doi:10.1093/fampra/cmm024
Family Practice Advance Access published on 29 June 2007

Cost-effectiveness of multidisciplinary wound care in nursing homes: a pseudo-randomized pragmatic cluster trial

Trang Vu[a], Anthony Harris[a], Gregg Duncan[b] and Geoff Sussman[c]

Vu T, Harris A, Duncan G, Sussman G. Cost-effectiveness of multidisciplinary wound care in nursing homes: a pseudo-randomized pragmatic cluster trial. *Family Practice* 2007; **24**: 372–379.

Objectives. To evaluate the cost-effectiveness of a multidisciplinary wound care team in the nursing home setting from a health system perspective.

Methods. Pseudo-randomized pragmatic cluster trial with 20-week follow-up involving 342 uncomplicated leg and pressure ulcers in 176 residents located in 44 high-care nursing homes in Melbourne, Australia in 1999–2000. Twenty-one nursing homes (180 wounds in 94 residents) were assigned to the intervention arm and 23 to the control arm (162 wounds in 82 residents). Residents in the intervention arm received standardized treatment from a wound care team comprising of trained community pharmacists and nurses. Residents in the control arm received usual care.

Results. More wounds healed during the trial in the intervention arm than in the control arm (61.7% versus 52.5%, $P = 0.07$). A Cox regression with shared frailty predicted that the chances of healing increased 73% for intervention wounds [95% confidence interval (CI) 20–150%, $P = 0.003$]. The mean treatment cost was $A616.4 for intervention and $A977.9 for control patients ($P = 0.006$). Most cost reduction was obtained from decreases in nursing time and waste disposal. The mean cost saving per wound, adjusted for baseline wound severity and random censoring, was $A277.9 (95% CI $A21.6–$A534.1).

Conclusions. Standardized treatment provided by a multidisciplinary wound care team saved costs and improved chronic wound healing in nursing homes. The main source of saving was in the cost of nursing time in applying traditional dressings and in the cost of their disposal.

Keywords. Chronic wounds, cluster trial, cost-effectiveness, multidisciplinary, nursing homes.

Introduction

Leg and pressure ulcers are common and costly medical conditions representing a major burden of illness for nursing home residents and their carers. The prevalence of pressure ulcers of all stages in institutionalized elderly varies between 6.5% and 23% depending on methodological approaches used to collect and analyse data.[1–4] There is little information on the frequency of leg ulcers in nursing home residents. In community-living elderly, leg ulceration is estimated to affect between 1% and 3% of the population.[5,6]

Given the extent of the burden and the anticipated future increase in the elderly population it is important that the most cost-effective model of care is implemented. A modern approach to treating chronic wounds involves four effective innovations—moist wound dressings to assist healing, holistic strategies to address local and systemic factors that can impair healing, specialist training for those regularly involved in wound management and provision of a multidisciplinary team that provides the appropriate mix of specialties.[7–14] The involvement of nurses or hospital pharmacists in wound management in a variety of settings has been separately evaluated.[9,15] However, to our knowledge there are no rigorous studies on the support role of community pharmacists in wound care in nursing homes.

Received 19 June 2006; Revised 21 March 2007; Accepted 30 April 2007.
[a]Centre for Health Economics, Monash University, Clayton, Victoria, [b]Department of Pharmacy Practice, Monash University, Clayton, Victoria and [c]Wound Foundation of Australia, Monash University, Parkville, Victoria, Australia. Correspondence to Trang Vu, Building 75, Monash University Clayton Campus, Wellington Road, Clayton 3800, Victoria, Australia; Email: trang.vu@buseco.monash.edu.au

In Australia, community pharmacists are graduates of a 4-year pharmacy degree course who have satisfactorily completed an additional 1 year of preregistration training under the supervision of the Pharmacy Board. Pharmacists working in the community provide a range of services including supplying prescription-only medicines, providing a clinical pharmacy service, providing general health and medical advice to the public and supplying nursing homes with drugs, equipment and products. As community pharmacists are already involved in the care of nursing home residents through medication reviews and pharmaceutical care provision an extension of their role into wound care with particular regard to product selection and use would seem to be appropriate and productive. In 1999–2000, we conducted a trial to test the hypothesis that trained pharmacists and nurses working in collaboration with a wound treatment protocol would improve wound healing and save costs. A cluster design was chosen because the intervention was aimed at the nursing home level. We examined both the differential costs and outcomes associated with the intervention for both acute (skin tears) and chronic (leg ulcers and pressure sores) wounds. This article reports results for chronic wounds.

