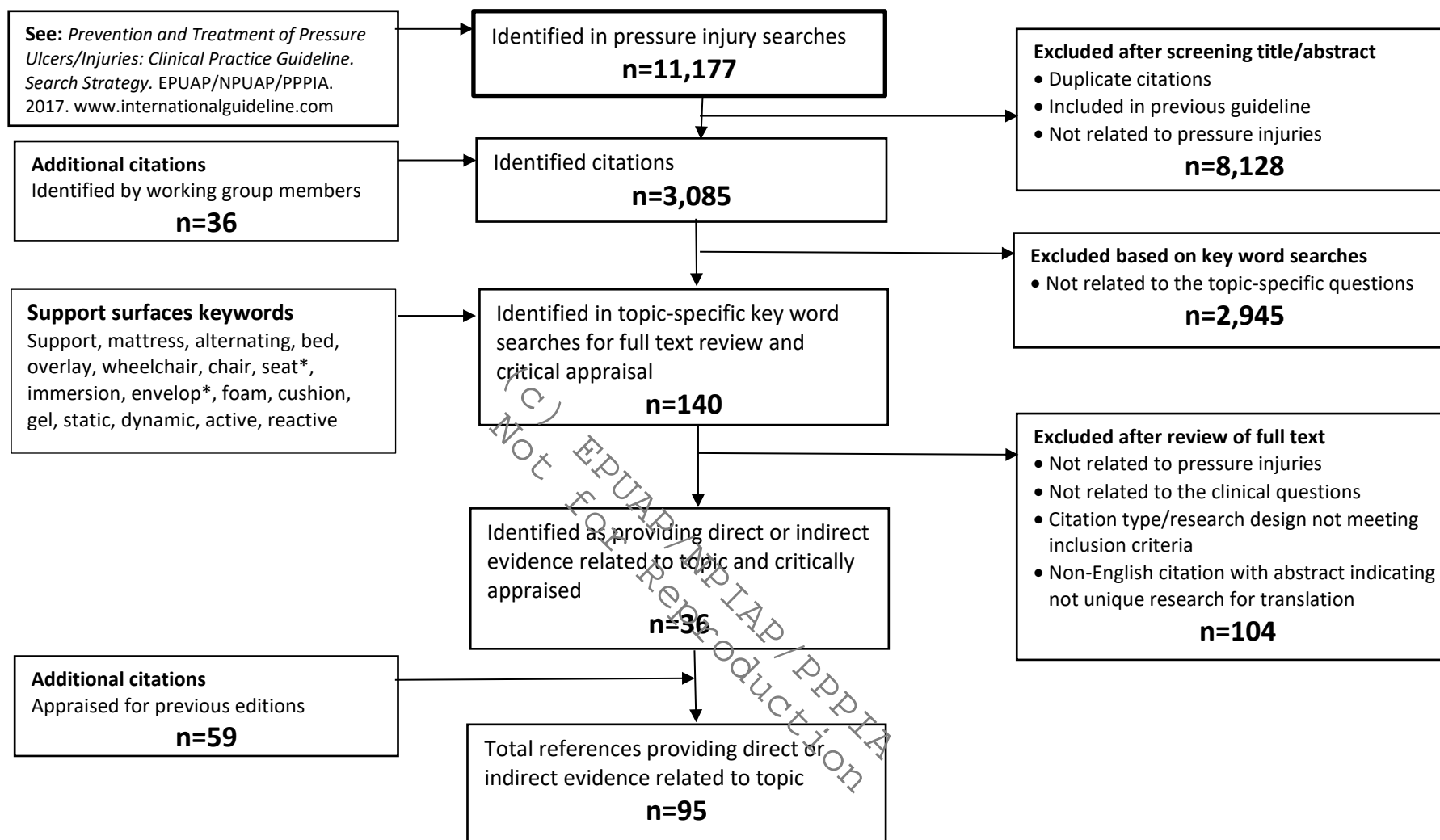


Support Surfaces: data extraction and appraisals

Search results for 2019 International Pressure Injury Guideline: Support Surfaces



European Pressure Ulcer Advisory Panel, National Pressure Injury Advisory Panel and Pan Pacific Pressure Injury Alliance. Prevention and Treatment of Pressure Ulcers/Injuries: Clinical Practice Guideline. The International Guideline. Emily Haesler (Ed.). EPUAP/NPIAP/PPPIA; 2019

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Articles Reviewed for International Pressure Injury Guideline

The research has been reviewed across three editions of the guideline. The terms pressure ulcer and pressure injury are used interchangeably in this document and abbreviated to PU/PI. Tables have not been professionally edited. Tables include papers with relevant direct and indirect evidence that were considered for inclusion in the guideline. The tables are provided as a background resources and are not for reproduction.

European Pressure Ulcer Advisory Panel, National Pressure Injury Advisory Panel and Pan Pacific Pressure Injury Alliance. Prevention and Treatment of Pressure Ulcers/Injuries: Clinical Practice Guideline. The International Guideline. Emily Haesler (Ed.). EPUAP/NPIAP/PPPIA; 2019

Ref	Type of Study	Sample	Intervention(s)	Outcome Measures & Length of Follow-up	Results	Limitations and comments	
Clinical question one: What reactive support surfaces are effective in preventing pressure injuries?							
High specification foam							
Ricci, Roberto, Ippolito, Bianco, & Scalise, 2013	RCT to assess two mattress overlays for the prevention of pressure ulcers development in elderly patients at moderate/high risk.	<p>Participants were recruited in 2 long term care facilities in Italy (n=50) Intervention group=25 Control group =25</p> <p>Setting: Two long-term care units in Italy</p> <p>Inclusion criteria:</p> <ul style="list-style-type: none"> aged ≥65 years old Stay same unit at least 28 days. Moderate/high risk pressure injuries (Braden scale score 8-14 or Norton1 scale score 6-12) no existing Category/Stage 2 or greater pressure injury <p>Characteristics:</p> <ul style="list-style-type: none"> Age between two groups was 83.6±6.9 ys vs 85.8 ± 8.4 yrs. BMI was 21.6±4.0 vs 	<p>Participants were randomized to receive either:</p> <ul style="list-style-type: none"> a CE-marked three-dimensional anti-decubitus mattress overlay (Airtex™) (n=25) control group: a commercially available viscoelastic mattress overlay (Aktou) (n=25) <p>All patients were repositioned every 2 hours, alternating lateral (30°) and supine position. until 28days</p>	<ul style="list-style-type: none"> Pressure injury incidence at day 28 Secondary outcome: change of the ulcer size; incidence of new ulcers; patient's safety and tolerability (include adverse event or allergic reaction ,Global safety and tolerability evaluation) Staging system: EPUAP-NPUAP guidance The observational period: 4 weeks 	<p>No participants in the study developed a pressure injury The presence of pain associated with staying in bed was no significant difference between the two groups. No adverse events occurred during the study. The global safety and tolerability was classified as "good" in 20 patients and as "excellent" in 5 patients who assigned to 3D overlay. But only 1 patient in the control group classified it as "excellent". The difference was not statistically significant (P=0.192) between the two groups.</p> <p>Conclusions: Two mattress overlays were equally effective, well-tolerated. The 3D mattress overlay provided a good performance in terms of pressure injury prevention in patients at high/moderate risk and preserved good conditions to the skin layer.</p>	<p>No formal power calculation was performed to address the determination of the sample size. Because no development of pressure injury was observed, whether 3D mattress overlay could help improve the healing of pressure injuries was still unclear.</p>	<p>Level of evidence: 1</p> <p>Quality: low</p>

