Reducing pressure ulcer prevalence in residential aged care: results from phase II of the PRIME trial

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Abstract

Pressure ulcers are a significant iatrogenic cause of morbidity and mortality in the aged care population, with prevalence reported to be as high as 43% in some aged care facilities. The PRIME trial was a 15-month pre- and post-intervention study designed to investigate the effectiveness of an integrated pressure ulcer management system consisting of pressure ulcer risk assessment tools, Australian Wound Management Association (AWMA) guidelines, digital imaging and clinical education in reducing pressure ulcer prevalence in residential aged care facilities. A total of 1228 residents from 23 residential aged care facilities were enrolled in this Commonwealth-funded study.

The findings suggest that the PRIME intervention significantly reduced pressure ulcer prevalence risk by 52% ($p<0.001$) and highlighted the association between cachexia, Braden sub-scales for activity, nutrition, friction/shear and pressure ulcer risk. The study also demonstrated that following the PRIME intervention, the use of appropriate pressure ulcer risk reducing equipment was significantly increased. Overall, the results suggest that an integrated approach combining the elements of the PRIME intervention is effective in reducing pressure ulcer prevalence in the frail elderly population in residential aged care facilities.

Introduction

Pressure ulcers are a major contributor to morbidity, mortality and decreased quality of life in the nursing home sector [1, 2]. The frail elderly resident is at particular risk of developing a pressure ulcer if immobile, incontinent or cognitively impaired [3]. Nutritional status has also been clearly linked to pressure ulcer development [4]. International estimates of pressure ulcer prevalence in residential aged care facilities vary greatly due to methodological issues, the use of differing pressure ulcer classification systems as well as under reporting [5, 6]. Prevalences have been reported in the ranges of 11.2-23% in the USA [7-9] and in the UK from 4.6-7.5% [10, 11]. European studies have reported prevalences as high as 83.6% in aged care facilities [12-18]. Recent Australian research within this sector has reported prevalences of 26% and 42% [1, 19].

The aim of our study was to investigate the effect on pressure ulcer prevalence of introducing an integrated pressure ulcer prediction and prevention system (PRIME system) into 23 'high care' aged care facilities in four Australian states. The PRIME system was comprised of risk assessment tools, clinical education, digital imaging and incidence monitoring and the introduction of the *Australian Wound Management Association (AWMA) Clinical Practice Guidelines for the Prediction and Prevention of Pressure Ulcers* [20].

Whilst the development of clinical practice guidelines for the prevention of pressure ulcers has been widespread, the link between the recommended practice and subsequent pressure ulcer rates has not been firmly established [4]. Furthermore, the introduction of pressure ulcer guidelines does not necessarily mean that they are effectively implemented in clinical practice [21, 22]. Barriers to the effective management of pressure ulcers in the aged care facilities have been identified as including ineffective communication between clinicians [4], workload [22, 23], knowledge [24], and the performance of management [25, 26]. Our study has attempted to deal with some of these barriers and to produce evidence of the link between introducing a guideline-driven, integrated system of pressure ulcer prevention in the aged care sector.

Methods

The trial comprised two prospective point prevalence surveys, the first prior to any intervention and the second following the introduction of the PRIME system. Essentially the trial was a pre- and post-clinical evaluation of the effectiveness of the PRIME system in reducing the prevalence of pressure ulcers. The trial was conducted over a 15-month period between November 2004 and February 2006 in 23 'high care' residential aged care facilities in Victoria (n=2), New South Wales (n=7), South Australia (n=1) and Western Australia (n=13). The trial was approved by the Human Research Ethics Committee of The Alfred Hospital prior to any data collection.

The PRIME intervention

The PRIME intervention comprised an integrated system of measures aimed at reducing the prevalence of pressure ulcers

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in the residential aged care sector. The components of the PRIME system comprised:

- *AWMA Clinical Practice Guidelines for the Prediction and Prevention of Pressure Ulcers* [20].
- PURA & PURAMS instruments (Silver Chain pressure ulcer risk assessment and management tools, including Braden scale) [1].
- Pressure ulcer prevention education programme [1, 27].
- Advanced medical wound imaging system v1.1 (AMWIS) [28].
- Pressure ulcer incidence monitoring database.

