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ORIGINAL ARTICLE

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

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The aim of this study was to identify independent risk factors for pressure ulcer (PU) development in a high-risk nursing home population receiving evidence-based PU prevention. This study was part of a randomised controlled trial examining the (cost-)effectiveness of static air support surfaces compared with alternating pressure air mattresses. The sample consisted of 308 residents at a high risk of PU development (presence of non-blanchable erythema, Braden score ≤ 12 or Braden subscale "mobility" ≤ 2). PU incidence was monitored for 14 days. Demographic variables; functional, physical, and psychological characteristics; and data on skin assessment were collected. Independent risk factors were identified using multiple logistic regression analysis. The overall PU incidence (category II-IV) was 8.4% ($n = 26$), and 1.9% ($n = 6$) of the residents developed a deep PU (category III-IV). PUs (category II-IV) were significantly associated with non-blanchable erythema, a lower Braden score, and pressure area-related pain in high-risk residents even if preventive care was provided. These results highlight the need of a systematic risk assessment, including pain assessment and skin observations, in order to determine and tailor preventive care to the needs of high-risk individuals.

KEYWORDS
high-risk population, nursing home, pressure ulcers, prevention, risk factors

1 | INTRODUCTION

Pressure ulcers (PUs) are one of the most frequently reported preventable adverse events in acute and long-term care settings.[1] Despite progress in technology, preventive measures, and increased health care expenditure, PUs remain a major concern.[2] PUs occur most often in individuals who have poor mobility and activity and are exposed to sustained pressure and/or shear forces for prolonged periods.[3] The elderly are especially susceptible for PU development because of their increasing age and reduced activity and mobility.[4,5] As a result, PUs are a common problem in nursing homes (NHs). Several European studies reported prevalence rates ranging between 6.4% and 31.4% in NHs.[6–8]

PUs impose a significant burden for NH residents. The elderly population with PUs experience pain, physical, psychological, and social problems and have a reduced quality of life.[9,10] Furthermore, both the prevention and treatment of PUs have a financial burden on NHs. The cost of prevention

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per NH resident per day ranged from 2.65€ to 19.69€, and the cost of treatment per NH resident per day ranged from 2.16€ for a PU category 1 to 170.43€ for a PU category 4.[11]

Because of the negative impact of PUs on residents and NHs, adequate prevention is needed. Adequate prevention starts with the accurate identification of residents at risk of PU development. To identify residents at risk, a structured approach should be used, including (a) the use of a risk assessment scale, (b) comprehensive skin assessment to identify changes in intact skin, and (c) clinical judgement based on knowledge of key risk factors.[12,13]

Numerous risk factors for PU development are reported in the literature. In a systematic review, mobility or activity, perfusion, and skin status emerged as the most frequent independent predictors of PU development.[4] Various studies explored risk factors of PU development in NHs,[4] but few studies examined risk factors in an at-risk NH population that received state-of-the-art preventive care.[14,15] Serraes and Beeckman identified time of sitting in a chair as a risk factor for the development of non-blanchable erythema.[14] Hypotension, a history of cerebral vascular accident, and contractures were found as independent risk factors for the deterioration of non-blanchable erythema into PUs category II to IV.[15] Furthermore, risk factors for the development of superficial (category II) and deep (category III-IV) PUs may differ. Lahmann and Kottner concluded that superficial PUs were associated with friction and shear, while deep PUs were strongly associated with complete immobility.[16] In addition, incontinence-associated dermatitis (IAD) was found to be an independent predictor for the development of superficial PUs (PU category II).[17]

Preventive measures based on international recommendations should be implemented for all individuals at risk. However, several studies confirmed that, even when preventive measures are applied, individuals may develop PUs.[14,15,17] The identification of independent risk factors in an at-risk population receiving preventive care supports the tailoring of preventive measures to decrease PU incidence.[17] The aim of this study was to identify independent risk factors for PU development in high-risk NH residents receiving PU prevention.