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Ref	Type of Study	Sample	Intervention(s)	Outcome Measures & Length of Follow-up	Results	Limitations and comments	
		<p>22.6±4.4(kg/m²)</p> <ul style="list-style-type: none"> • Albumin 3.3±0.6 vs 3.2 ± 0.6 (g/dl) • Hematocrit 38.1±4.2 vs 36.4±4.0(%) • Average Norton score values significant different between groups at first (p=0.042) and end of the study (p=0.042). • Average Braden score in two groups were no significant difference at first (p=0.199) and end of the study (p=0.125). 					
M. van Leen, Halfens, & Schols, 2018	RCT to evaluate the effectiveness of two reactive support surfaces for pressure injury prevention	<p>Participants were recruited in 21 nursing homes in the Netherlands (n 206)</p> <p>Inclusion criteria:</p> <ul style="list-style-type: none"> • Braden < 16 • Life expectancy >3M • Age >60 <p>Exclusion criteria:</p> <ul style="list-style-type: none"> • Pressure injury in last 3 months • Participation in comparative trial • Physical/mental condition making participation difficult <p>Participant characteristics:</p> <ul style="list-style-type: none"> • similar between groups 	<p>Participants were randomized to receive:</p> <ul style="list-style-type: none"> • Multilayer support system (Bedcare; Sense Textile, Herkogenbosch) overlay + transfer sheet . Overlay consists of 3 layers: a 9.5cm thick 3D pressure-relieving spacer fabric, a textile mattress cover and a knitted transfer fabric that replaces a bed sheet. The overlay is placed on a standard bed mattress (n=103), or • standard mattress (n=103) 	<ul style="list-style-type: none"> • Data collected by 4 research nurses • Braden • Dependence • Skin inspection weekly • Changes in PI prevention strategies • Inclusion stage 2,3,&4 PI • Follow up period of cm thick 12weeks 	<p>Pressure injury incidence</p> <p>There was no significant difference in pressure injury incidence between the multilayer support system and a standard mattress (8.7% in the intervention group versus 4.9% in control)</p> <p>Author conclusion: Product did not demonstrate benefit i.e. no added value over standard product</p>	Differences in the other PI prevention strategies may not have been controlled	<p>Level of evidence: 1</p> <p>Quality: low</p>
Ozyurek & Yavuz, 2015	To compare whether differences exist between	Participants were recruited in nan medical and a surgical ICU in Turkey (n=105)	<ul style="list-style-type: none"> • Participants were randomized to one of two support surfaces: 	<ul style="list-style-type: none"> • Braden Risk Assessment Scale: assess upon admission, again in 48 	<p>New pressure injuries</p> <p>No significant difference in people on the Viscoelastic Foam 1 developing pressure injuries compared to those the</p>	<ul style="list-style-type: none"> • Lack of blinded outcome assessments. 	<p>Level of evidence: 1</p>

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Ref	Type of Study	Sample	Intervention(s)	Outcome Measures & Length of Follow-up	Results	Limitations and comments	Quality:
	2 viscoelastic foam support surfaces in the preventing new pressure injuries	<p>Inclusion:</p> <ul style="list-style-type: none"> Older than 18 years old Stay at least 7 days <p>Exclusion:</p> <ul style="list-style-type: none"> Patient with Category/Stage I pressure injury or worse on admission Weigh more than 140kg or less than 45kg Braden score higher than 18 <p>Characteristics:</p> <ul style="list-style-type: none"> Mean age: 64.99±15.1years Ventilated: 48 (45.7%) Sedated: 34 (32.3%) With diabetes: 32 (30.4%) Nonsmoker: 76 (72.3%) Mean length of stay: 17.36 ±17.9days Mean Braden risk score: 13.5 ± 3.11 Mean Glasgow Coma Scale score: 10.22± 4.83 Body mass index: 26.46 ± 5.87kg/m² 	<ul style="list-style-type: none"> Viscoelastic foam 1 was composed of 2 layers, a 7-cm support surface with 8 cm of high-flexibility foam. (n=53) or Viscoelastic foam 2 was composed of 3 layers, the top active viscoelastic layer, lower support layer, and side safety barrier. (n=52) The two group received same nursing interventions including turning, repositioning, the cushions, the 30- tilt, nutritional support, skin care, diagnosis of skin problems and incision wound dressing. 	<p>hours, and then every day.</p> <ul style="list-style-type: none"> The skin assessment instrument included a list of the most common sites for pressure injuries and EPUAP staging system Skin follow-up evaluation daily Days to pressure injury development 	<p>Viscoelastic Foam 2 (42.8% vs 23 40.3%, p>0.05)</p> <p>Location of new Pressure injuries</p> <ul style="list-style-type: none"> There was no significant difference between the two groups for rate of new pressure injuries at any anatomical location Sacrum :13 (26.4%) in Viscoelastic Foam 1 group vs 12 (23.1%) in Viscoelastic Foam 2group (P>0.05) Shoulder bones: 10 (18.9%) in Viscoelastic Foam 1 group vs 9 (17.2%) in Viscoelastic Foam 2 group (P>0.05) Elbow: 5 (9.5%) in Viscoelastic Foam 1 group vs 1 (1.9%)in Viscoelastic Foam 2 group (P>0.05) Malleoli: 4 (7.5%) in Viscoelastic Foam 1 group vs 2 (3.9%) in Viscoelastic Foam 2 group (P>0.05) Heel: 3 (5.7%) in Viscoelastic Foam 1 group vs 3 (5.7%) in Viscoelastic Foam 2 group (P>0.05) Trochanter: 6 (8.4%) in Viscoelastic Foam 1 group vs 3 (5.7%) in Viscoelastic Foam 2 group (P>0.05) Ischium: 3 (5.7%) in Viscoelastic Foam 1 group vs 3 (5.7%) in Viscoelastic Foam 2 group (P>0.05) <p>Days to PU development</p> <p>No significant difference in time to develop a pressure injury between The two groups</p> <p>Author conclusion: There were no differences in the incidence of pressure</p>	<ul style="list-style-type: none"> -Small sample size at a single center. 	moderate

