


ORIGINAL ARTICLE

Could we prove the nursing outcomes utilising clinical data warehouse? Effectiveness of pressure ulcer intervention in Korean tertiary hospital

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Abstract

The use of Clinical Data Warehouse (CDW) for research and quality improvement has become more frequent in the last 10 years. In this study, we used CDW to determine the effectiveness of pressure ulcer interventions offered by ward nurses and wound care nursing specialists. A retrospective clinical outcomes study that utilise CDW has been carried out. We identified 1415 patients who were evaluated as pressure ulcer risk group from 1 July 2019 to 31 December 2019. Kaplan-Meier survival analyses were used to estimate the time to occurrence of pressure ulcers. We compared the survival curves of each group by applying the log-rank test for significance. The overall median time to occurrence for both groups was 13 days (95% CI range: 11-14 days). The control group showed a longer median time (14 days) to occurrence than the case group (12 days). In the pressure ulcer stage I, the case group showed a longer median time (14 days) to occurrence than the control group (8 days), indicating that the intervention provided by the wound care nursing specialist was effective in stage I, and delayed the occurrence of pressure ulcers. The findings may be used as preliminary data for the utilisation of the CDW in the field of nursing research in the future. Also, facilitating the accessibility of the wound care nursing specialist in the general wards should be effective to decrease the incidence rates.

KEYWORDS

clinical data warehouse, electronic health records, pressure ulcer, prevention

Key Messages

- the benefits and potential impact of data derived from the Clinical Data Warehouse (CDW) are clear in the large retrospective case-control study design

- the goal of this study was to use clinical data warehouse to determine the effectiveness of pressure ulcer interventions offered by ward nurses and wound care nursing specialists
- a retrospective clinical outcomes studies that utilize CDW has been carried out. We identified 1415 patients who were evaluated as pressure ulcer risk group from 1 July 2019 to 31 December 2019. Kaplan-Meier survival analyses were used to estimate the time to occurrence of pressure ulcers. We compared the survival curves of each group by applying the log-rank test for significance
- in the pressure ulcer stage I, the case group showed a longer median time (14 days) to occurrence than the control group (8 days), indicating that the intervention provided by the wound care nursing specialist was effective in stage I, and delayed the occurrence of pressure ulcers

1 | INTRODUCTION

Pressure ulcers are localised damages to the skin and underlying tissues that usually occur over a bony prominence as a result of long-term pressure or pressure in combination with shear or friction.¹ The incidence rates of pressure ulcers in Korea were 3.2% in medical institutions, 2.7% in general hospitals, and 8.2% in long-term care facilities.² Pressure ulcers cause pain and act as a major factor that deteriorates the quality of life.³ They prolong the length of stay and increase various medical complications that could have been associated with increased morbidity and mortality rates. Moreover, both patients and medical institutions face significant economic burdens.⁴ Furthermore, it was reported that approximately 2.65€ to 87.57€ was the cost of prevention, 1.71€ to 470.49€ was the cost incurred in healing each ulcer,⁵ and the cost of treatments in patients with stage 4 pressure ulcers exceeded twice the cost of treatment of stage 2.⁶ Therefore, the prevention and early detection of pressure ulcers are considered to be of utmost importance.

Prior research has developed and evaluated a pressure ulcer prediction model by identifying risk factors such as decreased consciousness, skin integrity disorder, reduced movement, and nutritional consultation.⁷ In addition, some studies have recommended the systematic assessment of risk factors and planning of interventions for preventing pressure ulcers.⁸ Moreover, interventions are recommended to alleviate the burden of work, because of the lack of direct care time,⁹ to facilitate the accessibility of the wound care nursing specialist, and to improve the performance of pressure ulcers.¹⁰ Prior studies have reported the effects of preventive interventions for pressure ulcers, such as position changing and preventive dressing for patients in intensive care units. However, few studies have been conducted on patients in general wards.¹¹⁻¹⁴

Seoul National University Hospital (SNUH) is a large urban tertiary care hospital in Seoul, South Korea. The SNUH Clinical Data Warehouse (CDW), developed in 2018, contains all the information from each visit, including not only routine clinical data such as the demographics, diagnosis, medication profiles, laboratory results, and length of stay of inpatients since 2001 but also electronic charts since 2004.¹⁵ The charts contain pressure ulcer-related records; Braden scale evaluation results; pressure ulcer onset, stages, and size; and pressure ulcer onset and healing dates.¹⁶ Through the CDW, data related to research issues can be retrieved using queries.