Following the first pressure ulcer prevalence survey which was conducted during September-October 2004, the PRIME system was introduced at each of the 23 participating residential aged care facilities. This process involved conducting specifically-tailored education sessions for all staff at each facility; these sessions were conducted by members of the research team (KC, JP & NS). The education sessions covered the PRIME study protocol and were designed to meet the differing needs of staff based on their level of resident contact and responsibility. Specifically, staff were taken through basic skin anatomy, pressure ulcer pathology and aetiology, pressure ulcer staging, prevention and risk assessment and the levels and types of equipment appropriate to the differing resident needs based on risk assessment results. Further, each facility had the AMWIS system and a pressure ulcer incidence monitoring system loaded onto computers in clinical areas. Staff responsible for using AMWIS and the incidence monitoring system were trained in digital wound photography and on the use of the two IT systems.

Instrumentation and data collection

Three main data collection instruments were used in the trial. Pressure ulcer prevalence was assessed using methods defined by Prentice *et al.* [27] and the Silver Chain PURA which includes a Braden score and a carer support score. Comorbidity was derived through resident chart review and the calculation of the Charlson comorbidity age adjusted index (CCARI). The third instrument was the PRIME demographic data collection form which collected usual demographic details combined with data on smoking status, steroid use (systemic, inhaled or topical) and the presence of lymphoedema.

Prior to data collection, all prevalence surveyors participated in an education programme provided by three of the research team (KC, JP & NS) covering study protocol, pressure ulcer aetiology, pathology, staging and instrument use. Each surveyor was tested to ensure pressure ulcer staging interrater reliability with a minimum pass requirement of 85% on a standardised interrater test. Data collection was then undertaken by the surveyors working in pairs in each facility.

Data

The first set of data, prior to the implementation of the PRIME intervention, was collected over the period September-November 2004. The second set of data was collected, post PRIME, between July-October 2005.

The first survey (Survey 1) comprised 1956 residents; the second survey (Survey 2) was made up of residents that had been surveyed both before and after the PRIME intervention and residents that had only been surveyed once. After removing duplicates and those records which had no response to the presence of an ulcer question, there were 1811 records in Survey 1 and 1542 records in Survey 2. Note that these records were still not necessarily complete for all variables. Of this sample, 1228 residents were surveyed at both time points and there were 897 records from residents that were surveyed once (583 responses for Survey 1 and 314 responses for Survey 2).

The analysis looked specifically at known risk factors for pressure ulcers. These are listed below:

- Age.
- Gender.
- RCS score.
- Weight.
- Presence of cachexia (morbidly underweight).
- Were there any lifting/turning devices currently in use (repositioning equipment)?
- No. lifting/turning devices currently in use (repositioning equipment)
- Were there any pressure-reducing/relieving equipment in use (static equipment)?
- No. pressure-reducing/relieving equipment in use (static equipment)
- Sensory perception assessment risk – Braden scale.
- Moisture risk – Braden scale.
- Activity risk – Braden scale.
- Mobility risk – Braden scale.
- Nutrition risk – Braden scale.
- Friction and shear risk – Braden scale.
- Current total risk score.
- CCARI score.
- No. days since last assessment.

The survey also requested information on the previous risk level at the last assessment and the previous risk score for the last assessment. However, these variables were not considered in the analysis for a number of reasons. The previous risk scores were from one of six scales – Norton, Braden, Waterlow, PURA, progress notes and other – and were therefore not directly comparable between surveys and/or residents. It was also not obvious that the risk level variable response related one to one to the previous risk score question as the risk scores did not always translate into the reported risk levels.

Statistical analysis

Pressure ulcer prevalences and sample demographics before and after the PRIME intervention were compared using a univariate generalised estimating equation (GEE) that takes into account the repeated measures for residents who were available for both surveys. Anatomical position, severity and number of pressure ulcers were also considered. For completeness, p values were used from chi-squared tests and McNemar tests (for proportions), and independent and paired t-tests (for continuous measures) were used depending on whether the resident had been surveyed once or twice.

To compare the significance of risk factors for those residents who had an ulcer and for those who didn't, p values for Wald chi-square statistics taken from a GEE univariate predictor model where having an ulcer, yes/no, is a function of the risk factor were used. The analysis also looked at interaction terms to see if the effects of these risk factors were different between Survey 1 and Survey 2.

