

ORIGINAL

Predictability of Pressure Ulcers Based on Operation Duration, Transfer Activity, and Body Mass Index Through the Use of an Alternating Decision Tree

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Abstract : **Objective :** To develop a prediction model for pressure ulcer cases that continue to occur at an acute care hospital with a low occurrence rate of pressure ulcers. **Methods :** Analyzing data were collected from patients hospitalized at Tokushima University Hospital during 2012 using an alternating decision tree (ADT) data mining method. **Results :** The ADT-based analysis revealed transfer activity, operation time, and low body mass index (BMI) as important factors for predicting pressure ulcer development. **Discussion :** Among the factors identified, only “transfer activity” can be modified by nursing intervention. While shear force and friction are known to lead to pressure ulcers, transfer activity has not been identified as such. Our results suggest that transfer activities creating shear force and friction correlate with pressure ulcer development. The ADT algorithm was effective in determining prediction factors, especially for highly imbalanced data. Our three stumps ADT yielded accuracy, sensitivity, and specificity values of $72.1\% \pm 3.7\%$, $79.3\% \pm 18.1\%$, and $72.1\% \pm 3.8\%$, respectively. **Conclusion :** Transfer activity, identified as an interventional factor, can be modified through nursing interventions to prevent pressure ulcer formation. The ADT method was effective in identifying factors within largely imbalanced data. *J. Med. Invest.* 63 : 248-255, August, 2016

Keywords : transfer, pressure ulcer, nursing needs score, imbalanced data, alternating decision tree

INTRODUCTION

The development of pressure ulcers slows down the recovery from illness, and decreases the quality of life (QOL) of patients (1-4). Generally speaking, the causes of pressure ulcers include : nutrition indicators (anemia, hemoglobin (Hb), albumin (Alb), nutrient intake, body weight) ; factors such as diabetes and low blood pressure ; moisture content of the skin ; and age (5). Patients whose voluntary activities are limited by conditions such as motor paralysis and disturbance of consciousness due to underlying disease easily develop pressure ulcers. However, it is possible to prevent pressure ulcer formation by providing high-quality care to patients who are at risk for developing pressure ulcers (6).

Due to the fact that pressure ulcers extend the duration of hospitalization for patients and increase medical fees (7, 8), medical institutions began to systematically implement measures to prevent pressure ulcers in Japan after medical treatment fees were revised to include “subtraction of fees for non-implementation of measures against pressure ulcer” in 2002. The medical treatment fees were subsequently revised to introduce “addition of fees for the management of patients with pressure ulcer” in 2004 and “addition of fees for the care of patients with a high risk of pressure ulcer.” These incentive systems proved effective in reducing medical expenses related to pressure ulcers (9).

1. Research on the Prevalence Rate of Pressure Ulcers in Japan

A study conducted by Ohura *et al.* on the prevalence rate of

pressure ulcers in Japan prior to the implementation of measures against pressure ulcers found the rate to be 5.8% (10). After measures against pressure ulcers were implemented, Nagano *et al.* conducted a study targeting large-scale hospitals in 2004, finding that the average, maximum, and minimum prevalence rates were 3.09%, 14.1%, and 0.01%, respectively (11). These results suggest that there are discrepancies between hospitals. Takeda *et al.* reported in their 2010 study that the pressure ulcer prevalence rate in hospitals ranged from 1.92 to 3.52% (12). Miyaji *et al.* conducted a study on changes in the prevalence rates before and after the implementation of measures against pressure ulcers, focusing on the same target groups in 2002, and found that the rate significantly decreased six months and one year after the implementation (13). As the result of the measures taken against pressure ulcers, the primary diseases affiliated with pressure ulcers changed from cerebral vascular diseases to the terminal stage of malignant diseases in acute care hospitals. Accordingly, there was an increase in pressure ulcer cases that were difficult to treat (14), and the occurrence rate of pressure ulcers was decreased. New challenges emerged, however, including hospitalization of aged patients with serious pressure ulcers (15) and development of pressure ulcers during the perioperative period (15, 16). Pressure ulcers that occurred during the perioperative period were observed to heal in a short period of time, and not to repeat (17). On the other hand, pressure ulcers that occurred in terminal malignant disease patients were hard to cure, and often repeated (17).

