

ORIGINAL ARTICLE

Implementation of pressure ulcer prevention best practice recommendations in acute care: an observational study

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Key words

Best practice guidelines; Pressure ulcer; Prevention strategies; Risk assessment tool

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Abstract

Pressure ulcers are a common but preventable problem in hospitals. Implementation of best practice guideline recommendations can prevent ulcers from occurring. This 9-year cohort study reports prevalence data from point prevalence surveys during the observation period, and three practice metrics to assess implementation of best practice guideline recommendations: (i) nurse compliance with use of a validated pressure ulcer risk assessment and intervention checklist; (ii) accuracy of risk assessment scoring in usual-care nurses and experienced injury prevention nurses; and (iii) use of pressure ulcer prevention strategies. The prevalence of hospital-acquired pressure ulcers decreased following implementation of an evidence-based prevention programme from 12.6% (2 years preprogramme implementation) to 2.6% (6 years postprogramme implementation) ($P < 0.001$). Audits between 2003 and 2011 of 4368 patient medical records identified compliance with pressure ulcer prevention documentation according to best practice guidelines was high (>84%). A sample of 270 patients formed the sample for the study of risk assessment scoring accuracy and use of prevention strategies. It was found usual-care nurses underestimated patients' risk of pressure ulcer development and under-utilised prevention strategies compared with experienced injury prevention nurses. Despite a significant reduction in prevalence of hospital-acquired pressure ulcers and high documentation compliance, use of prevention strategies could further be improved to achieve better patient outcomes. Barriers to the use of prevention strategies by nurses in the acute hospital setting require further examination. This study provides important insights into the knowledge translation of pressure ulcer prevention best practice guideline recommendations at The Northern Hospital.

Introduction

Pressure ulcers are preventable adverse events and continue to be a problem in many hospital settings despite the availability of best practice guidelines, pressure-relieving equipment and staff education. The financial cost for the health service and patient is high, and includes increased length of stay

Key Messages

- hospital-acquired pressure ulcers are recognised as a nursing sensitive outcome that contribute to increased patient discomfort, length of stay and expense

- pressure ulcers can be prevented by screening patients' risk on admission to hospital, daily reassessment of risk and timely application of prevention strategies
- this study found nurses under-estimated patients risk of developing a pressure ulcer and under-utilised prevention strategies compared with experienced injury prevention nurses
- implementation of an evidence-based pressure ulcer prevention programme appears acceptable, effective and feasible in the acute hospital setting
- further investigation of why risk factors are missed and preventative measures are under-utilised by nurses is needed

and lost work time (1). Pressure ulcers also result in substantial effects on quality of life with emotional and mental, physical and social impacts (2). The Institution for Healthcare Improvement estimated over 2.5 million patients in the USA develop pressure ulcers each year resulting in almost 60 000 predicted deaths (3). It has been estimated that pressure ulcers cost 4% of the total health care expenditure in the UK (4,5), and accounted for \$2.41 billion excess healthcare expenditure in the USA between 2005 and 2007 (6). In Australia, having a pressure ulcer has been found to increase a patients length of stay by more than 4 days and yearly public hospital expenditure by AU\$285 million (7).

It is generally recognised that pressure ulcers are mostly avoidable (5). Their prevention remains a priority for hospitals, and prevalence rates are increasingly being used as an indicator of quality of care (8–10). To improve quality of patient care and decrease the pressure ulcer prevalence, there has been a considerable growth in staff education, use of pressure ulcer risk assessment tools, availability of pressure-reducing equipment and dissemination of best practice guidelines in hospitals over the last decade (11,12). Pressure ulcer prevention best practice guidelines highlight the importance of screening patients' skin integrity risk on admission to hospital, daily reassessment of risk and timely application of prevention strategies (13). A systematic review of pressure ulcer prevention strategies, supports the use of support surfaces, such as alternating air mattresses or specialised foam, which relieve the pressure that the patient's body weight exerts on the skin (14). The effects of repositioning on pressure ulcers have limited evidence, however, it remains common inclusion in pressure ulcer prevention programmes (14).