Support Surfaces: data extraction and appraisals

Ref	Type of Study	Sample	Intervention(s)	Outcome Measures & Length of Follow-up	Results	Limitations and comments	
					injuries between the two viscoelastic foam support surfaces used in the care of patients treated in the ICU		
Park & Park, 2017	To compare a viscoelastic foam overlay with a standard hospital mattress with regards to pressure injury prevention and interface pressure	<p>Participants were recruited at a Medical Centre in South Korea (n=110)</p> <p>Inclusion criteria:</p> <ul style="list-style-type: none"> Age 19+ yrs with intact skin Braden \leq16 Weight \leq100kg <p>Exclusion criteria:</p> <ul style="list-style-type: none"> Stage 1 pressure injury or higher Incontinence dermatitis 	<ul style="list-style-type: none"> Participants were randomized to either: <ul style="list-style-type: none"> Treatment group: <ul style="list-style-type: none"> Viscoelastic foam overlay (Viscosafe overlay Yellow/Pink) on standard mattress (n=55) Control group: <ul style="list-style-type: none"> Standard mattress (n=55) All participants received standardised care: 2 hrly repositioning; regular skin cleansing and application of barrier cream; bed head elevation $<$30° 	<ul style="list-style-type: none"> Pressure injury incidence Average of 2x pressure mapping points at sacral/coccyx region Endpoint – 2 weeks or upon development of a pressure injury Daily skin checks Pressure mapping using PalmQ at sacrum/coccyx just before and just after mattress provision 	<p>Pressure injury incidence Participants in the Treatment group had a significantly lower pressure injury incidence than the control group (3.6% vs 27.3%, $\chi^2=11.75$, $p=0.001$).</p> <p>Interface pressure Treatment group had a significantly lower interface pressure compared with the control group (42.24 \pm13.78mmHg vs 72.48\pm29.8mmHg, $t=8.87$, $p<0.001$).</p> <p>Author Conclusion: Use of a viscoelastic foam overlay reduces pressure injury incidence for people at moderate risk of pressure injury development. This is likely due to the lowered interface pressure at the sacral/coccyx region.</p>	<ul style="list-style-type: none"> No ITT analysis completed Sample size slightly smaller than power calculations indicated due to higher than anticipated drop-out rate Interface pressure measurements were only taken for short periods, not allowing for immersion into the viscoelastic surface, measurements were also taken over a small region. 	<p>Level of evidence: 1</p> <p>Quality: moderate</p>
M. Van Leen, Hovius, Halfens, Neyens, & Schols, 2013	RCT to evaluate the clinical efficacy of a combination of a 15cm viscoelastic foam mattress with a static air overlay compared with	<p>n= 41 Phase 1 n=38 Phase 2</p> <p>Nursing home in Naaldwijk, The Netherlands</p> <p>Inclusion criteria: Braden \leq 19 Aged $>$ 65 yrs</p>	<ul style="list-style-type: none"> All participants were provided with a static air cushion for use when sitting out of bed Participants were randomized to either: <ul style="list-style-type: none"> Group A: Duosmart viscoelastic foam mattress replacement (n= 40), or 	<ul style="list-style-type: none"> Primary: Development of a Stage 2 or higher pressure injury Weekly skin inspections 	<ul style="list-style-type: none"> Although more people developed a pressure injury in Group A (8 pressure injuries) than in Group B (2 pressure injuries) these results were not statistically significant ($p=0.087$). 2 people in Group A developed G3 pressure injuries and were removed from the phase and placed on low-air-loss mattresses and none in Group B. Significantly more people needed repositioning (ie developed a G1 	<ul style="list-style-type: none"> Possible carry-over effect from crossover design Due to deaths of 5 participants, study may be underpowered as required sample size as determined by 	<p>Level of evidence: 1</p> <p>Quality: high</p>

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Ref	Type of Study	Sample	Intervention(s)	Outcome Measures & Length of Follow-up	Results	Limitations and comments	
	viscoelastic foam alone in preventing pressure injuries.	Exclusion criteria: pre-existing pressure injury	<ul style="list-style-type: none"> ○ Group B: viscoelastic foam mattress replacement with static air overlay (Duosmart with Repose overlay) (n= 39) ● Single-centre randomised crossover trial with 6 months in each treatment group (Any new pressure injuries were healed before commencing Phase 2) ● Repositioning commenced when a Stage 1 pressure injury developed 		<p>pressure injury) in Group A (n=8) compared with Group B (n=1) (p=0.014)</p> <p>Author conclusion: Use of a visco-elastic foam mattress with a static overlay provides better prevention than use of the visco-elastic foam mattress by itself. Repositioning is worth considering when using the static overlay however should be completed when using the foam mattress alone.</p>	power calculations was only just met at the beginning of the study.	
L. J. Russell et al., 2003	RCT comparing a viscoelastic polymer foam mattress to a standard hospital foam mattress to prevent Category/Stage I pressure injuries	<p>Participants were recruited in elderly acute care, orthopedic, and rehabilitation wards (n=1168)</p> <p>Inclusion criteria: At risk of pressure injuries (Waterlow 15-20) Aged > 65 years</p> <p>Exclusion criteria: Obesity based on weight >341 lb (155 kg)</p>	<ul style="list-style-type: none"> ● Participants received either: ● viscoelastic polymer foam mattress (CONFOR-Med mattress/cushion combination, n=562) ● standard hospital foam mattress and cushion (n=604) 	<ul style="list-style-type: none"> ● primary outcome in this study was non-blanchable erythema 	<ul style="list-style-type: none"> ● A non-significant decrease in the incidence of Category/Stage I pressure ulcers occurred in participants allocated to the experimental group (10.9% to 8.5%, p = 0.17). ● Survival analysis (at seven days) showed a statistically significant decrease in Category/Stage I pressure injuries in the experimental group (p = 0.042) ● Relative odds ratio of developing non-blanching erythema or worse was 1.46 (95% CI, 0.90 to 1.82) ● Number needed to treat to prevent any type of erythema was 11.5 ● Standard foam had significantly higher rate of any pressure injuries (26.6% versus 19.6%, p=0.004) 	<ul style="list-style-type: none"> ● No blinding 	<p>Level of evidence: 1</p> <p>Quality: moderate</p>

Support Surfaces: data extraction and appraisals

Ref	Type of Study	Sample	Intervention(s)	Outcome Measures & Length of Follow-up	Results	Limitations and comments	
Berthe, Bustillo, Melot, & de Fontaine, 2007	RCT comparing high specification foam to a standard mattress	Participants were recruited in medical and surgical units (n = 1,729).	Participants were randomized to receive either: <ul style="list-style-type: none"> foam mattresses with block structure, or standard hospital mattresses 	<ul style="list-style-type: none"> Pressure injuries Time to pressure injury 	<ul style="list-style-type: none"> No significant difference in pressure ulcer incidence was found between the experimental and control group (p = 0.154). Time to develop a pressure ulcer was longer in the group with the alternative foam mattress (31 days) than in the control group (18 days) (p < 0.001) 	<ul style="list-style-type: none"> 	<p>Level of evidence: 1</p> <p>Quality:</p>
Collier, 1996	RCT comparing seven high specification foam mattresses to a standard hospital mattress	Participants were recruited in a general medical ward (n=90)	Participants were randomized to receive one of eight foam mattresses: <ul style="list-style-type: none"> Standard hospital mattress 130mm thick (n=9) Clinifloat (n=11) Omnifoam (n=11) Softfoam (n=12) STM5 (n=10) Therarest (n=13) Transfoam (n=10) Vapoulex (n=14) 	<ul style="list-style-type: none"> Incidence of pressure injuries Category/Stage I or greater Skin inspections at timing determined by staff 	<ul style="list-style-type: none"> No pressure injuries developed in any patients 	<ul style="list-style-type: none"> Another mattress was trialed but the data was removed at the manufacturer's request Semi-blinded, general staff did not know the mattress, but the primary researcher did 	<p>Level of evidence: 1</p> <p>Quality: low</p>
D. Gray & Campbell, 1994	RCT comparing high specification foam mattress to a standard hospital mattress	Participants were recruited from orthopedic trauma, vascular and medical oncology wards (n=170) Inclusion criteria: <ul style="list-style-type: none"> Waterlow score > 15 No existing skin breaks 	Participants were randomized to receive either: <ul style="list-style-type: none"> Softfoam mattress (n=90), or standard hospital mattresses 130mm thick (n=80) 	<ul style="list-style-type: none"> Incidence of Category/Stage II or greater pressure injuries Skin inspections on day 5 and day 10 	<ul style="list-style-type: none"> Category/Stage II pressure injuries were significantly higher in the control group (7% versus 34%) Rate of transferring patients onto an active support surface was higher in the control group (19% vs 2%) Comfort score was higher for the high specification mattress 	<ul style="list-style-type: none"> Only 10 day follow up No blinding Unclear if there was any drop outs from this trial 	<p>Level of evidence: 1</p> <p>Quality: low</p>
Hofman et al., 1994	RCT	Participants were recruited in an orthopedic surgery setting (n=43, n=36 analyzed) Inclusion criteria: Femoral-neck fracture	Participants were randomized to receive either: <ul style="list-style-type: none"> Cubed foam mattress (Comfortex DeCube™, n=21) or 	<ul style="list-style-type: none"> Incidence of Category/Stage II or greater pressure injuries at 2 weeks Skin inspection by two independent observers 	<ul style="list-style-type: none"> Category/Stage II pressure injuries were significantly higher in the control group (24% versus 68%) 	<ul style="list-style-type: none"> Only 2 weeks follow up Non-blinded outcome assessment No ITT analysis 78% attrition 	<p>Level of evidence: 1</p> <p>Quality: low</p>