2. Nursing Needs Score (18, 19)

The basic hospitalization fee system was introduced in 2006, with the patient to nurse ratio being seven to one to ensure the quality of acute hospitalization medical care. The system requires medical institutions to check and maintain a record of the severity of patients' diseases, as well as their condition. Within this system,

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Received for publication December 1, 2015 ; accepted May 13, 2016.

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judgment criteria are provided by Nursing Needs Score A (NNS-A) and Nursing Needs Score B (NNS-B) (Tables 1 and 2). NNS-A provides items concerning treatment and care, and is related to patient disease severity ; NNS-B concerns patient mobility and activities of daily living (ADLs).

It has been reported that NNS-A and NNS-B are weakly correlated with pressure ulcer development (20). Furthermore, Nakamura *et al.* conducted a logistic regression analysis of total NNS scores and reported on the usefulness of total NNS-B scores in estimating risks during hospitalization periods (21). There is, however, no study that has conducted analysis using the detailed NNS items.

The data on NNS-A and NNS-B are always collected and stored at designated hospital information systems (HIS) throughout Japan. However, these data are not used for any other purposes. Nursing managers are therefore seeking ways to effectively use this huge dataset for nursing management.

OBJECTIVE

The objective of this study is to identify the main factors useful for predicting pressure ulcer development at an acute care hospital, which usually has a low rate of pressure ulcer cases, in order to take preventive measures. The study also examines whether the

use of an alternating decision tree (ADT) data mining method is effective in analyzing medical information and useful for acquiring new knowledge from imbalanced clinical data.

PATIENTS AND METHODS

1. Patients

The present study targeted patients hospitalized in the Tokushima University Hospital between January 1 and December 31, 2012. Patients were divided into case group and control group depending on whether or not they had developed pressure ulcers during hospitalization.

2. Content of Study

Data on pressure ulcers, as well as the following data (which were stored in the hospital database), were used :

- 1) Basic information on individuals, including sex, age, height, and weight
- 2) Disease name, history of operation(s), and operation duration
- 3) Information related to pressure ulcers
- 4) Other relevant pieces of information (i.e., NNS-A and NNS-B)

Table 1. Evaluation Chart (NNS-A)

A. Monitoring and treatment	0 points	1 point	2 points
1. Wound treatment	none	yes	-
2. blood pressure measurement	0-4 times	more than 5 times	-
3. Timed urine measurement	none	yes	-
4. Respiratory care	none	yes	-
5. More than three simultaneous IV lines	none	yes	-
6. ECG monitor	none	yes	-
7. Syringe driver	none	yes	-
8. blood transfusion or use of blood product	none	yes	-
9. Specialized treatment			
9.1 Use of an antineoplastic drug			
9.2 Use of medical drug injection			
9.3 radiotherapy treatment			
9.4 Use of an immunosuppressive drug	none	-	yes
9.5 Use of a vasopressure drug			
9.6 Use of an antiarrhythmic agent			
9.7 Management of the drainage			
			<u>A score</u>

Table 2. Evaluation Chart (NNS-B)

B. Patient's conditions	0 points	1 point	2 points
10. turn over	Can	can do if holding on to something	cannot
11. sit up	Can	cannot	-
12. maintain a sitting position	Can	can do if there is some support	cannot
13. transfer activity	Can	some assistance or supervision is	cannot
14. mouth care	Can	cannot	-
15. eating	no help is needed	some help is needed	complete help is needed
16. get (un)dressed	no help is needed	some help is needed	complete help is needed
			<u>B score</u>

3. Methods of Analysis

Decision trees are powerful classification methods that provide easily understandable if-then classification rules, and have been used successfully in many medical studies (22).