Logistic regression

To deal with the potential complication where some residents were surveyed once and some residents were surveyed twice, Liang & Zeger [29] developed generalised estimating equations to take into account the correlation between data that is collected on the same person over different points in time. Failure to do so means that the standard errors of the estimated coefficients are invalid and hypothesis testing is problematic. This approach extends generalised linear models and also allows for correlated binary data.

Pressure ulcer risk modelling

A pressure ulcer risk model was derived by modelling all significant univariate main effects on whether or not the residents had a current ulcer (yes=1 and no=0). After retesting variables with non-significant univariate main effects and interaction terms, the final specification was derived by reducing the number of variables using backwards stepwise reduction. That is, the variables that were least significant were deleted one at a time, in order of least significance, until all remaining variables were significant at the 5% level.

Results

Table 1 presents the demographic characteristics of the sample by residents who completed one survey (n=897) and for those who completed both surveys (n=1228). The GEE estimate suggests that, after taking into consideration repeated measures for the full sample, mean age is higher

at Survey 2. The number of residents who were cachexic at Survey 2 fell by 1.7%; this is supported by the GEE estimate of 1%. Univariate GEEs were used to test differences in characteristics between the two surveys without adjusting for other variables and consequently the GEE estimates were inconsistent with the differences between the survey variables of age, Braden scale, activity, mobility and friction/shear.

Table 2 indicates that there was no significant difference in comorbidity between the two surveys.

Table 3 shows that there was a decrease of approximately 10% in the prevalence of pressure ulcers following the PRIME intervention. This decrease was significant for the total cohort as well as for residents who completed only one survey or both surveys.

Table 4 demonstrates that the prevalence of residents with one ulcer increased slightly at Survey 2, and the proportion with two or more ulcers decreased by a similar amount following the PRIME intervention. Tables 5 & 6 show the pressure ulcer severity and pressure ulcer position before and after the PRIME intervention.

Surveyors were asked to assess the appropriateness of equipment that was in place for a resident who either had a pressure ulcer or was at risk of developing one at each survey. Table 7 shows that the percentage of these residents that had appropriate equipment in place increased from 39% at the first survey to 63% at the second, and that this increase was statistically significant.

Table 8 compares suspected risk factors for residents with and without an ulcer using a Wald chi-square statistic from a GEE univariate predictor model where having an ulcer is a function of the risk factor. The analysis also looked at interaction terms to see if the effects of these risk factors were different in Survey 1 to those in Survey 2. None of the interaction effects were significant, therefore the likelihood of developing a pressure ulcer from the identified risk factors was the same both before and after the PRIME intervention.

The complication with the PRIME trial analysis, as mentioned previously, was that some residents were surveyed once and some twice, creating the potential for errors in computing the standard errors of the estimated coefficients. To deal with this potential problem, we employed logistic regression methods where generalised estimating equations are used to take into account repeated measures and the correlation between data that is collected on the same person over different points in time. Our preferred multivariate model is presented in Table 8

Table 1. Sample characteristics at Survey 1 and Survey 2.

	Full sample		One survey		Both surveys		GEE (est†)
	Survey 1	Survey 2	Survey 1 n=583	Survey 2 n=314	Survey 1 n=1228	Survey 2 n=1228	
Age							
Age (mean)	84.2	83.5	85.3	82.3	83.8	83.9	0.03*
Gender							
Male (count)	635	517	233	115	402	402	
Male %	35.8	33.9	41.8	37.2	33.0	33.0	
Female (count)	1139	1009	324	194	815	845	
Female (%)	64.2	66.1	58.2	62.8	67.0	67.0	
Cachexic							0.99
Yes (count)	168	117	64	16	104	101	
Yes (%)	9.3	7.6	11.0	5.1	8.5	8.2	
No (count)	1643	1425	519	298	1124	1127	
No (%)	90.7	92.4	89.0	94.9	91.5	91.8	
Braden scales							
Sensory	2.976	2.910	2.949	3.052	2.989	2.874	-0.101*
Moisture	2.586	2.538	2.551	2.873	2.602	2.454	-0.115*
Activity	2.549	2.559	2.478	2.766	2.581	2.506	-0.050*
Mobility	2.410	2.447	2.371	2.656	2.427	2.394	-0.012*
Nutrition	2.947	2.900	2.864	2.854	2.984	2.911	-0.063
Friction/shear	1.800	1.816	1.707	1.964	1.842	1.779	-0.039*
Total	15.26	15.17	14.91	16.16	15.42	14.92	-0.409

* Age and Braden scales were modelled as scale variables and therefore the estimated coefficient is from a GEE linear model as opposed to a GEE logit model.

