Effectiveness Bulletin

Preventing and treating pressure sores

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This review is based on *Effective Health Care*, Volume 2, Bulletin No 1

Pressure sores (also known as bedsores, pressure ulcers, and decubitus ulcers) are areas of localised damage to the skin and underlying tissue caused by pressure, shear, or friction. They usually occur over bone prominences, such as the base of the spine, hips, and heels. Pressure sores occur in hospital and community settings: a case study of a district general hospital in the United Kingdom identified that new pressure sores occurred in 4%–10% of patients admitted, depending on case mix.¹ Pressure sores occur most often in elderly patients and immobile patients (for example, orthopaedic patients), those with severe acute illness (for example, patients in intensive care units), and in people with neurological deficits (for example, people with spinal cord injuries).

Pressure sores represent a major burden of sickness and reduced quality of life for patients and their carers, and they are costly to the National Health Service. The cost of preventing and treating pressure sores in a 600 bed large general hospital has been roughly estimated at between £600 000 and £3m a year.²

It is commonly thought that most pressure sores are avoidable, and several initiatives have been established to give priority to preventing them.^{3–4} The 1994–5 National Health Service *Priorities and Planning Guidance*⁵ encouraged health authorities to set annual targets for an overall reduction in prevalence of pressure sores of at least 5%. However, this type of target setting may not be sensible as the prevalence of pressure sores is affected by so many factors unrelated to the quality of care, such as the number of patients admitted with a sore and the discharge policy. Measures of the *incidence* of pressure sores may be used to compare the quality of care over time and among units but only if they are adjusted for patients' risk of developing sores.

It is essential that any initiatives to reduce the incidence of pressure sores are based on the best available evidence of clinical effectiveness and cost effectiveness. Healthcare professionals attempt to reduce incidence by identifying people at high risk and the use of prevention strategies such as pressure relieving equipment. This paper systematically reviews the evidence for the accuracy of predicting risk of pressure sores and the effectiveness of pressure relieving interventions.

Identifying people at risk: risk assessment scales

Interventions to prevent development of pressure sores can be expensive, and ensuring that resources are targeted towards patients who are at high risk of developing sores is important. Various scales have been developed to try to identify people at increased risk.^{6–14} These are based on assessments of a range of clinical variables such as mobility, incontinence, and activity; the total score is generally compared to a standard reference value to classify the level of risk. Most scales were developed ad hoc and are based on opinions of the relative importance of possible risk factors, rather than on hard evidence. However, the most valid way of constructing such a scale entails the use of statistical regression models to choose and weight the factors which best predict the development of a sore. No risk assessment scale has been developed in this way; thus the existing scales are unlikely to discriminate optimally between patients who will and will not develop a pressure sore.

No published evaluation reliably assesses whether the use of a risk assessment scale as an adjunct to care results in a reduction in the incidence of pressure sores. One study, which compared nurses' judgement of risk with that calculated using the Braden score, showed a high level of agreement¹⁵; however, the patients were not followed up and so it is unknown whether this risk scale *predicts* better than clinical judgement. Table 1 shows the studies which used valid techniques¹⁶ to assess the predictive validity of these scales. Owing to a variety of potential biases, most of the studies underestimate the accuracy of the scales.¹⁷

Great variation exists in the estimates of predictive validity across scales and between assessments of the same scale. Since the variation in methods of assessment and care settings is so great comparing the predictive validities of the scales is not possible. Although some of the estimates of predictive validity are quite high, there is great variation between them, and none of the scales seems to be unambiguously superior. For example, although one study found that six different scales had similar predictive validity when applied to the same patients¹⁸ another, comparing two scales on a cohort of orthopaedic

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patients, showed that the Waterlow scale had higher sensitivity and specificity than the Norton scale.¹⁹

Evaluating interventions to relieve pressure

The aim of strategies to prevent pressure sores is to reduce the pressure beneath a patient. This may be achieved by regular manual repositioning or the use of pressure relieving support surfaces such as mattress overlays, replacement mattresses, or whole bed replacements, and costs vary accordingly. Strategies to treat pressure sores usually comprise a combination of pressure relief and wound care.

Pressure relieving beds and mattresses may be classified as alternating pressure, constant low pressure, and turning devices.²⁰ Alternating pressure devices (available as mattress overlays and mattress replacements) generate alternating high and low interface pressures between the body and the support, usually by alternate inflation and deflation of air filled cells. Constant low pressure devices (either overlays, mattresses, or replacement beds) mould around the body to spread the load over a greater area and can be grouped according to their construction (foam, foam and air, foam and gel, profiled foam, hammocks, air suspension, water suspension, and air-particulate suspension or air fluidised). Turning beds move, either manually or automatically, those patients who are unable to turn themselves.