Key Messages

- despite the application of evidence-based pressure ulcer (PU) prevention, some high-risk residents still develop pressure ulcers (PUs)
- specific risk factors in residents at risk should be identified to monitor the effectiveness of preventive measures; independent risk factors for PU development were identified using multiple binary logistic regression analysis
- non-blanchable erythema, a lower Braden score, and pressure area-related pain were significantly associated with the development of PUs category II to IV
- daily skin observation and pain assessment on pressure points should be implemented for residents at high risk of developing PUs

2 | METHODS

2.1 | Design

A prospective cohort design was used to identify independent risk factors for PU development. In addition, this study was part of a multicentre randomised controlled trial (RCT). The RCT examined the cost-effectiveness and effectiveness of static air mattresses compared with alternating pressure air mattresses for the prevention of PUs. The allocation sequence was 1:1.[18]

2.2 | Setting and sample

The study was performed in a convenience sample of 26 Belgian NHs. In total, 79 NHs were asked to participate. All residents meeting the inclusion criteria were invited to participate. The inclusion criteria were: (a) aged 65 years or older, (b) using an alternating mattress, (c) being bed-bound (lying >8 hours in bed) or chair-bound (sitting >8 hours in chair), and (d) being at a high risk of PUs (the presence of non-blanchable erythema, Braden score ≤ 12, or Braden subscale "mobility" ≤ 2). Exclusion criteria were: (a) the presence of a PU category II to IV, (b) an expected length of stay of less than 2 weeks, (c) end-of-life care, and (d) a medical contraindication for the use of static air mattresses. In total, 308 residents participated in the study.

2.3 | Variables

Potential risk factors were selected based on a recent PU conceptual framework,[19] systematic reviews,[4,20] and risk factors studies.[17,21] In total, 33 potential risk factors were studied. An overview of the potential risk factors is presented in Table 1.

2.4 | Procedure

Two weeks before the start of the study, two researchers educated the ward nurses in skin assessment, classification and differences between PUs and IAD, risk assessment, and risk factor registration. To train the nurses in skin assessment, the European Pressure Ulcer Advisory Panel (EPUAP) Pressure Ulcer Classification set (PUCLAS4) was used.[22]

The head nurses of the participating NHs screened residents for eligibility. The residents and/or their representatives were informed about the study both orally and in written form by the head nurse or the researcher. Afterwards, informed consent could be given by the resident or his/her legal representative if the resident was unable to give informed consent.

TABLE 1 List of potential risk factors

Potential risk factors	
Patient characteristics	Age
	Gender
	Weight
	BMI
	Pressure area-related pain
	Body temperature
	Urinary incontinence
	Faecal incontinence
	Dual incontinence
	Presence of urinary catheter
	Smoking
Skin assessment	Non-blanchable erythema
	Skin discoloration
	Dryness
	Incontinence-associated dermatitis
	Previous pressure ulcers
Braden scale	Total Braden score
	Sensory perception
	Activity
	Mobility
	Moisture
	Nutrition
	Friction and shear
Mini-nutritional assessment (MNA)	Total score
Medication	Sleep medication and tranquillisers
	Corticosteroids
Comorbidities	Paralysis
	Neurological disorders[a]
	Heart and vascular disorders[b]
	Diabetes
	Psychiatric disorders[c]
Preventive measures	Repositioning in chair every 2 h
	Repositioning in bed every 4 h
	Use of support surface

[a] Neurological disorders including dementia, Parkinson and multiple sclerosis.
[b] Heart and vascular disorders including heart failure, heart attack and vascular disease.
[c] Psychiatric disorders including depression, psychosis and anxiety disorders.