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Ref	Type of Study	Sample	Intervention(s)	Outcome Measures & Length of Follow-up	Results	Limitations and comments	
		Pressure injury risk score > 8 on Dutch consensus scale Exclusion criteria: Existing Category/Stage II or greater pressure injury	<ul style="list-style-type: none"> standard polypropylene SG40 hospital mattresses (n=23) 	at 1 and 2 weeks post-surgery		<ul style="list-style-type: none"> High specification mattress was not always used correctly 	
D. G. Gray & Smith, 2000	RCT comparing foam mattress to a standard hospital mattress	participants from surgical, orthopedic, and medical wards (n=100)	Participants were randomized to receive either: <ul style="list-style-type: none"> new foam mattress (n = 50) , or standard hospital foam mattress (n = 50). 	<ul style="list-style-type: none"> 	<ul style="list-style-type: none"> There was no significant difference between the two groups in Category/Stage II to IV pressure ulcer incidence (2% in both populations). 	<ul style="list-style-type: none"> This study has a number of methodological flaws 	Level of evidence: 1 Quality: low
Stapleton, 1986	Quasi experiment comparing	(n=100) Inclusion criteria: <ul style="list-style-type: none"> Female fractured neck of femur no existing pressure injuries Norton score 14 or less Participant characteristics: <ul style="list-style-type: none"> Baseline data presented and groups well matched for age and Norton score. 	Participants were randomized to receive: <ul style="list-style-type: none"> Large Cell Ripple (Talley, n = 32) Polyether foam pad (3-inch thickness, n = 34). Silicore filled pad (Spenco) (n = 34). 	Category/Stage II or greater pressure injury incidence Follow up for 12 months	Category/Stage II or greater pressure injury incidence <ul style="list-style-type: none"> No significant difference between groups: <ul style="list-style-type: none"> Large Cell Ripple: 34% (11/32) Polyether foam pad: 41% (14/34) Silicore filled pad: 35% (12/34) Risk ratio for comparison between two reactive support surfaces: RR 1.17, 95% CI 0.64 to 2.14 Risk ratio for comparison between pooled reactive support surface groups versus alternating pressure: RR.90, 95% CI 0.51 to 1.58 Category/Stage II or greater pressure injury incidence Large Cell Ripple: 0% Foam pad: 24% (8/34) Silicore filled pad: 6% (2/34) (no significant difference)	<ul style="list-style-type: none"> Some participants were randomized and other assigned using alternation Allocation concealment and blinding not reported 2% drop out rate Only included female patients 	Level of evidence: 2 Quality: moderate

Support Surfaces: data extraction and appraisals

Ref	Type of Study	Sample	Intervention(s)	Outcome Measures & Length of Follow-up	Results	Limitations and comments	
					<ul style="list-style-type: none"> 45 Large Cell Ripple mattresses required 50 motor repairs and 90 material repairs Patients did not like the comfort of the ripples mattress 		
Static/constant low pressure air support surfaces							
Newton, 2014, 2015	Observational study to evaluate the mattress replacement for prevention of pressure injuries	<p>Participants were recruited by unknown methods in a regional UK hospital (n=61)</p> <p>Inclusion criteria: High risk of pressure injury</p> <p>Exclusion criteria: Patients with an existing pressure injury</p> <p>Participant characteristics:</p> <ul style="list-style-type: none"> Mean age 77 (range 22-100) Mean Waterlow risk score 15 (range 2-26) 	<ul style="list-style-type: none"> Participants provided with Atmosair™ 4000 mattress (ArjoHuntleigh), a non-powered mattress with combination of air cells and pressure reducing foam. As weight is applied the air is displaced from air cells via an exhaust system and the patient is immersed and enveloped in the surface Concurrent repositioning – 18% required assistance to reposition Length of stay on bed was average 9 days (range 1 to 32) 	<ul style="list-style-type: none"> Number of pressure injuries developed pressure injury risk using Waterlow Skin assessment Repositioning assistance requirement Care round frequency (checking patient comfort, toileting needs, position and nutritional requirement) Patient mobility Follow-up – 2 week post-evaluation on a high-specification foam mattress (n=26) 	<p>2 pressure injuries developed (3%)</p> <p>92% admitted with intact skin but 89% discharged with intact skin</p> <p>82% people could reposition themselves on the support surface despite only 24% able to mobilise independently</p> <p>Author conclusion: The mattress was a suitable for people with high to very high risk when used with repositioning</p>	<ul style="list-style-type: none"> Poor description of methodology no comparative information Unclear description of time spent on mattress Unclear what other interventions occurred May not be representative sample – 82% of participants could reposition self in bed and 24% fully mobile No statistical analysis completed, no endpoints described 	<p>Level of evidence: 4</p> <p>Quality: low</p>
Serraes & Beeckman, 2016	Cohort study exploring efficacy of static air support surfaces for reducing	Participants were purposely sampled from 6 nursing homes in Belgium (n= 867 screened, n=259 included, baseline measurement n=188, completed n=176)	<ul style="list-style-type: none"> Repose static air mattress overlay, a seat cushion, and a heel wedge that provide static pressure redistribution through tubular cells 	<ul style="list-style-type: none"> PI incidence and risk factors for developing category (stage) II-IV PU using staging in International Guideline 2014 	<p>Incidence of pressure ulcer</p> <ul style="list-style-type: none"> 23.3% developed Category I PU 5.1% developed category II to IV PU 3.4% developed a category II PU 1.7% developed category III PU 0% developed a category IV PU 	<ul style="list-style-type: none"> PU incidence prior to interventions was not measured and their was no comparator group Introduction of education and skin 	<p>Level of evidence: 3</p> <p>Quality: moderate</p>