Methods

Recruitment and assignment of nursing homes to trial arms

We received approval from appropriate ethics committees. All high-care nursing homes in the greater Melbourne metropolitan area in August 1999 were identified from a list provided by the Commonwealth Department of Health and Ageing and considered for this trial. They were subsequently grouped into 10 geographic regions encompassing eastern and western suburbs, inner urban areas and outer metropolitan and a wide range of socio-economic status. Within each region, nursing homes were approached by telephone to participate in the trial based on the order in which they appeared on the list. The first nursing home to accept our invitation was assigned to the intervention arm and the second with similar resident numbers from the same region allocated to the control arm.

Recruitment of residents

Recruitment took place over a 6-month period. In each nursing home, staff introduced residents to the trial. We included residents with leg or pressure wounds who could provide informed consent. Where a resident was not able to give consent, legal guardian consent was obtained. Residents may have had more than one wound of similar or different types. We excluded those residents with infected wounds or diabetes. Those undergoing long-term corticosteroid therapy, chemotherapy or treatment with immunosuppressants were also excluded. Residents were withdrawn from the trial if, after enrolment, they were admitted to hospital or required wound-related medical referral (for infection, grafts, etc.).

Intervention

Pharmacists and nurses in the intervention arm undertook a wound management training course developed and delivered by the Department of Pharmacy Practice at Monash University, Australia. The course covered wound aetiology, physiology of wound healing, pathophysiology of chronic wounds, factors impacting on wound healing and wound management. The course also included case studies and practical hands-on sessions. Course participants were not formally assessed.

Trial staff developed a standard treatment protocol for use in the intervention arm based on the colour, depth and exudate method for assessing wounds,[16] and their academic and clinical experience. Before the trial commenced, training was provided to nurses and pharmacists in the intervention arm in both how to use the protocol and documentation procedures for data collection purposes. Nurses and the pharmacist in each facility met at least weekly to identify any new wounds and discuss treatment options within the protocol. Between face-to-face meetings, the pharmacists and nurses discussed case management via telephone. Dressings, selected from a formulary comprised of the most common product classes, were changed by nurses and funded from the trial budget. Wounds were treated until healed or for a maximum of 6 months.

Nurses and pharmacists in the control arm received no wound care training, and the pharmacists were not involved in wound management. Hence, residents in the control arm received usual care from nurses as described in the Commonwealth Government prescribed manual.[17] Wound care was discussed in this manual; however, the information was non-specific. None of the control nursing homes had a wound treatment protocol.

Data collection

Pharmacists in the intervention arm collected baseline characteristics of enrolled residents and their wounds. These included demographic information, health status, medical history, local and systemic factors potentially affecting wound healing, wound type, location, aetiology, dimensions, colour, odour, current therapies and other treatments used as documented in residents' history. Treatment recommendations made by nurses in consultation with trained pharmacists were recorded. The frequency and detail of dressing changes were also recorded. Trial staff visited each nursing home every fortnight to complete documentation. In the control arm, trial staff collected all necessary data, including measuring and photographing wounds, using the same measurement methods and schedules as in the intervention arm. The trial staff were not involved in other aspects of the trial in either arm.

We used the short form 36-item general health questionnaire,[18] and the Assessment of Quality of Life index[19] to measure residents' quality of life at trial enrolment and exit. However, due to residents' level of dementia and low compliance, the results were not meaningful and not reported here. For residents who could communicate with trial staff, we used the Brief Pain Inventory (BPI), an 11-point (0–10) numeric scale, to assess wound-associated pain at each visit.[20]

Outcome assessments

The primary outcomes of interest were percentage of wounds healed in each arm, time to wound healing and treatment costs. Total pain relief was the secondary outcome of interest. We defined total pain relief as achieving a pain score of zero during the trial period.