At baseline, two researchers gathered the following information: gender, age, length, weight, body mass index (BMI), comorbidities, nutritional status, functional status, incontinence, Braden score, use of pressure-redistributing support surfaces, frequency of repositioning, pressure area-related pain, and body temperature (rectal). In addition, the researchers performed a baseline skin assessment. Subsequently, residents in the experimental group were allocated to static air support surfaces: a Repose static air mattress, a seat cushion, and a heel wedge or a foot protector (Frontier Medical Group, South Wales, UK). In static air support surfaces, there is a constant low air pressure that applies a pressure-redistributing effect.[23] Residents in the control group used the usual pressure-redistributing support surfaces in the participating NHs: an alternating pressure air mattress, a seat cushion, and a heel prevention device. The five most commonly used alternating pressure air mattresses in the control group were: (a) ESRI 200 mattress overlay, (b) AlphaXCell mattress overlay, (c) Air Wave Topper, (d) Eazyflow 512ST—DigiluxAgua, and (e) Panacea Plus Air Alternating. The most commonly used seat cushions in the control group were viscoelastic cushions (eg, Tempur) and air cushions (eg, RoHo). The minority of the residents used an alternating cushion, a gel cushion, or a water-filled cushion. In the control group, a wedge-shaped viscoelastic foam cushion or a pillow was used to elevate the heels from the mattress. The usual repositioning schemes were applied to the residents.

The participating residents were observed for 14 days. The skin assessment and the registration of body temperature, frequency of repositioning, and pressure area-related pain were completed daily by the ward nurses (qualified nurses and nursing assistants under supervision of a qualified nurse). Several studies showed that clinicians experience difficulties to classify PUs and to distinguish PUs from IAD.[24,25] Therefore, researchers performed independent and unannounced skin assessments for reliability testing on a weekly basis. The unannounced skin assessments took place during the morning shifts. During the unannounced visits, the researcher also checked if the pressure-redistributing devices were used and if the static air support surfaces were correctly positioned and sufficiently inflated. The interrater reliability of the classification of PUs among ward nurses and researchers was Cohen's $\kappa = 0.61$ (95% CI: 0.38-0.76). This κ-value indicates a substantial agreement between the ward nurses and researchers.[26] Data were collected over a time period of 14 months (April 2017 to May 2018).

2.5 | Measurement instruments

Validated measurement instruments were used to assess the risk of PU development (Braden scale[27]), the nutritional status (short-form Mini-Nutritional Assessment[28]), and the functional status (ADL-scale[29]). The NPUAP/EPUAP/PPPIA classification system (2014) was used to classify PUs. Non-blanchable erythema, partial-thickness skin loss, full-thickness skin loss, and full-thickness tissue loss were respectively classified as a PU category I, II, III, and IV. A deep tissue injury (DTI) is characterised by purple or maroon intact skin or a blood-filled blister that indicates damage of underlying soft tissue from pressure and/or shear. An unstageable PU is defined as a full-thickness tissue loss in which the depth of the ulcer is covered by slough or eschar.[13] To differentiate blanchable from non-blanchable erythema, the transparent disc method was used.[30]

Furthermore, patient characteristics and wound-related characteristics (causes, location, shape, depth, edges, and colour) were considered to distinguish between PUs and IAD.[31] The Ghent Global IAD Categorisation Tool

(GLOBIAD) was used to categorise IAD. The GLOABIAD distinguished between two main categories: IAD category 1 and IAD category 2. Persistent redness, with or without a variety of tones, is the critical criteria for IAD category 1. The critical criteria for IAD category 2 is skin loss. Both the main categories were additionally subdivided into two subcategories: presence of clinical signs of infection (A) and no clinical signs of infection (B). The mean sensitivity was 90% and the mean specificity 84%, indicating a high diagnostic accuracy. The intra-rater reliability as well as the interrater reliability were substantial (Cohen's kappa: 0.76; Fleiss kappa: 0.65).[32]