We identified studies by systematic searching of health related databases and by hand-searching relevant journals. Only randomised controlled trials were included because, when well designed, they provide the most reliable evidence for the efficacy of interventions. Random allocation of patients to treatment and control groups improves the comparability of the groups and so differences in outcomes can be more confidently attributed to a particular treatment, once random error is excluded by significance testing.¹⁶ Many evaluations simply measured the pressure on different parts of the body in contact with the support surface (interface pressure).²¹ However, interface pressure is an intermediate or surrogate outcome measure which has serious limitations as a proxy for clinical outcome. Only trials which report clinical outcome measures were considered.

We identified 16 trials which randomised patients at high risk of developing pressure sores (but without pressure sores on entry) to various pressure relieving, preventive interventions (table 2). Eight further trials recruited patients with pre-existing sores, to assess the treatment efficacy of pressure relieving supports, and six trials recruited a mixture of patients with and without pre-existing sores. The methodological quality of studies was generally poor. For example, only a third of the reports gave information that makes us confident that patients were truly randomly allocated.²²

A brief description of the study findings is provided below to give an overall picture of the

effectiveness of pressure relieving interventions in preventing and treating pressure sores. The results are summarised according to the type of interventions.

MANUAL REPOSITIONING

Manual repositioning, usually achieved by turning patients from side to side, is an established means of preventing pressure sores. At first sight it might seem to be the cheapest technique; however the cost in terms of staff time and the risk of back strain among staff and carers must be considered. Little research demonstrates the effectiveness of manual repositioning, and the optimum frequency of repositioning is unclear. Changes of position every two hours are often recommended, but alternatives have not been evaluated. Only one small randomised controlled trial evaluated routine manual repositioning compared with the normal ward regimen; however, only 10 patients actually received regular repositioning, and a regular turning regimen was found difficult to implement.²³ Two randomised controlled trials evaluated unscheduled turning,^{24 25} but in both the incidence of pressure sores was extremely low, sample sizes were small, and no significant difference was detectable between experimental and control groups. Little is known of the need for manual repositioning when patients are using pressure relieving surfaces.

"LOW TECH" CONSTANT PRESSURE SUPPORTS *Trials of standard hospital mattresses*

Six randomised controlled trials comparing "standard" mattresses or surfaces with "low tech" supports for preventing pressure sores were identified (J E Santy *et al*, report to Northern and Yorkshire Regional Health Authority, 1994).²⁶⁻³⁰ The incidence and severity of pressure sores in "high risk" patients on standard hospital mattresses were reduced when patients were put on either a Comfortex DeCube mattress,³⁰ a Beaufort bead bed,²⁸ a Softform mattress,²⁹ or a water filled mattress.²⁶ In a recent, unpublished study of older people with hip fractures admitted to orthopaedic trauma wards in the United Kingdom, patients allocated to receive a National Health Service standard foam mattress (manufactured by Relyon) experienced over three times the rate of pressure sores as those using one of several foam alternatives (Clinifloat, Therarest, Transfoam, and Vaperm (J E Santy *et al*, report to Northern and Yorkshire Regional Health Authority, 1994). There was insufficient power to distinguish between the low pressure foam mattresses. These alternatives to the cheaper standard hospital mattress may be cost effective if their durability is adequate. A small trial of the standard hospital mattress with and without sheepskin overlays was inconclusive and of poor quality.²⁷

Comparisons among low tech alternative mattresses

Older patients allocated to a convoluted foam overlay had a lower rate of pressure sores than those on a solid foam overlay; however, the

difference was not statistically significant.³¹ Bliss reported that fewer pressure sores deteriorated in patients on contoured foam overlays than in those on fibre filled overlays.³²

In the only randomised controlled trial identified which evaluated wheelchair cushions for preventing pressure sores, polyurethane foam cushions in slab form were compared with a customised contoured foam.³³ After five months' follow up no significant differences were evident in the incidence, location, severity, or healing time of the sores that developed.

Similar incidences of pressure sores were found in patients on an air filled overlay compared with a gel mattress in elderly nursing home residents.³⁴

"HIGH TECH" PRESSURE RELIEF

Alternating pressure supports

Various alternating pressure supports are used in hospital and in the community. The depth of the air cells and mechanical robustness vary between devices and these factors may be important in determining their effectiveness. Eleven randomised controlled trials were identified, within which there were 13 comparisons between alternating pressure and standard hospital mattresses (two studies), constant low pressure devices (eight studies), and other alternating pressure supports (three studies). Two studies showed that the use of alternating pressure surfaces reduced the incidence of pressure sores compared with standard hospital mattresses (table 2).^{23 26 35}

Alternating pressure compared with constant low pressure

Several studies have compared alternating pressure with constant low pressure devices; however, there is conflicting evidence of their relative effectiveness. Two studies from the same research group concluded that alternating pressure is more effective. Bliss compared an alternating pressure mattress (Large Cell Ripple) with similarly priced constant low pressure supports (Surgigoods Hollow-core Mattress Pad, Spenco, Ardo Watersoft mattress, Modular Propad, a groove prototype, and Preventix) in long stay elderly patients.³² The incidence of pressure sores on the alternating pressure mattress was about a third of that found on the constant low pressure devices; however, the study had several weaknesses in its design and outcome measurement. Gebhardt and colleagues reported that eight of twenty patients allocated to various low pressure supports developed pressure sores of grade 2 or greater compared with none of 23 patients in the alternating pressure group (K Gebhardt *et al*, unpublished data).