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Ref	Type of Study	Sample	Intervention(s)	Outcome Measures & Length of Follow-up	Results	Limitations and comments	
	pressure injury incidence	<p>Inclusion criteria:</p> <ul style="list-style-type: none"> • Bed bound and/or chair bound (> 8 hours/day in bed or chair) • Braden scale score < 18 and/or existing Category I PU • Aged ≥ 65 years • Weight < 139kgs (based on mattress specifications) <p>Exclusion criteria:</p> <ul style="list-style-type: none"> • Expected LOS < 2 weeks • Receiving palliative care • Medical contraindication for static mattress overlay • PU > Stage I on presentation <p>Participant characteristics:</p> <ul style="list-style-type: none"> • Mean, age 87±6.76 years • Mean Braden score 14±2.54 • 77% female • 67% taking tranquilizers or sedatives • 97% urinary incontinence • 69% fecal incontinence 	<ul style="list-style-type: none"> • Staff members received education about PI prevention, including differentiation from IAD, risk assessment and use of data collection tools • 4 hourly repositioning in bed and 2-3 hour repositioning in chair 	<ul style="list-style-type: none"> • Daily skin assessment commencing 24 hours after commencement of support surfaces • Weekly unannounced skin tests by research team to maintain inter-rater reliability • Standardised data collection form • Interrater reliability k=0.86 (95% CI 0.81 to 0.91) 	<ul style="list-style-type: none"> • Median time to develop PU 16 days (IQR 2 to 26) • 89% sacral PU <p>Withdrawals</p> <ul style="list-style-type: none"> • 18% dropout rate • 8.5% voluntary withdrawal with reason undescribed <p>Author conclusions: Static air support surfaces, alongside patient-tailored patient-repositioning protocols, should be considered to prevent PUs</p>	<ul style="list-style-type: none"> • assessment may have increased nurse motivation to implement other PU prevention techniques • No blinded outcome measurement • Some unexplained drop out 	
Sideranko, Quinn, Burns, & Froman, 1992	RCT comparing constant low pressure air overlay to a gel filled mattress	<p>Participants were recruited in a surgical ICU (n=57)</p> <p>Inclusion criteria: Surgical ICU stay > 48 hours No existing skin breakdown on admission.</p> <p>Participant characteristics: Water mattress group had heavier weight and shorter</p>	<p>Participants were randomized to receive either:</p> <ul style="list-style-type: none"> • Alternating air mattress (1.5-inch thick Lapidus Airfloat System; n = 20) • Static air mattress (4-inch thick Gay Mar SofCare, n = 20). 	<p>Pressure injury incidence</p> <p>Mean follow up 9,4 days</p>	<p>Pressure injury incidence</p> <ul style="list-style-type: none"> • No significant differences: <ul style="list-style-type: none"> ○ Alternating air mattress: 25%, 5/20) ○ Static air mattress: 5%, 1/20) ○ Water mattress: 12%, 2/17) • Static air mattress versus water mattress was not significantly difference (Risk ratio 0.43, 95% CI 0.04 to 4.29] 	<ul style="list-style-type: none"> • Short duration • Allocation concealment and randomization methods not reported 	<p>Level of evidence: 1</p> <p>Quality: low</p>

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Ref	Type of Study	Sample	Intervention(s)	Outcome Measures & Length of Follow-up	Results	Limitations and comments	
		duration in ICU than other groups	<ul style="list-style-type: none"> Water mattress (4-inch thick Lotus PXM 3666, n = 17) 		<ul style="list-style-type: none"> Pooled reactive surfaces versus active surface showed no significant differences (risk ratio 3.08, 95% CI 0.82 to 11.59) 		
Lazzara & Buschman, 1991	RCT comparing constant low pressure air overlay to a gel filled mattress	<p>Participants were recruited in a nursing home (n=74 randomized, n=66 analyzed)</p> <p>Inclusion criteria: at risk of pressure ulcers (Norton score > 15).</p>	<p>Participants were randomized to receive either:</p> <ul style="list-style-type: none"> air-filled overlay(SofCare) (n=33), or Gel mattress (n=33) 	<p>Category/Stage II or greater pressure injury</p> <p>Follow up 6 months</p>	<p>Category/Stage II or greater pressure injury incidence</p> <p>No significant different between air overlay (16%, 5/31) and Gel mattress (15%, 4/26).</p>	<ul style="list-style-type: none"> Analysis only included individuals with 4-6 month follow up 19 individuals who died during the study were excluded from reporting 	<p>Level of evidence: 1</p> <p>Quality: low</p>
Takala, Varmavuori, & Soppi, 1996	RCT comparing air mattress to standard hospital mattress	<p>Participants were recruited in an ICU in Finland (n=40)</p> <p>Inclusion criteria: Non-trauma patients admitted to ICU expected stay > 5 days</p>	<p>Participants were randomized to receive either:</p> <ul style="list-style-type: none"> Constant low pressure air mattress with 21 double air bags on a base (Optima, Capital, n=21), or standard hospital mattress (10cm thick foam density 35 kg/m³, n=19) 	<ul style="list-style-type: none"> Category/Stage I pressure injury incidence 14 day followup 	<ul style="list-style-type: none"> Significantly more pressure ulcers Category I or greater in the standard mattress group compared with the air mattress (37% versus 0%, p<0.005) RR 0.06; 95% CI 0 to 0.99). 9 ulcers were grade 1 (erythema), 4 were grade 2 (superficial and limited to the dermis). 	<ul style="list-style-type: none"> allocation concealment not reported No blinding. 40% withdrew from study No ITT analysis 	<p>Level of evidence: 1</p> <p>Quality: low</p>
Martin van Leen, Hovius, Neyens, Halfens, & Schols, 2011	Single center RCT comparing polyether foam to static air mattress overlay	<p>Participants were recruited from a geriatric long term care facility in the Netherlands (n=83)</p> <p>Inclusion:</p> <ul style="list-style-type: none"> Aged > 65 years Norton scale between 5 and 12 No existing PU at commencement 	<ul style="list-style-type: none"> All participants received standardized pressure reduction in sitting position by using a static air cushion No participants received repositioning before development of a stage II PU 	<ul style="list-style-type: none"> Primary outcome measure was development of stage II, III or IV PUs at the heel or in the sacral region Participants were checked weekly for PUs by an independent nurse Follow-up was at 6 months 	<ul style="list-style-type: none"> Less participants on the air mattress overlay developed a stage II or greater PU but the difference was not significant (4.8% versus 17.1%, p=0.088) There was no difference regarding PU incidence between patients with a high risk (Norton 5-8) and patients with a medium risk (Norton 9-12) 71% of participants who developed a PU on the control foam mattress 	<ul style="list-style-type: none"> Comorbidities influencing healing are not reported (e.g. nutrition) No blinding methods not reported PU healing protocol is not reported 	<p>Level of evidence: 1</p> <p>Quality: low</p>

Support Surfaces: data extraction and appraisals

Ref	Type of Study	Sample	Intervention(s)	Outcome Measures & Length of Follow-up	Results	Limitations and comments	
		<p>Exclusion:</p> <ul style="list-style-type: none"> • PU in previous 6 months <p>Characteristics:</p> <ul style="list-style-type: none"> • More participants in the static air mattress group had lower Norton scores (p=not reported, unclear if significant difference) • Mean age approx. 81 to 83 years • About 75% of participants had dementia 	<ul style="list-style-type: none"> • Participants were randomised to receive either: <ul style="list-style-type: none"> ○ 15cm cold foam mattress made of polyether foam (n=42) ○ a static air overlay on top of a 15cm cold foam mattress made of polyether foam (n=41) 		<p>showed no healing using the standard PU protocol versus 100% of participants on the air mattress overlay showing healing</p>	<ul style="list-style-type: none"> • ITT analysis is unclear • Length of time before PU development not reported 	
García-Molina et al., 2012	Historical comparison cohort survey investigating incidence of HAPU in a children nursed on continuous and reactive low pressure mattresses	<p>Participants were admitted over a 2 year period to the 5 bed Paediatric ICU in a Spanish hospital (n=30 children)</p> <p>Inclusion: aged 1 day to 10 years</p> <ul style="list-style-type: none"> • Admitted for > 24 hours • Braden score indicating at risk of developing PU (Braden-Q ≤ 16, Neonatal Skin Risk Assessment Scales ≤ 13) <p>Exclusion:</p> <ul style="list-style-type: none"> • Admitted < 24 hours • Aged > 10 years • No consent • Not received the pressure mattress support surface PMSS <p>Characteristics:</p>	<ul style="list-style-type: none"> • All participants received standard PU prevention including application of hyperoxygenated fatty acid oil to skin 8 hourly, and protective hydrocellular dressings) • Participants of interest to survey were nursed on one of two mattresses provided in the unit for children at risk for PU. • Both mattresses classified as continuous and reactive low-pressure special surfaces consisting of double air-cell construction that reacts to pressure in three different compartments (head, body, trunk) but maintains same level of support in each section 	<ul style="list-style-type: none"> • Presence of PU determined by daily skin assessment 	<ul style="list-style-type: none"> • 63.3% participants did not receive any repositioning due to their clinical condition • There was a significantly lower incidence of non-device related HAPU in the study participants compared with the estimated incidence in the previous year (3.3% versus 20%, 95% CI 0.08% to 17.2%, p=0.021) • 66.6% of participants admitted with a PU healed before discharge from the PICU • Study conclusions: the continuous and reactive low-pressure support surface was associated with a lower incidence of new PU in children in the absence of regular repositioning 	<ul style="list-style-type: none"> • Small sample size • Comparison cohort was not described and reported as an estimated incidence • Severity of PUs prior to admission not reported • Participating nurses were trained informally • Concurrent use of several local pressure-management devices in certain high-risk anatomical locations 	<p>Level of evidence: 3</p> <p>Quality: low</p>

