Adherence to Evidence-Based Pressure Injury Prevention Guidelines in Routine Clinical Practice: A Longitudinal Study

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Key Messages

- The aim of this longitudinal study was to describe adherence to evidence-based pressure injury prevention (PIP) guidelines in routine clinical practice in Australian hospitals; specifically the frequency and duration of use of nine PIP strategies.
- Of all patients, 165 (20.7%) received only 1 PIP strategy and 494 (61.8%) received ≥ 2 PIP strategies at some point during the study period.
- There was no statistical difference in proportion of time the *Not at risk*, *At risk* and *At high risk* groups received ≥ 1 and ≥ 2 strategies; on average this was less than half the time they were in the study.
- Patients in this study did not receive PIP strategies consistently throughout their admission although it is possible patients' risk changed over the study period.
- This is the first large, longitudinal study to document the frequency and duration of use of PIP strategies in patients at risk of pressure injuries.

Abstract

The aim of this longitudinal study was to describe adherence to evidence-based pressure injury prevention (PIP) guidelines in routine clinical practice in Australian hospitals. Data were analysed from four control sites in a larger cluster randomised trial of a PIP intervention. The sample of 799 patients included 220 (27.5%) *Not at risk*, 344 (43.1%) *At risk* and 110 (13.8%) *At high risk*. A total of 84 (10.5%) patients developed a PI during the study; 20 (9.0% of 220) in the *Not at risk* group, 45 (13.1% of 344) in the *At risk* group, 15 (13.6% of 110) in the *At high risk* group and 4 (3.2% of 125) patients who did not have a risk assessment completed. Of all patients, 165 (20.7%) received only one PIP strategy and 494 (61.8%) received ≥ 2 PIP strategies at some point during the study period. There was no statistical difference in proportion of time the three risk groups received ≥ 1 and ≥ 2 strategies; on average this was less than half the time they were in the study. Thus, patients were not receiving PIP strategies consistently throughout their hospital stay although it is possible patients' risk changed over the study period.

Keywords

Pressure ulcer, Adverse events, Prevention, Processes of care, Clinical practice guidelines

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Introduction

Prevention of pressure injuries (PIs) has become an international priority because of their frequency of occurrence and negative sequelae for individuals and their families as well as for the health system. In many countries PI prevalence in hospitals ranges from about 9 to 18% (1-4). Patients who develop PIs report pain, discomfort, restrictions on their social lives, and their quality of life in general is affected (5-9). On rare occasions, death can result from complications associated with PIs (9-11). The National Pressure Ulcer Advisory Panel, European Pressure Ulcer Advisory Panel and Pan Pacific Pressure Injury Alliance (12) note that yearly, PIs cost approximately \$US11 billion in the United States, £750 million in the United Kingdom and up to \$US2.8 billion in the Netherlands. One Australian study estimated PIs cost around \$983 million dollars per annum and consumed 524,661 additional bed days (13). Opportunity costs were valued at an additional AU\$820 million per annum, for a total combined cost of AU\$1.8 billion per annum (13). Further, in some Australian settings, financial penalties are imposed on hospitals when patients develop PIs (14) and in the US Medicare does not reimburse for PI treatment (15). In Australia, PI prevention and management is one of the ten National Safety and Quality Health Service Standards (16). Given PIs have negative outcomes for patients and place an economic burden on the healthcare system, PIP is a major healthcare priority.

International PIP guidelines describe recommended PIP strategies including (i) PI risk assessment of all patients, (ii) the use of pressure relieving measures such as regular repositioning, appropriate support surfaces and protection such as booties and elbow pads, (iii) good skin care including use of protective skin creams, (iv) adequate nutrition, and (v) patient education (12, 17). Yet globally, evidence from large multi-site studies demonstrates

implementation of PIP strategies is suboptimal at best. For example, in a Swedish study of 1,173 patients in five hospitals, only 40% of patients were risk assessed within 24 hours (18). For the 202 (20%) patients who were identified as at risk, less than 20% (n=39) of those had a PIP care plan and the most frequently used PIP strategy, pressure relieving foam mattresses, was used in less than 30% (n=342) of all patients (18). In a Norwegian study, 305 of 1,209 (25%) patients were identified as at risk of PI; 44% of those were provided with pressure redistributing support surfaces and 22% received planned repositioning (3). In another study of those patients who were identified as at risk, on average less than half received PIP strategies during their care (19). In fact, in one large Belgian study of almost 20,000 patients, only 10.8% of at risk patients received adequate PIP strategies (2). In another Belgian study of 2,105 patients in 94 randomly selected wards in 14 hospitals, 625 patients were identified as at risk but only 13.9% were found to have received adequate PIP (20). In the US, a retrospective analysis of data from 710,626 patients from 1,419 hospitals reported that of the 282,500 patients identified at risk of PI, 93% received PI risk assessment and a skin assessment within 24 hours of admission, but only 56-90% received PIP strategies (21).

In addition to these cross-sectional studies that have collected data at one point in time, a few small studies have undertaken a longitudinal approach. For example, one observational study of 241 at risk Australian patients in two hospitals collected data every 30 minutes for 24 hours on at risk patients and found only 30% had a fully completed risk assessment on admission (22). While 90% of these patients were repositioned regularly, only 11% had a chart note about patients receiving PIP education (22). In a German study 32 patients who were reported as high risk of developing a PI or who currently had a PI were observed during three nursing shifts (morning, afternoon and night) in a day (23). Only a third (n = 11) of patients in this study were risk assessed on admission and almost 90% (n = 28) had no skin assessment recorded. Repositioning occurred for just over 40% (n = 13) of

patients with a turning schedule used for 31% (n = 10) of patients (23). In another small study undertaken in Australia, 26 patients were observed six times over a 24 hour period (twice per 8-hour shift) (24). Over 90% (n = 24) of patients had a risk assessment completed and 39% (n = 10) had a formal PI management plan documented.

