A multilevel analysis of three randomised controlled trials of the Australian Medical Sheepskin in the prevention of sacral pressure ulcers

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ABSTRACT

Objective: To assess the effectiveness of the Australian Medical Sheepskin in preventing sacral pressure ulcers (PUs), based on combined data from existing published trials.

Design and setting: Data from two randomised controlled trials (RCTs) among Australian hospital patients and one RCT among Dutch nursing home patients were pooled, comprising a total population of 1281 patients from 45 nursing wards in 11 institutions. These data were analysed in two ways: with conventional meta-analysis based on the published effect sizes; and with multilevel binary logistic regression based on the combined individual patient data. In the multilevel analysis, patient, nursing ward and institution were used as levels and we controlled for sex, age, PU risk and number of days of observation.

Main outcome measure: Incidence of sacral PUs.

Results: Overall, the incidence of sacral PUs was 12.2% in the control group versus 5.4% in the intervention group with an Australian Medical Sheepskin. Conventional meta-analysis showed significantly reduced odds of developing a PU while using the sheepskin (odds ratio [OR], 0.37 [95% CI, 0.17–0.77]). Multilevel analysis gave an OR of 0.35 and narrowed the confidence interval by almost 50% (95% CI, 0.23–0.55).

Conclusions: These analyses of pooled data confirm that the Australian Medical Sheepskin is effective in preventing sacral PUs. Multilevel analysis of individual patient data gives a more precise effect estimate than conventional meta-analysis.

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Pressure ulcers (PUs) are a highly prevalent problem.[1,2] They have a large impact on quality of life[3,4] and high costs are involved in treatment.[5-7] There is a lack of knowledge about the effectiveness and cost-effectiveness of many of the devices that help prevent PUs.[8,9] One such preventive device is the sheepskin. Sheepskins were commonly used in the past, but due to poor product specification and inferior manufacturing practices, combined with the influx of synthetic, imitation products, the use of genuine sheepskins declined. Poorly manufactured natural sheepskins were difficult to launder and did not meet infection-control standards; synthetic sheepskins were found to have little pressure-relieving capacity.[10,11]

The Commonwealth Scientific and Industrial Research Organisation (CSIRO) renewed interest in the natural product and in 1998 introduced the Australian Medical Sheepskin, specified by the Australian Standard AS4480.1-1998.[12] This sheepskin is capable of withstanding repeated washing at 80°C, satisfying infection-control requirements.[13] Its dense, 25 mm natural wool pile reduces pressure, shear and friction forces, and has the capacity to absorb moisture away from the patient's skin. Its effectiveness has been studied in two randomised controlled trials (RCTs) in hospital patients[14,15] (in 2000 and 2004) and in a recent RCT in nursing homes (in 2009).[16]

We aimed to estimate the overall effectiveness of the Australian Medical Sheepskin in preventing sacral PUs across these three RCTs, using two methods: first, conventional meta-analysis of the pooled published effect sizes; and second, multilevel analysis of the combined individual patient data, which should give a more reliable and informative estimate of the effect size.[17,18]

METHODS

Selection of the three trials used for the combined analysis was based on the search results of two systematic reviews,[9,19] complemented by an additional recent trial known to us.[16] The characteristics of the three trials are described in Box 1.

To enable us to pool the results, we identified the common interventions and outcomes. In all three trials, patients were randomly allocated to either use of an Australian Medical Sheepskin overlay in their beds, or usual care with a standard mattress. While both Australian trials used the incidence of any PUs, the Dutch trial used the incidence of sacral PUs only. We therefore analysed the effect of the sheepskin only on the incidence of sacral PUs; we considered the three trials to be sufficiently comparable to allow this analysis. Severity of ulcers was categorised in the three trials according to comparable four-grade systems. The length of follow-up in the hospital trials was until discharge from hospital, and in the nursing home trial, to 30 days after admission or until discharge (whichever came first).

Differences in patient characteristics (PU risk, age, and hospital or nursing ward) between the trials were taken into account in the analyses.

We contacted the study authors and asked for permission to use their individual patient data and, if they consented, to send the original (de-identified) data of all patients for whom a completed record was obtained. Datasets were standardised by giving common variables the same names, and basic frequency analyses were performed and checked against the published results. The standardised datasets were sent to the study authors for verification that the process had been applied correctly, before being merged into one dataset of only those variables used in all three trials. The combined data were again sent to the study authors for a final check that the merging process had been performed correctly.