However, our data suffer from a very high degree of imbalance, the number of negative cases largely exceeds the number of positive cases. Decision trees and many other machine learning and statistical methods encounter difficulties when working with highly skewed data (23). Boosting decision trees (24) can improve the performance of decision trees, but can result in complicated trees that are difficult to understand. Freund *et al.* (25) have developed an easy-to-understand decision tree that uses AdaBoost (26) to provide weights to decision stumps (two-layer decision tree) and combine them to generate a single, easy to understand tree called ADT. ADT consists of decision nodes and prediction nodes. A decision node is a stump that selects the factor with the highest information gain ratio (the weighted entropy difference before and after the data split) and use it to split the data into two branches according to the values of the selected factor, while the prediction node contains a real-valued number that represents the weight of the prediction node. During the prediction phase, each input case spans over multiple paths along the tree, from the root to different prediction nodes. The weights of the related prediction nodes are summed and the final classification is determined by the sign of this sum. A positive sign indicates a positive case, and a negative sign indicates a negative case. A higher total sum indicates higher confidence in the decision.

In order to deal with the problem of class imbalance, positive and negative examples were weighted such that the total weights of each class were equal. The accuracy, sensitivity, and specificity of the model were estimated using the 10-fold cross validation process. The alternating decision tree was generated using RapidMiner Studio Ver. 6.4 (27).

RESULTS

1. General Situation of the Target Hospital

Among the total of 12,008 patients hospitalized in 2012 (those hospitalized more than once were aggregated accordingly), the prevalence rate and occurrence rate of pressure ulcers were 1.86% and 0.37%, respectively. Of these, 59 patients already had pressure ulcers at the time of hospitalization (hereinafter referred to as carry-on patients), whereas 71 patients developed new pressure ulcers during hospitalization (those who developed pressure ulcers more than once were aggregated accordingly). The average ratio of patients whose aggregated NNS-A and NNS-B scores were ≥ 5 was 16.2% in 2012.

1) Sex Difference and Pressure Ulcers

Of the 12,008 patients (5,940 men and 6,068 women) hospitalized in 2012, a total of 130 patients (82 men and 48 women) either had

pressure ulcers at the time of hospitalization (i.e., carry-on patients) or developed pressure ulcers during hospitalization. While the male-to-female ratio of hospitalized patients was almost 1 : 1 (49.5% and 50.5%, respectively), the proportions of male and female patients who developed pressure ulcers during hospitalization were 63.1% and 36.9%, respectively.

2) Age Difference and Pressure Ulcers

A total of 7,028 patients were aged < 65 years, and 4,980 patients were aged ≥ 65 years. The average age of patients with pressure ulcers was 65.4 ± 16.6 years. The numbers of patients with pressure ulcers in different age groups were as follows : 0-9 years : four patients ; 10-19 years : two patients ; 20-29 years : two patients ; 30-39 years : four patients ; 40-49 years : three patients ; 50-59 years : 17 patients ; 60-69 years : 35 patients ; 70-79 years : 42 patients ; 80-89 years : 33 patients ; and ≥ 90 years : three patients.

3) Comparison between Carry-on Pressure Ulcers and Pressure Ulcers that Developed during Hospitalization

Of the 59 carry-on patients, 13 achieved a recovery, and 10 of the remaining patients died. Since carry-on patients had developed pressure ulcers prior to hospitalization, the causes and circumstances were unknown. The total aggregated number of patients who developed pressure ulcers during hospitalization was 71, of whom 38 achieved a recovery, 19 developed pressure ulcers in the perioperative period, and 17 died (Table 3). Some patients repeatedly developed and recovered from pressure ulcers ; as such, the number of patients who developed pressure ulcers during hospitalization represents an aggregated number. Five of 11 patients who repeatedly developed pressure ulcers were hospitalized a number of times due to pressure ulcers, four developed new pressure ulcers in the hospital after having recovered from carry-on pressure ulcers, and two developed repeated pressure ulcers during hospitalization.

