P-ISSN 2586-9000
E-ISSN 2586-9027
Homepage : https://tci-thaijo.org/index.php/SciTechAsia
Science & Technology Asia
Vol.27 No.1 January - March 2022
Page: [128-135]
*Original research article*

# Enhancing the Quality of Long-Term Patient Care by Use of the Innovative "Electrical Bed-Turning System" for the Prevention of Pressure Injuries: A Pilot Study

Jinpitcha Mamom[1,2,*], Bunyong Rungroungdouyboon[2], Jak Chuanasa[2]

[1]*Department Of Adult Nursing and the Aged, Thammasat University, Pathum Thani 12120, Thailand*
[2]*Center of Excellence in Creative Engineering Design and Development, Thammasat University, Pathum Thani 12120, Thailand*

Received 3 October 2019; Received in revised form 27 June 2020
Accepted 11 August 2020; Available online 28 March 2022

**ABSTRACT**

Pressure injuries are a complication potentially occurring with long-term care residents. Prevention of pressure injuries significantly reduces the physical and psychological burdens on both patients and caregivers. The purpose of this quasi-experimental research design was to determine the effectiveness of an innovation: an electrical bed-turning system, and to study the opinions of caregivers on the use of this system. Samples consisted of 30 long-term care residents. Research instruments consisted of a demographic data questionnaire and pressure injury assessment form, together with an evaluation of the caregivers' viewpoints. Data were analyzed through descriptive statistics and Mann-Whitney U test. After three months into the study, there were two pressure ulcer cases in the experimental group. The ulcers developed in the third month. There was a significant statistical difference from the control group, which developed 15 pressure ulcer cases: two, four and nine pressure ulcers in the first, second and third months, respectively. The caregivers had the greatest satisfaction in the use of the patient-turning beds. These beds were a health-based innovation that helped to develop long-term care capacity and to reduce caregiver workload. As a health-based innovation, it is also in compliance with the national policy of Thailand 4.0.

**Keywords:** Innovative bed; Long-term care; Pressure injury prevention; Stroke patients; Turning electrical system

***Corresponding author:** jinpitcha@nurse.tu.ac.th

## 1. Introduction

Pressure injuries (PIs), also called tissue injuries (TIs), pressure sores and pressure ulcers (PUs), can be defined as localized injuries to the skin and/or underlying tissue, and while their etiology is multi-factorial, they typically develop over a bony prominence as a result of pressure or pressure and shear in combination [1-2]. TIs cause patients to suffer, and ulcers increase morbidity and mortality among residents in long-term care [3-5]. In recent systematic reviews of TIs, the risk factors among long term-care patients indicate that both intrinsic and extrinsic factors contribute to the development of TIs, a pattern particularly apparent in the findings of systematic reviews and randomized control trial studies [6-7]. However, much evidence indicates that immobility and mechanical loading, such as interface pressure, friction and shearing force, and deformed cells and tissue ischemia, are the main causative factors directly linked to the occurrence of TIs [7-8].

The repositioning of the patient contributes to the maintenance of microcirculation. Repositioning is a significant standard nursing care practice for the prevention of TIs in immobilized patients [2, 3, 8-9]. It is also important for redistributing the mechanical loading and minimizing circulation complications, which are the cornerstones of PUs prevention [3-4]. Caregivers need to reposition each long term-care patient twelve times a day, totaling 4,380 times per patient per year. If each repositioning takes 5 minutes, this repositioning will consume 21,900 minutes per patient per year [10]. The repositioning process usually requires at least two caregivers, thereby doubling the cost of repositioning intervention [10]. This constant turning schedule may additionally increase the discomfort of the patients from the frequent night awakenings that would be involved.

The family caregivers of long-term care residents in home-based care are often anxious about increased workloads, which can lead to several diseases, such as stress and musculoskeletal disease [4]. Moreover, evidence supports the fact that family caregivers often have low quality-of-life levels which also causes distress. Further, caregivers are often elderly and are acutely susceptible to the negative physical health effects caused by care-giving [4]. When a person has PIs, expenses for transportation and medical visits, prescription and non-prescription medications, equipment and medical supplies can affect the caregiver's ability to provide care [4]. Therefore, it is essential to prevent PIs and to discover ways to reduce the caregiver's workload.