In contrast, six small randomised controlled trials comparing different types of alternating pressure supports and various constant low pressure devices such as the Spenco (silicore) overlay,³⁶⁻³⁸ a water mattress,²⁶ a polyurethane convoluted foam pad,³⁹ a static air mattress,

and a water mattress⁴⁰ showed no difference in effectiveness.

Comparisons between different alternating pressure devices

Alternating pressure devices differ somewhat in structure, including the size of the inflatable air cells. One early study of prevention of pressure sores found that large celled alternating pressure mattresses (15 cm diameter) were more effective than those with small cells (3-8 cm diameter).²³ A second study of prevention, comparing two large celled alternating pressure devices (Pegasus Airwave and Large Cell Ripple, which are similar except that Airwave has two layers of cells), reported that the airwave system was significantly more effective in preventing and reducing severity of pressure sores in a high risk group of elderly patients.⁴¹ However, the allocation was not truly random, and an intention to treat analysis would not have shown a statistically significant difference in the rate of pressure sores (16% *v* 34%, $p > 0.05$). One small randomised controlled trial compared the effectiveness of the Nimbus I DFS device (composed of rows of figure of eight shaped cells) and the Pegasus Airwave device for treating existing pressure sores but found no significant difference.⁴²

Interpreting these studies is difficult because different (often poorly described) types of alternating pressure supports were used in the trials. The breakdown rates of these alternating pressure supports were often high, making it difficult to disentangle the impact of efficacy and reliability on effectiveness.

Low air loss beds

Two trials compared low air loss beds with low tech foam alternatives^{43 44} and one compared a low air loss bed with a low air loss overlay (L Caley *et al*, unpublished data). One trial showed that low air loss beds were more cost effective at decreasing the incidence of pressure sores in critically ill patients than a standard (but poorly described) intensive care unit bed⁴⁴; the other showed that this bed was better at treating pressure sores than a corrugated foam overlay.⁴³ The only trial that compared different types of low air loss support surfaces showed no significant differences, but was too small and of questionable quality (L Caley *et al*, unpublished data).

Air fluidised beds

Air fluidised beds are another type of "high tech" pressure relief system, comprising a deep bed of ceramic beads through which warmed air is circulated. Four randomised controlled trials evaluated the use of air fluidised beds for treating people with existing pressure sores compared with a range of "conventional therapies." Two studies showed enhanced healing associated with air fluidised beds used in hospital.^{45 46} A home based study showed no statistically significant difference.⁴⁷ One small trial in patients after plastic surgical repair of pressure sores showed no difference between an air fluidised bed and the Roho dry flotation mattress.⁴⁸

Turning beds (kinetic therapy)

Turning beds contain motors which constantly turn and tilt the patient, and they are used in critical care settings, primarily to prevent pneumonia and atelectasis. Four randomised controlled trials were identified in a meta-analysis of kinetic therapy,⁴⁹ only two of the trials in this review were obtainable.^{50 51} Sample size in all the trials was small, and no beneficial effect of kinetic therapy on the incidence of pressure sores was detected.

OTHER DEVICES

No randomised controlled trials evaluating other forms of pressure relieving equipment, such as special operating theatre tables, were identified.

Conclusion

The evidence of the accuracy of risk assessment scales for pressure sores is confusing, and it is not clear that these scales are better than clinical judgement or that they improve outcomes. Also there are few studies of sufficient quality which compare pressure relieving surfaces. The clearest conclusion is that the standard hospital mattress is outperformed by a range of foam based, low pressure mattresses and overlays and also by "higher tech" pressure relieving beds and mattresses, in both preventing and treating pressure sores.

Some types of large cell alternating pressure devices (cell diameter ≥ 10 cm) may be more effective than simple, low pressure mattresses, but further research is needed. Low air loss beds seem to be effective in preventing and treating pressure sores compared with foam mattresses, but no studies compare low air loss therapy with alternating pressure surfaces and other "high tech" low pressure supports.

There is no evidence to indicate the degree to which manual repositioning is effective, or of what would be an optimum turning regimen. Little is known about the degree to which manual repositioning of patients on pressure relieving surfaces provides additional benefit.

Patients at raised risk of developing pressure sores should at least be placed on one of the foam mattress alternatives shown to be better than the standard hospital mattress (for example, Comfortex DeCube, Softform, Clinifloat, Vaperm, Transfoam, Therarest). Without clear evidence for an optimal strategy, patients at very high risk of developing sores (such as those in intensive care, in orthopaedic units or with neurological deficits) and people with established sores should probably be placed on alternating pressure mattresses with large cells, or one of the other devices shown to be effective in randomised controlled trials in such patients (for example, Clinitron, KinAir).