Past studies highlight variable compliance with best practice guideline recommendations (15–20,23). A national quality-of-care retrospective study in the USA found high compliance with daily skin assessments (94%), but low compliance for application of pressure-relieving devices (7.5%), documentation of at-risk patients (22.6%) and repositioning (66.2%) (15). An Australian questionnaire found that most nurses did not use risk assessment tools (79%) and the most frequently used preventative strategy was repositioning (89%) (16). Of note, this study also found that nurses reported they used ineffective methods such as soap and water to prevent pressure ulcers (62%) (16). Data from a national

Dutch pressure ulcer survey, found no significant change in prevention care practices following the introduction of a specific hospital pressure ulcer policy and pressure-reducing mattresses (17).

Other studies report that nurse values have an effect on nurse beliefs of pressure ulcer prevention practice (21) and that these values are formed by the nurse's experience with high-grade pressure ulcers, rather than through education alone (22).

Three recent studies compared nurse pressure ulcer prevention knowledge, attitudes and beliefs to nurse pressure ulcer prevention practice (18,19,23). The first was a survey of nurses in Ireland which reported ad hoc pressure ulcer prevention practices despite positive nurse attitudes. Seventy-five percent of surveyed nurses reported all patients were at risk of developing a pressure ulcer, all nurses should concern themselves with ulcer prevention (99%) and prevention was more important than treatment (92%) (23). However, most of the nurses were unable to correctly name the pressure ulcer grading tool in use at the institution (78%) (23). The second was a survey of nurses in Spain that identified low levels of implementation of pressure ulcer prevention recommendations, despite higher levels of knowledge and beliefs of their importance (18). The third was a survey of nurses in Sweden that found nurses had good knowledge and attitudes towards ulcer prevention but poor levels of pressure ulcer prevention practice (19). There were low levels of compliance with risk assessment tool completion (9%), documentation of a pressure ulcer prevention care plan (42%) and infrequent daily care plan updates of skin assessment (25%) (19). These studies suggest that positive beliefs and attitudes towards pressure ulcer prevention practice may not be adequate to effectively implement pressure ulcer best practice guidelines.

In contrast to these six studies that provide little evidence for effective implementation of pressure ulcer prevention best practice guideline recommendations in the hospital setting, one Australian study reported increased use of a risk assessment tool (7.9% increase) and pressure-relieving devices (46.5% increase) following the introduction of a nurse practitioner-led pressure ulcer programme (20).

Studies specifically investigating the impact of ulcer prevention programmes have had variable findings. Four studies identified a reduction in pressure ulcers after a prevention programme was introduced (17,20,24,25), and two found no change (26,27).

In summary, nine studies reported poor uptake of guideline recommendations in daily nursing care or no change in pressure ulcer prevalence after implementing an evidence-based programme (15–19,21,22,26,27), and only four studies identified a reduction in pressure ulcer prevalence after a prevention programme was introduced (17,20,24,25). This suggest that knowledge translation of pressure ulcer prevention best practice guideline recommendations remains less than optimal in the hospital setting.

Identified barriers to integration of research into clinical practice include inappropriate training and support, negative attitudes to evidence-based practice, traditional knowledge/ritualistic practice, lack of effective clinical role models

and lack of focus on wound management (28). Nurse reported barriers to pressure ulcer prevention included lack of time and staff (23). Unlike the studies that found no change, the studies that did report a reduction in pressure ulcers, emphasised key elements in successful implementation including involvement of inter-professional teams (20,24), clinical leaders and champions (17,24,25); adequate staff education and awareness campaigns (17,20,24,25); simplification and incorporation of documentation into work flow (24,25); support from senior management and allocation of resources (17,20,25).