Economic analysis

We based the economic analysis on a health system perspective. Total estimated cost of treatment per wound included cost of staff time, training, wound care products and waste disposal. A typical dressing change took 15 minutes and produced 150 g of waste. Nurses employed performed all the changes, and they were typically employed at Division 1, Grade 1 under the Residential Aged Care Nursing Home Award. Pharmacists in the intervention arm were paid a flat hourly fee for their time. The mean cost of training per wound in the intervention arm was derived from the cost of conducting the training course including cost of producing training materials and treatment protocol. We applied wholesale prices to wound care products used and if unavailable, we used trial prices. Products that could be reused or those that could be used over a period of time were included only once. All costs are in Australian dollars at 2000 prices ($A1 = $US 0.724 at 2005 purchasing power parity).

Exact methods for estimating confidence intervals (CIs) for cost-effectiveness ratios are not possible; therefore, we used the net benefit framework described by Stinnett and Mullahy[21] to evaluate the cost-effectiveness of the intervention and its precision. The incremental net benefit—extra number of wounds healed valued at society's willingness-to-pay (WTP) for a unit of effectiveness minus the extra cost—was expressed in money. A range of hypothetical WTP values was used in the calculation of the distribution of net benefits. If incremental net benefits are significantly positive across the range of plausible decision maker's WTP for the outcomes, then we can say that the intervention is cost-effective.

Sample size

Based on an assumed improvement in the healing rate from 15% to 30%, 108 wounds per arm were required to have an 80% chance of detecting a two-fold increase in healing rates at a significant level of 5%. To adjust for clustering we increased this number to 151 in each group.

Statistical analysis

All calculations, graphing and statistical modelling were performed using Stata version 9.[22] We compared categorical data using the chi-square test and continuous data using the *t*-test or Mann–Whitney test. Kaplan–Meier survival functions and the log-rank test were used to describe time to wound healing. We developed two Cox regression models to identify explanatory variables and adjust for confounding factors using a forward selection method—a standard Cox model ignoring within-patient correlation and a Cox model with shared frailty incorporating a latent (unmeasured) gamma-distributed patient-level effect.[23,24] For all covariates included in the model, the assumption of proportionality of hazards over time was verified using both graphical and statistical methods.

We adjusted estimates of treatment costs for baseline wound severity using a generalized linear model (GLM). A gamma model with log link was chosen because of the non-negative skewed distribution of costs. To account for the effect of random censoring, treatment costs were weighted by the inverse of the probability of being censored as described by Bang and Tsiatis.[25] We used the adjusted difference in mean costs and wounds healed to test the null hypothesis that net benefits were zero versus the alternative hypothesis that they were positive.[26] Ninety percent CIs were used for this one-sided test. The test requires information on the correlation between costs and outcomes and this was estimated using seemingly unrelated regression of an exponential shared frailty survival function for healing and the GLM for costs (with robust SEs calculated to account for the clustering of wounds in patients). The potential efficiency gains from considering the clustering of data at the nursing home and patient levels were explored using a random coefficients hierarchical model using the GLLAMM procedure in Stata.

As a small number of wounds in both arms had missing cost and/or outcome data, we reviewed the paper records to extract the required information. Where the number of dressing changes was unrecorded, we assumed that if products were used one change had occurred. Data were analysed on an intention-to-treat (ITT) basis and no imputation of missing data (3.2% of ITT population) was performed.

Results

Baseline characteristics

Forty-four nursing homes across metropolitan Melbourne, Australia, participated and 342 chronic wounds in 176 residents were enrolled in the trial, 180 wounds in 94 residents in the intervention arm (21 nursing homes) and 162 wounds in 82 residents in the control arm (23 nursing homes). The intervention nursing homes were serviced by 10 pharmacies with some pharmacies providing services to more than one nursing home. One pharmacist from each participating pharmacies was trained in wound care and became part of the multidisciplinary team at each nursing home. A similar number of pharmacies provided a clinical pharmacy service to the control nursing homes; however, pharmacists from these pharmacies were neither trained nor involved in wound care.

Residents in the intervention arm were comparable to their counterparts in the control arm with respect to age, length of stay in nursing homes, wound risk due to incontinence and ability to describe pain and discomfort (see Table 1). However, intervention residents were more likely to be underweight or overweight ($P = 0.000$) and less likely to have a history of leg or pressure ulcers ($P = 0.011$) compared to control residents (Table 1).