A conventional meta-analysis was performed on the pooled published effect sizes from each trial using the Mantel–Haenszel method with a random effects model, computed using Review Manager, version 5.0, 2008 (Nordic Cochrane Centre, Cochrane Collaboration, Copenhagen, Denmark).

Multilevel binary logistic regression analysis was performed on the individual patient data using MLwiN, version 2.02,

1 Characteristics of the three randomised controlled trials of the effectiveness of the Australian Medical Sheepskin analysed in this study

	McGowan 2000[14]	Jolley 2004[15]	Mistiaen 2010[16]
Inclusion criteria	Admitted with an orthopaedic diagnosis	Admitted to one of the hospital wards	Admitted to one of the wards for a primarily medical reason
	Age ⩾ 60 years	Age ⩾ 18 years	Age ⩾ 18 years
	Low or moderate risk of developing a pressure ulcer (Braden scale[20])	Low or moderate risk of developing a pressure ulcer (Braden scale[20])	
Exclusion criteria	A pressure ulcer on admission	A pressure ulcer on admission	A pressure ulcer on admission
	Anticipated stay < 48 h	Anticipated stay < 48 h	Anticipated stay < 1 week
	Patients with darkly pigmented skin	Patients with darkly pigmented skin	Patients with darkly pigmented skin
	No risk or high risk for pressure ulcers	No risk or high risk for pressure ulcers	
Institutions	Two Australian hospitals	One Australian hospital	Eight Dutch nursing homes
Nursing wards	Four orthopaedic wards	18 nursing wards (all types of medical and surgical specialty)	23 nursing wards (mainly rehabilitation)
Intervention	Usual care with standard hospital mattress and an Australian Medical Sheepskin overlay on the bed	Usual care with standard hospital mattress and an Australian Medical Sheepskin overlay on the bed	Usual care with standard hospital mattress and an Australian Medical Sheepskin overlay on the bed
	Sheepskin heel and elbow protectors if required	Sheepskin heel and elbow protectors if required	Sheepskin under heels or in chair allowed
Control condition	Usual care with standard hospital mattress	Usual care with standard hospital mattress	Usual care with standard hospital mattress
Outcome			
Type of ulcer	Incidence of all kinds of pressure ulcers (all grades)	Incidence of all kinds of pressure ulcers (all grades)	Incidence of sacral pressure ulcers (all grades)
Assessment	Daily visual inspection of the skin by nurse; regular checks by primary investigator	Daily visual inspection of the skin by nurse; regular checks by primary investigator	Daily visual inspection of the skin by nurse; regular checks by primary investigator
Study endpoint	Discharge (including dying) or transfer to other ward or institution	Discharge (including dying) or transfer to other ward or institution	Discharge (including dying) or transfer to other ward or institution or 30 days after admission
	Became high risk	Became high risk	

2005 (Centre for Multilevel Modelling, University of Bristol, Bristol, UK), with three nested levels: patients within wards within institutions. The independent variable was the allocated group; the dependent variable was the incidence of sacral PUs during the period of observation. We controlled for age, sex, number of days of observation and the PU risk at admission (measured with the Braden scale in all three RCTs[20]). Multilevel analyses were done for the three trials separately and for the combined dataset. The results are expressed as odds ratios with 95% confidence intervals.

2 Assessment of the risk of bias in the three randomised controlled trials (RCTs) analysed in this study, according to two reviews and our own judgement

	McGowan 2000[14]		Jolley 2004[15]		Mistiaen 2010[16]
Aspect of trial	**2008 review[9]**	**2009 review[19]**	**2008 review[9]**	**2009 review[19]**	**Own judgement**
Designed as RCT	No	Yes	Yes	Yes	Yes
Concealed allocation	Unclear	Yes	Yes	Yes	Yes
Sample size calculation	Yes	Yes	Unclear	Yes	Yes
Blinded outcome assessment	No	No	No	No	No
Intention-to-treat analysis	Not stated in review	No	No	Yes	Yes

Risk of bias in the studies was assessed on five aspects as published in the two systematic reviews[9,19] for the two Australian trials, and on our own judgement for the Dutch trial (Box 2).