The current body of research shows that while PI risk assessment may occur during hospitalisation, implementation of appropriate PIP strategies does not always happen, which leads to a clear evidence-practice gap. However, most of the research has been either cross-sectional or retrospective in nature (8, 19, 21, 25) therefore, there is no way of knowing whether these ‘snapshots’ accurately reflect the PIP strategies patients receive throughout the duration of their hospital stay. There is a need to better understand PIP practices that occur beyond those observed at one point in time, on one day or those only recorded in the patients’ medical record.

Research aim

The aim of this longitudinal study was to describe adherence to evidence-based pressure injury prevention (PIP) guidelines in routine clinical practice in Australian hospitals; specifically the frequency of use and duration of nine specific PIP strategies. A secondary aim was to compare PIP strategy use across PI risk subgroups. Understanding current PIP practice identifies both areas of best practice and areas for improvement, and will help guide others to reduce the occurrence of PIs and to improve implementation of evidence based recommendations for the prevention and treatment of PIs.

Materials and Methods

This longitudinal study reports on an analysis of observational data collected between July 2014 and December 2014 from the control sites (i.e. routine care) in a larger cluster randomised trial of a PIP intervention (citation masked for blinded peer review).

Setting and Sample

This study was conducted in four acute care hospitals in two Australian states (Queensland and Victoria). All were metropolitan referral hospitals that catered for diverse adult patient populations and case-mix groups and offered acute medical, acute surgical and rehabilitative services. Of the four hospitals, one was private and three were public facilities, with a combined median of hospital beds of 659 (Interquartile Range IQR=20) and a range of 508-750 beds. All hospitals met the Australian National Safety and Quality Health Service Standard 8 (Preventing and Managing Pressure Injuries), and had documented PI governance structures and processes such as hospital-wide PI or wounds committees and PI policies and procedures (e.g. screening patients on admission and implementing PIP interventions where clinically indicated). They also provided PIP education in hospital orientation for new nursing graduates. Three sites used the Braden Risk Assessment Tool/Scale (26) and one site used the Waterlow Scale/Score (27) pressure injury risk assessment.

Patients were eligible for the study if they were: aged ≥ 18 years; had an expected hospital length of stay of ≥ 48 hours; at risk of PI as measured by limited mobility (i.e. requiring physical or mechanical assistance to reposition or ambulate); and able to read English and provide informed consent. Patients' hospital admission or current PI risk score was not an inclusion criterion. Patients were excluded if they were: admitted to hospital for >36 hours prior to recruitment; admitted as a day-only patient (e.g. day surgery and/or for infusions), admitted to critical care, emergency, maternity, paediatrics, mental health or dialysis; previous trial participants; or were receiving palliative or receiving end-of-life care. Patients reached the trial endpoint when they: developed a PI; were discharged from hospital; reached 28 days; were transferred to another hospital or to critical care requiring mechanical ventilation; or died. The sample for this analysis included patients in the control group, who received routine care only. Based on patients' admission risk assessment score determined by

hospital nursing (and not trial) staff, three subsamples were extracted from this sample: *Not at risk* of PI (Braden score >18 or Waterlow score <10); *At risk* of PI (Braden score 13-18 or Waterlow 10-14); and *At high risk* of PI (Braden 6-12 or Waterlow 15-64) (26, 27).

Data collection

Data collection was longitudinal, using observation, patient self-reporting and daily chart review during the study. Baseline patient demographic and clinical data, including diagnosis and PI risk assessment and other data related to PI risk factors such as body mass index and co-morbidities were collected immediately after recruitment from patients' medical records. After one day of training, research assistants undertook daily skin assessments until patients reached the trial endpoint. Data on nine evidence-based PIP strategies including documented repositioning regimen and nutrition care plan, use of six pressure relieving devices (i.e. pillows for heel elevation, air-mattresses, chair cushions, wedges, elbow/heel booties and other pressure relieving devices), and use of skin care products for PIP, such as barrier creams, were also collected daily using observation and/or chart review. At or near the trial endpoint, patients were asked a series of questions about the assistance they received in relation to five PIP strategies (education on PIP, help to reposition, help with skin care, nutritional needs identifies and help to meet nutritional needs). All data were entered directly into a web-based electronic case record form using tablet computers. Data collection occurred from July, 2014 to December, 2014.

Ethical considerations

The trial was registered with the Australian New Zealand Clinical Trials Registry (registration number ACTRN # masked for peer review) and received a human research ethics committee approval from the hospitals and university. All participants were given a

verbal outline of the study, a study information sheet and provided written consent to participate.

Statistics

Data was exported from the trial study database and analysed using IBM SPSS Statistics (V.22) and StataCorp Stata Statistics/Data Analysis (V.13.1) (StataCorp LP, College Station, TX, USA). To examine sample characteristics and the use of PIP strategies, frequency and percentages for categorical variables and, depending on the data distribution, means and standard deviations or medians and IQR for continuous variables were calculated. Cluster (hospital) adjusted chi-square tests were used to compare implementation of each strategy between the three risk groups stratified by the baseline PI risk levels. Cluster (hospital) adjusted chi-square tests were also used to compare patients' perceptions of assistance between the three risk groups stratified by the baseline PI risk levels.