† Exp(b) at Survey 2 or estimated b (for non-logit model) at Survey 2.

and was derived by modelling all significant univariate main effects on whether or not residents had a current pressure ulcer. After retesting variables with non-significant univariate main effects and interaction terms, the final specification was derived by reducing the number of variables using backward stepwise reduction.

Table 9 reveals that, in our model, residents were 53% less likely to have a pressure ulcer at Survey 2 than at Survey 1. Residents who were cachexic were 50% more likely to have an ulcer compared to those who were not cachexic. A 1-year increase in age increased the likelihood of a pressure ulcer by 1.4%. Conversely, lower risk levels on the Braden scale for activity, nutrition, friction and shear decreased the risk of pressure ulcer formation by 31%, 13% and 33% respectively. Whilst the

Table 2. Age-adjusted CCARI at Survey 1 and Survey 2.

Mean CCARI index	Survey 1	Survey 2	p value
	6.36	6.33	0.720

Table 3. Pressure ulcer prevalence before and after PRIME intervention.

Current ulcer	Survey 1 (n=1811)	Survey 2 (n=1542)
Yes	26%	15.8%
No	74%	84.2%
Wald chi-square from GEE n^1=1811, n^2=1542		p<0.001
Independent sample chi-square n^1=583, n^2=314		p<0.001
Dependent sample McNemar test n^1=1228, n^2=1228		p<0.001

Table 4. No. pressure ulcers per resident before and after PRIME intervention.

No. ulcers	Survey 1 n (%)	Survey 2 n (%)
1.00	293 (63%)	160 (66%)
2.00 or more	173 (37%)	84 (34.2%)
Total*		
Wald chi-square from GEE n^1=466, n^2=244	p=0.276	

* Five records did not provide number of ulcers.
Individual McNemar tests were not performed as it was not always the case that residents had an ulcer at both surveys.

Table 5. Pressure ulcer severity before and after PRIME intervention.

Stage of ulcers	Survey 1 n (%)	Survey 2 n (%)
1	334 (46%)	155 (43%)
2	297 (41%)	160 (44%)
3	47 (6%)	26 (7%)
4	28 (4%)	15 (4%)
Unseen/unable to stage	21 (3%)	8 (2%)
Total	727 (100%)	364 (100%)
Wald chi-square from GEE n^1=462, n^2=245		p=0.599

Individual McNemar tests were not performed as it was not always the case that residents had an ulcer at both surveys.

Table 6. Pressure ulcer position before and after PRIME intervention.

Position	Survey 1 n (%)	Survey 2 n (%)
Sacrum/coccyx	255 (35%)	132 (36%)
Posterior heel	94 (13%)	57 (15%)
Toes	86 (12%)	57 (15%)
Lateral heel	37 (5%)	18 (5%)
Medial heel	35 (5%)	8 (2%)
Foot	33 (5%)	16 (4%)
Lateral malleolus	45 (6%)	16 (4%)
Other	147 (20%)	65 (18%)
Total	732 (100%)	369 (100%)

Table 7. Appropriateness of equipment before and after PRIME intervention.

Appropriate equipment in place	Survey 1 n (valid %)	Survey 2 n (valid %)
No	266 (61.4%)	66 (37.1%)
Yes	167 (38.6%)	112 (62.9%)
Missing*	38 (0%)	66 (0%)
Total	471 (100%)	244 (100%)
Wald chi-square from GEE n^1=433, n^2=178		p<0.001

* Missing values were not used in the analysis, consequently only valid percentages were used

Table 8. Risk factors for residents with and without an ulcer.

