



## Integrative Review

# Integrating Nursing with Biomedical Engineering: A Multidisciplinary Integrative Innovative Approach to Home- Base Care for Aging Society in Thailand

Jinpitcha Mamom<sup>1\*</sup>, Manyat Ruchiwit<sup>2</sup> and Debra Hain<sup>3</sup>

<sup>1</sup>Faculty of Nursing, Thammasat University, Thailand

<sup>2</sup>Faculty of Nursing, Thammasat University, Thailand

<sup>3</sup>Christine E Lynn College of Nursing, Florida Atlantic University, USA

### Abstract

**Background:** Pressure ulcers constitute a significant public-health problem that is both dangerous and severe, impacting the multi-morbidity and mortality of the elderly person. Especially affected are elderly patients, as demographic changes in numerous countries have penetrated the society of the elderly. Health-care teams and the Public Health Ministry should maintain preparedness and readiness in providing care for the elderly.

**Purpose:** This paper has as its objective a proposal for constructing an innovative repositioning bed that can adjust person into the appropriate position. The proposal applies principles and empirical evidence derived from an integration of medical knowledge and biomedical engineering for the management of mechanical loading, which is a significant cause of PUs, and from the interrelationship of mechanical loading with the impact it imposes upon the skin and tissues.

**Method:** Conduct a literature review using the databases CINAHL, MEDLINE, DYNAMED, Web of Science, ISI and PubMed that focused on mechanical loading-related pressure ulcers. The key terms are: innovation, pressure ulcers, loadings and targeted studies published in Thai and English from January 2010 to December 2017.

\*Corresponding author: Jinpitcha Mamom, Faculty of Nursing, Thammasat University, Thailand, Tel: +66 635916561; Email: aorjinpitcha@gmail.com

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**Findings and discussion:** It was discovered from research analysis and empirical evidence that an effective management method for mechanical-loading-related pressure ulcers is repositioning. In previous researches, it was found that a study had been conducted on the effects of many innovations. There were, however, gaps in practice, such as actually adopting them for use, the rather high prices involved and, importantly, the fact that they were never actually applied to the care of elderly patients who were in home-based care.

**Suggestions:** A new innovation which integrates a multidisciplinary knowledge base of health care and the engineering and architectural sciences will provide an alternative approach to lessening the burdens being borne by relatives administering the care. It will also assist the management and prevention of future PUs in the society of the elderly that are imminent.

**Keywords:** Biomedical engineering; Elderly; Home-Base Care; Innovation; Nursing

## Introduction

Pressure Ulcers (PUs), also known as pressure sores or bedsores are an important healthcare problem throughout the world [1-3], especially in Thailand where the prevalence of pressure ulcers in the public tertiary care hospital is about 1.7 per 1,000 persons-years [4]. Home-Acquired Pressure Ulcers (HAPU) are an often suffer and serious issue that provides to increased morbidity and mortality among adults in home-based care [5-8]. PUs is complications that are found to occur frequently in elderly and immobilized patients whom physicians release for home-base care [9]. It thus falls to family caregivers to assume the responsibility of looking after the patient. In many research were found that the most commonly perceived barriers to pressure-ulcer prevention are the patient's condition, a lack of time, personnel, agreed-on routines, pressure-redistribution surfaces and inadequate knowledge [10,11]. Included also is the fear that turning will cause the patient to discomfort, pain or risk of imminent danger [11]. Also, caregivers risk causing musculoskeletal injury [12,13]. Additionally, when combined with correctly positioning and turning, this task becomes quite difficult, as it involves numerous steps that must be taken and creates a troublesome situation for the caregivers. It may dissuade the caregivers from placing a high priority on properly positioning or turning. It could thus become Pus development when they stay at home [12].

The design and construction of innovative beds that can turn person that will reduce the forces imposed on the human tissues and skin (mechanical loading). The beds will be designed to adjust the head level upward and to adapt to the knee joint to allow it to bend. It must especially be capable of adjusting the position into 30 tilt lateral, as the pressure ulcer prevention guidelines [14-17].

## Purpose

This article revealed the development of innovations that employ an integrated blend of knowledge and science drawn from medical, nursing, the engineering sciences and an analytical review of

evidence-based practice. These innovations will be devised for the construction of innovative repositioning beds that employ techniques in the management of mechanical loading.

## Method

A literature review is conducted using the databases CINAHL, MEDLINE, DYNAMED, Web of Science, ISI and PubMed that focuses on pressure injury-related mechanical loading in each setting. Keywords are: pressure ulcer; innovation; bed and loadings and targeted studies published in English from January 2010 to December 2017.

## Findings

**Mechanical Loading:** interface pressure, shearing force and friction/surface resistance are significant causes of PUs [11,18-22]. When mechanical loading impinges upon the body continuously over an extended period of time, it causes an insufficiency of skin microcirculation, ischemia, and tissue injury. Shearing force constitutes restraining force acting between layers of skin whenever the patient slides the body while in a sitting or lying position. It causes a tearing of the tissues which then develops into wounds and blockage of the subcutaneous blood capillaries. The result is that circulation of the blood in the area of skin subject to interface pressure is reduced, and the reduction in blood leads to subsequent tissue death. A friction/surface-resistance force is generated by sliding the patient on his bed or by the patient himself sliding along the bed. Consequently, the superficial layers of skin become torn and breakdown. Likewise, the subcutaneous blood capillaries are injured, pressure injuries will occur.

