alliance; the National Institute for Health and Clinical Excellence; and the Wound, Ostomy, and Continence Nurses Society elaborated a set of evidence-based recommendations for the treatment and prevention of PIs in clinical practice, to help healthcare professionals, particularly nurses, make better decisions about preventing PIs, specially HAPIs.[1] The 3 fundamental pillars in the prevention of PIs are risk factors and risk assessment, skin and tissue assessment, and preventive skin care.[8]

Previous studies have shown that the availability of guidelines per se is not sufficient to translate best practices into improved care settings.[9,10] Instead, several hospitals/care units are making efforts to develop PI prevention programs with multiple interventions, known as bundles. Although the interventions included within PI prevention bundles have shown effectiveness, globally, these bundles are described in the literature as an effective strategy for preventing PIs.[11–18] The most used strategies are staff education (dissemination strategy), using tools to assess skin PI status or PI risk regularly (implementation process strategy), and multidisciplinary teams.[19]

In 2019, the cost of treating PIs in the United States was estimated to range from $20,900 to $151,700 per patient.[20]

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Therefore, the implementation of a PI prevention bundle represents a promising area to explore. However, the burden of implementing this HAPI prevention bundle is unclear.[21] Hospitals need to invest in human resources (healthcare professionals and quality management teams) and technology to prevent HAPIs, namely beds, dressings, and sensors.[20] Nursing best practices for HAPI prevention, such as risk assessment using the Braden Scale, are time-consuming and require training to be completed daily and entered into a patient's electronic medical record.[22] A number of studies have been published on the implementation of PI prevention strategies, but the total costs of HAPI prevention are still provided by economic evaluations only.[21,23–26] Previous economic evaluations determined that hospital compliance with best practices for HAPI prevention was cost-saving.[21,23] Although one might have concerns about the value of directing resources to perform risk assessments to all patients if only ~4% to 7% of patients are at high risk for developing a HAPI, Padula et al[21] showed that the most cost-effective strategy was to perform follow-up risk assessment in all hospitalized patients and demonstrated improved quality compared with delivering risk-stratified prevention exclusively to high-risk patients. In fact, applying the same care process to all patients helps standardize care, enhances efficiency, and facilitates monitoring, thereby improving reliability.

Despite the increasing popularity of quality management projects to improve outcomes and prevent hospital-acquired conditions, the cost-effectiveness of those projects is rarely considered.[27] In fact, only a study by Singh et al[28] addressed this aspect. Ocampo et al[29] reviewed various PI prevention approaches; however, the lack of a common methodology prevents solid conclusions about the extent of cost-effectiveness of these approaches. In fact, organizations generally do not or cannot assess how much prevention costs. In this way, the authors performed a cost-effectiveness analysis of various PI prevention strategies within a quasi-experimental design framework. The specific objectives were:

1. Evaluate the cost-effectiveness of different PI prevention strategies, including support surface interventions, repositioning schedules, and skin care protocols.
2. Compare the efficacy and cost-effectiveness of traditional preventive measures with innovative technologies, such as pressure-relieving mattresses and advanced wound dressings.
3. Investigate the impact of healthcare setting characteristics, patient demographics, and comorbidities on the cost-effectiveness of PI prevention strategies.
4. Provide evidence-based recommendations for optimizing resource allocation and improving patient outcomes in PI prevention efforts.

METHODS

Study Design, Participants, and Setting

The authors conducted a quasi-experimental study between September 2022 and February 2023 in a hospital in Saudi Arabia. This quasi-experimental study had 2 arms: the routine care for PI group, group 1, and the PI prevention bundle group, group 2.

The researchers included all individuals identified as high risk of PI 24 hours following admission, assessed by a registered nurse for risk assessment for PI and eligible for bundle implementation within 3 hours of admission.

For both groups, the researchers excluded all patients with preexisting wounds over pressure points or extensive traumatic wounds or other types of wounds. Patients who died within 48 hours of admission were not included in the study.

The research study team comprised a diverse group of professionals, each bringing unique expertise to the project. Among them were healthcare researchers, economists, and clinical experts specializing in wound care and PI prevention. One key member was a wound care leader whose extensive experience provided valuable insights into effective prevention strategies. In addition, a leading researcher in health economics with expertise in bed management contributed essential knowledge for assessing both direct and indirect costs associated with PIs.