In 2005, The Northern Hospital (TNH) implemented an evidence-based pressure ulcer prevention programme. The programme includes a validated risk assessment tool – The Northern Hospital Pressure Ulcer Prevention Plan (TNH-PUPP) (29); use of pressure-relieving equipment including alternating air mattresses, chair cushions and heel wedges; and staff education resources for the risk assessment and management processes. A key attribute of the programme is that the risk assessment and prevention strategy checklist are integrated into daily nurse work flow by including them on the daily patient care plan documentation. Another key attribute of the programme is the inclusion of injury prevention nurse leaders and ward champions. Past research has identified that nurses are more likely to implement the evidence-based practice when provided with appropriate education and clinical role models to promote positive attitudes and show standardised best practice (28). The injury prevention nurse leaders at TNH were specifically trained to deliver staff education on injury prevention, including pressure ulcer prevention at the hospital. The ward champions are responsible for promoting use of the programme to the front-line team members – the ward nurses. They receive the same training that the ward nurses but have regular contact with the injury prevention nurse leaders to discuss the local assimilation of the programme on their ward, and also assist with conducting 'spot audits' of risk assessment tool completion and use of strategies.

This study sought to determine whether implementation of an evidence-based pressure ulcer prevention programme has reduced the prevalence of hospital-acquired pressure ulcers and to determine if best practice guideline recommendations are being implemented as part of daily patient care at TNH.

Methods

Setting and design

This prospective observational cohort study was undertaken at TNH, a 370 bed, acute, metropolitan, public teaching hospital located in Melbourne, Australia. Prevalence of hospital-acquired pressure ulcers was assessed by conducting point prevalence surveys. Implementation of best practice guideline recommendations was assessed by three practice metrics:

1. nurse compliance with use of a validated pressure ulcer risk assessment and intervention checklist;
2. accuracy of pressure ulcer risk assessment scoring; and
3. use of prevention strategies.

Study sample

Prevalence of hospital-acquired pressure ulcers

Data on hospital-acquired pressure ulcer prevalence were obtained from point prevalence surveys of 1045 adult inpatients from the general wards, critical care and emergency departments at TNH conducted in 2003, 2004, 2006, 2007 and 2011.

Practice metric 1: nurse compliance with pressure ulcer prevention documentation

Data for practice metric 1 were derived from 4368 patient medical record audits on seven medical and surgical wards at TNH conducted between 2003 and 2011.

Practice metrics 2 and 3: accuracy of pressure ulcer risk assessment scoring and use of prevention strategies

Data for practice metrics 2 and 3 were derived from a consecutive sample of 270 general medical and surgical patients admitted to TNH over a 3-week period in December 2008. Patients who had been admitted for <4 or >48 hours at the time of assessment were excluded from the study ($n = 11$).

Study procedures

Prevalence of hospital-acquired pressure ulcers

The point prevalence surveys involved trained surveyors assessing inpatients for pressure ulcers and when present, the stage and body location were determined and recorded. The trained surveyors were Baccalaureate Nurses who had completed a full day of education on pressure ulcer development, stages and survey procedures and documentation. On the survey day, surveyors visited all adult patients in the general wards, critical care and emergency departments and operated in pairs to ensure data collection was reliable. The surveyors needed to be in agreement before data were recorded. If there were any disagreements, for example, stage of ulcer, the coordinator was consulted. Patients for discharge and those that had scheduled appointments were seen as a priority. A chart audit of all patients included in the survey was also performed to ensure that pressure ulcers which developed after the survey were captured. Each pressure ulcer was classified as pre-existing (present at hospital admission) or hospital-acquired (acquired during their current hospital admission), based on interviews with the patient, family, hospital caregiver or as documented on the patient record or transfer form. Pressure ulcers that were considered possibly or definitely hospital-acquired were classified as hospital-acquired.

Practice metric 1: nurse compliance with pressure ulcer prevention documentation

Information about the nurse compliance with pressure ulcer prevention documentation was obtained from quality audits conducted by the TNH Injury Prevention Unit. Audits were also conducted by the injury prevention ward champions at two monthly intervals using a standardised tool to extract information from the records.