More research on the development of innovations aimed at improving the quality of care as it relates to patient repositioning for the prevention of PIs is essential, because there have thus far been few studies of long-term care residents in Asia. Therefore, an innovation that can decreases workload and prevents PIs is urgently needed. In particular, an innovative bed should be able to maintain the patient at a 30° lateral tilt, because the conventional method using pillow support cannot maintain that position over time [11-12]. Importantly, healthcare providers should be concerned about the actual tissue relief of their turning and repositioning interventions [9].

The purpose of this study was to examine the effect of electrical bed-turning systems on incidences of PIs in long-term care patients and to study the satisfaction and related opinions of caregivers.

## 2. Materials and Methods

### 2.1 Settings and subjects

The participants were recruited from community facilities in the central region of Thailand. Between May, 2018 and September, 2018, a total of 30 subjects were assessed for eligibility according to the following criteria: (i) aged 18 years or older; (ii) long-term care residents receiving care from a family caregiver; and (iii) had a

Braden score of less than 17 with a subscale of activity and mobility of less than 3.

In order to define the sample size of the group by G*Power 3.1.9, an effect size from the previous study [13], a test power of 0.80, and an α value of 0.05 were set [13]. The individuals were randomly allocated to the intervention group or to the control group (n = 15 per group) within each facility. The randomized allocation was done using a random-number table independently generated by a co-researcher.

Matched pairs were used on the criteria that members of each pair would be of the same sex, differ in age by no more than 5 years, have a similar body mass index (BMI), have similar blood-albumin levels – which are indicators of the nutritional state of the patients – and have equal PU risk scores.

### 2.2 Development of the turning bed electric system

The electrical bed-turning system, an innovative structural steel bed, has $30^0$ of head-bed level, $30^0$ for the knee level and $30^0$ lateral tilt to distribute loadings on the bony prominences [4]. This bed was designed by a researcher, and created by staff, at the Faculty of Engineering at Thammasat University, Thailand. [12]

The patient-turning beds that had already been constructed were examined by five qualified individuals, including a surgeon, a professor of wound-care nursing, an advanced-practice nurse (APN) and two mechanical engineering experts. This innovation was tested for its safety, strength suitability, and functionality according to its purpose following a medical-engineering standard guarantee guideline. The procedures of the finite-element method were used in the calculations through the SolidWorks three-dimensional design program. The material that was used consisted of structural steel. Strength calculations of the bed structure were made along both the width and length axes to simulate the stresses imposed on the material when it undergoes loading. Stress values, in general, must measure to be less than twice the yield strength with a factor of safety ≥ 2. In the case of the beds, the calculated factors of safety must be greater than 2 in each dimension.

### 2.3 Research instruments

1) Pressure-injury assessment form, as created by the National Pressure Injury Advisory Panel (NPIAP, 2014), distinguishes six stages of PIs, namely, 1) Stage 1, which refers to red marks on the skin with no skin tears; 2) Stage 2, which refers to skin bruises with clear blisters; 3) Stage 3, which refers to the total destruction of the outer layer of the skin; 4) Stage 4, which refers to the total destruction of every layer of skin, spreading to the muscles, bones, tendons or joints; 5) A stage that cannot be identified, and which refers to a black necrosis covering the entire surface of the skin; and 6) A stage of deep-tissue injury, in which the skin shows a dark purplish color or has blood blisters. Researchers relied on the accuracy of the evaluation form to conduct trials on 10 patients with ulcers whom they had wished to study and who had shown the same characteristics of the experimental group. Scores were analyzed to find a reliability value for the device by using a Cronbach's α coefficient of 0.85.
2) A booklet and DVD for the intervention groups providing information on PIs, prevention strategies, the bed- turning function and the steps for the two-hourly repositioning method. Meanwhile, the booklet and DVD for the control group provided information on the steps for the conventional method (the manual two-hourly repositioning method). The content validity was improved by five experts, including a surgeon, a professor of wound-care nursing, an APN and two mechanical engineering experts.

3) The opinion-evaluation form was used to assess the satisfaction and opinions of the caregivers toward the use of the electric-turning bed system in the form of a 5–point Likert-type scale ranging from 1 (strongly disagree) to 5 (strongly agree). There were 21 questions. Question groups were subdivided into four aspects, with five questions of each aspect, namely 1) the design aspect, 2) materials and equipment aspect, 3) strength and maintenance aspect 4) convenience aspect, and 5) storage and cleaning aspect. Another question requested and assessed opinions about the features of the bed. This assessment form was evaluated for content validity by the five qualified persons (set as in a booklet).