Baseline characteristics of the 342 enrolled wounds are shown in Table 2. At entry, wounds in the intervention arm were comparable to those in the control arm with respect to location, colour, depth and type. However, the two arms differed considerably on the severity and width of wounds, and level of pain. Wounds in the intervention arm were more likely to be severe, as indicated by the mean width (24.0 versus 15.2 mm, $P = 0.000$) and the proportion with moderate or profuse exudate ($P = 0.022$). Additionally, intervention wounds were three times more likely than control wounds to be present for less than 1 week at the time of enrolment into the trial ($P = 0.013$). With respect to BPI score at baseline, control wounds were more likely to cause no pain (42% versus 25%) and less likely to produce severe pain (11.8% versus 15%) than intervention wounds ($P = 0.017$).

Clinical outcomes of enrolled wounds

The percentage of wounds healed was higher in the intervention arm compared to control arm (61.7% versus 52.5%). In addition, intervention wounds healed faster than control wounds. The mean time to healing was 82 days and 101.1 days for intervention and control arms, respectively, suggesting that residents in the intervention arm had on average 19.1 more wound-free days than control residents. If the survival curves were exponentially extended to zero to account for the censoring of the longest follow-up time, an extended mean estimate of time to healing was 92.9 days for the intervention arm compared with 129.4 days for the control arm, giving a difference of 36.5 wound-free days in favour of the intervention arm. When we analysed leg ulcers and pressure sores separately similar trends were obtained (Fig. 2).

None of the differences between treatment arms identified through univariate analyses was statistically significant (see Table 3); however, in the multivariate analyses, differences between treatment arms were statistically significant. Table 4 presents results of these analyses. There was a significant patient-level effect (shared frailty variance = 0.22, $P = 0.048$) indicating that the time to healing for wounds within the same resident maybe correlated. Frailty at the nursing

TABLE 1 *Characteristics of nursing home residents at entry, by group*

Characteristic	Intervention, 94	Control, 82	*P* value
Mean (SD) age (years)	83.0 (9.1)	83.7 (8.9)	0.635
Mean (SD) days in nursing home	681.5 (877.2)	731.7 (973.0)	0.749
Women	60 (63.8%)	64 (78.0%)	0.039
Physical status			
Underweight	46 (48.9%)	17 (20.7%)	0.000
Average	37 (39.4%)	59 (72.0%)	
Overweight	11 (11.7%)	6 (7.3%)	
History of previous leg or pressure ulcers			
Yes	40 (42.6%)	49 (62.0%)	0.011
No	54 (57.4%)	30 (38.0%)	
Ability to describe pain or discomfort			
Yes	62 (66.0%)	57 (69.5%)	0.615
No	32 (34.0%)	25 (30.5%)	
Urinary incontinence			
None	46 (48.9%)	50 (61.0%)	0.460
Minor	4 (4.3%)	3 (3.6%)	
Significant	38 (40.4%)	25 (30.5%)	
Catheterized	6 (6.4%)	4 (4.9%)	
Faecal incontinence			
None	51 (54.3%)	55 (67.1%)	0.176
Minor	11 (11.7%)	9 (11.0%)	
Significant	32 (34.0%)	18 (21.9%)	

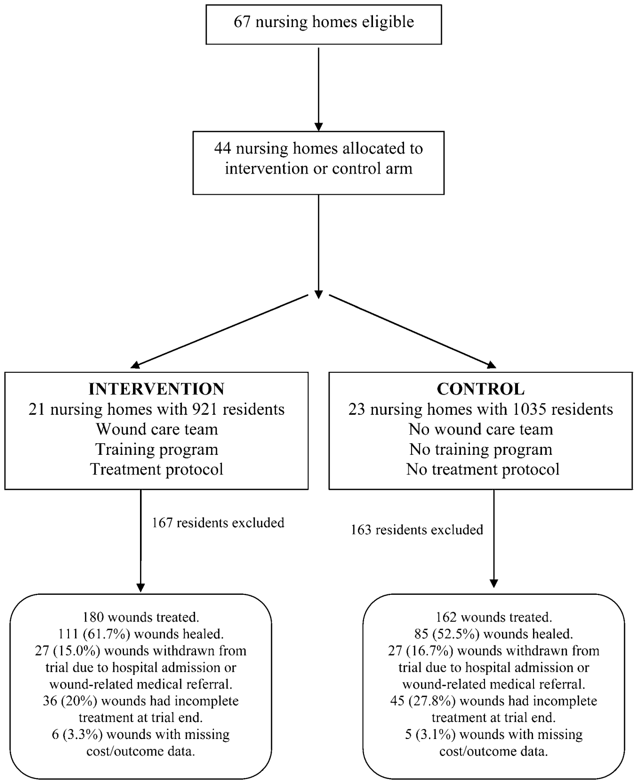

FIGURE 1 *Profile of a cluster trial of the cost-effectiveness of multidisciplinary wound care in nursing homes, Melbourne, Australia 2000*