Support Surfaces: data extraction and appraisals

Ref	Type of Study	Sample	Intervention(s)	Outcome Measures & Length of Follow-up	Results	Limitations and comments	
		<ul style="list-style-type: none"> Primarily aged from 1 month to 3 years (73.3%, n=22) Average Braden score for those aged >1 month 10.4±2.4 Average Braden score for those aged < month 13.2±3.03 About half participants were sedated and had vasoactive medication (n=15) 33.3% had a PU on admission to study 	<p>(i.e. not alternating pressure).</p> <ul style="list-style-type: none"> First mattress (Cartio Neo®): designed for children weighing 500g to 6kg (n=4) Second mattress (Cartio Juve®): designed for children weighing ≥6 Kg (n=26) <ul style="list-style-type: none"> Participants were placed on the study mattresses for a mean of 7±7 days (range 1 to 25 days) 				
Vermette, Reeves, & Lemaire, 2012	RCT – prospective study comparing efficacy of inflated static overlay to a microfluid overlay or low air loss dynamic mattress	<p>Participants recruited from medical, surgical, ICU and geriatric wards. Country not stated. (n=110)</p> <p>Inclusion:</p> <ul style="list-style-type: none"> Aged ≥ 18 years Without existing PU on visual inspection Weigh <300lb Moderate to high risk of PU with a Braden score ≤ 14 <p>Characteristics:</p> <ul style="list-style-type: none"> No statistical differences between groups at baseline Mean Braden score 11 to 12 Mean age approx. 77 yrs More participants in study group had BMI <18 and more in control groups had BMI >25 (p=0.0241) 	<ul style="list-style-type: none"> Both groups had identical protocols with repositioning and device check every 2 hrs, sacral moisturizer, minimal raising of bed head, pillow supports. Participants were randomized to receive either: <ul style="list-style-type: none"> Study surface: inflated static overlay, (Waffle® overlay, EHOB) (n=55) Control surfaces: microfluid static overlay (RIK®, KCI Medical) for participants <200lb (n=50) or low-air-loss dynamic mattress TheraKair®, KCI Medical) with pulsation for participants 200 to 	<ul style="list-style-type: none"> Pressure injury incidence within the study period of 2 weeks Head to toe assessments performed 3 times a week with PUs classified on NPUAP scale Comfort level rated by participants on a 5 point Likert scale 	<p>Microfluid overlay or a low air loss dynamic mattress (n=55) versus inflated static overlay (n=55)</p> <ul style="list-style-type: none"> No significant difference in pressure injury incidence was found between the control and study groups (11% versus 4%, p=0.2706) No significant difference in comfort (90% for control versus 85% for study, p=0.7129) There was a significant difference in total cost with the ISO was less expensive (\$16086 versus \$3364, p<0.001) <p>Microfluid overlay (n=50) versus inflated static overlay (n=55)</p> <ul style="list-style-type: none"> No significant difference in pressure injury incidence was found between the control and study groups (12% versus 4%, p=0.1269) 	<ul style="list-style-type: none"> Experiment was not blinded Cost analysis was limited to the rental or the purchasing of surfaces A priori sample size Inflation may not have been at optimal levels 	<p>Level of evidence: 1</p> <p>Quality: high</p>

Support Surfaces: data extraction and appraisals

Ref	Type of Study	Sample	Intervention(s)	Outcome Measures & Length of Follow-up	Results	Limitations and comments	
		<ul style="list-style-type: none"> More study group participants had diabetes (unclear if statistical due to conflicting data in paper) Matched for bed-ridden/chair ridden status 	300lb or who required edema management (n=5)		<ul style="list-style-type: none"> No significant difference in comfort (89% for control versus 85% for study, p=0.1.00) There was a significant difference in total cost with the ISO was less expensive (\$13086 versus \$3364, p<0.001) 		
Stapleton, 1986	Quasi experiment comparing	<p>(n=100)</p> <p>Inclusion criteria:</p> <ul style="list-style-type: none"> Female fractured neck of femur no existing pressure injuries Norton score 14 or less <p>Participant characteristics:</p> <ul style="list-style-type: none"> Baseline data presented and groups well matched for age and Norton score. 	<p>Participants were randomized to receive:</p> <ul style="list-style-type: none"> Large Cell Ripple® (Talley, n = 32) Polyether foam pad (3-inch thickness, n = 34). Silicone coated (Spenco® Silicore®) pad (n = 34). 	<p>Category/Stage II or greater pressure injury incidence</p> <p>Follow up for 12 months</p>	<p>Category/Stage II or greater pressure injury incidence</p> <ul style="list-style-type: none"> No significant difference between groups: <ul style="list-style-type: none"> Large Cell Ripple: 34% (11/32) Polyether foam pad: 41% (14/34) Silicone pad: 35% (12/34) Risk ratio for comparison between two foam overlays: RR 1.17, 95% CI 0.64 to 2.14 Risk ratio for comparison between pooled reactive support surface groups versus alternating pressure: RR.90, 95% CI 0.51 to 1.58 <p>Category/Stage II or greater pressure injury incidence</p> <p>Large Cell Ripple: 0%</p> <p>Foam pad: 24% (8/34)</p> <p>Silicone pad: 6% (2/34)</p> <p>(no significant difference)</p> <p>Other outcomes</p> <ul style="list-style-type: none"> 45 Large Cell Ripple mattresses required 50 motor repairs and 90 material repairs Patients did not like the comfort of the ripple mattress 	<ul style="list-style-type: none"> Some participants were randomized and other assigned using alternation Allocation concealment and blinding not reported 2% drop out rate Only included female patients 	<p>Level of evidence: 2</p> <p>Quality: moderate</p>
Other reactive support surfaces							