Wound care nurses played a crucial role, leveraging their clinical experience to inform the design and implementation of prevention strategies. A statistician, adept in quasi-experimental design and data analysis, played a pivotal role in ensuring the robustness of the study's methodology and the accuracy of its findings.

The team also included research assistants and data analysts, who were instrumental in managing and analyzing the vast amounts of data collected throughout the study. Collaboration with nursing staff and healthcare providers at participating hospitals ensured that the strategies under investigation were not only theoretically sound but also practical and applicable in real-world healthcare settings.

Table 1 compares the methodology of care used in each group, training and education, as well as monitoring.

Data Collection

Clinical data of hospitalized patients were collected from the electronic medical record system of the Military Hospital, Saudi Arabia, with ~1345 beds. Data on PI incidence, severity, and associated costs were collected before and after the study period to compare outcomes between group 1 and group 2. The study aimed to assess not only the clinical effectiveness of the intervention but also its cost-effectiveness. Therefore, differences in healthcare costs between the 2 groups were analyzed to determine the economic impact of the intervention. The researchers established cost-effectiveness by comparing data at the end of the project to standard care.

Statistical Analysis

Frequency distribution, percentages, and measures of central tendencies to describe the characteristics of each group included in the study were analyzed with the Statistical Package for Social Sciences (SPSS) version 27 (IBM Corp.). The differences between the group receiving standard prevention and the group receiving bundled PI prevention were compared using a t test. The level of significance was set at $P < .05$.

In a 2 step process, the researchers calculated cost-effectiveness. First, the study authors subtracted the mean cost of prevention and treatment of patients in the bundle care Group (group 2) from that of the routine care group (group 1), and then divided this difference in mean cost by the mean difference in PI-free days between the 2 groups. This cost-effectiveness calculation produced a mean cost for each day of PI-free life gained as a result of the prevention program.

The researchers compared the length of time to PI development between the 2 groups using survival analysis techniques. Survival time in this study was the time to PI development. The researchers used a life-table analysis to perform survival analysis between the 2 groups.

TABLE 1. COMPARISON OF THE CARE METHODOLOGY, TRAINING AND EDUCATION, AND MONITORING BETWEEN GROUP 1 AND GROUP 2

	Group 1 Routine Care for PI	Group 2 PI Prevention Bundle
Care methodology	Patients in this group received routine care for PI prevention based on existing hospital protocols and practices. This may have included basic interventions such as turning schedules, skin inspections, and the use of standard support surfaces.	A comprehensive bundle of care for PI prevention was implemented. This bundle likely consisted of multiple evidence-based interventions such as regular repositioning, skin assessments, moisture management, appropriate support surfaces, nutrition optimization, and patient education.
Training and education	Healthcare staff received standard training on PI prevention protocols as per hospital guidelines. However, the level of emphasis on specific prevention strategies may have varied compared with the intervention group.	Healthcare staff received extensive training on the bundle components, including proper techniques for repositioning, skin assessment methods, and the importance of maintaining skin integrity. Patients and caregivers were also educated on the prevention strategies and the importance of their active involvement.
Monitoring	Monitoring of PI incidence and adherence to routine care protocols was conducted throughout the study period to ensure consistency in care delivery.	Regular monitoring and evaluation of the implementation process were conducted to ensure adherence to the bundle of care. Quality improvement measures were employed to address any barriers to implementation and to continuously refine the process.
Data collection	Data on PI incidence, severity, and associated costs were collected before and after the study period to compare outcomes with the intervention group.	Data on PI incidence, severity, and associated costs were collected before and after the intervention period to assess the effectiveness of the bundle of care.

Abbreviation: PI, pressure injury.

Ethical Considerations

This research was conducted in accordance with the Declaration of Helsinki and with national and institutional standards. This study was approved by the Scientific and Ethical Committee under approval number E-2384. Written informed consent was obtained from participants before inclusion in the study. All data were handled in accordance with ethical research standards to ensure confidentiality and privacy. Patient data were deidentified before analysis to prevent any personal identification. The data set was stored in a password-protected computer accessible only to the principal investigator and authorized research team members. No identifiable patient information was used or disclosed at any stage of the study. In addition, all procedures adhered to the principles outlined in the Declaration of Helsinki and relevant institutional guidelines.