Ethics approval had been obtained for each of the trials. Permission to pool the data was obtained from the primary authors and their managers. All individual patient data were de-identified.

RESULTS

The total population consisted of 1281 patients from 11 institutions and involved 45 nursing wards. The three combined RCTs covered more than 20 000 observation days. The mean observation length was about 17 days, varying from about 7 and 11 in the hospital trials to 28 in the nursing home trial. Intervention and control groups were comparable in the separate trials and in the combined dataset with respect to age, sex, PU risk and number of observation days. The main characteristics of the

3 Main characteristics of patients in the three randomised controlled trials of the Australian Medical Sheepskin analysed in this study, by allocated group

Patient characteristic	Study	Intervention group	Control group	*P*
Number included in analysis (number undergoing randomisation)	McGowan 2000[14]	155 (155)	142 (142)	
	Jolley 2004[15]	218 (270)	223 (269)	
	Mistiaen 2010[16]	271 (295)	272 (293)	
	Pooled data	644 (720)	637 (704)	0.75
Mean age, years (median [range])	McGowan 2000	73.7 (74 [60–97])	74.0 (74 [60–96])	
	Jolley 2004	63.2 (68 [18–97])	61.1 (64 [18–99])	
	Mistiaen 2010	78.5 (80 [26–97])	78.3 (81 [28–98])	
	Pooled data	72.1 (75 [18–97])	71.3 (75 [18–99])	0.33
Sex, % female	McGowan 2000	53.5%	61.3%	
	Jolley 2004	48.6%	51.6%	
	Mistiaen 2010	72.0%	66.5%	
	Pooled data	59.6%	60.1%	0.86
Pressure ulcer risk, mean Braden scale score[20]	McGowan 2000	13.9	14.0	
	Jolley 2004	15.7	15.9	
	Mistiaen 2010	18.2	18.1	
	Pooled data	16.2	16.3	0.49
Mean number of days of observation	McGowan 2000	10.6	10.7	
	Jolley 2004	7.9	7.0	
	Mistiaen 2010	27.9	27.7	
	Pooled data	16.9	16.6	0.59
Total number of days of observation	McGowan 2000	1 635	1 513	
	Jolley 2004	1 728	1 561	
	Mistiaen 2010	7 549	7 510	
	Pooled data	10 912	10 584	

patients in the individual studies and in the total group are shown in Box 3.

The overall incidence of sacral PUs in the three trials was 5.4% (35 PUs) in the intervention group versus 12.2% (78 PUs) in the control group (bivariate χ^2, $P < 0.001$). The relative risk reduction was 56% (95% CI, 35%–70%). Of the 113 newly acquired sacral PUs, 92 (81%) were grade 1 (least severe), 19 (17%) were grade 2, and 2 (2%) were grade 3.

The conventional meta-analysis showed an odds ratio for developing a grade 1–4 sacral PU during the period of observation while using a sheepskin of 0.37 (95% CI, 0.17–0.77; heterogeneity, $I^2 = 59\%$), compared with no sheepskin. The multilevel logistic regression analysis showed an odds ratio of 0.35 (95% CI, 0.23–0.55). The results of both analyses are shown in Box 4 and Box 5.

4 Incidence of sacral pressure ulcers (PUs) and results from analyses of data from three randomised controlled trials of the Australian Medical Sheepskin

	Intervention group		Control group		Odds ratio (95% CI)	
Study	No. of PUs (grade 1, 2, 3, 4)	Patients	No. of PUs (grade 1, 2, 3, 4)	Patients	Conventional meta-analysis*	Multilevel analysis†
McGowan 2000[14]	4 (4, 0, 0, 0)	155	22 (20, 2, 0, 0)	142	0.14 (0.05–0.43)	0.14 (0.04–0.43)
Jolley 2004[15]	7 (5, 2, 0, 0)	218	16 (13, 3, 0, 0)	223	0.43 (0.17–1.06)	0.32 (0.12–0.85)
Mistiaen 2010[16]	24 (18, 6, 0, 0)	271	40 (32, 6, 2, 0)	272	0.56 (0.33–0.96)	0.53 (0.29–0.95)
Overall	*35 (27, 8, 0, 0)*	*644*	*78 (65, 11, 2, 0)*	*637*	*0.37 (0.17–0.77)*	*0.35 (0.23–0.55)*