Pressure ulcer risk assessment tools are widely used across all healthcare settings to help identify prevention strategies in patients and make the best use of limited resources. The Braden scale is one of the most widely used tools in Korea.¹⁷ In order to reduce the workload of ward nurses, to provide nursing care in an appropriate time, and to improve the performance of pressure ulcers, the wound care nursing specialist were randomly assigned to the internal medicine wards to provide pressure ulcer preventive intervention in SNUH.

This study aimed to establish the effectiveness of preventive interventions for pressure ulcers provided by ward nurses and wound care nursing specialists in internal medicine wards. We conducted a retrospective case-control study to investigate the pressure ulcer indicators through CDW to determine the outcomes of the intervention.

2 | METHODS

2.1 | Study design

This is a retrospective case-control study that compared the effectiveness of the preventive interventions provided

by wound care nursing specialists on clinical outcomes. The study was approved by the institutional review board of SNUH (IRB No. H-2002-115-1103) before data collection and analysis. Therefore, written informed consent was not required for CDW-based studies using anonymised data.

2.2 | Sample

SNUH is a large urban tertiary care hospital in Seoul, South Korea. In SNUH, preventive intervention against pressure ulcers was provided via two routes. The first one was the general route provided by the ward nurses, which included position changing, massage, provision of a pressure ulcer preventive mattress, and observation of skin condition. The other was the special route provided by the wound care nursing specialist, which included general pressure ulcer preventive interventions, pressure ulcer education, wound care, and the time required for this intervention was approximately 30 minutes. If the nurse in charge decided on the need for the special pressure ulcer preventive intervention, a

referral request was entered in the EMR wound care nursing specialist request sheet. The wound care nursing specialist confirmed the referral request in the EMR and planned the intervention based on the medical records.

Data were obtained from the CDW that was synchronised with the EMR system as part of the usual clinical practice. The SNUH CDW encompasses all routine clinical information, such as demographics, diagnosis, medication profiles, and laboratory results from each visit since 2001. We retrieved data from the CDW, including recording date, recording department, and pressure ulcer risk evaluation.

The study population included all adult patients over 18 years of age who were admitted to the internal medicine ward of SNUH from 1 July to 31 December 2019. Using the Braden scale, we categorised the patients with pressure ulcers into a risk group (total score, 6-15) and a non-risk group (total score, 16-23). From this sample, we included the patients categorised into the pressure ulcer risk group at least once.

The Braden scale is a tool used to help health professionals, especially nurses, to assess a patient's risk of developing pressure ulcers by examining six criteria: sensory