Practice metrics 2 and 3: accuracy of pressure ulcer risk assessment scoring and use of prevention strategies

TNH-PUPP pressure ulcer risk assessment tool

On admission, nursing staff used the validated TNH-PUPP to assess patient risk of developing a pressure ulcer (29). The TNH-PUPP consists of six risk factors:

1. presence of pressure ulcers (score = 3);
2. requires assistance to move in bed (score = 2);
3. admission to intensive care during current admission (score = 1);
4. aged ≥ 65 years (score = 1);
5. reduced sensation (score = 1); and
6. cognitive impairment (score = 1).

Each risk factor is scored either present or absent resulting in maximum total score of nine. A score of zero indicates minimal risk, one low risk, two medium risk and three or higher indicates a high pressure ulcer risk. A description of the tool can be found in the publication by Page *et al.* (29).

Assessors

The pressure ulcer risk of each patient using the TNH-PUPP was completed by two experienced (gold standard) injury prevention nurses (Assessors 1 and 2) from the TNH Injury Prevention Unit. The assessors were specifically trained to deliver staff training on patient injury prevention at the hospital. Assessor 1 was a registered nurse (Bachelor Degree in Nursing) with 12 years of acute nursing experience. Assessor 2 was an enrolled nurse (Diploma in Nursing) with 42 years of nursing experience.

Risk assessment scoring and use of prevention strategies

Prior to completing the TNH-PUPP tool, Assessors 1 and 2 independently checked the patient admission date, visually assessed all pressure points of patient skin and observed functional performance of patient transfer from the bed or chair and ambulation distance. Assessors 1 and 2 then independently scored the patient's pressure ulcer risk using the TNH-PUPP tool. The assessors were instructed not to discuss their assessments with each other and were blind to the usual-care nurses scoring of the patient's pressure ulcer risk assessment and documented prevention strategies until after they had documented their own assessment scores and prevention strategies. Assessor 1 or 2 then recorded the usual-care nurse pressure ulcer risk assessment scoring, preventative strategies recorded in the patient's medical record, and strategies that were currently in place for the patient. Additional demographic data were collected from the patient's medical record. These data included age, sex, admission source, ability to walk independently, continence, development of a pressure ulcer during admission, length of stay and non English speaking background, as reported in Table 1.

Ethical considerations

The study was approved by the Hospital Human Research Ethics Committee.

Table 1 Patient characteristics for the accuracy of pressure ulcer risk assessment scoring and use of prevention strategy study

	N = 270
Age*	64-92 (18-15)
Female [†]	125 (46-30)
Admission source [†]	
Private residence alone	35 (12-96)
Private residence accompanied	209 (77-41)
Residential aged care facility (low care)	11 (4-07)
Residential aged care facility (high care)	15 (5-56)
Able to walk independently [†]	79 (29-26)
Continence [†]	
Incontinent of urine	6 (2-22)
Incontinent of faeces	3 (1-11)
Incontinent of urine and faeces	22 (8-15)
Intensive care unit during admission [†]	11 (4-07)
Developed a pressure ulcer during their admission [†]	2 (0-74)
Length of stay*	8-32 (8-26)
Non English speaking background [†]	99 (36-67)

*Mean (SD).

[†]Frequency (percentage).

Statistics

Data were analysed using STATA (Version 11, Stata Corp, College Station, TX). Descriptive statistics were calculated for pressure ulcer prevalence, documentation compliance, patient demographic, risk assessment and prevention strategy data. Trends in pressure ulcer prevalence throughout the 9-year observation period were assessed by Poisson regression models where the hospital-acquired pressure ulcer counts were the outcome variable, the year of observation the single explanatory variable and number of patients surveyed the exposure variable. This analysis used the 2003, 2007 and 2011 prevalence data only to ensure equal time interval between observation points.