### 2.4 Procedure of the intervention and data collection

Thirty long-term care participants were randomly allocated to either the experimental group using the electrical bed-turning system $(n=15)$, or the control group using a conventional bed $(n=15)$ using the SPSS V. 22.0 random-number generator for an equivalent number of participants in each group.

In the intervention group, the researcher took the electrical bed-turning system, along with the accompanying booklet and DVD to the patients' homes to advise the caregivers individually, and then taught them about the overall nature of PIs, the methods of preventing PIs, skin assessment, patient positioning, the approximate two-hourly repositioning and how to use the turning mechanism. The researcher then gave a demonstration and a repeat demonstration until it was certain that the caregivers were able to use and manage the turning beds appropriately. Meanwhile, in the control group, the researcher took the booklet and DVD to the patients' homes to advise them individually and then taught them about the overall nature of PIs, pressure-ulcer prevention methods, skin assessment, patient positioning and manual two-hourly repositioning.

### 2.5 Assessment of outcomes

The key outcome measured by this study was the incidence rate of PIs as measured by the National Pressure Ulcer Advisory Panel staging system [4], within 72 hours of recruitment, then followed up with monthly reassessments. PIs were measured by skin observations that were documented over the seven sites, including the left and right trochanter, the sacrum, the left and right scapula, and the left and right heels, for a period of three months. Good reliability of the NPUAP staging system in the Thai version was confirmed (Cronbach's $\alpha =$ 0.85).

### 2.6 Statistical analysis

The demographic and clinical variables were compared between the experimental group and control group at baseline; additionally, the opinion assessment form used the descriptive statistic. A Mann-Whitney U test was conducted to determine whether a PI had occurred. Statistical analysis was performed using SPSS Statistics 22.0 for Windows. Values of $p<0.05$ were considered statistically significant.

### 2.7 Ethical considerations

The study was approved by the ethical committee of the Nursing Faculty, Thammasat University (No. 128/2558), as well as the ethical committees of the hospitals at which the study was conducted.

## 3. Results and Discussion

### 3.1 Characteristics of the study participants (n =30)

The ages of the participants were between 45- 67 years, with a mean age of 55.67 years (SD = 5.95) and most (~73.3%), were female. The participants' body weights ranged from 40 to 80 kg (mean = 55.10, SD

= 9.17). The mean height was 1.60 m (SD = 0.09), and the mean BMI was 17.05 kg /m$^2$ (S. = 2.05). The mean hematocrit was 27.87 (SD = 1.52), and the mean hemoglobin was 8.66% (SD = 0.58). The Braden scale scores ranged from 7 to 11 (mean = 8.77, SD = 1.00). The chi-square test and t-test showed that the characteristics of the experimental and control groups were not significantly different.

### 3.2 Effects of the intervention

Firstly, a Mann-Whitney U test analysis was conducted to determine whether PIs had occurred. PI is a dichotomous variable and was coded as 0 (if the participant did not have a PI), or 1 (if the participant presented with a PI).

Based on an analysis of PI rates between the experimental group and the control group, it was found that the experimental group had 0, 0 and 2 PI cases occurring in the first, second and third months, respectively. The control group had 2, 4 and 9 PI cases occurring in the first, second and third months, respectively. When testing for a difference in the PI rates during month 1 by Mann-Whitney U Test, there was no statistically significant difference ($p > 0.05$) while the PI rates between the experimental and control groups in the second and third months were statistically significantly different ($p < 0.05$) as shown in Table 1.

**Table 1.** Comparison of the Tissue injury scores between the control and experimental group using the Mann-Whitney U test $p < 0.05$.

| group | n | Mean Rank | Sum of Ranks | Mann-Whitney | p-Value |
|---|---|---|---|---|---|
| **1st month** | | | | | 1.000 |
| Experimental | 15 | 15.50 | 232.50 | 112.500 | |
| Control | 15 | 15.50 | 232.50 | | |
| **2nd month** | | | | | 0.043* |
| Experimental | 15 | 12.00 | 200.00 | 90.000 | |
| Control | 15 | 17.00 | 255.00 | | |
| **3rd month** | | | | | 0.000* |
| Experimental | 15 | 10.00 | 150.00 | 30.000 | |
| Control | 15 | 21.00 | 315.00 | | |

Part 3: Study of the caregivers' opinions and satisfaction toward the use of the electrical patient-turning bed system by statistical averaging, with standard deviation

The results showed that the majority of caregivers $(n = 12)$ held the opinion that this innovation facilitated the task of repositioning their patients, making the task much more convenient. There were no musculoskeletal problems (back pain or arm-and-leg pain) at all. In terms of the caregivers' satisfaction, the total satisfaction score was high, meaning very satisfied, with this innovation (4.68). The average strength-and-convenience score and the average functionality-and-design score for this system were the highest (X = 4.67).