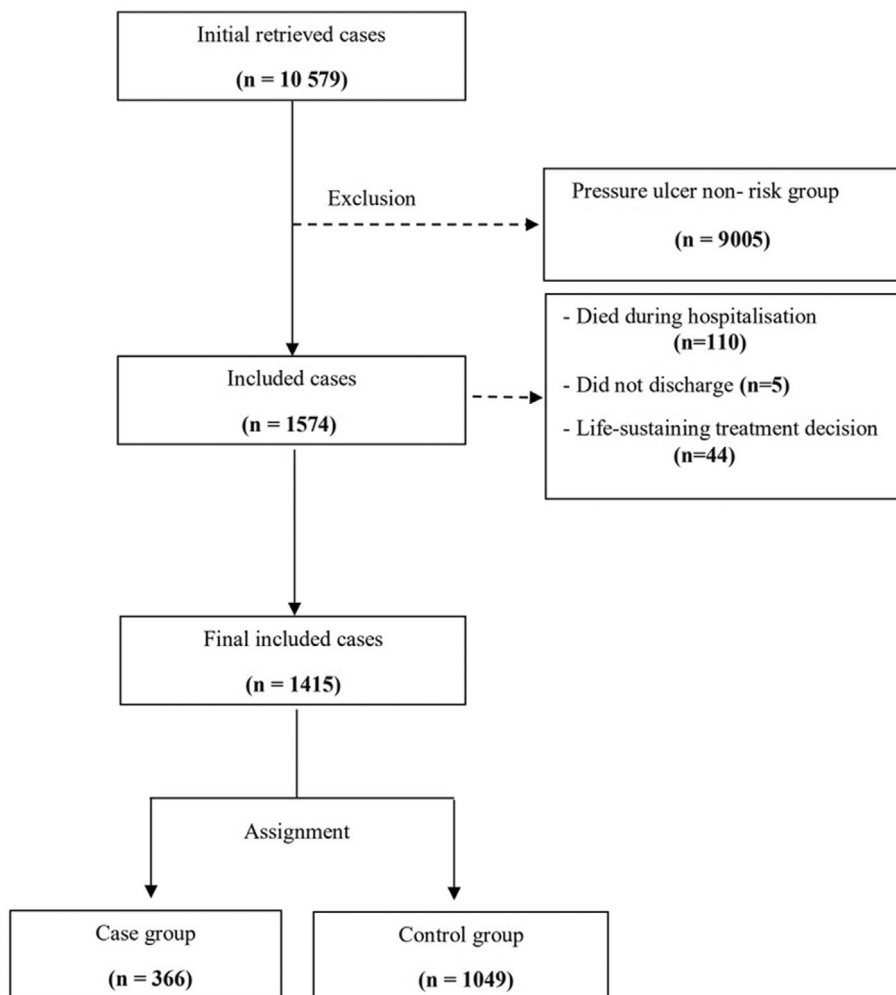


FIGURE 1 Flow chart of study cases enrolment

TABLE 1 General and pressure ulcer-related characteristics of participants (N = 1415)

Characteristics	Categories	Case. (n = 366)		Cont. (n = 1049)		t/ χ^2	P
		n/(mean)	%/(\pm SD)	n/(mean)	%/(\pm SD)		
Age at baseline, years, n (%)	≤34	4	1.1%	142	13.5%		
	35-49	19	5.2%	61	5.8%		
	50-64	84	23.0%	241	23.0%		
	≥65	259	70.8%	605	57.7%		
	Mean (SD)	69.84	\pm 12.14	63.29	\pm 20.40	7.307	<.001
Sex	Male	240	65.6%	678	64.6%	0.105	.745
	Female	126	34.4%	371	35.4%		
Occurrence of pressure ulcer	Before admission	228	62.3%	498	47.5%	23.858	<.001
	After admission	138	37.7%	551	52.5%		
Site of pressure ulcer	Buttock	36	9.8%	164	15.6%	N/A	N/A
	Coccyx	134	36.6%	327	31.2%		
	Ear	8	2.1%	46	4.4%		
	Foot and heel	48	13.1%	73	7.0%		
	Leg	7	1.9%	26	2.5%		
	Others	39	10.7%	151	14.4%		
	Sacrum	57	15.6%	146	13.9%		
	Trochanter	27	7.4%	82	7.8%		
	Vertebra	10	2.7%	34	3.2%		
Stage of pressure ulcer at the admission time	Stage 1	124	33.9%	328	31.3%	6.466	.263
	Stage 2	169	46.2%	497	47.4%		
	Stage 3	26	7.1%	79	7.5%		
	Stage 4	3	0.8%	30	2.9%		
	SDTI	25	6.8%	73	7.0%		
	Unstageable	19	5.2%	42	4.0%		
Stage of pressure ulcer at the discharge time	Stage 1	120	34.4%	356	33.9%	11.353	.078
	Stage 2	154	42.1%	442	42.1%		
	Stage 3	27	7.4%	101	9.6%		
	Stage 4	4	1.1%	33	3.1%		
	SDTI	25	6.8%	58	5.5%		
	Unstageable	30	8.2%	59	5.6%		
Braden scale score		12.79	\pm 2.29	13.52	\pm 2.78	4.995	<.001