To examine whether the total number of PIP strategies differed between risk groups, the total number of PIP strategies received was computed for all patients and using mixed models analysis, with risk group as the fixed effect and hospital intercept as the random effect (to account for cluster). The data was then analysed to calculate the number of days patients in each risk group received each PIP strategy, divided by the number of days they were in the trial, resulting in the proportion of time patients in each subsample received each strategy. Risk group differences for this computed variable were also compared using a mixed models design.

Both computed dependent variables (number of PIP strategies received and proportion of time patients in each subsample received each strategy) were examined using a linear mixed effects model to account for the within-subjects nature of the trial, the unbalanced group data and the effect of cluster (hospital), using the mixed procedure in SPSS (28). All

models used risk group (*Not at risk*, *At risk* and *At high risk*) as the fixed categorical effect and used random effects for the intercept and hospital (4 levels) (29, 30). Though multiple covariance structures were tested, the best fitting models used scaled identity and maximum likelihood estimation methods, with convergence achieved within 100 iterations and 10 step-halvings. For significant fixed effects found, pairwise comparisons using marginal means compared risk group differences using a Bonferroni adjustment for multiple comparisons to control for Type 1 error. P values <0.05 were considered significant.

Finally, as using multiple strategies to help prevent PIs is a clinical practice guideline recommendation (12), box and whisker plots are used for visual understanding and descriptive comparisons between the 3 risk group's average proportion (%) of time (days) patients received at least 1 and ≥ 2 PIP strategies during the trial.

Results

Of 800 patients recruited to the control group, 799 patients' data were analysed as one patient was incorrectly recruited. Patients were mostly from medical and surgical wards at each site. Data was collected for 4 months and 28 days (151 days), which reflects a total of 523 study days across all four sites. Based on their initial PI risk assessment completed by hospital nurses, the *Not at risk* subsample size was 220 (27.5%); the *At risk* subsample size was 344 (43.1%); and the *At high risk* subsample size was 110 (13.8%). There were 125 (15.6%) patients who did not have a risk assessment completed on admission so were excluded from analyses that examined subgroup differences. Patient characteristics are provided in Table 1. A total of 84 (10.5%) patients developed a PI during the study; 20 (9.0% of 220) in the *Not at risk* group, 45 (13.1% of 344) in the *At risk* group, 15 (13.6% of 110) in the *At high risk* group and 4 (3.2% of 125) patients who did not have a risk assessment completed.

The various PIP strategies used at least once during the study period are outlined in Table 2. Almost two thirds of the sample had a repositioning schedule implemented and about half had some form of support surface/pressure relieving device. There were no statistically significant differences in the use of these two strategies by risk group, however more pillows for heel elevation were used in the *At high risk* group. About half the sample received some form of special skin care (e.g. barrier creams) to prevent PI, but only about a quarter of the sample had a nutritional care plan implemented.

Of all patients, 165 (20.7%) received only one PIP strategy and 494 (61.8%) received ≥ 2 PIP strategies at some point during the study period (Table 2). There were 140 (17.5%) patients who received no PIP strategies during the study period including 49 (14.2%) who were *At risk* and 11 (10.0%) who were assessed as *At high risk* of PI. Approximately 86% of patients identified as *At risk*, or *At high risk* of PI ($n=394$) received ≥ 1 PIP strategy at some point during the study period (see Table 2 for full group summaries). Using the patient sample of those who received a risk assessment at admission ($n=674$), a linear mixed model analysis was conducted. The intraclass correlation (ICC) was used to explore the clustering effect of hospital. The ICC for hospital was 0.09, indicating that only 9% of the total variability in the number of PIP strategies received was attributable to differences between hospitals. Due to ICC size, removal from the model was considered, however subsequent analyses without the hospital variable led to a poorer model fit and hence it was retained (-2 Log Likelihood=2055.6). The final model showed significant fixed effects, that is, significant risk group differences in the total number of PIP strategies patients received at some point during the study were found ($F[2, 28.2] = 15.5, p < .001$). Pairwise comparisons between group levels with a Bonferroni correction, show all risk group marginal means were significantly different from one another ($p < .001$). That is, patients who were *At high risk* received, on average, more PIP strategies ($m=3.5, std\ error = 0.2$ [95% CI 3.1-3.9]) when

compared to the *At risk* ($m=2.8$, $std\ error=0.1$ [95% CI 2.6-3.1]) and those *Not at risk* ($m=2.3$, $std\ error=0.1$ [95% CI 2.1-2.6]), who received on average the least number of PIP strategies.

Additionally, a linear mixed model analysis was conducted to examine risk group differences in the proportion of time patients received PIP strategies during the study. The ICC for hospital was 0.23, indicating that approximately 23% of the total variability in the proportion of PIP strategies received for patients occurs between hospitals. The final model (-2 Log Likelihood =4909.5) found no significant risk group effect ($F [2, 16.0] = 1.1$, $p = .366$) for patients who received ≥ 1 PIP strategy ($n=558$). Consistent findings are reported for patients who received multiple (≥ 2) PIP strategies ($n=416$); no significant differences between risk groups were found ($F [2, 15.6] = 0.8$, $p = .470$). That is, patients' average proportion of time implemented PIP strategies were received was similar across the three risk groups. It was also noted that only 33 patients (4.1% of 799), received their implemented PIP strategies 100% of the time they were in the study.