Support Surfaces: data extraction and appraisals

Ref	Type of Study	Sample	Intervention(s)	Outcome Measures & Length of Follow-up	Results	Limitations and comments	
Emejulu, Nwadi, & Obiegbu, 2015	Cohort study to determine if low-cost improvised waterbed would sufficiently decrease the incidence of pressure injury development for spinal cord injured patients on bedrest	Participants were recruited at a University Teaching Hospital in Nigeria (n=51) Inclusion criteria: <ul style="list-style-type: none"> spinal-cord injury admitted through A7E conservative management with nil surgery consent obtained 	Treatment Group: Improvised water bed made from sachets of water placed in bags to create a water mattress (n=21) Control Group: Standard foam mattress (not specified) (n=30)	Pressure injury incidence	Pressure injury incidence <ul style="list-style-type: none"> Significantly fewer pressure injuries developed for participants on the water bed compared with the foam mattress (28.6% and 56.7% respectively, $\chi^2 = 3.9381$, $p = 0.0472$) Nil difference in incidence when comparing participants with complete spinal cord injury compared with incomplete spinal cord injury ($\chi^2 = 0.1169$, $p = 0.5724$) <p>Author conclusion: The improvised waterbed is a cost-effective way of significantly reducing pressure injury incidence for people with spinal cord injury compared to a standard foam mattress, particularly in developing countries where more expensive options are not available.</p>	<ul style="list-style-type: none"> Relatively small sample with limited reporting of other interventions provided Participants have a new SCI, meaning complications experienced with long-term SCI have not yet occurred eg muscle atrophy 	Level of evidence: 3 Quality: low
Nwadinigwe, Anyaehie, & Onyegbulue, 2012	Retrospective review investigating a static water mattress for preventing PU	Participants were consecutive patients admitted to a spinal unit in Nigeria (n=99) in 2005 to 2006 (foam group) or in 2007 to 2008 (water group) Inclusion: <ul style="list-style-type: none"> complete traumatic SCI Exclusion: <ul style="list-style-type: none"> Missing record data PU on admission Incomplete SCI Characteristics: <ul style="list-style-type: none"> All males 	<ul style="list-style-type: none"> All participants received 4 hourly turning, IDC and structured care programs. Participants received either: <ul style="list-style-type: none"> foam mattresses were unbranded, 6" thick made from conventional firm foam and covered with a waterproof plastic canvas (n=35) water mattress is a static device that reduces pressure by spreading the weight of the body over the larger area (n=64) 	<ul style="list-style-type: none"> Incidence of PUs through staging based on NPUAP classification 	<ul style="list-style-type: none"> There were significantly less PUs in participants treated with a water mattress ($p=0.003$) PUs in water mattress group were all stage II or less and less likely to require a flap cover ($p=0.001$) but no difference in rate of split-skin grafts ($p=0.307$) 	<ul style="list-style-type: none"> Retrospective control Data base reviews Insufficient data on concurrent treatments Frequency of PU assessment unclear Follow-up only 40 to 50% of cases in each group Analyses not controlled for differences in baseline characteristics 	Level of evidence: 4 Quality: low

Support Surfaces: data extraction and appraisals

Ref	Type of Study	Sample	Intervention(s)	Outcome Measures & Length of Follow-up	Results	Limitations and comments	
		<ul style="list-style-type: none"> Water mattress group were significantly older (41.5±3.2 versus 39.0±4.6, p=0.002) No significant difference in length of hospital stay Significant differences in cause of SCI 					
Clinical question 2: What active support surfaces are effective in preventing pressure injuries? Clinical question 3: When should an active support surface be used to prevent pressure injuries?							
Gleeson, 2016a	To evaluate the an alternating pressure mattress for use in an acute stroke ward for people at medium to high risk of developing pressure injuries	<p>Participants were recruited by unknown methods in one acute stroke ward in UK (n=7)</p> <p>Inclusion criteria:</p> <ul style="list-style-type: none"> Existing pressure injury or high risk as per Maelor score <p>Participant characteristics:</p> <ul style="list-style-type: none"> Mean weight 66.5kg Mean age 73.1 years 	<ul style="list-style-type: none"> Participants were provided with Pro-Care Auto pressure mattress (Apex) on admission Mean time spent on the alternating pressure mattress was 31 days Staff and patients were given a survey about the mattress 	<ul style="list-style-type: none"> Patient perceptions of comfort, pain, ability to reposition, temperature and likes/dislikes of the mattress Staff ratings on 5-point scales of performance and features of mattress; new pressure injuries developed; usefulness of features, ease of use, noise and quality of product Staff undertook 2-hourly skin assessments (methods not reported) 	<p>Pressure injury incidence</p> <p>None of the participants developed a pressure injury over mean time on mattress of 31 days</p> <p>Subjective ratings of mattress</p> <ul style="list-style-type: none"> Only 4/7 participants responded 100% (4/4) rated mattress as very comfortable 25% stated mattress reduced pain level 65% reported increased ability to reposition or move on the mattress 100% staff (unknown number) felt the mattress was superior to other mattresses used 	<ul style="list-style-type: none"> Non-validated survey Very small sample of participants and highly biased (observer bias, assessor bias) 3 of 7 participants unable to effectively communicate Data from staff questionnaires not discussed in detail 	<p>Level of evidence: 4</p> <p>Quality: Very low</p>
Sauvage et al., 2017	An RCT exploring efficacy of an alternating pressure mattress compared to a viscoelastic foam mattress for preventing	<p>Participants were recruited in 9 medium to long stay aged care facilities in France (n= 77 screened, n=76 included and analyzed)</p> <p>Inclusion criteria:</p> <ul style="list-style-type: none"> Aged ≥ 70 years Bed bound (> 15 hours/day in bed or chair) 	<ul style="list-style-type: none"> Participants were randomized to receive either: <ul style="list-style-type: none"> alternating pressure air mattress (Axtair One™) with therapeutic cells of height 12cm, compressor adjusts on individual's 	<ul style="list-style-type: none"> Daily skin assessment Weekly Braden scale risk assessment Patient comfort on a satisfaction survey Maximum follow up 30 days or to first PU Cox model exploring time to PU based on mattress type, Braden scale, BMI or daily bed rest hours. 	<p>Rate of PUs</p> <p>More pressure injuries occurred in viscoelastic foam group versus alternating pressure group (2/39 [5.1%] versus 13/37 [35.1%])</p> <p>Risk factors over time</p> <p>Over time the following factors remained at steady rates, comparable between groups: Braden score, bed rest</p>	<ul style="list-style-type: none"> Drop out rate of 30% (including those not receiving intervention), with 50% more dropouts from intervention group, some of which were replacement of the mattress ITT analysis 	<p>Level of evidence: 1</p> <p>Quality: moderate</p>

Support Surfaces: data extraction and appraisals

Ref	Type of Study	Sample	Intervention(s)	Outcome Measures & Length of Follow-up	Results	Limitations and comments
	PU in older adults	<ul style="list-style-type: none"> Unable to repositioning independently Braden scale score ≤ 14 No pre-existing PU Karnofsky scores $\leq 40\%$ <p>Exclusion criteria:</p> <ul style="list-style-type: none"> Weight > 120 kgs BMI < 12kg/m² Expected LOS < 2 weeks Min Nutritional Assessment (MNA) Score < 12 <p>Participant characteristics:</p> <ul style="list-style-type: none"> Mean, age 84 to 86 years Mean Braden score 11 to 12 76 to 75% female MNA score mean 17 <p>Mean daily hours bed rest approx. 17 hours</p>	<p>weight with alternating inflation of one out of two cells on a 6 min cycle (n=39, of which n=13 did not receive intervention or discontinued intervention) OR</p> <ul style="list-style-type: none"> viscoelastic foam mattress (ALOVA™) made of high resilience foam with density >34kg/m³ and upper layer of viscoelastic foam of density >75kg/m³ (n=37, of which n=7 did not receive intervention or discontinued intervention) 	<ul style="list-style-type: none"> Also measured if PU interventions were equivalent between groups 	<p>duration, time in chair, number of times per pay repositioned, number or times per day provided with education, number of massages per day</p> <p>PU risk over 30 days</p> <ul style="list-style-type: none"> Cumulative risk of PU over 30 days was significantly higher in viscoelastic group (38.91%, 95% CI 24.66 to 57.59) compared with alternating pressure group (6.46%, 95% CI 1.64 to 23.66, p=0.001) Adjusted Cox model hazard ratio 7.57 (95% CI 1.67 to 34.38, p=0.009) i.e. 7.57 higher risk in viscoelastic group Type of mattress was the only significant factor in the Cox model, risk increased to 7.94 (95% CI 1.79 to 35.21, p=0.006 when non-significant factors removed from model) <p>Preventive care</p> <ul style="list-style-type: none"> Preventive care (number of times per pay repositioned, number or times per day provided with education, number of massages per day) was not different between group (p=0.78) Preventive interventions were performed infrequently (e.g over 17 hours average time in bed, mean repositioning was 1.42±2.02 in alternating pressure group versus 1.68±2.17 in viscoelastic group (p=ns) <p>Patient satisfaction</p> <p>No significant difference, p=0.21</p>	<ul style="list-style-type: none"> Short study over only 30 days with high PU rate Noncompliance with recommended best practice It is unclear if the alternating pressure mattress is superior to a viscoelastic foam mattress with best practice preventive care