2.6 | Data analysis

The data analysis was conducted using IBM SPSS Statistics (Version 24, IBM Corporation, New York, NY). Categorical variables were presented as frequencies (percentages). The normality of continuous variables was checked using histograms, Q-Q plots, and by comparing mean and median. Normally distributed continuous variables were described using means and SDs. Non-normally distributed continuous variables were reported as medians and interquartile ranges (IQRs). Independent PU risk factors were determined using a multiple binary logistic regression model. To form the multiple regression model, a purposeful selection process of variables was performed.[33] First, all potential risk factors were analysed in single binary logistic regression analysis. Second, the variables with $P < 0.25$ in the single regression analyses were entered in the multiple binary logistic regression using a forward selection procedure. Variables were retained in the multiple regression model if $P < 0.1$ or if confounding occurred. Confounding was defined as a change in the regression coefficient of any retained variable greater than 20%. Third, all variables with $P > 0{,}25$ in the single regression analysis were added one at a time in the multiple model. This last step helps identify variables that contribute significantly in the presence of other variables.[33] The dependent variable in the multiple regression model was the presence of a PU category II to IV. Sub-analyses to identify risk factors for the development of superficial (category II) and deep (category III-IV) PUs could not be performed because of the low event rates. Odds ratios and 95% confidence intervals (CI) were calculated. Multicollinearity between continuous variables was tested using Pearson's rank correlation coefficient (cut-off value ≥ 0.6).[34] Furthermore, an independent sample *t*-test was used to examine the correlation between one continuous and one nominal variable. The correlation between two nominal variables was tested using a chi square test. The quality of the prediction models was explored by calculating Nagelkerke's R^2 and the Hosmer–Lemeshow statistic.[35] A significance level of $P < 0.05$ was used.

2.7 | Ethical approval

This study was approved by the Ethical Committee of Ghent University Hospital (B670201731706) and fulfilled according to the ethical principles stated in the Declaration of Helsinki. Oral and written informed consent was obtained from the participating residents or their legal representatives.

3 | RESULTS

3.1 | Characteristics of the participants

Most of the residents (76.9%; $n = 237/308$) were female, and the median age was 88 years (IQR = 82-92). The mean Braden score was 13 (SD = 2.2). The majority of the residents suffered from dementia (52.3%; $n = 161/308$), dual incontinence (72.4%; $n = 223/308$), had a very limited mobility (62.7%; $n = 193/308$), and were chair bound (89.3%; $n = 275/308$). At baseline, 16.6% ($n = 51/308$) of the residents had IAD, and 10.7% ($n = 33/308$) had non-blanchable erythema; 24% ($n = 66/275$) developed non-blanchable erythema during the study period. The cumulative PU incidence (category II-IV) was 8.4% ($n = 26/308$), and the incidence density was 0.006 PUs per person day. Six residents (1.9%) developed a deep PU (category III-IV). Most of the PUs appeared in the sacral area (69.2%; $n = 18/26$).

3.2 | Risk factors associated with the development of PUs category II to IV

In the single binary logistic regression model, the presence of non-blanchable erythema ($P = 0.001$), pressure area-related pain ($P = 0.005$), and being placed on an alternating mattress ($P = 0.046$) were significantly associated with the development of PUs category II to IV. Seven other potential risk factors had a $P < 0.25$ (Table 2). Multicollinearity was detected between the total Braden score and the Braden subscores "moisture" and "nutrition." The total Braden score was retained because of the lowest *P* value in the single regression analysis. In total, eight variables were entered in the multiple logistic regression model. In the multiple regression analysis, pressure area-related pain (OR 2.91; 95% CI 1.06-7.98), non-blanchable erythema (OR 4.06; 95% CI 1.50-11.00), and a lower Braden score (OR 0.81; 95% CI 0.66-0.98) were independent risk factors of the development of PUs category II to IV (Table 3). The variable "neurological disorders" was retained because of confounding. No variables with a $P > 0.25$ in the single analysis were meaningful in the multiple regression model. The final model explained 16% of variance in the development of PUs category II to IV (Nagelkerke R^2 0.160). The Hosmer–Lemeshow test detected no statistically significant difference between the expected and observed probabilities (χ^2 7.402, degrees of freedom 8, $P = 0.494$).