Accuracy of tool completion and use of prevention strategies were measured using Cohen's kappa statistic (κ). This statistic provides a measure of agreement between two or more scores or responses. In this study they were the risk assessment score and strategies recorded by the experienced injury prevention nurse (Assessor 1) and the usual-care nurses. If there was good agreement between the injury prevention nurse (Assessor 1) and the usual-care nurses' risk assessment scores this was interpreted as being accurate scoring of the risk assessment tool. If there was good agreement between the injury prevention nurse (Assessor 1) and the usual-care nurses' selection of strategies this was interpreted as appropriate selection of prevention strategies. κ scores range from -1 for agreement lower than expected by chance, to 1 which indicates complete agreement. The Cohen's κ is the chance-corrected proportional agreement and as such is a more robust measure than simple percentage agreement (30). The results of κ analysis were interpreted as follows: $0.81-1.00$: very good agreement; $0.61-0.80$: good agreement; $0.41-0.60$: moderate

Table 2 Prevalence of hospital-acquired pressure ulcers and usual-care nurse compliance with pressure ulcer prevention documentation

	2003	2004	2005	2006	2007	2008	2009	2010	2011
Patients surveyed	151	201	–	201	219	–	–	–	273
Hospital-acquired pressure ulcer (<i>N</i>)	19	23	–	16	10	–	–	–	7
Pressure ulcer present on admission (<i>N</i>)	9	8	–	7	5	–	–	–	11
Hospital-acquired pressure ulcer prevalence (%)	12.58	11.44	–	7.96	4.57	–	–	–	2.56
Documentation compliance (%)	78	75.20	89.14	92.80	96.29	95.00	92.29	88.29	83.69

–, point prevalence survey not completed.

agreement; 0.21–0.40: fair agreement, while values <0.21 represented poor agreement (31).

Results

Prevalence of hospital-acquired pressure ulcers

Pressure ulcer prevalence reduced from 12.6% in 2003 2 years prior to programme implementation, to 2.6% in 2011 6 years after the programme implementation (Table 2). The reduction was significant (incidence rate ratio = 0.44, 95% confidence interval = 0.28–0.67, $P < 0.001$)

Practice metric 1: nurse compliance with pressure ulcer prevention documentation

Audits conducted by the Injury Prevention Unit identified that compliance with pressure ulcer prevention documentation in TNH acute medical and surgical wards was high (>84%) (Table 2).

Practice metrics 2 and 3: accuracy of pressure ulcer risk assessment scoring and use of prevention strategies

The mean age of patients in the study population was 64.92 (SD \pm 18.15) years and 46.30% were women (Table 1). Prior to admission most patients lived accompanied in a private residence (77.4%), and were continent (88.5%). The mean length of stay in acute care was 8.32 (SD \pm 8.26) days, and only 4.1% had been admitted to an intensive care bed during their current admission and prior to the study assessments being performed. Two of the 270 patients (0.74%) developed a pressure ulcer during their admission.

Accuracy of pressure ulcer risk assessment scoring

The agreement between the two injury prevention nurses (Assessors 1 and 2) was good for classifying patient's risk of developing a pressure ulcer during their admission ($\kappa = 0.63$) (Table 3). Agreement between usual-care nurses and the experienced injury prevention nurse (Assessor 1) was moderate for classifying patients risk of developing a pressure ulcer during their admission ($\kappa = 0.46$) (Table 3).

Table 4 shows the injury prevention nurses (Assessors 1 and 2) and usual-care nurses' risk assessment classification results. The experienced injury prevention nurses identified more patients as being at high risk of developing a pressure ulcer than did the usual-care nurses when using the risk assessment tool (37% versus 21%).