home level was found to be statistically insignificant (shared frailty variance = 0.06, $P = 0.156$). The point estimate of the relative risk of healing is similar across models, with heterogeneity increasing the CIs slightly. The chances of healing increased 73% for wounds in the intervention arm (95% CI 20–150%, $P = 0.003$). For every 1 mm increase in the width of the wound at enrolment, the chances of healing decreased by 4.0% (95% CI 2.0–5.0%, $P = 000$). The model predicted that deep wounds had 60% (95% CI 38–75%, $P = 0.000$) reduced chances of healing compared to superficial wounds. Age, wound exudate, wound risk, weight category, duration of wound, time in nursing home were not statistically significant and hence excluded as explanatory variables for the differences between treatment arms.

An analysis of BPI score in assessable patients showed that there was significant pain reduction in the intervention arm. The percentage of wounds achieving total pain relief was greater in the intervention arm (38.6%) than in the control arm (24.4%) ($P = 0.017$).

Economic evaluation

Table 5 presents a comparison of the mean costs of treatment for control and intervention arms. Standardized treatment provided by a wound care team resulted in a reduction (unadjusted) in the mean

TABLE 2 *Baseline characteristics of enrolled wounds, by group*

Characteristic	Intervention, 180	Control, 162	*P* value
Wound type			
Leg ulcer	40 (22.2%)	41 (25.3%)	0.503
Pressure ulcer	140 (77.8%)	121 (74.7%)	
Wound location			
Foot	41 (23.2%)	51 (31.9%)	0.267
Back	3 (1.7%)	2 (1.2%)	
Leg	42 (23.7%)	38 (23.8%)	
Sacrum	64 (36.2%)	42 (26.2%)	
Other	27 (15.2%)	27 (16.9%)	
Wound colour			
Black (necrotic)	16 (9.0%)	9 (5.6%)	0.200
Green (infected)	7 (4.0%)	2 (1.2%)	
Red (granulating)	97 (54.8%)	89 (54.9%)	
Yellow (sloughy)	57 (32.2%)	62 (38.3%)	
Wound depth			
Superficial	129 (71.7%)	123 (75.9%)	0.372
Deep	51 (28.3%)	39 (24.1%)	
Mean (SD) width (mm)	24.0 (20.4)	15.2 (12.2)	0.000
Wound exudate			
None	26 (14.4%)	30 (18.5%)	0.022
Scanty	85 (47.2%)	93 (57.4%)	
Moderate	51 (28.3%)	33 (20.4%)	
Profuse	18 (10.0%)	6 (3.7%)	
BPI score[a]			
Score of 0	32 (25.2%)	50 (42.0%)	0.017
Score 1–3 (mild)	38 (29.9%)	20 (16.8%)	
Score 4–7 (moderate)	38 (29.9%)	35 (29.4%)	
Score 8–10 (severe)	19 (15.0%)	14 (11.8%)	

[a]Assessable residents (246 wounds, 119 control arm and 127 intervention arm).

treatment costs of $A357.7 ($P$ = 0.006) when training costs were included or $A361.5 when training costs were excluded (P = 0.004). Most of the cost reduction was obtained from decreases in nursing time and waste disposal (Table 6). When the costs of treatment were analysed for leg ulcers and pressure sores separately, a similar pattern of cost reduction emerged, although for leg ulcers the difference between treatment arms was not statistically significant.

Adjusting for baseline wound depth and width and random censoring in the GLM, the predicted cost saving per wound was $A277.9 (95% CI $A21.6–$A534.1). We calculated the net benefit statistic from this cost estimate along with the predicted mean time with an unhealed wound from the duration analysis. The estimated correlation between costs and the rate of wound healing was negative (results not shown), but sensitivity analysis showed that it had little impact on the CIs around the net benefits. As shown in Figure 3, net benefits and their 95% CIs were always positive for any non-negative social WTP for a day without a chronic wound. In other words, the intervention resulted in both significant cost savings and significantly improved outcomes. The results of the hierarchical model confirmed the savings predicted in the GLM. There was significant patient-level variation in the cost of wound healing, but not significant variation across nursing homes.