Abbreviations: Case., case group; Cont., control group; SD, standard deviation; SDTI, suspected deep tissue injury.

perception, moisture, activity, mobility, nutrition, and friction and shear. Each category is rated on a scale of 1 to 4, excluding 'friction and shear', which is rated on a 1 to 3 scale. This totalled up to 23 points, with higher scores indicating lower risks of developing a pressure ulcer and vice versa. For example, a score of 23 indicated no risk of developing a pressure ulcer, whereas the lowest possible score of 6 points represented the most severe risk for developing a pressure ulcer.¹⁸ The pressure ulcer stages were evaluated and categorised into six stages following the international pressure ulcer evaluation system.¹

In the pressure ulcer report sheet, we selected pressure ulcer indicators from CDW, such as presence or absence, site, onset date, and first and last evaluation stages. We also retrieved related data such as inpatient date, pressure ulcer risk evaluation result, recording department, and recording date to verify the data. We retrieved the wound care activity reports provided by the wound care nursing specialist from the Electronic Nurse Record (ENR) database. Because the report data were only managed by the wound care nursing specialist through the ENR, the CDW did not contain this

information. Thereafter, we merged the two datasets retrieved from the ENR and the CDW based on patient IDs.

Patients who did not get discharged, died, or made life-sustaining treatment decisions during the investigation period were excluded. We also excluded data if the onset of pressure ulcers was not from the time of admission in the internal medicine wards.

During the investigation period from 1 July 2019 to 31 December 2019, data of approximately 10 579 patients admitted to the internal medicine wards were retrieved, and approximately 1574 patients were evaluated as the pressure ulcer risk group at least once. Of the total included cases, we excluded 110 cases that died during hospitalisation, 5 who did not get discharged during the investigation period, and 44 who made life-sustaining treatment decisions. Thus, a total of 1415 cases were included in the final analysis. Further, we separated the cases into two groups. The control group included the patients who were provided the preventive intervention for pressure ulcers by ward nurses, and the case group included the patients who were provided the intervention by the wound care nursing specialist. Finally, of the 1415 cases, 366 were classified into the case group, and 1049 were classified into the control group Figure 1.

2.3 | Statistical analysis

Statistical analyses were performed using SPSS version 25.0. The patients' general characteristics, including age, sex, and pressure ulcer evaluation, were analysed using frequency, percentage, mean, and SD. To determine the effectiveness of pressure ulcer preventive intervention provided by nurses and wound care nursing specialist, independent t-tests and chi-square tests were used. All the statistical tests were two-sided, and *P*-values <.05 were considered statistically significant. We estimated the median time to occurrence for the two groups using the Kaplan-Meier survival curves. To determine the effectiveness of the intervention provided by the wound care nursing specialist, we compared the survival curves of each group by applying the log-rank test for significance.

3 | RESULTS

3.1 | Sample description

A total of 1415 cases that met the inclusion criteria were included in the analysis. Of these, 366 were included in the case group, and 1049 were included in the control group.

The average ages of the patients were 69.84 ± 12.14 years in the case group and 63.29 ± 20.40 years in the control group, and there were significant differences between the two groups ($P < .001$). In the case group, 240 (65.6%) patients were men, and 126 (34.4%) were women. In the control group, 678 (64.6%) were men, and 371 (35.4%) were women, and there were no significant differences ($P = .745$).