RESULTS

This study compared the cost-effectiveness of implementing the PI prevention bundle over routine care. A total of 368 patients were enrolled in the study. Patients either received routine care (group 1) or PI prevention bundle care (group 2). Group 2 received a more intensive and comprehensive bundle of care specifically tailored for PI prevention, whereas group 1 received standard care protocols. Regarding education and training, group 2 likely received more extensive education and training on PI prevention strategies compared with group 1, which may have influenced staff and patient/caregiver behaviors.

TABLE 2. DEMOGRAPHICS DATA OF GROUP 1 AND GROUP 2

Demographics	Group 1 (n = 218)	Group 2 (n = 150)
Mean Age/SD, y	64.8 ± 24.7	58.7 ± 29.2
Sex	Male: 116 (53%) Female: 102 (47%)	Male: 80 (53%) Female: 70 (47%)
Mean LOS	140.6 d ± 190.4 d	298.8 d ± 229.8 d
Mortality	62 (28%)	33 (22%)

Abbreviation: LOS, length of stay.

Group 1 included 218 patients, whereas group 2 comprised a total of 150 patients. The mean age of patients in group 1 was 64.8 years and 58.7 years in group 2. Fifty-three (53%) percent were men and 47% were women in both groups. The mean length of stay was longer in group 2, with 298.8 days compared with 140.6 days in group 1. Twenty-two (22%) died in group 2, whereas 28% died in group 1 during the course of the study (Table 2).

The mean PI-free days in group 2 were 298.8 days compared with 19.7 days in the routine care group (Table 3). The routine care group had the shortest time to development of PI, which was statistically significant ($P < 0.01$). The mean indirect costs for group 2 (1,792,760.00 SAR; ~$478,069.33 on June 16, 2024) were significantly higher than for group 1 (1,687,500.00 SAR; ~ $450,000.00 on June 16, 2024). The mean direct costs for the bundle care group were lower (156,866.50 SAR; ~$41,831.06 on June 16, 2024) than for the routine care group (298,156.00 SAR; ~$79,508.27 on June 16, 2024) (Table 3). Overall, the mean total cost for the bundle care group was 36,029.88 SAR (~$9,608.00 on June 16, 2024) lower than for the routine care group, with this difference being statistically significant (Table 3). The bundle care group had negative costs and positive effects. Therefore, this group's care was a cost-effective modality when compared with the routine care group.

Survival analysis of days to PI development for group 1 versus group 2 is presented in the Figure. The routine care group had a significantly shorter time to PI development than the bundle group, with a P value of $< .01$.

DISCUSSION

The social, economic, and quality importance of preventing PIs is documented in the literature[19,21,29–32]; however, it is unclear what the estimated cost of prevention and its financial burden are that are absorbed by the hospital. In this study, prevention resulted in cost savings and greater effectiveness compared with the standard care group per hospitalization. The estimated cost of prevention was 36,029 SAR (~$9,602 on June 16, 2024) lower than the standard care, and the intervention was estimated to be 129.09 SAR (~$34.42 on June 16, 2024) less expensive per PI-free day than standard care (Table 3).

TABLE 3. COMPARISON OF OUTCOMES BETWEEN GROUP 1 AND GROUP 2

Treatment Groups	No. Patients	Mean PI-free Days	Mean Indirect Cost (in SAR and USD)	Mean Direct Cost (in SAR and USD)	Mean Total Cost (in SAR and USD)
Group 1	218	19.7 ± 39.9 d	1,687,500.00 ± 2,285,281.45 SAR (450,000.00 ± 609,408.40 USD)	298,156.00 ± 397,623.79 SAR (79,508.27 ± 106,033.01 USD)	1,985,656.38 SAR (529,508.37 USD)
Group 2	150	298.8 ± 229.8 d	1,792,760.00 ± 1,378,898.00 SAR (478,069.33 ± 367,706.13 USD)	156,866.50 ± 120,653.58 SAR (41,831.06 ± 32,174.30 USD)	1,949,626.50 SAR (519,900.40 USD)
ICER			105,260 SAR (28,069.33 USD)	(141,289.50) SAR (37,677.20 USD)	(36,029.88)/279.1 SAR (9,608.00)/279.1 USD (129.09 SAR) Cost per PI-free day (34.42 USD) Cost per PI-free day
P		< .01	< .01	< .01	< .01

Abbreviations: ICER, incremental cost-effectiveness ratio; PI, pressure injury; SAR, Saudi Riyal; USD, United States dollar.