Due to these results, risk group distributions were examined. Figures 1 and 2 visually depicts the average proportion (%) of time (days) patients received ≥ 1 and ≥ 2 PIP strategies during the study. The box represents the upper and lower quartiles, the line in the box representing the median and the whiskers representing the range of data, with outliers depicted as dots. Of the 558 patients in the three risk groups who received ≥ 1 strategy, the 164 *Not at risk* patients had a median of 40% (IQR 30-57%), the 295 *At risk* patients a median of 50% (IQR 33-67%) and the 99 *At high risk* patients a median of 44% (IQR 33-60%). Of the 416 patients in the three risk groups who received ≥ 2 strategies, the 105 *Not at risk* patients had a median of 42% (IQR 30-57%), the 227 *At risk* patients a median of 50% (IQR 37-63%) and the 84 *At high risk* patients a median of 42% (IQR 33-56%). Regardless of risk rating, all groups showed a similar trend in the proportion of time the PIP strategies were received. The majority (75%) of all risk assessed patients received their implemented PIP

strategies 63% or less of the time while observed during the trial. However, on average this was less than half the time they were in the study.

Patients' perceptions of the assistance they received with their PIP care is summarised in Table 3. On average, about 60% of the patients reported receiving adequate assistance in repositioning and skin care, had their nutritional needs identified and received adequate support in meeting those needs. Just over a third of patients reported receiving education on PIP. The pooled chi-square adjustment for each strategy found that the groups did not differ. The cluster adjusted *p*-values of the chi-squares are also provided in Table 3.

Discussion

The results of this study provide a better understanding of the use of PIP strategies in routine clinical practice, both in terms of frequency and duration of use. About 10% of patients developed a PI during the study. Just over 60% of patients received ≥ 2 PIP strategies at some point during the study. We found that the use of PIP strategies at some point in the study was positively associated with risk group assessment, but, when considering the duration of time patients received PIP strategies, there was no difference between risk groups. That is, patients from all three risk groups received their implemented PIP strategies a median of 50% or less of the time they were in the study.

The Australian National Safety and Quality Health Service Standards (16) mandate PI risk assessment on admission, yet this did not occur for about 15% of patients. The reason for suboptimal PI risk assessment is unknown. However, previous research suggests several factors influence completion of PI risk assessment tools. First, adequacy of knowledge (31, 32) and limited training in use of PI screening tools (33) may affect nurses' completion of PIP risk assessment tools. Second, nurses consider some patient characteristics more important than others in predicting PI risk factors, which may influence whether or not a risk

assessment is performed (34). Third, the large number of other assessments tools required to be completed by nurses and duplications of information contained within these tools may overburden nurses (35). Finally, the extent to which risk scores accurately predict patients who will develop a PI, and their benefit over clinical judgement has been questioned (36-38). Thus, there are likely a multitude of reasons why PI risk assessments are not completed.

Implementation of a repositioning schedule was the most predominant PIP strategy used across all subgroups. Previous researchers have also shown that repositioning and mobilisation are often the most frequently used PIP strategies in practice (12, 21, 39-41). Yet, the most recent Cochrane review examining empirical support of repositioning highlights that there is still uncertainty for the ideal frequency and positioning to help prevent PIs (40). Perhaps such an ideal does not exist, with a better approach of tailoring repositioning regimes to individual patient circumstances.

Use of pressure relieving support surfaces or devices was another frequently used PIP strategy across all subgroups. Support surfaces alone do not prevent PIs; instead they are recommended for patients who have been identified as at risk of developing PIs in conjunction with an appropriate PIP plan (12, 42). The recently updated Cochrane review by McInnes et al. (42) found that when compared to standard hospital foam mattresses, use of alternative foam mattresses may decrease PI development in patients at risk. However, insufficient evidence was found to determine the value of seat cushions and other constant low pressure devices as effective PIP strategies (42).

When considering other PIP strategies that were implemented, lower numbers of patients across all subgroups received a nutritional care plan (23, 43). This finding is consistent with a much smaller German study, that found assessment and recording of nutritional status was infrequently undertaken (23). Malnutrition in hospitals is a well-

documented phenomenon (44-46) and its prevention relies on a multidisciplinary approach, with the team often implementing multiple strategies (47-49). Given this and the association between malnutrition and PI (50-52), it is likely a multifaceted intervention will be required to improve nutritional practices for all patients, including those who are at risk of PI.

When we asked, less than 40% of patients stated they received education on PIP. Educating patients and their families' about PIs supports shared decision making in patient care and increases patient participation, which may lead to improved patient satisfaction and safety, and decreases in adverse events and hospital length of stay (9, 53, 54). Educating patients is important as patients are an untapped source of assistance in their own care. For example, patients and family can assist in detecting PIs, initiate prevention strategies and be aware of detrimental practices such as aggressive massaging and or rubbing of bony prominences (55), which can lead to shared responsibility of care (56). Yet, our study is only one of several that have documented limited PIP patient education. For example in an Australian study that examined PIP strategies a cohort of 241 patients from two large metropolitan hospitals found that only 11% of charts had documented evidence of PIP education (22). In another smaller Australian study (n=26) only 2 patients (or their caregivers) received PIP education (19). Moore et al. (19) reported that patient education was adopted the poorest of all PIP strategies with only 4 of 180 Norwegian and Irish patients receiving this strategy. Hoviattalab et al. (23) report similar results in their small German study (n=36) where patient education was not received at all. Yet, by being informed, patients and families can better participate in their own care, as was found in a small Swedish study examining the effect of a PI information pamphlet on patients' participation in PIP (57). Patients who participate in their care are safer, have a decreased risk of errors and adverse events, and enhanced perceptions of the quality of care (58, 59). Thus, once educated, patients who have a vested interest in PIP may be an additional resource in the combat of PIs.