	Ulcer			No ulcer			P value
	Count	%	Mean	Count	%	Mean	
Survey number							
Survey 1	471	66%		1340	51%		<0.001*
Survey 2	244	34%		1298	49%		
Total	715	100%		2638	100%		
Age			85.2			83.6	<0.001*
Gender							0.364
Male	235	33%		917	35%		
Female	473	67%		1675	65%		
Total	708	100%		2638	100%		
RCS			1.7			1.8	0.010
Cachexic							<0.001*
No	611	85%		2457	93%		
Yes	104	15%		181	7%		
Total	715	100%		2638	100%		
Lifting/turning equipment							0.001*
No	10	1%		105	4%		
Yes	705	99%		2533	96%		
Total	715	100%		2638	100%		
No. pieces of lifting/turning equipment			2.21			1.96	<0.001*
Static equipment							0.037*
No	509	71%		1983	75%		
Yes	206	29%		655	25%		
Total	715	100%		2638	100%		
Braden scales							
Sensory			2.8			3.0	<0.001*
Moisture			2.3			2.6	<0.001*
Activity			2.2			2.7	<0.001*
Mobility			2.0			2.5	<0.001*
Nutrition			2.7			3.0	<0.001*
Friction/shear			1.5			1.9	<0.001*
Total			13.6			15.7	<0.001*
CCARI			6.5			6.3	0.104
Days since last assessment			202.6			218.3	0.394

* Denotes those risk factors that are significantly different at 5% (Wald Chi-Square statistic derived from univariate GEE predictor model.

number of days since the last assessment was significant, the value of the odds ratio for this variable suggests that there is only a slight decrease in the likelihood of a pressure ulcer developing as the time between assessments decreases. The finding that the number of pieces of equipment is significantly related to the increase in pressure ulcer development appears confusing until one realises that residents with a pressure ulcer were more likely to have a greater number of pieces of equipment due to their clinical need.

Discussion

Pressure ulcer development in any clinical facility is a complex, multifactorial process involving such diverse factors as resident characteristics, clinical facility resources, staff knowledge, attitudes and skills as well as the clinical and administrative leadership provided by those in charge of such facilities [5]. The situation in the aged care sector is further compounded by residents' age, fragility, dependency levels and comorbidity profile. The levels of highly trained staff are lower on a per resident basis and the sector is generally under significant cost pressure.

The PRIME trial specifically attempted to investigate the effectiveness of an integrated system to reduce the prevalence of pressure ulcers in 23 'high care' residential aged care facilities. The results demonstrate that the cohorts were generally comparable on demographic characteristics at both survey points (Table 1) before and after the PRIME intervention, with the exception of a slightly higher age and marginally lower number of residents who were cachexic at Survey 2. Obviously it is important to ensure that the cohorts are equivalent at both survey points when investigating the clinical effectiveness of an intervention such as PRIME because we have previously demonstrated that there is a significant role played by comorbidity in pressure ulcer development in the aged care sector [19]. As there was no statistically significant difference in the cohorts for comorbidity (Table 2) at either survey point, we are confident that our findings were not affected by this potential risk factor. The multivariate model presented in Table 9 includes age and cachexia and thus adjusts for differences in these variables.

The finding that pressure ulcer prevalence significantly decreased at the second survey (Table 3) suggests that the PRIME intervention was effective in reducing overall prevalence; however, of those residents who did develop an ulcer, there was no significant change in the proportion that developed one or more ulcers nor the severity of the ulcers that were developed (Tables 4 & 5). Similarly the anatomical distribution of the ulcers (Table 6) did not change between Surveys 1 and 2. We believe that these findings indicate that individual (person) risk factors are ultimately more influential in pressure ulcer development. This assertion is supported by our analysis of residents who did and did not have an ulcer at each survey point (Table 8) which demonstrates the roles of cachexia and Braden sub-scales.

Our findings on the appropriateness of pressure ulcer-reducing equipment that was in place at the two survey points (Table 7) demonstrated that there was a significant increase in the use of appropriate equipment following the PRIME intervention. We believe that this increase was due to the effectiveness of the PRIME education component which strongly emphasised the need for appropriate equipment based on risk assessment and the adherence to the AWMA guidelines [20]. We note that, following communication of our first survey results to management, significant investment in mattress replacement and other equipment was undertaken by the participating residential aged care facilities.