Many expensive, "high tech" pressure relieving devices are in use; however there is insufficient evidence to identify a "best buy." Therefore, investment in more expensive, "high tech" pressure relieving equipment should occur only within the context of randomised controlled trials. Given current

knowledge, the most cost effective strategies for meeting prevalence targets are unclear.

Whenever a pressure sore occurs thought should be given as to whether and how it could have been avoided – for example, was a patient who was obviously at high risk not provided with a suitable pressure relieving intervention? Guidelines for preventing and managing pressure sores may be useful to improve the cost effectiveness of care, but they must be based on rigorous, comprehensive, systematic reviews of the research evidence and kept up to date.⁵²

Independent, well designed, multicentre randomised controlled trials are needed to compare the cost effectiveness of different types of pressure relieving devices for patients at different degrees of risk in various settings. In particular, this research should aim to compare (a) alternating pressure devices with other "high tech" equipment (such as low air loss and air fluidised beds) and (b) alternating pressure devices with lower tech alternatives (such as different types of foam mattresses). Patients must be truly randomised (with concealed allocation) and trials should be of sufficient size, with clear criteria for measuring outcomes, which should be assessed without knowledge of the intervention received (blinded).

Given better evidence of the relative cost effectiveness of different interventions, research will also be needed to compare the cost effectiveness of alternative strategies for preventing and treating pressure sores in hospital and in the community.

We thank the following for their useful comments on a draft of the bulletin: Mary Bliss, Peter Bourdillon, Jane Bridel, Howard Cuckle, Carol Dealey, Edward Dickinson, Tony Dowell, Krzysz Gebhardt, Jeanette Hencher, Andrew Long, Peter Lowthian, Richard Walsh, and John Young. The Department of Health funds the *Effective Health Care* Bulletins and the NHS Centre for Reviews and Dissemination. However, the views expressed are those of the authors and not necessarily the funding body.

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Table 1 Studies of predictive validity of risk assessment scales

Study	Scale (scores for group at risk)	Setting	Sample size	Proportion developing sores	Follow up	Sensitivity* (95% confidence interval)	Specificity* (95% confidence interval)
Bergstrom et al 1992 ⁵³	Braden (16 or less)	Medical-surgical unit (shorter stay)	100	7%	Not clear	100%* (59% to 100%)	90% (82% to 96%)
Bergstrom et al 1992 ⁵³	Braden (16 or less)	Medical-surgical unit (longer stay)	100	9%	Not clear	100%* (66% to 100%)	64% (53% to 74%)
Bergstrom et al 1987 ⁵⁴	Braden (16 or less)	Adult intensive care unit (with follow up on other units)	60	40%	2 Weeks (or discharge if earlier)	83% (63% to 95%)	64% (46% to 79%)
Langemo et al 1991 ⁵⁵ (a)	Braden (16 or less)	Medical-surgical and orthopaedic acute care	74	15%	2 Weeks (or discharge if earlier)	64% (30% to 89%)	87% (75% to 95%)
Salvandalea et al 1992 ⁵⁶ (b)	Braden (16 or less)	Medical acute care unit	99	20%	3 Weeks (or discharge if earlier)	40% (19% to 64%)	70% (59% to 80%)
Barnes and Payton 1993 ⁵⁷	Braden (16 or less)	General medical and cardiovascular unit	361	6%	15 Days (or discharge if earlier)	73% (50% to 89%)	91% (87% to 94%)
Braden and Bergstrom 1994 ¹⁴	Braden (16 or less)	Nursing home	102	28%	4 Weeks (or discharge if earlier)	46% (28% to 66%)	88% (78% to 94%)
Norton et al 1962 ⁶	Norton (14 or less)	Care of the elderly unit	250	24%	8 Weeks (or discharge if earlier)	63% (50% to 75%)	70% (64% to 77%)
Goldstone and Goldstone 1982 ⁵⁸ (c)	Norton (14 or less)	Orthopaedic unit (emergency elderly admissions)	40	45%	Until discharge	89% (65% to 99%)	36% (17% to 59%)
Lincoln et al 1986 ⁵⁹ (d) (e)	Norton (14 or less)	Medical and surgical unit (elderly patients)	36	14%	Until discharge maximum length of stay 4 weeks)	0%* (0% to 52%)	94% (79% to 99%)