TABLE 2 Single binary logistic regression with PU category II to IV as dependent variable

Potential risk factor	Total (n = 308) n (valid %) Mean (SD) Median (IQR)	No PU (n = 282) n (valid %) Mean (SD) Median (IQR)	PU (n = 26) n (valid %) Mean (SD) Median (IQR)	P	OR (95% CI)
Patient characteristics					
Age (median [IQR])	88 (82.0-92.0)	88 (82.0-92.3)	88 (82.0-91.3)	0.816	0.994 (0.943-1.047)
Gender				0.625	0.797 (0.321-1.980)
Male[a]	71 (23.1)	64 (22.7)	7 (26.9)		
Female	237 (76.9)	218 (77.3)	19 (73.1)		
Weight (median [IQR])	62.8 (51.0-74.0)	61.4 (50.5-74.0)	56.5 (51.7-76.4)	0.643	0.994 (0.969-1.020)
BMI (median [IQR])	24.0 (20.0-28.0)	24.0 (20.0-28.0)	23.5 (19.8-29.3)	0.825	0.992 (0.925-1.064)
Pressure area-related pain[b]	38 (12.3)	30 (10.6)	8 (30.8)	**0.005**	3.733 (1.496-9.320)
Body temperature (median [IQR])	36.3 (35.9-36.5)	36.2 (35.8-36.5)	36.3 (35.9-36.5)	0.900	0.961 (0.516-1.790)
Urinary incontinence[b]	58 (18.8)	53 (18.8)	5 (19.2)	0.960	0.943 (0.099-8.958)
Faecal incontinence[b]	16 (5.2)	14 (5.0)	2 (7.7)	0.783	1.429 (0.113-18.004)
Dual incontinence[b]	223 (72.4)	205 (72.7)	18 (69.2)	0.904	0.878 (0.106-7.252)
Presence of urinary catheter[b]	24 (7.8)	22 (7.8)	2 (7.7)	0.984	0.985 (0.218-4.444)
Smoking[b]	11 (3.8)	11 (4.1)	0 (0.0)	0.999	0.000 (0.000-)
Skin assessment					
Non-blanchable erythema at baseline[b]	33 (10.7)	25 (8.9)	8 (30.8)	**0.001**	4.569 (1.805-11.563)
Skin discolouration[b]	116 (37.7)	104 (36.9)	12 (46.2)	0.353	1.467 (0.654-3.292)
Dryness[b]	76 (24.7)	67 (23.8)	9 (34.6)	**0.223**	1.699 (0.724-3.988)
Incontinence-associated dermatitis[b]	51 (16.6)	45 (16.0)	6 (23.1)	0.354	1.580 (0.601-4.153)
Previous pressure ulcers[b]	100 (32.5)	88 (31.2)	12 (46.2)	**0.124**	1.890 (0.840-4.253)
Braden scale					
Total Braden score (mean [SD])	13 (2.2)	13.1 (2.2)	12.3 (2.4)	**0.086**	0.851 (0.707-1.023)
Sensory perception				0.531	1.293 (0.579-2.888)
Slightly limited and no impairment[a]	172 (55.8)	159 (56.4)	13 (50.0)		
Completely and very limited	136 (44.2)	123 (43.6)	13 (50.0)		
Moisture				**0.087**	2.126 (0.895-5.049)
Occasionally and rarely moist[a]	145 (47.1)	137 (48.6)	8 (30.8)		
Constantly and often moist	163 (52.9)	145 (51.4)	18 (69.2)		
Activity				0.796	0.821 (0.183-3.669)
Chair-bound and walks occasionally/frequently[a]	280 (90.9)	256 (90.8)	24 (92.3)		
Bed-bound	28 (9.1)	26 (9.2)	2 (7.7)		
Mobility				0.535	1.294 (0.573-2.924)
Very/slightly limited and no impairment[a]	195 (63.3)	180 (63.8)	15 (57.7)		
Completely immobile	113 (36.7)	102 (36.2)	11 (42.3)		
Nutrition				**0.217**	1.660 (0.742-3.716)
Adequate and excellent[a]	189 (61.4)	176 (62.4)	13 (50.0)		
Very poor and probably inadequate	119 (38.6)	106 (37.6)	13 (50.0)		
Friction and shear				0.541	1.590 (0.359-7.039)
No problem[a]	35 (11.4)	33 (11.7)	2 (7.7)		
Problem and potential problem	273 (88.6)	249 (88.3)	24 (92.3)		
Mini-nutritional assessment (MNA) score					
Total MNA score (median [IQR])	8 (6.0-10.0)	8 (6.0-10.0)	8 (6.0-9.3)	0.584	0.960 (0.828-1.113)
Medication					
Sleep medication and tranquillisers[b]	180 (58.4)	165 (58.5)	15 (57.7)	0.935	0.967 (0.429-2.181)
Corticosteroids[b]	17 (5.5)	16 (5.7)	1 (3.8)	0.698	0.665 (0.085-5.225)
Comorbidities					
Paralysis[b]	45 (14.6)	43 (15.2)	2 (7.7)	0.308	0.463 (0.106-2.032)
Neurological disorders[b]	178 (57.8)	166 (58.9)	12 (46.2)	**0.213**	0.599 (0.267-1.342)
Heart and vascular disorders[b]	80 (26.0)	71 (25.2)	9 (34.6)	0.297	1.573 (0.671-3.687)