The experimental group consisted of more females (73.3%) than males, with an average age of 55.67 years. A majority (65%) were in the age group of 60 years and above. This distribution is in agreement with a number of studies [14-16], who all found that the patient groups were mostly elderly who were at risk for PUs because of age-induced changes to the dermis layers of skin, in which collagen production is reduced. Various components associated with skin integrity are reduced, along with a decrease in body movement, resulting in reduced resistance to pressure, shear and friction, making the skin suffer from injury and develop PIs, especially in patients with underlying chronic illness. The participants with chronic illness (100%), in particular, suffered

reduced blood flow, leaving their body unable to deliver enough nutrients and oxygen to its cells. Yet another factor was the control of bodily humidity, which was the subject of a study pertaining to mechanical loading (interface pressure, shearing force and friction force). It was found that all three forces had a statistically significant relationship to the development of Pls, and may serve as statistically significant predictors of the formation of PUs [17]. It was found that long-term care patients are usually prone to shear and friction forces when being moved, with a resulting ten-fold increase in PUs [17].

A systematic review and clinical practice guideline reveal that repositioning is crucial in maintaining skin and tissue integrity, as it redistributes loading thereby preventing PI development [8-9, 12, 15], especially the 2-3-hourly repositioning with 30° tilt, which is the best strategy to allow oxygen to nourish the tissues [15, 18]. Following this principle, the electrical bed-turning system, a recent healthcare innovation, can be classified as a "repositioning intervention", redistributing mechanical loading, increasing blood flow and tissue perfusion, and also preventing skin integrity impairment, thus preventing occurrences of PIs. Therefore, this innovation can reduce spasticity, activate sensory function, stimulate environmental orientation and minimize circulation complications, which are the cornerstones of PI prevention. It is based on the widely accepted clinical practice guideline that tolerates higher tissue perfusion, which can prevent localized tissue ischemia with an upsurge in nutrient supply to wash out metabolic waste products and to prevent reperfusion injury and, moreover, to sustain cell formation to prevent leakage of the cell membrane. Well-perfused tissue not only prevents localized tissue ischemia but also promotes oxygen delivery to the tissues by increasing blood circulation and increasing interstitial fluid flow, activating lymphatic functions [3]. In addition, repositioning done using this repositioning bed with its mechanical-loading redistribution can decrease skin stress, which in turn helps prevent skin impairment. This potential benefit confirms the fact that redistribution loading is an important strategy in tissue ischemia-related PI prevention [19]. These positioning beds make two-hourly repositioning easy and convenient so that the caregivers appreciate their use of it.

Furthermore, teaching the benefits of intervention, together with weekly telephone calls and monthly home visits (though a three-month period), allowed the researchers to monitor and maintain the caregivers' knowledge and to help them use the patient-turning beds, as well as to check their ability to follow the user manual and video. There were also opportunities to ask questions about patient care and preventing complications that may have arisen while at home. Methods of communicating requests for assistance from the health team were helpful for the patients and their families, enabling them to learn how to confront problems and to deal appropriately with whatever problems may develop. In addition, building good relationships among the nurses, patients and their families through cooperation within the health team imparted to the patients' relatives a feeling that they are themselves a part of the health team in their care of the patients, helping the patient care achieve desirable results, in accordance with previous studies [8, 12, 15].

## 4. Conclusion

This innovative bed not only creates higher blood flow and tissue perfusion, but also prevents skin integrity impairment and thus prevents PIs. The patient-turning bed worked successfully as a pressure-redistribution strategy, as it took into consideration both the patients' and caregivers' safety. In this study, the importance of using this new innovative bed is highlighted by its capacity to prevent PIs

thereby reducing the risk of injury to caregivers. It cannot be overemphasized that caregivers are an important component of any effective PI prevention strategy.

## Acknowledgements

This study was supported by the national research of Thailand.

## References

[1] Mervis JS, Phillips TJ. Pressure ulcers: Prevention and management. Journal of the American Academy of Dermatology. 2019 Oct 1;81(4):893-902.