4) Diseases and Pressure Ulcers

The target hospital, a university hospital, is also a regional core acute-care hospital characterized by a high number of patients with varying disease types and severity. Below are the numbers of patients with malignant tumors who developed pressure ulcers by disease type. Among 604 patients with otolaryngological diseases, 151 had malignant tumors ; of these, two developed pressure ulcers. Among 984 patients with respiratory system diseases, 609 had malignant tumors ; of these, 19 developed pressure ulcers. Among 2,066 patients with digestive diseases or liver, biliary, and pancreas diseases, 1,228 had malignant tumors ; of these, 23 developed pressure ulcers. Among 344 patients who had diseases of the skin or subcutaneous tissue, 14 had malignant tumors ; of these, one developed a pressure ulcer. Among 899 patients who had diseases of the kidney and urinary tract or the male reproductive system, 326 had malignant tumors ; of these, 11 developed pressure ulcers. Among 1,002 patients who had female reproductive system or puerperium diseases, 20 developed pressure ulcers, but none had malignant tumors. Among 222 patients who had breast diseases, 202 had malignant tumors ; none of these patients developed pressure

Table 3. Comparison between Carry-on Pressure Ulcers and Pressure Ulcers that Developed during Hospitalization

	Total patients	Recovered patients	Patients who developed pressure ulcers during the perioperative period	Deceased patients
Carry-on patients	59	13	unknown	10
Patients who developed pressure ulcers during hospitalization	71*	38*	19	17

*Aggregated numbers

ulcers. Thus, differences in pressure ulcer development were observed by disease.

2. Analysis Using ADT

Before generating an ADT, data cleansing was carried out to exclude the data of patients whose nursing needs were not assessed, and data with missing items. Each patient who developed repeated pressure ulcers during the hospitalization period was counted as one case ; thus, the total number reflects the actual number of patients. Patients who already had pressure ulcers at the time of hospitalization were removed from the case group, which was the analysis target ; hence, the case group included 51 patients (35 men and 16 women) who developed pressure ulcers during hospitalization, and the control group included 8,235 patients (4,566 men and 3,669 women) without pressure ulcers (Table 4). In the case group, the average age was 62.1 ± 14.1 years in men, and 67.2 ± 14.7 years in women ; in the control group, the average age was 62.6 ± 15.6 years in men, and 59.4 ± 18 years in women. NNS-A values were 0.5 ± 1 for the case group and 0.3 ± 0.8 for the control group. NNS-B values were 3.2 ± 4 for the case group and 1.1 ± 2.3 for the control group. The values for the case group were higher for both indicators, with the case group NNS-B values being particularly high. Body mass index (BMI) values were 22.2 ± 4.6 for men and 22.2 ± 3 for women among patients with pressure ulcers, and 23.1 ± 3.7 for men and 22.6 ± 4.3 for women among patients without pressure ulcers. These results indicate a slightly lower BMI in the group of patients with pressure ulcers than in the group of patients with no pressure ulcers. Among the patients who underwent operations, 3,158 were negative for pressure ulcers and 28 people were positive for pressure ulcers. The average operation time was 2.7 ± 2.2 hours for patients who were negative for pressure ulcers and 6.5 ± 4.4 hours for patients who were positive for pressure ulcers. In other words, the average operation time was longer among patients with pressure ulcers.

The attributes used for ADT analysis included sex, age, disease, BMI, and the items of NNS-A and NNS-B. The resulting ADT is shown in Figure 1. The resulting tree was validated using a 10-fold cross validation process. The average and standard deviation of the accuracy, sensitivity, and specificity are $72.1\% \pm 3.7\%$, $79.3\% \pm 18.1\%$, and $72.1\% \pm 3.8\%$, respectively. The identified factors were operation time (expressed as “duration” in Figure 1), low BMI, and transfer activity.