TABLE 2 (Continued)

Potential risk factor	Total (n = 308) n (valid %) Mean (SD) Median (IQR)	No PU (n = 282) n (valid %) Mean (SD) Median (IQR)	PU (n = 26) n (valid %) Mean (SD) Median (IQR)	P	OR (95% CI)
Diabetes[b]	49 (15.9)	44 (15.6)	5 (19.2)	0.629	1.288 (0.461-3.597)
Psychiatric disorders[b]	11 (3.6)	10 (3.5)	1 (3.8)	0.937	1.088 (0.134-8.850)
Preventive measures					
Repositioning in chair every 2 h[b]	21 (6.9)	20 (7.1)	1 (3.8)	0.493	0.488 (0.063-3.791)
Repositioning in bed every 4 h[b]	139 (45.4)	129 (45.1)	10 (38.5)	0.457	0.732 (0.321-1.668)
Use of support surface				**0.046**	0.414 (0.174-0.983)
Alternating pressure air mattress[a]	154 (50.0)	136 (48.2)	18 (69.2)		
Static air support surfaces	154 (50.0)	146 (51.8)	8 (30.8)		

PU, pressure ulcer category II-IV; IQR, interquartile range; OR (95% CI), odds ratio (95% confidence interval); Variable entered in the multiple binary logistic regression analysis ($P < 0.25$).
[a] Reference category
[b] Absence of the dichotomous variable is reference category

4 | DISCUSSION

The aim of this study was to identify independent risk factors for the development of PUs in high-risk NH residents who received evidence-based PU prevention. The results deliver important knowledge to tailor preventive care in a high-risk population. In this study, the presence of pressure area-related pain, non-blanchable erythema, and a lower Braden score were independent risk factors for the development of PUs category II to IV. The identified risk factors were in accordance with results from other studies.

The presence of non-blanchable erythema was the strongest risk factor of PU development. In residents with non-blanchable erythema, the odds of developing a PU category II to IV was four times as high as residents without non-blanchable erythema. Multiple studies confirmed that non-blanchable erythema was an independent risk factor.[4,15,17,36,37] Moreover, two high-quality studies indicated that the presence of non-blanchable erythema increases the odds of a PU category II by two- to threefold.[36,37] Non-blanchable erythema is the first pathological tissue reaction to pressure and/or shear forces in the top-to-bottom model. Prolonged pressure causes tissue deformation, occlusion of the capillaries, and local ischaemia. If ischaemia persists, red blood cell aggregation occurs in the capillaries. These blood cell aggregations can block the capillaries and, consequently, maintain ischaemia.[38] This process occurs in the papillary dermis and results in non-blanchable erythema.[38,39] If adequate preventive measures are not provided in a timely manner, non-blanchable erythema may deteriorate into a higher-category PU (PU category II-IV).[40,41] In addition, the findings of this study, and other studies considering preventive care when exploring risk factors, suggested that non-blanchable erythema is a significant risk factor, even when individuals receive preventive care.[17,42] Therefore, it is necessary to provide more strict preventive measures for individuals with non-blanchable erythema.[15] Because pressure relief is a crucial aspect of PU prevention, tailoring the repositioning care plan can be the first step to avoid deterioration of non-blanchable erythema.[13] Furthermore, a daily skin assessment is recommended to monitor the effectiveness of the current PU prevention strategies.[17]