In the case group, 228 (62.3%) patients developed pressure ulcers before admission, and 138 (37.7%) developed them after admission. In the control group, the number of patients developing pressure ulcers was 498 (47.5%) before admission and 551 (52.5%) after admission. The rate of pressure ulcer occurrence was higher in the control group (52.5%) than that in the case group (37.7%), and there was a significant difference between the two groups ($P < .001$). The coccyx was the most common area of occurrence in the two groups, with 134 (36.6%) patients in the case group and 327 (31.2%) in the control group. The leg was the area with the lowest occurrence in each group, with 7 (1.9%) in the case group and 26 (2.5%) in the control group. Both the case group and the control group showed the highest rates of stage 2 ulcers at the first evaluation 169 (46.2%) and 497 (47.4%), respectively, and at the discharge point 154 (42.1%) and 442 (42.1%), respectively. There were no significant differences between the groups at both the first evaluation ($P = .263$) and the time of discharge ($P = .078$). The Braden scale scores were 12.79 ± 2.29 in the case group and 13.5 ± 2.78 in the control group, and the case group showed significantly lower scores ($P < .001$), indicating a higher risk of developing pressure ulcers.

All the clinical parameters associated with pressure ulcers are presented in Table 1.

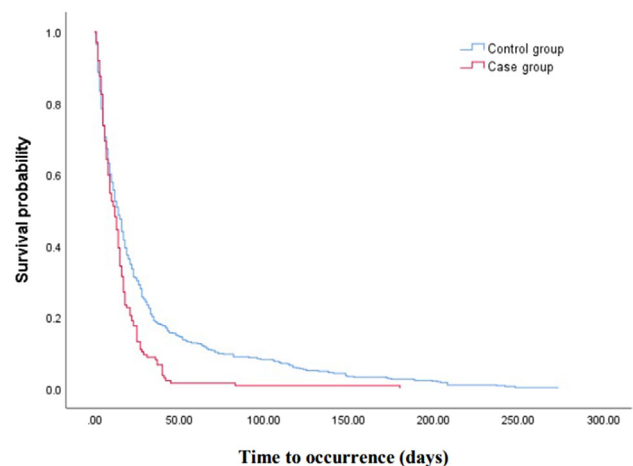


FIGURE 2 Kaplan-Meier curve for time to occurrence of pressure ulcer (overall stages)

TABLE 2 Median time to pressure ulcer

	Number of pressure ulcer occurrences (after admission)	Number of pressure ulcer occurrences (after admission)		Log-rank tests (Mantel-Cox)
		Median (days)	95% CI	
Overall stages				
Control	551 (38.9%)	14	12.2-15.8	15.689 ($P < .001$)
Case	138 (9.8%)	12	9.3-14.7	
Stage 1				
Control	167 (36.9%)	8	6.0-10.0	4.341 ($P < .001$)
Case	48 (10.6%)	14	11.7-16.3	

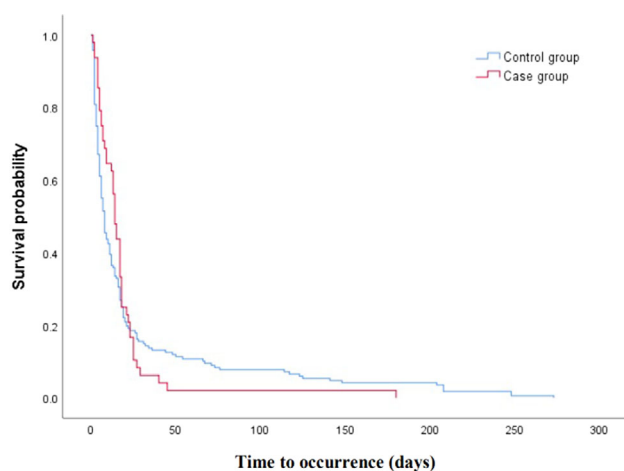


FIGURE 3 Kaplan-Meier curve for time to occurrence of pressure ulcer (Stage 1)

3.2 | Pressure ulcer occurrence

Of the 1415 episodes, 689 (48.7%) pressure ulcers occurred during the inpatient period. The median overall time to occurrence for any group was 13 days (95% CI range: 11-14 days). The control group showed a longer median time (14 days) to occurrence than the case group (12 days). Kaplan-Meier survival curves for time to occurrence by group are shown in Figure 2. The log-rank test revealed significant differences between the two groups ($P < .001$), as shown in Table 2.