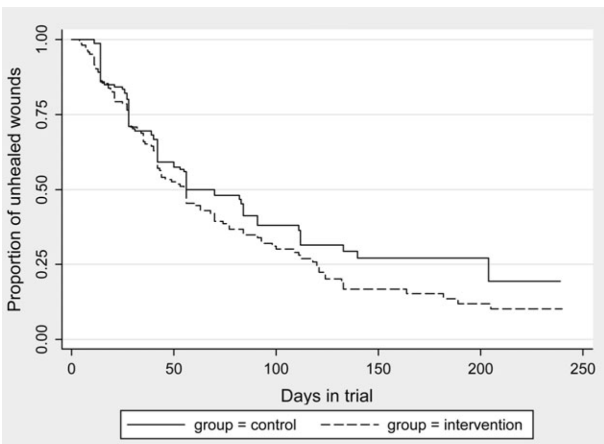

FIGURE 2 *Kaplan–Meier failure curves for time to healing*

Discussion

Standardized treatment provided by a trained multidisciplinary wound care team significantly improved healing outcomes of uncomplicated leg and pressure ulcers and reduced treatment costs. The cost of training of $A14.2 per wound was offset by a saving of $A263.7 per wound. We found that the cost saving was consistent across all the analyses and robust across a range of parameters included to adjust for differences in baseline wound severity, the correlation between costs and outcomes, the random censoring of wounds and the hierarchical nature of the data. Savings were seen in all cost categories, although differences between treatment arms with respect to the cost of products were not statistically significant.

In Australia, pharmacists have already been involved in the care of nursing home residents through various processes such as medication reviews. Our findings suggest extending their role to support wound management services in nursing homes, particularly

TABLE 3 *Clinical outcomes, by group*

Outcome	Intervention, 180	Control, 162	P value
Percentage healed	61.7%	52.5%	0.074
Mean time to healing (days) (95% CI)	82.0 (69.1–94.9)[a]	101.1 (84.5–117.6)[b]	0.095
Total pain relief (BPI score = 0)[b]	49 (38.6%)	29 (24.4%)	0.017

[a]Largest observed analysis time is censored, mean is underestimated.
[b]Assessable residents (246 wounds, 119 control and 127 intervention).

TABLE 4 *Estimated hazard ratios and 95% CIs for 308 chronic wounds*

Variable	Ordinary Cox model		Cox model with shared frailty	
	Relative risk (95% CI or SE)	P	Relative risk (95% CI or SE)	P
Group	1.67 (1.23–2.26)	0.001	1.73 (1.20–2.50)	0.003
Increasing wound width (mm)	0.97 (0.95–0.98)	0.000	0.96 (0.95–0.98)	0.000
Increasing wound depth	0.46 (0.30–0.70)	0.000	0.40 (0.25–0.62)	0.000
Shared patient frailty			0.22	0.048
Shared nursing home frailty			0.06	0.156

Table 5 *Mean treatment costs, by wound type and group*

Wound type	Intervention mean (95% CI)	Control mean (95% CI)
All chronic wounds		
Treatment costs excluding training	$A602.2 (465.2–739.2)	$A977.9 (754.7–1201.1)
Treatment costs including training	$A616.4 (479.4–753.4)	$A977.9 (754.7–1201.1)
Total number of wounds	174	157
Number of wounds healed (%)	111 (63.8)	85 (54.1)
Leg ulcer		
Treatment costs excluding training	$A739.1 (358.6–1119.5)	$A897.7 (420.3–1375.0)
Treatment costs including training	$A753.3 (372.9–1133.8)	$A897.7 (420.3–1375.0)
Total number of wounds	40	40
Number of wounds healed (%)	31 (77.5)	27 (68.5)
Pressure ulcer		
Treatment costs excluding training	$A561.3 (421.7–701.0)	$A1005.3 (750.0–1260.6)
Treatment costs including training	$A575.6 (435.9–715.3)	$A1005.3 (750.0–1260.6)
Total number of wounds	134	117
Number of wounds healed (%)	80 (59.7)	58 (49.6)