The total Braden score was also found to be an independent risk factor for the development of PUs. Several studies confirmed that the total Braden score is significantly associated with PU development.[43–45] However, a subscale of a risk assessment tool emerged most frequently as an independent predictor in studies where both total score and subscales were included.[4] In this study, the Braden subscales "moisture" and "nutrition" were not entered in the multiple regression model because of multicollinearity with the total Braden score. Although the total Braden score was an independent risk factor for PU development in this study, the use of a risk assessment tool alone is inadequate to identify

TABLE 3 Multiple binary logistic regression

	Beta coefficient	Standard error	Wald	P	OR (95% CI)
Pressure area-related pain[a]	1.069	0.514	4.318	**0.038**	2.911 (1.063-7.977)
Non-blanchable erythema at baseline[a]	1.401	0.508	7.603	**0.006**	4.061 (1.500-10.995)
Total Braden score	−0.217	0.100	4.664	**0.031**	0.805 (0.661-0.980)
Use of support surface[b]	−0.762	0.460	2.744	0.098	0.467 (0.189-1.150)
Neurological disorders[a]	−0.558	0.447	1.728	0.189	0.555 (0.231-1.335)
Constant	0.531	1.307	0.165	0.684	1.700

OR (95% CI) = odds ratio (95% confidence interval). **Significant result ($P < 0.05$).**
[a] Absence of the dichotomous variable is reference category.
[b] Alternating pressure air mattress is reference category compared with static air mattress.

individuals at risk of PUs.[46–48] Furthermore, different studies demonstrated that the validity and accuracy of the Braden scale in long-term care is questionable.[49–51] In addition, a Cochrane review indicated that there is no reliable evidence that the use of a structured risk assessment tool reduces the development of new PUs.[48] It is therefore important that a risk assessment tool is combined with a clinical judgement and skin assessment to identify individuals at risk.[12,13] Moreover, there is no evidence that risk assessment scores can distinguish individuals who need more or less stringent preventive measures.[12] The risk factors identified in this study, however, can be helpful to tailor preventive measures to the needs of a high-risk individual.

Residents experiencing pressure area-related pain at baseline had a significantly higher risk of developing a PU compared with residents who had no pressure area-related pain at baseline. Multiple studies found that pain is associated with PUs because of the tissue damage and is worsened by repositioning, medical treatment, and inappropriate selection of wound dressings.[52–54] It is important to note that pain is not just a symptom of PUs but also a possible indicator of early tissue damage caused by pressure and/or shear forces.[10,55] A recent study confirmed that pressure area-related pain is an independent predictor for PU development in a high-risk population.[21] In addition, a systematic review concerning the quality of life in patients with PUs found that patients experienced pain at pressure areas before a PU was visible.[10] These findings highlight the need for a systematic pain assessment and treatment among individuals at risk of PU development. Furthermore, the presence of pressure area-related pain can also be used to monitor the effectiveness of PU prevention strategies. To evaluate if residents had pressure area-related pain, two questions can be asked with yes or no responses: (a) at any time, do you have pain, soreness, or discomfort at a pressure point (eg, back, bottom, heels, elbows)? and (b) do you think this is related to either your PU or pressure because of being in bed/chair for a long time[54,55]? To determine pain intensity, the use of a valid and reliable pain assessment tool is recommended.[13] However, the use of the two questions and a visual or numerical pain assessment tool are not feasible for use in residents with severe cognitive impairment. A variety of observational pain assessment tools, consisting of behavioural indicators of pain, were developed to identify pain in individuals with dementia or other cognitive impairments. However, a meta-review found that no one tool is more reliable and valid than another.[56] Therefore, caregivers are recommended to use a valid and reliable pain assessment tool in combination with a systematic risk assessment, including a thorough skin observation.