This study is the first to our knowledge to identify both the numbers and the frequency (i.e. duration) of use of PIP strategies. We found that there was little difference in the proportion of time patients of various risk groups (*Not at risk*, *At risk* and *At high risk*) received any PIP strategies. In fact, when considering the proportion of time they received these strategies, it was evident that it was most common for the three groups to receive ≥ 1 and ≥ 2 strategies $\leq 50\%$ of the time. We did not collect daily risk scores; therefore we do not know if a change in patient risk influenced these findings, thus this is one possible reason for our findings. Another possible reason relates to nursing culture and local practices. For example, one study conducted in Belgium, found nurse's attitudes towards PIs was associated with the implementation of PIP strategies (20). Other studies identify nurses' knowledge influences their practice (32).

Less than 5% of patients received their implemented PIP strategies 100% of the time they were in the study. Yet, two systematic reviews of PIP programs (reflecting multiple strategies aimed at multiple levels of the organisation) have shown beneficial effects, although the quality of the primary research reviewed was a major limitation in both reviews (60, 61). For example, most of the 39 quality improvement studies in one review involved multiple interventions and had positive outcomes; however none of these studies were randomised trials (60). Also, most of the programs in these two reviews were comprehensive, and did not focus only on PIP strategies aimed at individual patients but on organisational practices, thus our findings are not directly comparable to these systematic review findings.

Limitations

There are a number of limitations to this study. First, while it is one of only a few longitudinal studies, we only collected data once per day and relied on documentation and observation for some PIP strategies such as a repositioning routine. It is possible that some

strategies were missed; however we also asked patients if they had received assistance with these various strategies. Second, data was only available for patients' initial risk score, which may have changed during their hospitalisation. It would be expected that as PI risk changes, so might the strategies nurses use. Third, we do not have any information on the extent to which specific PIP strategies were required for patients nor do we know why some patients received or did not receive each strategy. Thus, while this is the first study to examine both the frequency and duration of use of PIP strategies throughout hospital admission to the best of our knowledge, we cannot determine the extent to which these strategies were appropriate. However, international guidelines recommend the use of multiple strategies (12) and given our sample all had limited mobility, it is plausible that more patients should have received ≥ 2 strategies more often than less than half of the time they were in the study.

In conclusion, this longitudinal study documented the daily use of PIP strategies during routine clinical practice in four Australian hospitals. It showed repositioning regimes and some form of support surface/pressure relieving devices were the most frequently used PIP strategies but in general, PIP strategies were used less than half the time patients were in the study. A better understanding of why PIP strategies are not used consistently may help to identify and tailor future interventions focusing on ensuring evidence-based guidelines are used consistently throughout patients' hospital stay.

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References

1. Gunningberg L, Hommel A, Bååth C, Idvall E. The first national pressure ulcer prevalence survey in county council and municipality settings in Sweden. *J Eval Clin Pract* 2013;**19**:862–7.
2. Vanderwee K, Defloor T, Beeckman D, Demarre L, Verhaeghe S, Van Durme T, et al. Assessing the adequacy of pressure ulcer prevention in hospitals: a nationwide prevalence survey. *BMJ Qual Saf* 2011;**20**:260–7.
3. Bredesen I, Bjørø K, Gunningberg L, Hofoss D. The prevalence, prevention and multilevel variance of pressure ulcers in Norwegian hospitals: a cross-sectional study. *Int J Nurs Stud* 2015;**52**:149–56.
4. Brito P, de Vasconcelos Generoso S, Correia M. Prevalence of pressure ulcers in hospitals in Brazil and association with nutritional status - a multicenter, cross-sectional study. *Nutr* 2013;**29**:646–9.
5. Fox C. Living with a pressure ulcer: a descriptive study of patients' experiences. *Br J Community Nurs* 2002;**7**:10–22.
6. Gorecki C, Closs S, Nixon J, Briggs M. Patient-reported pressure ulcer pain: a mixed-methods systematic review. *J Pain Symptom Manage* 2011;**42**:443–59.
7. Gorecki C, Brown J, Nelson E, Briggs M, Schoonhoven L, Dealey C, et al. Impact of pressure ulcers on quality of life in older patients: a systematic review. *J Am Geriatr Soc* 2009;**57**:1175–83.
8. Barker A, Kamar J, Tyndall T, White L, Hutchinson A, Klopfer N, et al. Implementation of pressure ulcer prevention best practice recommendations in acute care: an observational study. *Int Wound J* 2013;**10**:313–20.
9. Latimer S, Chaboyer W, Gillespie B. Patient participation in pressure injury prevention: giving patient's a voice. *Scand J Caring Sci* 2014;**28**:648–56.
10. Essex H, Clark M, Sims J, Warriner A, Cullum N. Health-related quality of life in hospital inpatients with pressure ulceration: Assessment using generic health-related quality of life measures. *Wound Repair Regen* 2009;**17**:797–805.
11. Redelings M, Lee N, Sorvillo F. Pressure ulcers: more lethal than we thought? *Adv Skin Wound Care* 2005;**18**:367–72.
12. National Pressure Ulcer Advisory Panel, European Pressure Ulcer Advisory Panel, Alliance PPPI. Prevention and Treatment of Pressure Ulcers: Clinical Practice Guideline. Emily Haesler (Ed.). Osborne Park, Western Australia: Cambridge Media; 2014.
13. Nguyen K, Chaboyer W, Whitty J. Pressure injury in Australian public hospitals: a cost-of-illness study. *Aust Health Rev* 2015;**39**:329–36.
14. Miles S, Fulbrook P, Nowicki T, Franks C. Decreasing pressure injury prevalence in an Australian general hospital: a 10-year review. *Wound Prac & Res* 2013;**21**:148–56.
15. Rosenthal M. Nonpayment for performance? Medicare's new reimbursement rule. *N Engl J Med* 2007;**357**:1573–5.
16. Australian Commission on Safety and Quality in Health Care. National Safety and Quality Health Service Standards. Sydney; 2011.
17. Australian Wound Management Association. Pan Pacific Clinical Practice Guideline for the prevention and management of pressure injury. Osborne Park, WA; 2012.
18. Gunningberg L, Stotts N, Idvall E. Hospital-acquired pressure ulcers in two Swedish County Councils: cross-sectional data as the foundation for future quality improvement. *Int Wound J* 2011;**8**:465–73.