For pressure ulcer prevention, the interventions were conducted with more emphasis on pre-stage and stage I; we analysed the results in stage I to check if the intervention met the purpose. In 452 episodes, 215 (47.6%) pressure ulcers occurred during the inpatient period. The case group showed a longer median time (14 days) to occurrence than the control group (8 days), indicating that the intervention provided by the wound care nursing specialist was effective in stage I and delayed the occurrence of pressure ulcers. Kaplan-Meier survival curves for time to occurrence by group are shown (Figure 3).

4 | DISCUSSION

This study involved 1415 patients admitted to the internal medicine ward of a tertiary care hospital and classified as an at-risk group for pressure ulcers based on the electronic health record data extracted using a CDW. This study presents a comparison of the incidence and stages of pressure ulcers between a control group that underwent preventive intervention for pressure ulcers from a ward nurse and a case group that underwent preventive interventions from a wound care nursing specialist.

On observing the duration and site of pressure ulcers among the study participants, the average duration of pressure ulcers was 13 days (range: 11.4-14.6 days), similar to the 11.6 to 15 days observed in previous studies.^{19,20} This may be attributed to the increased risk of pressure ulcers in patients admitted to internal medicine wards because of longer hospitalisation, leading to weakness, poor nutrition, and reduced movement.²¹ In this study, the most frequent site of pressure ulcers was the coccyx (case, 36.6%; control, 31.2%), which is supported by findings from other studies.²²

The case group comprised 366 participants (25.9%), whereas the control group comprised 1049 participants (74.1%). The lower number of participants in the case group may be attributed to the fact that a request for intervention from a wound care nursing specialist was only made when a patient was transferred from another department to internal medicine or when intervention from a wound care nursing specialist was deemed necessary. In addition, one wound care nursing specialist could not provide preventive interventions to all at-risk patients with pressure ulcers. Therefore, this was the most reasonable method for caregivers to provide high-quality care. Further, the case group had fewer participants because the patients may have been transferred or discharged from the hospital after the request for intervention from a wound care nursing specialist was submitted. This may be due to the capability of the wound care nursing specialist to provide care for only a selected number of

patients upon review of the EMRs during a surge of requests.

Throughout this study, 10 579 patients were admitted to the internal medicine ward of the hospital. Of these, 1415 participants were classified as 'at-risk', and 689 developed pressure ulcers. Pressure ulcers developed in 138 of the 366 participants (9.8%) in the case group and 551 of the 1049 participants (38.9%) in the control group. The lower incidence of pressure ulcers in the case group demonstrated the effectiveness of the preventive intervention provided by the wound care nursing specialist. Among the participants who developed pressure ulcers, there were 452 stage I pressure ulcers. Of these, 48 (10.6%) participants developed pressure ulcers after admission, with 14 being the average number of days from hospital admission to the development of ulcers. However, 167 (36.9%) participants developed ulcers after admission, with an average of 8 days from admission to the development of ulcers. Although the control group generally developed ulcers in fewer days than the case group in the evaluation of pressure ulcers at all stages, a significantly shorter period was observed in the development of stage I ulcers in the case group than that in the control group. This can be attributed to the effectiveness of the preventive intervention for pressure ulcers provided by the wound care nursing specialist, and the findings of this study demonstrate that such preventive interventions can delay the onset of stage I pressure ulcers.