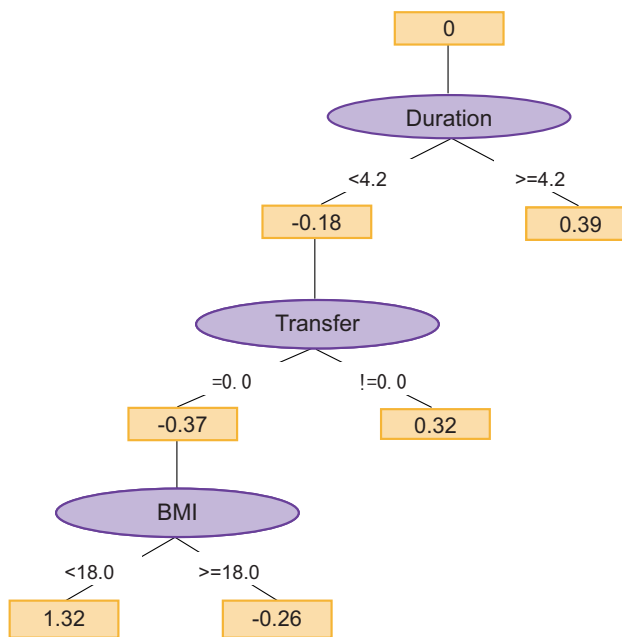


Figure 1. Diagram of Pressure Ulcer Causing Factors Expressed via ADT

DISCUSSION

The yearly average prevalence rate and occurrence rate of pressure ulcers at Tokushima University Hospital were 1.86% and 0.37%, respectively, which are relatively low for a Japanese hospital. These results suggest that appropriate care for pressure ulcers is being provided at the hospital. Since this is a university hospital that provides high-level medical care, a specialized team of plastic surgeons, certified nurses, dietitians, dentists, and pharmacists takes measures against pressure ulcers, appropriately blending their respective skills. The low occurrence rate may also be attributed to the fact that mattresses used for depressurization are appropriate for patients in need. Research and analysis were conducted to investigate the pressure ulcer cases that still occurred despite the appropriate measures taken at the hospital.

1. Age and Sex

Braden Scale does not include the items of age and sex. However,

Table 4. Descriptive Statistics of Patient Characteristics

All inpatients		PU-positive	PU-negative
Class	Male	35	4566
	Female	16	3669
Age (years)	Male	62.1 (14.1)	62.6 (15.6)
	Female	67.2 (14.7)	59.4 (18.0)
NNS score	A	0.5 (1.0)	0.3 (0.8)
	B	3.2 (4.0)	1.1 (2.3)
BMI	Male	22.4 (4.6)	23.1 (3.7)
	Female	22.2 (3.0)	22.6 (4.3)
Surgery inpatients		PU-positive	PU-negative
Class		28	3158
Surgery duration (hr)		6.5 (4.4)	2.7 (2.2)
			Mean (SD)

PU-positive : pressure ulcer-positive PU-negative : pressure ulcer-negative

while Braden admits that age is an important risk factor for pressure ulcers (28, 29), she also posits that the effects of gender cannot be estimated (29). According to the Waterlow Scale (30), advanced age and female gender are high-risk factors. The Ohura-Hotta (OH) Scale (31) deliberately excludes demographics; hence neither age nor sex is included.

Focusing first on age, although the ADT did not identify age as a contributing factor, the number of patients who developed pressure ulcers increased in those over the age of 50 years. Since 50 years is below the threshold for being an aged person, as defined by the World Health Organization (WHO), it is necessary that measures be taken to prevent pressure ulcers in this age group under the premise that "advanced age" as a pressure ulcer causing factor can be as low as 50 or 60 years, and that patients belonging to this age group are at a higher risk. Advanced age contributes to the formation of pressure ulcers because aging results in decreases in biological functions, decreases in ADL, and vulnerable skin. Moreover, aging decreases the moisture content of the stratum corneum and causes wrinkles on the skin (32). Skin wrinkles are related to skin diseases, including pressure ulcers (33). Vohra *et al.* examined pressure ulcers and concluded that aging is a systemic contributing factor (34).

As for sex, while the numbers of hospitalized male and female patients were almost equal, the number of male patients with pressure ulcers was 1.7 times higher than the number of female patients affected. Other studies have found that female patients are more likely to have pressure ulcers (6, 35, 36), male patients are more likely to have pressure ulcers (37, 38), or the numbers of male and female patients with pressure ulcers are almost equal (10). These divergent results suggest that sex is not a constant risk factor.