19. Moore Z, Johansen E, van Etten M, Strapp H, Solbakken T, Smith B, et al. Pressure ulcer prevalence and prevention practices: a cross-sectional comparative survey in Norway and Ireland. *J Wound Care* 2015;**24**:333 –9.
20. Beeckman D, Defloor T, Schoonhoven L, Vanderwee K. Knowledge and attitudes of nurses on pressure ulcer prevention: a cross-sectional multicenter study in Belgian hospitals. *Worldviews Evid Based Nurs* 2011;**8**:166 –76.
21. Bergquist-Beringer S, Dong L, He J, Dunton N. Pressure ulcers and prevention among acute care hospitals in the United States. *Jt Comm J Qual Saf* 2013;**39**:404 –14.
22. Latimer S, Chaboyer W, Gillespie B. Pressure injury prevention strategies in acute medical inpatients: an observational study. *Contemp Nurse* 2016;**52**:326 –40.
23. Hoviattalab K, Hashemizadeh H, D'Cruz G, Halfens R, Dassen T. Nursing practice in the prevention of pressure ulcers: an observational study of German Hospitals. *J Clin Nurs* 2015;**24**:1513 –24.
24. McInnes E, Chaboyer W, Allen T, Murray E, Webber L. Acute care patient mobility patterns and documented pressure injury prevention-an observational study and survey. *Wound Prac & Res* 2013;**21**:116 –8.
25. Balzer K, Kottner J. Evidence-based practices in pressure ulcer prevention: Lost in implementation? *Int J Nurs Stud* 2015;**52**:1655 –8.
26. Braden B, Maklebust J. Preventing pressure ulcers with the Braden scale: an update on this easy-to-use tool that assesses a patient's risk. *Am J Nurs* 2005;**105**:70 –2.
27. Waterlow J. From costly treatment to cost-effective prevention: using Waterlow. *Br J Community Nurs* 2005;**10**:S25 –S30.
28. Verbeke G, Molenberghs G. Linear mixed models for longitudinal data. *Springer Science & Business Media*; 2009.
29. Wolfinger R. Covariance structure selection in general mixed models. *Com in stats-Sim & comp* 1993;**22**:1079 –106.
30. Judd C, Westfall J, Kenny D. Treating stimuli as a random factor in social psychology: a new and comprehensive solution to a pervasive but largely ignored problem. *J Pers Soc Psychol* 2012;**103**:54 –69.
31. Gunningberg L, Martensson G, Mamhidir A, Florin J, Muntlin Athlin A, Baath C. Pressure ulcer knowledge of registered nurses, assistant nurses and student nurses: a descriptive, comparative multicentre study in Sweden. *Int Wound J* 2015;**12**:462 –8.
32. Sutherland-Fraser S, McInnes E, Maher E, Middleton S. Peri-operative nurses' knowledge and reported practice of pressure injury risk assessment and prevention: A before-after intervention study. *BMC Nurs* 2012;**11**:25 –30.
33. López M, Jiménez J, Peña I, Cao M, Simarro M, Castro M. Ongoing nursing training influence on the completion of electronic pressure ulcer records. *Nurse Educ Today* 2017;**52**:22 –7.
34. Balzer K, Kremer L, Junghans A, Halfens R, Dassen T, Kottner J. What patient characteristics guide nurses' clinical judgement on pressure ulcer risk? A mixed methods study. *Int J Nurs Stud* 2014;**51**:703 –16.
35. Redley B, Raggatt M. Use of standard risk screening and assessment forms to prevent harm to older people in Australian hospitals: a mixed methods study. *BMJ Qual Saf* 2017;**10**:1 –11.
36. Moore Z, Cowman S. Risk assessment tools for the prevention of pressure ulcers. *Cochrane Database Syst Rev* 2014;**2**.
37. Chou R, Dana T, Bougatsos C, Blazina I, Starmer A, Reitel K, et al. Pressure ulcer risk assessment and prevention: a systematic comparative effectiveness review. *Ann Intern Med* 2013;**159**:28 –38.