$A1 = 0.477£.[27]

Table 6 *Mean treatment costs, by cost type and group*

Wound type	Intervention mean (95% CI)	Control mean (95% CI)
Mean nursing costs	$A54.5 (43.9–65.0)	$A234.0 (181.3–286.7)
Mean product costs	$A507.3 (378.8–635.8)	$A729.8 (558.2–901.4)
Mean disposal costs	$A3.3 (2.6–3.9)	$A14.1 (10.9–17.2)

$A1 = 0.477£.[27]

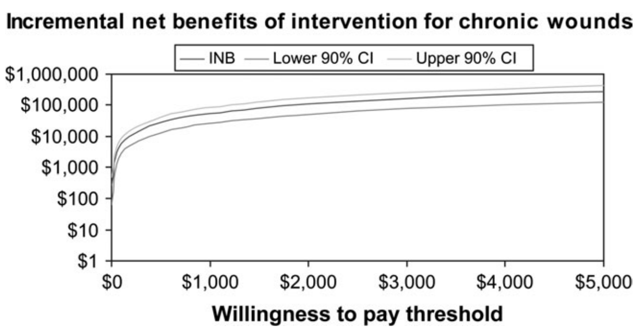

Figure 3 *Incremental net benefits of intervention for chronic wounds*

advising on product selection and appropriate use. Informal feedback from nursing homes in the intervention arm indicated that the support pharmacists provided to nurses in clinical decision making was highly valued. These facilities also reported that the treatment protocol was readily accepted and universally endorsed by those who used it.

Limitations

There was an imbalance between the two arms particularly with respect to the severity of wounds at baseline that may have confounded treatment comparison. However, it should be noted that the imbalance favours the control arm and not the intervention arm, and that this was taken into account in the analysis. We have adjusted for the obvious sources of potential bias such as baseline wound severity, random censoring, the covariance between cost and outcomes and the error structure arising from the inherently hierarchical nature of the data. There may remain some unobserved heterogeneity in the wounds treated in each arm. This is a particularly complex set of data and we were not able to adjust for all these factors simultaneously. It maybe that other approaches such as Bayesian simulation methods might offer a more integrated way of analysis.

We allocated participating nursing homes to intervention or control arm using a pseudo-randomized approach for practical reasons. On the other hand, our pragmatic approach to the trial mirrors ‘real-world’ practice and allows generalization of the results to facilities typically seen in the nursing home setting. This study design does make it difficult to distinguish the key elements of the intervention that contributed most significantly to outcomes. It maybe that no single element was responsible and that the combination of the pharmacist involvement as part of the multidisciplinary team, the availability of the standard treatment protocol and the training programme has produced the positive outcomes observed.

In conclusion, treatment of uncomplicated chronic wounds in the nursing home setting by a trained multidisciplinary team using a standardized treatment protocol was cost-effective compared with usual care. The intervention was relatively inexpensive and easy to implement. Opportunities exist for provision to be made for a standardized and multidisciplinary approach to wound care for Australians in residential aged care facilities.

Acknowledgements

We wish to thank the participating nursing homes for their involvement, trial staff for their dedication and hard work, Wendy McCulloch, Sarah Andrews, Tam Vuong, Lauren Mansell and Margot Syme who contributed to data collection and Ian Story for assistance with the design of the trial.

Declaration

Funding: This project was funded by the Australian Government Department of Health and Ageing under the Third Community Pharmacy Agreement Research and Development Grants Program that is managed by the Pharmacy Guild of Australia (Community Pharmacy Agreement Research and Development Grant No. 5002553/99).

Ethical approval: We received approval from appropriate ethics committees.

Conflicts of interest: None.

References

[1] Berlowitz DR, Brandeis GH, Brand HK, Halpern J, Ash AS, Moskowitz MA. Evaluating pressure ulcer occurrence in long-term care: pitfalls in interpreting administrative data. *J Clin Epidemiol* 1996; **49:** 289–292.

[2] Coleman EA, Martau JM, Lin MK, Kramer AM. Pressure ulcer prevalence in long-term nursing home residents since the implementation of OBRA '87. Omnibus Budget Reconciliation Act [comment]. *J Am Geriatr Soc* 2002; **50:** 728–732.