Table 3 Pressure ulcer risk scoring and prevention strategy selection agreement between the injury prevention nurses (Assessors 1 and 2) and usual-care nurses and Assessor 1

	Assessors 1 and 2 κ	Usual-care nurse and Assessor 1 κ
Risk classification	0.63	0.46
Prevention strategies		
Air mattress	0.69	0.33
Chair cushion	0.27	0.01
Repositioning	0.50	–0.01
Continence aids	0.93	0.93
Heel wedge	0.58	0.15
Ear protectors	0.75	0.03

Table 4 Pressure ulcer risk classification by experienced injury prevention (Assessors 1 and 2) and usual-care nurses for sample 2

Pressure ulcer risk	<i>N</i> = 270		
	Assessor 1 (%)	Assessor 2 (%)	Usual care (%)
Minimal	64 (23.70)	62 (22.96)	98 (36.30)
Low	67 (24.81)	56 (20.74)	81 (30.00)
Medium	40 (14.81)	41 (15.19)	34 (12.59)
High	99 (36.67)	111 (41.11)	57 (21.11)

Use of prevention strategies

Table 5 outlines the pressure ulcer prevention strategies selected for high-risk patients by the experienced injury prevention and usual-care nurses. There was poor agreement between the experienced injury prevention and usual-care nurses ($\kappa < 0.16$) for the selection of all prevention strategies except alternating air mattress for which there was moderate agreement ($\kappa = 0.33$), and continence aids for which there was very good agreement ($\kappa = 0.93$). Experienced injury prevention nurses prescribed more prevention strategies for high-risk patients than usual-care nurses. Importantly, of the 57 patients identified as being at high risk of developing a pressure ulcer by the usual-care nurses, all received at least one prevention strategy.

Discussion

The aims of this observational study were to determine whether knowledge translation of pressure ulcer best practice guideline recommendations is evident at TNH as measured by improved patient outcomes and uptake of guideline

Table 5 Pressure ulcer prevention strategies selected for high-risk patients by experienced injury prevention and usual-care nurses

Prevention strategies	Assessor 1		Assessor 2		Usual care		κ^*
	High risk <i>N</i> = 99		High risk <i>N</i> = 111		High risk <i>N</i> = 57		
Air mattress	72	72.7%	69	62.2%	20	35.1%	0.33
Chair cushion	69	69.7%	34	30.6%	0	0.0%	0.01
Repositioning	96	97.0%	110	99.1%	56	98.2%	-0.01
Continence aids	55	55.6%	60	54.05%	39	69.4%	0.93
Heel wedge	64	64.6%	57	51.4%	11	19.3%	0.15
Ear protectors	30	30.3%	37	33.3%	2	3.5%	0.03
Total prevention strategies prescribed	429		417		146		

* κ value for the agreement in strategy selection between the usual-care nurses and Assessor 1.

recommendations in daily patient care. Key pressure ulcer prevention best practice guidelines recommendations include: screening patients' skin integrity risk on admission to hospital, daily reassessment of risk and timely application of prevention strategies (13). Following implementation of the evidence-based pressure ulcer prevention programme, we found a substantial decrease in pressure ulcer prevalence, high compliance with use of a validated pressure ulcer risk assessment and intervention checklist, moderate accuracy when scoring the risk assessment and under-utilisation of prevention when compared with experienced injury prevention nurses. This suggests knowledge translation has occurred as patient outcomes have improved and there is evidence that practice is reflective of best guideline recommendations in that screening patients' skin risk is being undertaken and prevention strategies are being applied to patients identified as being at high risk of developing a pressure ulcer. These outcomes are likely to have been driven by good integration of the pressure ulcer risk assessment and management processes into daily patient care and provision of appropriate education and clinical role models. However, there remain areas for improvement in the accuracy of the pressure ulcer risk assessment tool scoring, and application of prevention strategies.

Nurse compliance with risk and strategy documentation was high (>84%). This result may be reflective of good integration of these processes into daily nurse work flow. The risk assessment tool and a prevention strategy checklist were included on the daily patient care plan used by nurses. A common finding in prior research has been that despite risk assessment tools being introduced into daily care practices; compliance with document completion was often poor (15,16,19). Past studies reporting low compliance with risk assessment and strategy documentation did not state whether documentation was integrated with daily work flow. We believe this is critical to achieving high compliance.