* Pooled published effect sizes. † Pooled individual patient data. ◆

DISCUSSION

Conventional meta-analysis of effect sizes for the three trials demonstrated that the Australian Medical Sheepskin was effective in preventing sacral PUs, with an odds ratio of 0.37. The multilevel analysis on the combined individual patient data resulted in an odds ratio of 0.35, confirming that the Australian Medical Sheepskin is effective. Using individual patient data gave a confidence interval almost 50% smaller than that from the conventional meta-analysis, and hence a more precise effect estimate. Moreover, multilevel analysis of individual patient data is preferred because it can take patient and ward characteristics into account.

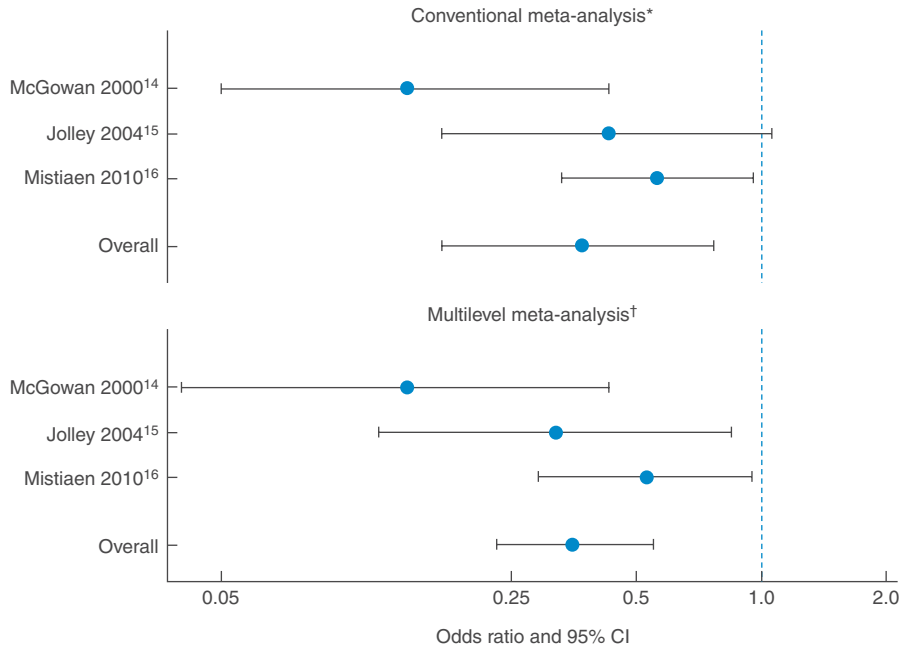
Although both approaches give an overall effect estimate, both remain liable to risk of bias in the trials, for instance due to inadequate allocation concealment or suboptimal outcome assessment. Furthermore, although the risk of bias of the underlying studies was assessed as much as possible on judgements from published systematic reviews, there might still be a bias in the pooled analysis because we were all also co-authors of the pooled studies.

In line with earlier studies, our results have shown that the Australian Medical Sheepskin is an effective aid in preventing PUs.[9,19] However, further research about the effectiveness of the Australian Medical Sheepskin is still needed. All three trials involved short observation periods, and this can be a critical stage, as it is known that many PUs develop when patients are relatively immobile,[21] and most PUs in nursing homes develop within the first 3 weeks after admission.[22] How good the Australian Medical Sheepskin is in preventing PUs in patients confined to bed for longer terms is still unknown. Research involving larger sample sizes is also needed to study its effect in the prevention of higher grade PUs. In practice, the Australian Medical Sheepskin is an effective option for use in the prevention of pressure ulcers, and our findings suggest that guidelines need no longer discourage its use.

COMPETING INTERESTS

We are also authors or co-authors of the previous trials from which data were pooled. Mark Hickey is employed by the CSIRO, which coordinated the development of the Australian Standard 4480.1-1998 for the Australian Medical Sheepskin. No supplier of Australian Medical Sheepskins was

5 Conventional and multilevel analyses of pooled data from three randomised controlled trials of the Australian Medical Sheepskin



* Pooled published effect sizes. † Pooled individual patient data. ◆

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