Repositioning is considered to be an important strategy and is absolutely essential in the prevention of pressure ulcer of elderly patient [23]. In a systematic review, it was suggested that repositioning must be performed at least every two hours [12], but the duration may vary according to the condition of the patient. Patients who are at high risk for developing PUs can be repositioned more frequently than every two hours if red marks have been found on the skin. In a study conducted by Bergstrom [15], it was found that there was no difference incidence over three weeks of observation between those turned at 2-, 3-, or 4-hour intervals in patients using high-density foam mattresses.

## Discussion

In a previous empirical-evidence analysis, it was discovered that the factor affecting the development of PUs is mechanical loading. Mechanical loading impacts microcirculation in ways that differ according to supine position. For instance, in lying position, a weight-bearing point is the occiput, which becomes subject to a pressure of 58-60 millimeters of mercury (mmHg). Another such point is the scapula, which comes under a pressure of 28-36 mmHg. Yet another is the sacrum, under a pressure of 120 mmHg; and yet another is the heel of the foot, under a pressure of 65-80 mmHg. When positioned on the lateral position, the weight-bearing points bearing the greatest pressure loads are the ear lobe, the shoulder, the ribs, the femur, the thigh and the ankle. As for the sitting position with the back straight, and knees bent at a 90-degree angle, the weight-bearing point is at the back of the thigh; but, if the body is slithering down with the knees further bent and the hip joint at more than 90-degrees, the weight-bearing point is shifted downward to the pelvic bone and the coccyx. Consequently, properly repositioning can reduce and redistribute the mechanical loading being sustained and thereby help to prevent occurrences of Pus [10].

Lying positioning leads to minimum contact pressure upon the skin. Head elevating should not over than 30-degrees, with both knees raised of 0-30 degrees, as well as using a pillow to support the heels, help to prevent PUs, reduce problems from shearing and avoids muscular contraction and tension of the joints [15,24]. In lateral positioning, patients should be turned at a 30-degree lateral tilt. This position will reduce pressure on the coccyx and the shoulders, and will allow oxygen to nourish the tissues in the region of greater trochanter more effectively than when positioned to lie at angle of 60 or 90 degrees [22,24].

Accordingly, innovative repositioning beds that turn a patient on his side have been developed. These beds are capable of managing the mechanical loading that affects human tissues and skin; their function is to forestall occurrences of PUs and to lessen the burden being borne by caregivers. Use of these beds thus continues to improve the quality of life of both patient and caregiver, by applying physiological concepts to the development of pressure-injuries and managing interface pressures by properly repositioning.

Innovative repositioning beds, the In RB, were built and developed by researchers from beds that turned position by use of a remote control. The In RB, a new innovative structural steel bed, has 30-degrees of head-bed level, 30-45 degrees for the knee level, and 30-degrees lateral tilt to redistribute mechanical loadings on the bony prominences [15]. They conducted pilot research studies on enhancing the quality of care for patients who are stroke victims through the use of beds that can turn someone, and the caregivers' satisfaction. The goal is promoting the proper patients positioning, to reduce and distribute the interface pressure and to stimulate the blood flow so that the tissues can receive nourishment and oxygen. It is thus intended to help prevent and reduce the occurrences of PUs in the high risk of developing PUs when at home and also decreased workload of caregivers. Statistically significant results from the study have shown that this bed, which has been built to turn a patient by use of a manual crank, is safe and can prevent PUs. Also, care givers have a high level of satisfaction in the use of a bed that can turn the patient. Continued development has thus been directed toward achieving greater efficiency and effectiveness in the prevention of PUs. The quality of the instruments was sought through a proposal presented to five qualified specialists, among them a professor of medicine with expertise in the care of patients with injuries, a skilled nurse with experience in the care of injured patients (Advanced Practitioner Nurse: APN) and a professor of mechanical engineering, to test for safety, sturdiness and functionality according to the objective, design and suitability of the invented product.

## Conclusion

This innovative repositioning bed is a concept derived from basic medical principles directed at preventing the development of PUs, and is collaborated with principles drawn from the field of biomedical engineering. It functions by managing and preventing the continual impingement of forces upon the body over extended periods of time, which are a significant cause of PUs. In addition, it can prevent and manage surface-resistance, friction and shearing forces that originate whenever the patient slides his body or is dragged or pulled. It prevents accidents that cause PUs and even reduces the time involved in caring for the patient; it also improves the activity of nursing the patient, as well. Developing this innovative approach has shown the results of cooperative, multidisciplinary and interdisciplinary

professional work. It has involved engineers in the design of the structure and performance of the construction, as well as testing for the safety and functional integrity of this bed. They are joined with nurses who undertake the responsibility of directly administering care to patients who have developed medical complications and groups who are at risk for health problems in their communities; the nurses meet this responsibility from the time that the patients are received into the hospital to the time that they return home. Their work includes prevention of complications that can arise both in the hospital and at home. However, in recent years there has been increased study on PU prevention, but only one study has presented findings that support the use of a new innovative bed [25]. This innovative bed was constructed with a 1-axis and 2-segment tilt and was studied in hospitals; very few of these studies were conducted in home-based care in the Asian care setting however. Nurses are important health-team personnel in coordinating their work with an interdisciplinary professional team, expanding and building care networks. It is they who access and manage nursing outcomes by applying evidence and researches process with a goal of developing and improving the health system of the people and aiding their access to life in the policy of Thailand 4.0, a policy time of constructing and developing innovative products for the continual development of the Nation in the area of public health.

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