The average number of days between hospital admission and the development of pressure ulcers was shorter in the case group (12 days) than that in the control group (14 days). This may be due to the increased severity of injury in the patients referred to a wound care nursing specialist, who is mostly referred to confirm the diagnosis after the pressure ulcers develop. This may explain why the case group had fewer participants than the control group. Another reason may be the statistically significant difference in age between the two groups, with the average age of the case group being 69.84 years and that of the control group being 63.29 years. There have been reports that the average age was higher in a group of patients who developed pressure ulcers.⁷ This may be attributed to several factors related to old age, increasing the prevalence of pressure ulcers. Furthermore, this is consistent with a meta-analysis report of a preventive intervention programme for patients with pressure ulcers in intensive care units, which demonstrated that an integrated intervention was more effective than interventions at an individual level.¹³ This may indicate the need to establish a system that allows ward nurses and caregivers to participate in preventive interventions for pressure ulcers rather than solely relying on a wound care nursing

specialist. Therefore, it is necessary to identify factors that hinder the performance of preventive interventions for pressure ulcers and consequently increase efforts to raise awareness, education, and translation into practice.

In this study, 23 participants (15.2%) who had developed ulcers with Braden scale scores of 16 or higher were classified into the non-risk group. This concurs with the predictive validity of the Braden scale, which is low²³; because of the lack of predictive tools for pressure ulcers, the tools that were included did not give consistent measures.⁷ Moreover, although previous studies have identified indwelling catheter retention, oxygen therapy, cardiac medication, low serum albumin, and surgery as additional risk factors for pressure ulcers,⁷ this is not reflected in the Braden scale. Such items are related to the drugs, surgical treatments, and medical devices used during nursing care or medical interventions provided to patients during inpatient treatment. Thus, to increase the predictive power of risk assessment tools for pressure ulcers, a detailed and objective index must replace the current subjective index used by nurses, including the number of therapeutic interventions provided to patients during inpatient treatment as risk factors for pressure ulcers.

In this study, the hospital CDW was used to select study participants and retrieve the related parameters. The use of de-identified EMR patient health information for research and quality improvement has become more frequent in the last 10 years.²⁴ A recent retrospective analysis used de-identified wound expert EMR from 242 wound care facilities across the United States over a 5-year period. The results found significant differences in frequency and the time of healing when using human fibroblast-derived dermal substitute in patients with diabetic foot ulcers, and the findings could imply overall cost savings for medical resources, home health, prescription drugs, physician office visits, emergency department visits and hospitalizations.²⁵ However, there were still major methodological issues and challenges of retrospective study design, which was the cohort selection bias.²⁶ In this study, we tried to minimise the bias during the retrieving, combining, and cleansing processes. Also, the risk factors for the pressure ulcer were considered by reviewing the previous articles.^{7,19} Moreover, the multidisciplinary group was formed to review if the data contained the target population, loss of information, including follow-ups, dropouts, and deaths that might be associated with outcome.

This study evaluated the effectiveness of preventive interventions for pressure ulcers among patients admitted to the internal medicine ward in a hospital based on data collected in a real clinical setting instead of a randomised experimental study designed for a clinically

controlled environment. The findings of this study demonstrated a lower incidence of pressure ulcers in the case group that received preventive intervention from wound care nursing specialist, which may indicate the effectiveness of high-quality, intensive intervention for the prevention of pressure ulcers. Furthermore, the findings demonstrated that such interventions could delay the onset of stage I pressure ulcers, which is encouraging given the specificity of the study participants. This study also utilised the CDW established in 2018 and demonstrated its effectiveness in nursing interventions. Our findings may also be used as preliminary data for the utilisation of the CDW in the field of nursing research in the future.

A limitation of this study is its retrospective, case-control design. Because of the nature of the real clinical environment, various risk factors affecting the onset of pressure ulcers were uncontrolled, limiting the generalizability of the study findings. Therefore, a randomised experimental study that explores and verifies the effectiveness of preventive interventions using a structured intervention programme is warranted.

CONFLICT OF INTEREST

The authors declare no conflicts of interest.

DATA AVAILABILITY STATEMENT

The data that support the findings of this study are available on request from the corresponding author. The data are not publicly available due to privacy or ethical restrictions.

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