Table 1 – continued

Study	Scale (scores for group at risk)	Setting	Sample size	Proportion developing sores	Follow up	Sensitivity* (95% confidence interval)	Specificity* (95% confidence interval)
Stotts 1988 ⁶⁰ (e) (f)	Norton (14 or less)	Elective cardiovascular and neurosurgery units	387	17%	3 Weeks	16% (8% to 28%)	94% (91% to 97%)
Smith 1989 ¹⁹ (e) (g)	Norton (16 or less)	Elective and emergency orthopaedic admissions	101	30%	Until discharge	60% (41% to 77%)	31% (21% to 43%)
Towey and Erland 1988 ¹¹	Knoll (12 or above)	Long term care (elderly patients)	60	47%	4 Weeks (or transfer if earlier)	86% (67% to 96%)	56% (38% to 74%)
Lowthian 1989 ¹⁰	PSPS (6 or above)	Orthopaedic patients	1244	4%	3 Weeks	89% (77% to 96%)	76% (74% to 78%)
Andersen <i>et al</i> 1982 ⁶¹	Own (2 or more)	General hospital acute care admissions	3398	1%	3 Months	88% (73% to 96%)	86% (85% to 87%)
Gosnell 1973 ¹²	Gosnell (15 or less)	Long term care (elderly patients)	30	13%	4 Weeks (or discharge if earlier)	50%* (7% to 93%)	73% (52% to 88%)
Smith 1989 ¹⁹ (c) (g)	Waterlow (20 or more)	Elective and emergency orthopaedic admissions	101	30%	Until discharge	73% (54% to 88%)	38% (27% to 50%)

*Calculation of all confidence intervals and many sensitivities and specificities was performed by one of the research team (JD).

**Calculated from data on fewer than 10 individual patients.

(a) Only patients with expected length of stay of at least 5 days were included.

(b) Only patients with expected length of stay of at least 3 days were included.

(c) Patients with "unique factors" were excluded.

(d) Patients staying fewer than 3 days were excluded (26%).

(e) Surgical patients were evaluated before surgery.

(f) Categories in the Norton scale were defined according to Gosnell.¹²

(g) Only patients with expected length of stay of at least 7 days were included.

Table 2 Randomised controlled trials of pressure relieving interventions for preventing and treating pressure sores

Study	Patients	Devices (sample size)	Follow up	Incidence of pressure sores in patients without sores at entry	Severity of pressure sores	Acceptability and reliability
Allman <i>et al</i> 1987 ⁴⁵	Patients (>18 years) from surgical units with pressure sores, activity expected to be limited to bed/chair in the hospital for at least 1 week	1 Clinitron air fluidised bed (31) 2 Conventional treatment, including two-hourly turning, heel and elbow protectors, alternating air mattress plus 19 mm foam (34)	13 Days (mean)		Median change in total sore surface area: air fluidised, -1.2 v conventional treatment, +0.5 (p = 0.01). Differences between air fluidised beds and alternating air mattress were more pronounced for larger sores (median -5.3 v +4.0, p = 0.01)	Four patients withdrew because of difficulty in transferring in/out of the air fluidised bed
Andersen <i>et al</i> 1982 ²⁶	Acute patients with high risk of pressure sores (own risk scale) without existing pressure sores	1 Alternating air mattress (166) 2 Water filled mattress (155) 3 Standard mattress (161)	10 Days	Sores (grade 2 or greater): Alternating air mattress: 4.2% (7/166) Water mattress: 4.5% (7/155) Standard mattress: 13.0% (21/161)		Alternating air mattress easily punctures and in this study was not always set at optimum pressure. Water mattress is heavy and time consuming to fill. Patients more satisfied with ordinary bed; complained of the noise and pressure changes of alternating air mattress
Bliss <i>et al</i> 1966, ²³ Bliss <i>et al</i> 1967 ³⁵	Geriatric patients with Norton score >6	Series I (1963) 1 Small celled ripple bed (50) 2 Foam mattress (48) 3 Regular turning (23) 4 Normal ward care (63) Series II (1964) 1 Large celled ripple bed (42) 2 Small celled ripple bed (35) 3 Sierex air mattress (39) 4 Ordinary hospital mattress (41)	2 Weeks	Series I (1963) Trunk sores (grade 2 or greater): Small celled ripple: 24% (6/25) Foam mattress: 39% (9/23) Regular turning: 50% (5/10) Normal ward care: 59% (23/39) Heel sores (including grade 1): Small celled ripple: 17% (6/35) Foam mattress: 18% (6/33) Regular turning: 0% (0/13) Normal ward care: 32% (14/44) Series II (1964) Trunk sores (grade 2 or greater): Large celled ripple: 27% (4/15) Small celled ripple: 47% (7/15) Sierex air mattress: 17% (2/12) Ordinary mattress: 67% (12/18) Heel sores (including grade 1): Large celled ripple: 7% (2/29) Small celled ripple: 15% (3/20) Sierex mattress: 4% (1/23) Ordinary mattress: 38% (9/24)	Mean (standard error) pressure sore indices in patients with superficial sores at entry: Series I (1963) Small celled ripple: 18.4 (4.2, n = 13) Foam mattress: 22.2 (3.0, n = 14) Regular turning: 6.3 (2.2, n = 3) Normal ward care: 29.3 (4.0, n = 20) Series II (1964) Large celled ripple: 11.7 (1.4, n = 20) Small celled ripple: 15.1 (1.6, n = 14) Sierex mattress: 10.5 (1.4, n = 22) Ordinary mattress: 29.9 (4.4, n = 17)	Series I (1963) 3 Patients on small celled ripple bed withdrew because of faulty mattress or because mattress had been repeatedly switched off Series II (1964) 3 Patients on large celled ripple bed and 2 on small celled ripple bed had to be removed from trial because of mattress breakdown