[2] Haesler E, editor. Prevention and treatment of pressure ulcers: quick reference guide. Osborne Park, Western Australia: Cambridge Media; 2014.

[3] Boyko TV, Longaker MT, Yang GP. Review of the current management of pressure ulcers. Advances in wound care. 2018 Feb 1;7(2):57-67.

[4] Kaur S, Singh A, Tewari MK, Kaur T. Comparison of two intervention strategies on prevention of bedsores among the bedridden patients: A quasi experimental community-based trial. Indian journal of palliative care. 2018 Jan;24(1):28.

[5] Anrys C, Van Tiggelen H, Verhaeghe S, Van Hecke A, Beeckman D. Independent risk factors for pressure ulcer development in a high-risk nursing home population receiving evidence-based pressure ulcer prevention: Results from a study in 26 nursing homes in Belgium. International wound journal. 2019 Apr;16(2):325-33.

[6] Coleman S, Smith IL, McGinnis E, Keen J, Muir D, Wilson L, Stubbs N, Dealey C, Brown S, Nelson EA, Nixon J. Clinical evaluation of a new pressure ulcer risk assessment instrument, the Pressure Ulcer Risk Primary or Secondary Evaluation Tool (PURPOSE T). Journal of advanced nursing. 2018 Feb;74(2):407-24.

[7] Grap MJ, Munro CL, Wetzel PA, Schubert CM, Pepperl A, Burk RS, Lucas V. Tissue interface pressure and skin integrity in critically ill, mechanically ventilated patients. Intensive and critical care nursing. 2017 Feb 1;38:1-9.

[8] Oomens CW, Broek M, Hemmes B, Bader DL. How does lateral tilting affect the internal strains in the sacral region of bed ridden patients? A contribution to pressure ulcer prevention. Clinical Biomechanics. 2016 Jun 1;35:7-13.

[9] Yap TL, Kennerly SM, Horn SD, Bergstrom N, Datta S, Colon-Emeric C. TEAM-UP for quality: a cluster randomized controlled trial protocol focused on preventing pressure ulcers through repositioning frequency and precipitating factors. BMC geriatrics. 2018 Dec;18(1):1-5.

[10] Bergstrom N, Horn SD, Rapp M, Stern A, Barrett R, Watkiss M, Krahn M. Preventing pressure ulcers: a multisite randomized controlled trial in nursing homes. Ontario health technology assessment series. 2014;14(11):1.

[11] Powers J. Two methods for turning and positioning and the effect on pressure ulcer development: a comparison cohort study. Journal of Wound Ostomy & Continence Nursing. 2016 Jan 1;43(1):46-50.

[12] Mamom J, Ruchiwit M, Hain D. Strategies of Repositioning for Effective Pressure Ulcer Prevention in Immobilized Patients in Home-Based Palliative Care: An Integrative Literature Reviews. Journal of the Medical Association of Thailand. 2020 Apr 1;103(4):111.

[13] Cohen J. Statistical power analysis for the behavioral sciences. Academic press; 2013 Sep 3.

[14] Mamom J. The Nurses role and pressure ulcers: Challenge in prevention and management. Journal of Science and Technology. 2012;20:478-90.

[15] Mamom J. The effects of a community-based discharge-planning model for continuing pressure ulcer care on wound healing rates, nutritional status, and infection rates of elderly patients in Thailand. Songklanakarin Journal of Science & Technology. 2017 May 1;93(3).

[16] Zeevi T, Levy A, Brauner N, Gefen A. Effects of ambient conditions on the risk of pressure injuries in bedridden patients—multi-physics modelling of microclimate. International Wound Journal. 2018 Jun;15(3):402-16.

[17] Fleming LT, Leung PH. Effects of friction and pressure on skin in relation to pressure ulcer formation. In Innovations and Emerging Technologies in Wound Care 2020 Jan 1 (pp. 281-291). Academic Press.

[18] Woodhouse M, Worsley PR, Voegeli D, Schoonhoven L, Bader DL. How consistent and effective are current repositioning strategies for pressure ulcer prevention?. Applied Nursing Research. 2019 Aug 1;48:58-62.

[19] Hoogendoorn I, Reenalda J, Koopman BF, Rietman JS. The effect of pressure and shear on tissue viability of human skin in relation to the development of pressure ulcers: a systematic review. Journal of tissue viability. 2017 Aug 1;26(3):157-71.