[3] Spector WD, Kapp MC, Tucker RJ, Sternberg J. Factors associated with presence of decubitus ulcers at admission to nursing homes. *Gerontologist* 1988; **28:** 830–834.

[4] Young JB, Dobrzanski S. Pressure sores epidemiology and current management concepts. *Drugs Aging* 1992; **2:** 42–57.

[5] Panfil EM, Mayer H, Junge W *et al*. Wound management in patients with chronic wounds in ambulatory nursing-a pilot study. *Pflege* 2002; **15:** 169–176.

[6] Johnson M. Healing determinants in older people with leg ulcers. *Res Nurs Health* 1995; **18:** 393–403.

[7] Harding KG, Morris HL, Patel GK. Science, medicine and the future: healing chronic wounds [comment]. *Br Med J.* 2002; **324:** 160–163.

[8] Krichbaum K, Pearson V, Savik K, Mueller C. Improving resident outcomes with GAPN organization level interventions. Gerontological advanced practice nurses. *West J Nurs Res* 2005; **27:** 322–337.

[9] Law J. Education. Pressure ulcer prevention: education for nursing home staff. *Br J Nurs* 2003; **12:** 566–569.

[10] Tetterton M, Parham IA, Coogle CL *et al*. The development of an educational collaborative to address comprehensive pressure ulcer prevention and treatment. *Gerontol Geriatr Educ* 2004; **24:** 53–65.

[11] Maklebust J. Pressure ulcers: the great insult. *Nurs Clin North Am* 2005; **40:** 365–389.

[12] Davies D, Danaher A. Crossing area and staff boundaries in wound care. *Prof Nurse* 1998; **13:** 472–473.

[13] Douglas WS, Simpson NB. Guidelines for the management of chronic venous leg ulceration. Report of a multidisciplinary workshop. British Association of Dermatologists and the Research Unit of the Royal College of Physicians. *Br J Dermatol* 1995; **132:** 446–452.

[14] Kartes SK. A team approach for risk assessment, prevention, and treatment of pressure ulcers in nursing home patients. *J Nurs Care Qual* 1996; **10:** 34–45.

[15] Zieglmeier M. Management of chronic wounds: the role of the hospital pharmacist. *Krankenhauspharmazie* 2005; **26:** 41–47.

[16] Auchincloss S. Thinking 'CDE' assists in the assessment phase. *Australian Doctor* 1997.

[17] Commonwealth of Australia (COA). *The Residential Care Manual.* Canberra: COA, 2005.

[18] Ware JE Jr, Sherbourne CD. The MOS 36-item short-form health survey (SF-36). Conceptual framework and item selection. *Med Care* 1992; **30:** 473–483.

[19] Hawthorne G, Richardson J, Day N. A comparison of the assessment of quality of life (AQoL) with four other generic utility instruments. *Ann Med* 2001; **33:** 358–370.

[20] Cleeland CS. Measurement of pain by subjective report. In: Chapman CR, Loser JD. (eds). *Advances in Pain Research and Therapy. Vol 12: Issues in Pain Measurement.* New York: Raven Press, 1989: 391–403.

[21] Stinnett AA, Mullahy J. Net health benefits: a new framework for the analysis of uncertainty in cost-effectiveness analysis. *Med Decis Making* 1998; **(suppl 2):** S68–S80.

[22] Stata Corp. *Intercooled Stata Version 9.* College Station, TX: Stata Corp, 2005.

[23] Cox DR. Regression models and life tables. *J R Stat Soc B* 1972; **34:** 187–220.

[24] Vaupel JW, Manton KG, Stallard E. The impact of heterogeneity in individual frailty on the dynamics of mortality. *Demography,* 1979; **16:** 439–454.

[25] Bang H, Tsiatis AA. Estimating medical costs with censored data. *Biometrika* 2000; **87:** 329–343.

[26] Willan AR, Briggs AH, Hoch JS. Regression methods for covariate adjustment and subgroup analysis for non-censored cost-effectiveness data. *Health Econ* 2004; **13:** 461–475.

[27] OECD. *PPP for GDP—Historical Series.* 2006. http://www.oecd.org/document/15/0,2340,en_2825_293564_1873295_1_1_1_1,00.html#PPPs (accessed on February 27, 2006).