Table 2 – continued

Study	Patients	Devices (sample size)	Follow up	Incidence of pressure sores in patients without sores at entry	Severity of pressure sores	Acceptability and reliability
Bliss 1995 ³²	Long term elderly patients at risk as shown by superficial skin breaks	1 Large Cell Ripple (71) 2 Surgicoods Hollow Core (41) 3 Spenco (63) 4 Water mattress (32) 5 Modular Propad (60) 6 Groove prototypes (66) 7 Preventix (25)	17.7 Days (mean)		13% of patients on Large Cell Ripple Beds showed deterioration of pressure areas compared with 54% and 51% respectively on fibre fills (Surgicoods Hollow Core and Spenco), 47% on the water mattress, 37% on Modular Propad, 35% on groove prototypes, 32% on Preventix (ripple bed v fibre fills v foam overlays, $p < 0.01$)	Supports were frequently used incorrectly – for example, ripple bed tubes detached/kinked or pressure dial wrongly set
Brown <i>et al</i> 1985 ²⁴	Geriatric patients in nursing homes, Norton score < 14	All received standard care: 1 Small shifts in body position (8) 2 Controls (6)	2 Weeks	No patient developed a pressure sore in the “small shift” group; one developed a sore in the control group		Positive reactions of the nursing staff to assessment guide and small shifts of body position were reported
L. Caley <i>et al</i> , unpublished data	Acute care patients with existing pressure ulcers for whom low-air-loss therapy had been recommended by their physician or nurse	1 Low air loss bed (23) 2 Low air loss overlay (32)	24 Days (mean)		No significant difference in change in ulcer size between subjects in the two groups. Low air loss overlays may be as effective as low air loss beds and are much cheaper	Staff satisfaction similar for both products
Conine <i>et al</i> 1990 ³⁶	Non-geriatric adult patients in an extended care facility for chronic neurological conditions, Norton score ≤ 14 .	1 Alternating air overlay (72) 2 Silicore (Spenco) overlay (76)	3 Months	Sores (including grade 1): Alternating overlay: 54% (39/72) Spenco overlay: 59% (45/76)	Alternating air overlay group had a slightly lower than average “Exton-Smith severity score” (1.59 v 1.69) and a shorter than average healing duration (25 days v 29 days) (not statistically significant)	Alternating air overlay needed frequent monitoring and expensive prolonged repairs. Patients sank into the Spenco overlay and found it difficult to move. Patients complained of bad odour build up, instability (especially Spenco), and noise of the alternating pressure motor. High dropout rate due to discomfort
Daechsel and Conine 1985 ³⁷	Patients in a long-term care hospital for chronic neurologic conditions, 19–60 years of age, at high risk of developing pressure sores.	1 Alternating air overlay (16) 2 Silicore (Spenco) overlay (16)	3 Months	Sores (including grade I): Alternating overlay: 25% (4/16) Spenco overlay: 25% (4/16)	No statistically significant differences between the two groups for location and severity of pressure sores	Patients’ satisfaction similar for both devices
Devine 1995 ⁴²	Patients in a geriatric unit with pressure sores (grade 2 or above)	1 Alternating air mattress (Nimbus I) (22) 2 Alternating air mattress (Pegasus Airwave) (19)	4 Weeks		11 Patients died or moved to other hospitals. Rate of complete healing was higher for the Nimbus mattress but not statistically significant (10/16 v 5/14). The reduction in size of pressure sores was similar in the two groups	Neither mattress showed any significant breakdown. No significant difference in patient/staff acceptability
Economides <i>et al</i> 1995 ⁴⁸	12 Patients who had stage 4 pressure sores needing myocutaneous flap closure	1 Roho dry flotation mattress (6) 2 Air fluidised Clinitron bed (6)	2 Weeks		Wound breakdown: 2/6 on Roho v 2/5 on Clinitron. No significant difference between two support surfaces in preventing flap breakdown in the immediate postoperative period	
Ewing <i>et al</i> 1964 ²⁷	Patients in the geriatric unit of a convalescent hospital	1 Sheepskins were adjusted so that both legs were supported on the woolly fleece (18) 2 Control, without sheepskins (18) All patients submitted to the same 4 hourly routine skin care	6 months		Study too small and poorly designed to detect a difference	
Exton-Smith <i>et al</i> 1982 ⁴¹	Newly admitted geriatric patients, patients with fractured neck of femur, and long stay patients; without pressure sores of grade 2 or greater. Norton score ≤ 14	1 Pegasus Airwave system (31) 2 Large Cell Ripple mattress (31)	2 Weeks	Grade 2 or greater sores: Airwave: 16.1% (5/31) Large Cell Ripple: 38.7% (12/31)	Superficial or deep sores (grade 3–4) developed in 38.7% of patients on Large Cell Ripple and only 6.5% of patients on Airwave	During the trial no breakdowns with Airwave, 10 breakdowns with Large Cell Ripple
Ferrell <i>et al</i> 1993 ⁴³	Elderly nursing home residents with multiple medical problems, and with trunk or trochanter pressure ulcers (Shea stage 2 or greater)	1 Low air loss bed (43) 2 Convuluted foam mattress (41)	33–40 Days		Decrease in size of ulcers was 9.0 mm ² /day for low air loss beds v 2.5 mm ² /day for foam mattresses ($p = 0.0002$). 26 (60%) completely healed on low air loss v 19 (46%) on foam mattress ($p = 0.19$). Number of patients died: 11 (26%) on low air loss v 7 (17%) on foam mattress	