2. Operation Duration

One study compared a group in which pressure ulcers occurred and a similar control group, concluding that operation duration was not correlated with the occurrence of pressure ulcers (15). However, the Waterlow Scale considers major surgery to be a special risk. Chao-Ton Su *et al.* analyzed the occurrence of pressure ulcers among surgical patients using a data mining method, concluding that operation duration was one of the risk factors associated with the occurrence of pressure ulcers (39). The results of the current study suggest that the estimated probability of pressure ulcer occurrence is high for cases in which operation duration is longer than 4.2 hours, and that longer operation duration is a causative factor for pressure ulcers in acute care hospitals. Conversely, transfer activity was identified as an independent factor for cases in which the operation duration was shorter than 4.2 hours; no pressure ulcers occurred in cases in which BMI was 18 or greater. These results suggest that pressure ulcers may occur when patients with low BMI scores or limited transfer activity undergo surgery.

Among patients who developed pressure ulcers after undergoing an operation, 70% of cases occurred within one day following the operation (15). Since treatment is prioritized at the time of operation, the reality is that measures against pressure ulcers are of secondary importance. Currently, pressure ulcer occurrence and prevalence rates are considered to be quality indicators for hospitals. Therefore, for acute care hospitals that have successfully lowered pressure ulcer occurrence and prevalence rates through countermeasures, preventing pressure ulcers for patients in the perioperative period is a remaining challenge.

3. BMI

BMI scores can contribute to pressure ulcers in patients who are extremely obese or thin (40, 41). Our study found low BMI to be a causative factor for pressure ulcers. Average BMI was 22.4 ± 4.6 for men and 22.2 ± 3 for women in the pressure ulcer group; average

BMI was 23.1 ± 3.7 for men and 22.6 ± 4.3 for women in the control group. These average values are within the normal range in both cases. According to a study that examined the relationships between BMI, weight, and pressure ulcers (42), the BMI of patients with pressure ulcers was 28.2 ± 8 for men and 29.5 ± 9.7 for women in 2006, and 28.4 ± 8 for men and 29.5 ± 9.7 for women in 2007. All of these average values are considered to be overweight, corresponding to level I obesity.

Obesity is also a risk factor for deep tissue injury (43). Thin and obese body shapes give rise to shear force and surface pressure on different body parts (44). Our study identified low BMI as a causative factor for pressure ulcers, suggesting that thin body shapes contribute to pressure ulcers more than obese body shapes in the Japanese population. Moreover, pathologic bone protrusion (relative protrusion of the sacral region due to disuse atrophy), a pressure ulcer causing factor specific to Japanese individuals, is caused by emaciation. Accordingly, it is necessary to provide pressure ulcer preventive measures for thin patients in Japan.

4. Relationships between Diseases and Pressure Ulcers

The ADT did not identify disease as a related factor to pressure ulcers. The leading cause of death in Japan has been malignant neoplasm since 1981. Acute care hospitals frequently find patients in the terminal stage of malignant disease to have pressure ulcers (14). The deterioration of general health conditions, regardless of whether it is due to malignant disease or not, leads to difficulties in treatment of pressure ulcers. The existence of pressure ulcers is one of the end indicators for various systemic diseases (45). This indicator stands in stark contrast to patients who develop pressure ulcers in the perioperative period, as their risk of developing pressure ulcers disappears once they are past the perioperative period, a rather unique state. There exist patients with intractable pressure ulcers in acute care hospitals, due to the hospitalization of patients in poor general condition. Diseases that cause systemic oxygen shortages, such as respiratory diseases, decrease the oxygen content of peripheral tissues. Aging similarly deteriorates respiratory functions. In this sense, one remaining challenge is to prevent the development of pressure ulcers in patients with respiratory diseases or limited respiratory functions, the number of which increases with aging.

5. Transfer Activity, Shear Force, and Friction

Ibe *et al.* (20) and Nakamura *et al.* (21) conducted research on the relationships between NNS-A, NNS-B, and the occurrence of pressure ulcers, focusing on total scores. No study has yet focused on NNS items and their relationships with pressure ulcers. To reveal more detailed causative factors for pressure ulcers, our study focused on NNS items through the use of an ADT, and identified transfer activity as a related factor.