38. Webster J, Coleman K, Mudge A, Marquart L, Gardner G, Stankiewicz M, et al. Pressure ulcers: effectiveness of risk-assessment tools. A randomised controlled trial (the ULCER trial). *BMJ Qual Saf* 2011;**20**:297 –306.
39. Latimer S, Chaboyer W, Gillespie B. The repositioning of hospitalized patients with reduced mobility: a prospective study. *Nurs Open* 2015;**2**:85 –93.
40. Gillespie B, Chaboyer W, McInnes E, Kent B, Whitty J, Thalib L. Repositioning for pressure ulcer prevention in adults. *Cochrane Database Syst Rev* 2014; **7**.
41. Moore Z, Cowman S, Conroy R. A randomised controlled clinical trial of repositioning, using the 30 tilt, for the prevention of pressure ulcers. *J Clin Nurs* 2011;**20**:2633 –44.
42. McInnes E, Jammali-Blasi A, Bell-Syer S, Dumville J, Middleton V, Cullum N. Support surfaces for pressure ulcer prevention. *Cochrane Database Syst Rev* 2015;**9**.
43. Langer G, Fink A. Nutritional interventions for preventing and treating pressure ulcers. *Cochrane Database Syst Rev* 2014; **6**.
44. Agarwal E, Ferguson M, Banks M, Bauer J, Capra S, Isenring E. Nutritional status and dietary intake of acute care patients: results from the Nutrition Care Day Survey 2010. *Clin Nutr* 2012;**31**:41 –7.
45. Barker L, Gout B, Crowe T. Hospital malnutrition: prevalence, identification and impact on patients and the healthcare system. *Int J Environ Res Public Health* 2011;**8**:514 –27.
46. Ray S, Laur C, Golubic R. Malnutrition in healthcare institutions: a review of the prevalence of under-nutrition in hospitals and care homes since 1994 in England. *Clin Nutr* 2014;**33**:829 –35.
47. Bell J, Bauer J, Capra S, Pule R. Multidisciplinary, multi-modal nutritional care in acute hip fracture inpatients-results of a pragmatic intervention. *Clin Nutr* 2014;**33**:1101 –7.
48. Ross L, Mudge A, Young A, Banks M. Everyone's problem but nobody's job: staff perceptions and explanations for poor nutritional intake in older medical patients. *Nutr Diet* 2011;**68**:41 –6.
49. Tappenden K, Quatrara B, Parkhurst M, Malone A, Fanjiang G, Ziegler T. Critical role of nutrition in improving quality of care: an interdisciplinary call to action to address adult hospital malnutrition. *J Acad Nutr Diet*. 2013;**113**:1219 –37.
50. Banks M, Bauer J, Graves N, Ash S. Malnutrition and pressure ulcer risk in adults in Australian health care facilities. *Nutr* 2010;**26**:896 –901.
51. Hengsternmann S, Fischer A, Steinhagen-Thiessen E, Schulz R. Nutrition status and pressure ulcer: what we need for nutrition screening. *J Parenter Enteral Nutr* 2007;**31**:288–94.
52. Iizaka S, Okuwa M, Sugama J, Sanada H. The impact of malnutrition and nutrition-related factors on the development and severity of pressure ulcers in older patients receiving home care. *Clin Nutr* 2010;**29**:47 –53.
53. Sahlsten M, Larsson I, Sjöström B, Plos K. An analysis of the concept of patient participation. *Nurs Forum* 2008;**43**:2 –11.
54. Snyder H, Engström J. The antecedents, forms and consequences of patient involvement: a narrative review of the literature. *Int J Nurs Stud* 2016;**53**:351 –78.
55. Mallah Z, Nassar N, Kurdahi Badr L. The effectiveness of a pressure ulcer intervention program on the prevalence of hospital acquired pressure ulcers: controlled before and after study. *Appl Nurs Res* 2015;**28**:106 –13.
56. Armstrong D. New opportunities to improve pressure ulcer prevention and treatment: implications of the CMS inpatient hospital care present on admission indicators/hospital-acquired conditions policy: a consensus paper from the

- International Expert Wound Care Advisory Panel. *Adv Skin Wound Care* 2008;**21**:469–78.
57. Schoeps L, Tallberg A, Gunningberg L. Patients' knowledge of and participation in preventing pressure ulcers—an intervention study. *Int Wound J* 2017;**14**:344–8.
 58. Doyle C, Lennox L, Bell D. A systematic review of evidence on the links between patient experience and clinical safety and effectiveness. *BMJ open* 2013;**3**.
 59. Weingart S, Zhu J, Chiappetta L, Stuver S, Schneider E, Epstein A, et al. Hospitalized patients' participation and its impact on quality of care and patient safety. *Int J Qual Health Care* 2011;**23**:269–77.
 60. Soban L, Hempel S, Munjas B, Miles J, Rubenstein L. Preventing pressure ulcers in hospitals: a systematic review of nurse-focused quality improvement interventions. *Jt Comm J Qual Saf* 2011;**37**:245–52.
 61. Niederhauser A, Lukas C, Parker V, Ayello E, Zulkowski K, Berlowitz D. Comprehensive programs for preventing pressure ulcers: a review of the literature. *Adv Skin Wound Care* 2012;**25**:167–88.