The good agreement between the two injury prevention nurses for classifying patient's risk of developing a pressure ulcer is comparable with those reported for other commonly recommended tools such as the Modified Norton Score (32). This level of reliability supports the clinical utility of the TNH-PUPP tool.

An important finding of this research was that in this acute care hospital setting, usual-care nurses under-estimated the risk of pressure ulcer development for patients and under-utilised prevention strategies compared with experienced

injury prevention nurses. This suggests that risk factors were being missed by the usual-care nurses when scoring the TNH-PUPP risk assessment tool. There are a number of factors which could explain this finding including time pressures, knowledge, beliefs and attitudes of the nurses. First, the experienced injury prevention nurses had a focus on injury prevention and were allocated specific time to complete the risk assessments for the purpose of this study. Therefore, they are likely to have been under less time pressures when performing their assessments than the usual-care nurses who were working in busy ward environments with many competing demands. Second, usual-care nurses may have received variable amounts of training in the use of the tool and the importance of pressure ulcer prevention. At TNH each staff member attends pressure ulcer Injury Prevention Unit training at hospital orientation when they first commence work at the hospital, then annually each year after. As such, some staff may have completed training within the last month while others may have completed it up to a year prior. This shows the importance of ongoing staff training in pressure ulcer risk assessment and prevention, as highlighted by others (20,24,25). Finally, past studies have identified that nurses believe that clinical judgement is superior to the use of risk assessment scales (19). Nurses may be less concerned with accuracy when filling out a risk assessment tool, as they would prefer to use clinical judgement. This may be an explanation for only moderate accuracy of usual-care nurse scoring on the TNH-PUPP tool.

Pressure-relieving mattresses, chair cushions, heel wedges and aids to protect ears from oxygen delivery tubing were found to be under-utilised by the usual-care nurses. Barriers to the use of these strategies may be dependent on equipment availability and sufficient time to put the equipment in place (19). The impeded appropriate application is reflected in low air mattress utilisation rates for risk patients in this study (35% by usual-care versus 62% by experienced injury prevention nurses). This is despite the agreement between usual-care and experienced injury prevention nurses for the use of air mattresses being measured as moderate. Insufficient air mattresses on surgical wards, and the additional effort, time delays and expenses involved in renting equipment, are all barriers to appropriate application of low air mattress.

Chair cushions, heel wedges and ear protector aids are readily available on the wards at TNH and are quick and easy to apply. Therefore availability would not appear to be a

barrier for their use. However, other barriers not measured by this study such as staff values, attitudes, beliefs and knowledge may be reasons why staff did not optimally use these equipment. As the completion of this study, the TNH pressure ulcer education package has been adapted to highlight that pressure-relieving chair cushions and heel wedges are effective devices for preventing pressure ulcers in high-risk patients. Further study is required to investigate whether the revised education package has resulted in improved use of pressure-relieving chair cushions, heel wedges and air mattresses.

The level of agreement between usual-care nurses and experienced injury prevention nurse assessors for continence aids was very good ($\kappa = 0.93$). This finding may reflect that these strategies are not just specific to pressure ulcer prevention, but may be considered standard nursing care. The Australian Clinical Practice Guidelines for the Prediction and Prevention of Pressure Ulcers, clearly states that measures to promote continence, including continence aids, should be used as a part of skin care which should include skin hygiene, moisture maintenance, stable skin temperature and nutrition (11). The more recent pressure ulcer prevention guidelines published by the European Pressure Ulcer Advisory Panel and the National Pressure Ulcer Advisory Panel state that skin care should include protection from excessive moisture with a barrier product, but there is no mention of continence aids (12).