The duration of pressure was considered to be the pressure ulcer causing factor until the mid-20th century (46). However, new findings have been reported since then, including the following: friction does not cause ischemia (47); and as shear force increases, tissues are destroyed more quickly (48). Consequently, it is now believed that the causes of pressure ulcers include pressure, shear force, friction, and microclimate, and that these factors multiply the effects of each other in a complex manner (49). Given that shear force and friction tend to occur when patients who cannot conduct ADLs independently are transferred, it is significant that transfer activity was identified as a pressure ulcer causing factor. For example, when raising the bed of a patient for daily care, it is necessary to pay attention to friction against and shear force on the back, pressure on the sciatic region, and friction against the heels, because shear force and pressure occur differently depending on bed movements and body types (43). Among patients who use wheelchairs and have difficulties in seating, pressure ulcers are likely to develop

on the back, buttocks, or heels due to their bodies sliding down while seated in the wheelchair, causing shear force. It is therefore necessary to select a wheelchair suitable for each patient and to maintain the right sitting position to prevent the patient from slipping down (50). Studies have been conducted on wheelchair seat cushions (51) and mattresses (46, 52) for the purposes of alleviating friction, shear force, and pressure; the results of these studies are incorporated into pressure ulcer prevention measures in clinical practice.

The NNS-B defines transfer activity as “moving ‘from a bed to a wheelchair,’ ‘from a bed to a stretcher,’ ‘from a bed to a portable toilet’” (18). According to these evaluation criteria, even if a patient crawls to make such moves, he/she is considered to be “capable” of transfer activity. In cases in which patients can move little by little on their own, while a nurse is watching over them, these patients are considered to be “partially assisted.” In such examples, among patients who crawl or move slowly on their own, shear force and friction occur. Given that shear force increases when the body surface experiences friction, the skin is damaged more quickly than otherwise (53); thus, care providers should perhaps refrain from thoughtlessly recommending patients to move on their own. It is necessary for patients to use assistive devices in order to prevent shear force and friction from occurring, while nurses are required to provide sufficiently attentive support.

Hospitals with good pressure ulcer prevention methods can reduce pressure ulcer cases even more by recognizing factors other than postural change. Movements and positions that might cause friction or shear force, such as patients’ transfer activity, should also be considered in order to reduce pressure ulcer cases. This work shows, based on NNS criteria, that transfer activity is related to pressure ulcer formation. Care providers are thus faced with the challenge of developing devices that minimize friction or shear force.

6. Consideration of Related Factors for Pressure Ulcers Using ADT

ADT is a powerful classification algorithm that can identify factors important for class prediction. In this study, ADT shows that pressure ulcer occurrence can be predicted by operation duration, transfer activity, and BMI. While many studies have revealed that shear force and friction are risk factors for pressure ulcer occurrence, these studies made empirical judgments without showing evidence that transfer activities give rise to shear force and friction, thus causing pressure ulcers. The results of the current study form a foundation that shows that transfer activity, which gives rise to shear force and friction, is related to the future development of pressure ulcers. Since interventions can be implemented to impact transfer activity, this new finding can be used not only for prediction of pressure ulcer occurrence through evaluation at the time of hospitalization, but also for prevention of pressure ulcers through nursing management.

CONCLUSIONS

In this study, data were analyzed from patients hospitalized in the Tokushima University Hospital during 2012. The analysis, which was conducted through the use of ADT, revealed that long operation duration, low BMI, and transfer activity are the main factors that predict pressure ulcer development at an acute care hospital that utilizes advanced measures of pressure ulcer prevention. Transfer activity, a new factor found to contribute to pressure ulcers, has the potential to be impacted through interventional activities. Finally, ADT has been shown to be an effective method for isolating factors from highly imbalanced data.

ACKNOWLEDGEMENTS

We would like to thank Mr. Toshifumi Osawa (Tokushima University Hospital) for his advice, and Mr. Hachiro Nakagawa for his technical assistance with data management.

CONFLICTS OF INTEREST

We have no conflicts of interest to declare.

Certificate of Native Proofreading is issued by ProEdit Japan, Inc.

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