Table 2 – continued

Study	Patients	Devices (sample size)	Follow up	Incidence of pressure sores in patients without sores at entry	Severity of pressure sores	Acceptability and reliability
K Gebhardt <i>et al</i> , unpublished data	Newly admitted patients (>18 years) in intensive care units, with Norton scores <13 and without existing pressure sores	1 Alternating pressure air mattresses (23) 2 Constant low pressure (foam, fibrefill, air, water, gel) supports (20). Patients with deteriorated sores were transferred to more advanced medium cost supports in the same group (for example, Pegasus, Nimbus, Orthoderm Convertible, Roho)	Mean 11 Days	Grade 2 or greater sores: Alternating pressure: 0% (0/23) Constant low pressure: 40% (8/20)		Mechanical unreliability and poor management of alternating pressure supports a problem
Gentilello <i>et al</i> 1988 ^{5b}	Critically ill patients, immobilised because of head injury or traction	1 Kinetic treatment table (27) 2 Conventional beds (38)	?	Kinetic treatment table: 29.6% Conventional: 26.3%		
Goldstone <i>et al</i> 1982 ²⁸	Patients (>60 years) with fracture of femur (mean Norton score 13)	1 Beaufort bead bed (32) 2 Standard supports (43)	?	Grading of sores not given: Beaufort bed: 15.6% Standard surface: 48.8%	Maximum width of broken skin (mean): 6.4 mm on Beaufort beds v 29.5 mm on standard surfaces	Patients removed from Beaufort bed for unknown reasons
Gray and Campbell 1994 ²⁹	Patients from orthopaedic trauma, vascular, and medical oncology units without breaks in the skin (Waterlow score ≥15)	1 Softform mattress (90) 2 Standard National Health Service mattress (80)	10 Days	Grade 2 or greater sores: Softform: 7% Standard: 34%	Rate of transfer to dynamic support surface: 19% in standard group v 2% in Softform group	Nurses were more positive and patients gave higher comfort scores to Softform mattress
Hofman <i>et al</i> 1994 ^{3d}	Patients with a femoral neck fracture and risk score <8 (Dutch consensus scale). Patients with pressure sores of grade 2 or greater on admission excluded	1 Comfortex DeCube mattress (21) 2 Standard hospital mattress (23)	2 Weeks	Grade 2 or greater sores: Comfortex DeCube: 24% (4/17) Standard: 68% (13/19)	Maximum pressure sore gradings significantly higher for the standard mattress than the DeCube mattress at 1 and 2 weeks	DeCube mattress not always used correctly and its size was not optimum for all patients
Inman <i>et al</i> 1993 ⁴¹	Patients (>17 years) with an Acute Physiology and Chronic Health Evaluation (APACHE II) score greater than 15 who had an expected stay in intensive care of ≥3 days	1 Low air loss beds (49) 2 Standard intensive care unit bed (49)	17 Days (mean)	Grade 2 or greater sores: Low air loss bed: 12% Standard intensive care unit bed: 51%	Patients with multiple pressure sores: 2% on low air loss bed and 24% on standard intensive care unit bed	
Kemp <i>et al</i> 1993 ³¹	Geriatric patients (>65 years) without pressure ulcers, Braden score ≤16	1 Convuluted foam overlay (45) 2 Solid foam overlay (39)	1 Month or discharge	Included grade 1 sores: Convuluted foam: 46.7% Solid foam: 30.8%		
Lazzara and Buschmann 1991 ³¹	Elderly private nursing home residents (modified Norton score >15)	1 Air overlay (33) 2 Gel mattress (33)	6 Months	Grade 2 or greater sores: Air overlay: 16.1% (5/31) Gel mattress: 15.4% (4/26)	All pressure sores of grade 1 or 2	Difficult to maintain inflation of the air overlay; it also punctured easily. During the trial 110 air overlays were used for 76 patients. Gel mattress was heavy
Lim <i>et al</i> 1988 ³¹	Residents of an extended care facility (>60 years), using a wheelchair for 3 or more hours daily, at high risk of developing pressure sores (Norton Score ≤14)	1 Polyurethane foam wheelchair cushions in slab form (33) 2 Customised contoured foam wheelchair cushions (29)	5 Months	Included grade 1 sores: Slab foam: 73.1% (19/26) Contoured foam: 69.2% (18/26)	Mean severity score 1.9 in the slab and 1.7 in the contoured (p > 0.05), mean healing duration 6.2 weeks in the slab and 5.4 weeks in the contoured group (p > 0.05)	
Munro <i>et al</i> 1989 ⁴⁰	Patients with pressure sores of grade 2–3 who were expected to remain in hospital for at least 15 days. Patients with grade 4 ulcers and those weighing >250lb or who were malnourished were excluded	1 Clinitron air fluidised bed (20) 2 Standard bed plus usual nursing measures such as sheepskin or gel pads placed beneath pressure areas (20)	15 Days		Mean size of ulcers reduced in the Clinitron group and increased in the “standard bed” group (p = 0.05). Pressure sore healing enhanced on the Clinitron bed; fewer medications used to treat sores in the Clinitron group than in the “standard bed” group	The air fluidised group rated their satisfaction higher than the control group (p = 0.067)
J E Santy <i>et al</i> , report to Northern and Yorkshire Regional Health Authority, 1994	Patients (>55 years old) with hip fracture with or without pressure sores. Patients with a pressure sore of grade 3 or 4 at entry excluded.	1 Clinifloat (87) 2 National Health Service contract (150mm) (64) 3 Vaperm (116) 4 Therarest (136) 5 Transfoam (102)	14 Days	Rates of removal from the study due to skin deterioration: Clinifloat: 9.19% NHS contract: 26.56% Transfoam: 10.29% Therarest: 10.78% Vaperm: 7.75%		Omni foam mattresses showed foam collapse after six weeks and were withdrawn and replaced with Vaperm mattresses. Problems with mattress cover in two Therarest mattresses, three Transfoam mattress covers, and three times with the Clinifloat mattress
Sideranko <i>et al</i> 1992 ⁴⁰	Adult, surgical intensive care unit patients stay >48 h, without existing skin breakdown on admission	1 Alternating air mattress (20) 2 Static air mattress (20) 3 Water mattress (17)	9.4 Days	Grade of sores not reported: Alternating mattress: 25% (5/20) Static air mattress: 5% (1/10) Water mattress: 12% (2/17)		