Table 1: Patient Characteristics

Characteristic	Total Sample N=799	<i>Not at risk</i> Subsample n=220 (27.5%)	<i>At risk</i> Subsample n=344 (43.1%)	<i>At high risk</i> Subsample n=110 (13.8%)
Gender				
Male	365 (45.7)	114 (51.8)	149 (43.3)	49 (44.5)
Age (years)				
Median IQR	74.0 (22.0)	73.0 (24.0)	74.0 (22.0)	76.0 (19.0)
Range	19-104	21-104	19-100	36-97
Admission type n (%)				
Surgical	463 (57.9)	117 (53.2)	206 (59.9)	62 (56.4)
Medical	316 (39.5)	93 (43.3)	132 (38.4)	47 (42.7)
Cancer	20 (2.5)	10 (4.5)	6 (1.7)	1 (0.9)
BMI range n (%)				
Obese	259 (32.4)	80 (36.3)	111 (32.3)	38 (34.6)
Overweight	266 (33.3)	69 (31.4)	120 (34.9)	32 (29.1)
Healthy weight	247 (30.9)	67 (30.5)	104 (30.2)	31 (28.2)
Underweight	27 (3.4)	4 (1.8)	9 (2.6)	9 (8.2)
Comorbidities per patient n (%)				
0	193 (24.2)	42 (19.1)	83 (24.1)	33 (30.0)
1	232 (29.0)	59 (26.8)	107 (31.1)	25 (22.7)
2	193 (24.2)	66 (30.0)	77 (22.4)	27 (24.5)
3	125 (15.6)	35 (15.9)	54 (15.7)	20 (18.2)
≥4	56 (7.0)	18 (8.3)	23 (6.7)	5 (4.5)
Hospital length of stay (days)				
Median (IQR)	6.0 (5.0)	5.0 (4.0)	6.0 (4.0)	7.0 (4.0)
Range	1-84	2-34	1-84	2-36
Time in study (days)				
Median (IQR)	5 (4.0)	4.0 (3.0)	5.0 (4.0)	5.0 (4)
Range	1-29	1-21	1-28	1-15
Risk assessment at admission n (%)				
Completed	674 (84.4)	220 (100.0)	344 (100.0)	110 (100.0)
Not administered	125 (15.6)	0 (0.0)	0 (0.0)	0 (0.0)
Risk assessment tool used n (%)				
Braden	530 (66.3)	196 (89.1)	301 (87.5)	33 (30.0)
Waterlow	144 (18.0)	24 (10.9)	43 (12.5)	77 (70.0)
PI at baseline n (%)	95 (11.9)	20 (9.1)	56 (16.3)	9 (8.2)
PI obtained during study n (%)	84 (10.5)	20 (9.1)	45 (13.1)	15 (13.6)

Note. IQR=interquartile range, BMI=body mass index, PI=pressure injury

Table 2: Summary of Pressure Injury Prevention Strategies

Pressure Injury Prevention Strategy	Total Sample n = 799 n (%)	<i>Not at risk</i> Subsample n=220 n (%)	<i>At risk</i> Subsample n=344 n (%)	<i>At high risk</i> Subsample n=110 n (%)	Cluster adjusted χ^2 <i>p</i>
Repositioning schedule implemented	512 (64.0)	120 (54.5)	232 (67.4)	74 (67.3)	0.839
Any support surface/pressure relieving device	418 (52.3)	80 (36.4)	176 (51.2)	91 (82.7)	0.243
Pillow for heel elevation used	232 (29.0)	44 (20.0)	102 (29.7)	42 (38.2)	0.001
Air mattress used	197 (24.7)	24 (10.9)	68 (19.8)	64 (58.2)	0.362
Chair cushion used	90 (11.3)	17 (7.7)	30 (8.7)	23 (20.9)	0.557
Wedge used	81 (10.1)	20 (9.1)	37 (10.8)	11 (10.0)	0.988
Elbow/heel bootie used	54 (6.8)	9 (4.1)	13 (3.8)	20 (18.2)	0.492
Other pressure relieving device used	136 (17.0)	22 (10.0)	70 (20.3)	25 (22.7)	0.521
Special skin care to prevent PIs	386 (48.2)	83 (37.7)	194 (56.4)	49 (44.5)	0.757
Nutritional care plan implemented	201 (25.1)	43 (19.5)	92 (26.7)	43 (39.1)	0.826
^a N (%) patients with 1 PIP strategy	165 (20.7)	59 (26.8)	68 (19.8)	15 (13.6)	0.113
^a N (%) patients with 2 PIP strategies	149 (18.6)	45 (20.5)	68 (19.8)	16 (14.5)	0.453
^a N (%) patients ≥ 3 PIP strategies	345 (43.1)	60 (27.3)	159 (46.2)	68 (61.8)	0.173
Total N (%) patient who received ≥ 1 PIP strategy	659 (82.5)	164 (74.5)	295 (85.8)	99 (90.0)	0.610

^a number of patients who received Pressure Injury Prevention (PIP) strategies at some point during the study

Table 3: Patients' Reported Assistance with Pressure Injury Prevention Care

Pressure Injury Prevention Strategy	Total Sample n = 799 n (%)	Not at risk Subsample n=220 n (%)	At risk Subsample n=344 n (%)	At high risk Subsample n=110 n (%)	Cluster adjusted χ^2 p
Received adequate help to reposition	506 (63.3)	146 (66.4)	222 (64.5)	63 (57.3)	0.999
Received adequate help for skin care	477 (59.7)	128 (58.2)	213 (61.9)	62 (56.4)	0.992
Nutritional needs were identified	455 (57.0)	127 (57.7)	197 (57.3)	60 (54.4)	0.998
Received adequate help to meet nutritional needs	477 (59.7)	129 (58.6)	209 (60.8)	66 (60.0)	0.998
Received education on pressure injury prevention	293 (36.7)	80 (36.4)	136 (39.5)	38 (34.5)	0.997

Figure 1. Box plot with whiskers from minimum to maximum displaying the proportion of time the three risk groups received ≥ 1 PIP strategies in the study (n= 558)

Figure 2: Box plot with whiskers from minimum to maximum displaying the proportion of time the three risk groups received ≥ 2 PIP strategies in the study (n= 416)