It is important to note that the cost to implement the PI prevention bundle in the researchers' organization was not considered for this analysis. There is no reimbursement for the cost of products for preventing PIs, which leaves the financial responsibility solely on the hospital. However, the savings of 129.09 SAR (~$34.42 on June 16, 2024) per PI-free day are considered by the researchers' hospital to be a good rate of return when sustained over a long time period, motivating the continuation of the training and maintenance of the prevention bundle.

Pressure injuries are classified from stages 1 to 4, or least to most severe. The probability of healing within 90 days varies with severity: 67% (Stage 2), 44% (Stage 3) and 32% (Stage 4).[33] In the present study, the mean length of stay was longer in group 2, with 298.8 days, compared with 140.6 days in group 1. Unfortunately, the study authors did not account for the severity of the PI in calculating the length of stay to understand whether group 2 had more patients with severe stages of PI when compared with group 1. Therefore, the authors can only speculate why they found a higher length of stay in group 2. The INTACT cluster randomized trial showed similar results and considered them unlikely to be directly associated with the prevention intervention.[34] Nevertheless, the cost of managing a Stage 2 PI is substantially higher than the remaining stages, Stage 3 being the least expensive to manage.[35] The present analysis did not take into account the number of each stage in each group.

Ocampo et al[29] undertook a narrative review of the literature on economic evaluations of preventive strategies and reported the cost of prevention to vary between Can $32.93 to 72.70 (~89.94 SAR to 198.56 SAR on June 16, 2024) per patient, across all care settings. However, the studies contributing data to this review were mostly based on secondary data. The present findings are in accordance with previous economic models that concluded that labor-intensive efforts via a care bundle aimed at reducing PI can be cost-effective.[21,23–26] Several economic models suggested that the care bundle was likely to be dominant (both cost-saving and more effective at preventing PI than standard care), but that the magnitude is dependent on the choice of the analytic approach, with conclusions regarding cost-effectiveness dependent on the choice of cost-effectiveness analysis or cost-benefit analysis.[36]

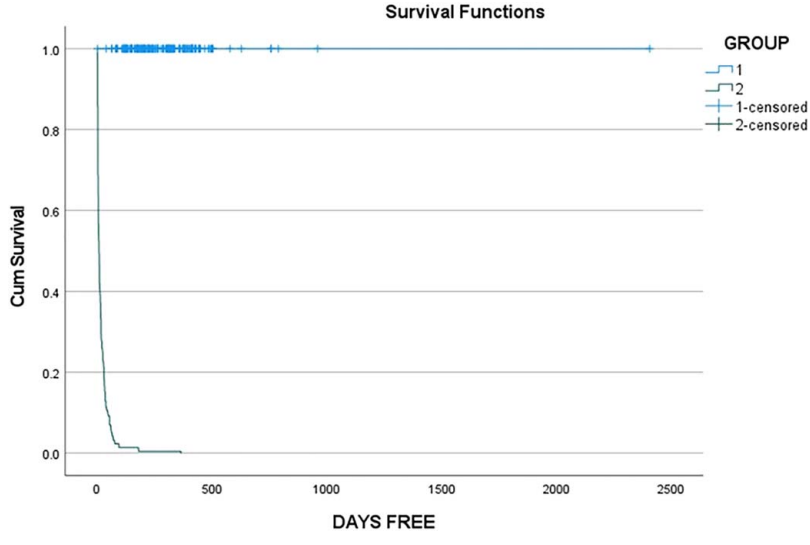

FIGURE. SURVIVAL ANALYSIS OF DAYS TO PRESSURE INJURY DEVELOPMENT FOR GROUP 1 VERSUS GROUP 2

Limitations

This study's limitations were primarily due to the lack of random assignments. This absence increases the risk of confounding variables. As a result, it becomes challenging to conclusively establish cause-and-effect relationships because differences between groups may be due to preexisting factors rather than the treatment itself. In addition, this study faces difficulties in generalizing findings beyond the specific context of the study, and controlling extraneous variables can be problematic.

CONCLUSIONS

The study authors showed that the cost of preventing PI was more effective than routine standard care. The success of this cost-effectiveness was due to the team's interdisciplinary nature, which allowed for a comprehensive approach by addressing the multifaceted challenges of PI prevention. By combining their collective expertise, the researchers generated evidence-based findings that could inform future healthcare policies and practices, ultimately leading to improved patient outcomes and resource utilization.

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