Table 9. Pressure ulcer risk multivariate model for PRIME trial.

Variable	B	S.E.	Wald	df	Sig	Exp(B)
Survey number						
Survey 1 = 0, Survey 2 = 1	-0.755	0.0996	57.96	1	0.000	0.470
Cachexia						
Not cachexic = 0, Cachexic = 1	0.406	0.1646	6.091	1	0.014	1.501
Age	**0.014**	**0.0047**	**8.526**	**1**	**0.004**	**1.014**
Braden scales						
Activity	-0.365	0.0840	18.863	1	0.000	0.694
Nutrition	-0.138	0.0688	4.005	1	0.045	0.871
Friction/shear	-0.396	0.1002	15.652	1	0.000	0.673
Days since last assessment	**-0.001**	**0.0002**	**9.224**	**1**	**0.002**	**0.999**
No. pieces of repositioning equipment	**0.133**	**0.0587**	**5.100**	**1**	**0.024**	**1.142**
Constant	-0.462	0.523	0.777	1	0.378	0.630

Our final risk model (Table 9) demonstrated that the PRIME intervention resulted in a 53% reduction in the likelihood of pressure ulcer development by the second survey; however, it does not explain the mechanism for the reduction. This is an unavoidable outcome of a pre- and post-designed study such as that used in the PRIME trial. The nature of an integrated intervention that was used in this study is such that it is impossible and perhaps unwarranted to attempt to unravel the effects of the individual components of the intervention as it was designed to be integrated as a total system. As mentioned previously, pressure ulcer development in the aged care sector is a complex, multifactorial event and we strongly believe that success in reducing the prevalence of pressure ulceration requires a similarly multifaceted evidence-based approach involving the components utilised in the PRIME trial. We believe that future research, employing alternative methodologies, may shed further light on the effectiveness of individual interventions.

Our findings show that cachexia plays an important role in pressure ulcer development; this is supported by the finding that the Braden sub-scale for nutrition is also significantly associated with pressure ulceration. This finding is also consistent with the literature on nutrition and pressure ulcer risk modelling [4, 30, 31]. Similarly, our findings for the Braden sub-scales of activity and friction/shear showed these to be important predictors for ulceration. The unexpected finding was that the number of days since the previous pressure ulcer risk assessment played a minimal role in reducing pressure ulcer prevalence and may be related to the quality of the assessment as opposed to the frequency of assessment. We believe that this finding requires further investigation.

The relationship between the number of pieces of equipment and the formation of a pressure ulcer is initially confusing as our risk model suggests that the more equipment there is in place the greater the risk of developing an ulcer. This finding is the result of the analytical methods employed that examine relationships rather than causation. When viewed in this light, the result merely demonstrates that residents with an ulcer had more equipment in place than those without an ulcer, as one would expect.

Our trial is limited by the pre- and post-intervention design; ideally a randomised controlled trial would have been a more methodologically pure design. We believed that this would not have been practical to conduct in the residential aged care facilities that participated in our trial due to the inability of 'blinding' staff to the trial intervention either within or between facilities. Furthermore, our intervention was based on accepted, evidence-based clinical guidelines for the

prevention of pressure ulcers and therefore we believed that it would be ethically untenable to deprive some residents of the potential benefits of the PRIME intervention. The fact that there was a significant decrease in the prevalence of pressure ulcers following the introduction of the PRIME intervention could be partially attributed to the phenomenon of regression to the mean; however, we believe that the magnitude of the decrease in prevalence that we detected is greater than could reasonably be expected through regression. A further limitation of our study is that the characteristics of the residents changed slightly during the 12 months between the first and second surveys; however, these differences were adjusted for in the multivariate modelling.

Overall, the PRIME trial demonstrates that it is possible to significantly decrease the prevalence of pressure ulcers in the 'high care' residential aged care sector through the introduction of an integrated system for the prediction and prevention of pressure ulcers based on best available evidence. We acknowledge the importance of facility level managerial support and the commitment of clinical staff in the implementation of interventions such as ours. As with any research, we believe that our results have raised a number of questions that need to be investigated further by those attempting to reduce the prevalence of pressure ulcers in the frail elderly.

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Competing interests

None of the authors hold competing interests in the design, methods or results of this study.

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