The analyses indicated that residents being allocated to a static air support surface had lower odds of developing a PU than residents being allocated to an alternating pressure air mattress. However, the odds ratio appeared not to be statistically significant ($P = 0.098$). This can be a result of a very small sample size.[57] This result indicates that a static air support surface provides possibly protection against PU development. Indeed, static air support surfaces were suggested to be more effective in PU prevention than standard hospital mattresses and pressure-redistributing foam mattresses.[58] Several studies comparing the effectiveness of static air support surfaces with high technology support surfaces (eg, alternating pressure air mattresses) did not, however, find significant differences in effectiveness between these two types of support surfaces.[58–62] As there is insufficient evidence about which pressure-redistributing support surface is superior over another, decisions about which support surface to use should be based on an assessment including the risk of PU development, comfort, and general health state of the individual.[12]

4.1 | Study limitations

This study was performed in 26 NHs in Belgium; thus, the results of this study can be seen as representative for a high-risk population in NHs. However, our results cannot be generalised to other populations (eg, hospitalised patients). Non-response bias was possible because of the voluntary participation of NHs and residents and voluntary informed consent of the representatives of cognitive-impaired residents. On the other hand, all eligible residents in the 26 NHs were included, which supported the representability of our results. Another limitation was the study period of 14 days. It was possible that this study period was too short to observe PU development in patients who were allocated to a static air support surface. Serraes and Beeckman found that the median time to develop a PU category II to IV was 16 days in patients at risk (Braden score ≤ 17) placed on a static air support surface.[14] The population of this study, however, consisted of high-risk patients (Braden score ≤ 12 and/or Braden subscale "mobility" ≤ 2). Because of the inclusion of a high-risk population, a study period of 14 days was determined. Furthermore, the final model explained only 16% of variance in PU development (Nagelkerke R^2 0.160). One possible explanation for this low explanatory power might be a very small sample size. On the other hand, there might be other risk factors explaining the development of PUs in a high-risk population that were not explored in this study. Other risk factors on organisational (eg, staff levels, staff turnover) and staff (eg, nurses' knowledge and attitudes) levels might have an influence on adequate PU prevention, resulting in a potential lower PU incidence.[63,64]

4.2 | Practice recommendations

The risk factors identified in this study can be used to tailor preventive measures according to the risk profile of an individual. Demarre et al suggested a stepped care model in

which preventive measures will be adapted in steps when an individual's risk profile is changing or if the current preventive care fails.[17] Based on the results of this study, the presence of non-blanchable erythema and/or pain at the pressure points indicates that the current preventive measures in a high-risk population are not sufficient. Consequently, tailoring the preventive measures is needed. In addition, a daily risk assessment, including a thorough skin observation and pain assessment, among high-risk individuals is recommended to monitor the effectiveness of the PU prevention strategy.

5 | CONCLUSION

Non-blanchable erythema, a lower Braden score, and pressure area-related pain were independent risk factors of PU development in high-risk residents receiving preventive care. These results highlight the importance of a daily risk assessment, including a skin assessment for the timely detection of non-blanchable erythema. Furthermore, systematic pain assessment at the pressure points and treatment are recommended among residents at high risk of PU development. However, further research is required to examine the effect of a systematic pain assessment at the pressure points on PU incidence. The use of the independent risk factors is useful to tailor preventive measures into a stricter PU prevention plan for high-risk residents. Tailoring preventive measures to the needs of an individual at risk will be an opportunity to reduce health care costs and PU incidence.

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CONFLICTS OF INTEREST

The authors have no conflicts of interest to report.

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