The under-utilisation of pressure ulcer prevention strategies for hospital inpatients by nurses has been reported by other studies. A recent Belgium study found only 10.8% of hospital patients that were assessed as being at risk received fully adequate prevention in bed and while sitting (33). A national quality-of-care retrospective study in the USA reports similar findings to the Belgium study. It reported that only 51% of patients classified as being at high risk of developing a pressure ulcer by the Norton scale had a preventive strategy in place (34). Despite under-estimation of patients pressure ulcer risk and under-utilisation of pressure ulcer strategies by nurses in this study, there is evidence that the nurses were being effective at managing pressure ulcer risk. This is confirmed by the hospital quality improvement audit data which showed that the prevalence of hospital-acquired pressure injury decreased from 12.6% in 2003 to 2.6% in 2011 since the implementation of the programme in 2005.

As reported in Table 3, 111 patients in this study were identified as being at high risk of developing a pressure ulcer but only two developed a pressure ulcer during acute admission (Table 2). This low prevalence of pressure ulcers might be explained by the finding that all patients classified as high pressure ulcer risk by usual-care nurses received at least one pressure ulcer prevention strategy. This suggests adequate use of pressure ulcer preventive strategies by nurses at TNH. Of note, there was high agreement between experienced injury prevention and usual-care nurses with the use of air mattresses and continence aids. These strategies may be highly effective methods for reducing the risk of pressure ulcers. A systematic review supports the use of support surfaces that reduce pressure on patients' skin (14). The Australian Clinical Practice Guidelines for the

Prediction and Prevention of Pressure Ulcers include the use of continence pads to assist in maintenance of skin integrity by providing a quick-drying surface (11). The guidelines also support the use of alternating air mattresses to reduce the incidence of pressure ulcers in moderate to high-risk individuals (11).

There are several limitations of this study which should be acknowledged. First, this study was not a randomised controlled trial, and thus, some observed effects may have been because of factors other than the pressure ulcer programme, for example, changes in the hospital population, policy and environment. Although the magnitude and direct effect of these other changes cannot be quantified, this study used robust analyses with a long observation period. The chosen methodology addressed a specific question: are changes in the rates of hospital-acquired pressure ulcers associated with the implementation of an evidence-based prevention programme? This 'real-world' study suggests there is an association and provides meaningful insights into the drivers of successful implementation. Second, it was not possible to blind the experienced injury prevention nurse assessors to the usual-care nurses' use of alternating air mattresses, heel wedges, foam and air chair cushions, ear protectors and continence aids. This is likely to have artificially inflated the estimates of agreement between injury prevention and usual-care nurses with respect to the use of these prevention strategies. Third, this was a single-centre study therefore the generalisation of the findings to other patient groups or settings needs to be explored. Finally, the study did not include any measures of use of guideline recommendations prior to the implementation of the pressure ulcer prevention programme; therefore, we were unable to assess change in use of recommendations as a result of the programme implementation.

Conclusions

The evidence-based pressure ulcer prevention programme at TNH appears to be well integrated into the daily nursing practice. We found a substantial reduction in pressure ulcer prevalence, and high levels of nurse compliance with use of a validated pressure ulcer risk assessment and intervention checklist. Despite this, nurses had moderate levels of accuracy when scoring pressure ulcer risk and under-utilised prevention strategies when compared with experienced injury prevention nurses. The results of this research show that pressure ulcer best practice guideline recommendations are integrated into daily nursing patient care at TNH but the use of the pressure ulcer risk assessment tool and application of prevention strategies could be improved.

Importantly, all patients identified as being at high risk of developing a pressure ulcer had at least one prevention strategy in place. Of the six pressure ulcer prevention strategies studied, air mattress and continence aids were the strategies for which the injury prevention and usual-care nurses displayed high levels of agreement in applying these strategies for patients. These strategies may be essential in preventing pressure ulcer development. This study did not specifically explore why some strategies are under-utilised. This requires further examination in future studies but is likely to be

due to limited equipment access, usual-nurse time restraints and nurse knowledge and beliefs about efficacy. Further study incorporating nurse knowledge, values, attitudes and beliefs, with actual levels of pressure ulcer prevention practice change, would give further insight into the complex nature of behavioural change in pressure ulcer prevention.

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