Table 2 – continued

Study	Patients	Devices (sample size)	Follow up	Incidence of pressure sores in patients without sores at entry	Severity of pressure sores	Acceptability and reliability
Stapleton 1986 ³⁸	Elderly female patients with fractured neck of femur without existing pressure sores, Norton score ≤ 14	1 Large Cell Ripple (32) ? 2 Polyether foam pad (34) 3 Spenco pad (34)		Sores of Grade 2 or greater: Large Cell Ripple: 34% (11/32) Foam pad: 51% (14/34) Spenco pad: 35% (12/34)	Grade 3 and greater: Large Cell Ripple: 0% Foam pad: 23.5% Spenco pad: 5.9%	45 Large Cell Ripple mattresses required 50 motor repairs and 90 material repairs during 12 month study. Patients did not like the feel of the ripples
Strauss <i>et al</i> 1991 ⁴⁷	Patients (>16 years) at home with grade 3–4 pressure sores	1 Clinitron air fluidised beds (47) 2 Conventional care including alternating pressure pads (50)	36 Weeks		A higher proportion of air fluidised bed patients was classified as improved ($p > 0.05$; not reliable since considerable missing data). Air fluidised bed patients had significantly fewer pressure sore related admissions per patient (0.23 <i>v</i> 0.58, $p < 0.05$). Note. Withdrawal rate: 50% on air fluidised mattress <i>v</i> 44% on control bed. Number of deaths: 24% <i>v</i> 35%. Blinded assessment	Six air fluidised mattress beds had minor bead leaks and seven overheated. Several patients noted dry skin and one experienced mild dehydration
Smith and Malone 1990 ²⁵	Geriatric patients, Norton score < 14	All patients turned every two hours: 1 Small unscheduled shifts of position (9) 2 Control (10)	2 Weeks	One patient developed a pressure sore in each of the two groups	There were 3 patients in the "small shift" group and 1 in the control group with pressure sores at entry. The size of the pressure sores was reduced in 2 patients in the "small shift" group and one in the control group. The size of sore in the other patient in the shift group did not change	
Summer <i>et al</i> 1989 ⁵¹	Patients admitted to the intensive care unit	1 Kinetic treatment table ? (43) 2 Routine turning on conventional beds (43)		One patient developed small facial ulcer on kinetic treatment table; none on conventional beds		
Whitney <i>et al</i> 1984 ³⁹	Patients on medical-surgical units in bed for ≥ 20 h daily. Most patients had relatively little skin breakdown	1 Alternating pressure mattress (25) 2 Convoluted foam pad (Eggcrate) (26) In both groups patients were turned every two hours	8 Days		Changes in skin condition did not differ significantly between patients using the alternating pressure air mattress and the foam mattress (better: 20% <i>v</i> 19.2%; same: 60% <i>v</i> 57.7%; worse: 20% <i>v</i> 23.1%).	Alternating pressure mattress: pump maintenance was costly, patients objected to the movement, easier to clean, and retained its original properties over several weeks compared with the foam mattress, which compressed and flattened