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Support Surfaces: data extraction and appraisals

Ref	Type of Study	Sample	Intervention(s)	Outcome Measures & Length of Follow-up	Results	Limitations and comments	
Gleeson, 2015a	Observational study reporting outcomes for preventing and healing PU using an alternating pressure support surface	<p>Participants were recruited in a rehabilitation ward of a hospital in UK (n=13)</p> <p>Inclusion criteria:</p> <ul style="list-style-type: none"> At medium to high risk using Maelor Pressure Ulcer Risk Assessment Score <p>Participant characteristics:</p> <ul style="list-style-type: none"> Primarily female Mean age 82 years (range 68 to 92) Mean weight 62kgs (range 36 to 105) <p>At commencement, 4/13 (31%) had an existing PU (three Grade 2 PUs and one Grade 1 PU)</p>	<ul style="list-style-type: none"> Air-Flo 8® deep cell replacement mattress system made up of 20 air cells, inflating and deflating using a 1-in-2 cell technology 	<ul style="list-style-type: none"> PU classified using NPUAP/EPUAP Classification System Mean period of observation was 14 days (range 4 to 21) Unclear how often skin was assessed or by whom 	<p>PU prevention</p> <p>No new PUs developed in the study period of 52 days</p> <p>PU healing</p> <ul style="list-style-type: none"> 100% of four existing PUs healed during the study period of 52 days 	<ul style="list-style-type: none"> Small study Recruitment strategies poorly reported No comparator Non-blinded assessment Concurrent management strategies (e.g. repositioning) not reported No statistical analysis Unclear how outcomes were evaluated 	<p>Level of evidence: 4</p> <p>Quality: very low</p>
Fletcher, Tite, & Clark, 2016	A retrospective analysis of the incidence of pressure ulcer occurrence pre and post implementation of a powered hybrid mattress the Dyna-Form® Mercury Advance.	<p>8 acute trusts in England and 650000 patient admissions coupled with a improvement methodology</p> <p>Data related to new PU occurrence and monthly admissions for 6 months prior to intervention are collected. Also data 6 months post installation</p>	<p>Implementation of powered hybrid mattresses across 8 acute trusts in England.</p> <p>75.8% of beds using the power hybrid mattress replacement system or 5580 beds and 4230 hybrid mattresses installed</p>	<p>The PU occurrence data for each site was analysed and plotted on an SPC chart. Data were configured against a week 0 — implementation with a standard 6 month pre- and post view.</p> <ul style="list-style-type: none"> This evaluation differs from traditional PU equipment research in 	<p>An overall reduction of 56% (t-test result <0.001) in the number of pressure ulcers for the 6 months immediately post installation. It equates with a 93% reduction in incidence rates</p> <p>Tissue viability nurses believed that size and severity of pressure injuries reduced and deterioration appeared less.</p> <p>Significant cost savings as a result of reductions in alternating pressure ulcer air mattresses rentals.</p> <p>All organizations were able to simplify their mattress selection criteria.</p>	<p>This evaluation is based on NHS data generated from the daily care of patients delivered by its nurses, no additional resources were allocated to the implementation projects.</p> <ul style="list-style-type: none"> No clear inclusion or exclusion criteria. Unclear how the prevalence and incidence data is collected. No information about the implementation 	<p>Level of evidence: 4</p> <p>Quality: low</p>

Support Surfaces: data extraction and appraisals

Ref	Type of Study	Sample	Intervention(s)	Outcome Measures & Length of Follow-up	Results	Limitations and comments	
					that by looking at a broad range of outcomes in real clinical settings.	process of the powered hybrid mattresses	
Ochs, Horn, van Rijswijk, Pietsch, & Smout, 2005	Study to compare healing of PUs on air fluidized bed versus other support surfaces	Participants in long term care (n=664)	<ul style="list-style-type: none"> • on air fluidized bed (n=82) • non fluidized support surfaces- <ul style="list-style-type: none"> ○ Group 1 static overlay and mattresses) (n=463) • Group 2 (LAL bed, alternating pressure air mattresses and overlays) (n=119) 	<ul style="list-style-type: none"> • Changes in wound size in cm²/week • 	<ul style="list-style-type: none"> • Air fluidized superior to other surfaces: • Air fluidized (mean 5.2cm²/week) vs static surfaces 1.5cm²/week vs active surfaces 1.8cm²/week • For Category III and IV pressure injuries: air fluidized (mean decrease 3.1cm²/week) versus static surfaces (mean 0.6cm²/week) vs alternating (mean 0.7cm²), air fluidized vs alternating p=0.0211 <p>For ulcers comparable sizes at baseline: Group 3 (mean 2.3cm²/week) versus alternating surface group (mean - 2.1cm²/week, p=0.0039)</p>	<ul style="list-style-type: none"> • Two separate studies • Support surfaces were not well described and it was unclear what the comparator surfaces were • Non-comparable for ulcer size at baseline (air fluidized larger) 	<p>Level of evidence: 3</p> <p>Quality: low</p>
Demarré et al., 2012 (prevention)	Multicenter Randomized controlled trial comparing alternating low pressure air mattresses with different inflation/ deflation cycles	<p>Participants were recruited via convenience sample in 25 hospital wards in Belgium. (n=610)</p> <p>Inclusion:</p> <ul style="list-style-type: none"> • Aged ≥ 18 years • At risk of PU as determined by Braden scale score <17 <p>Exclusion:</p> <ul style="list-style-type: none"> • Incomplete Braden score • Not at risk of PU • PU stage I to IV on admission • Expected admission <3 days • Do not resuscitate • Weighing < 30 kgs or > 160 kgs 	<ul style="list-style-type: none"> • Participants were randomly allocated to either: <ul style="list-style-type: none"> ○ Experimental group: alternating low pressure air mattress with multi-stage inflation and deflation cycle (between 10 and 12 minutes) of the air cells with a sensor at the sacral zone measuring the applied pressure of the body on the mattress (n=298) ○ Control group: alternative low pressure air mattress 	<ul style="list-style-type: none"> • Daily skin observations and risk assessments • Cumulative PU incidence (stage II to IV) • Inter-rater reliability in classification of PU and Braden scoring was established 	<ul style="list-style-type: none"> • There was no significant difference in cumulative PU incidence between groups (5.7% in experimental group versus 5.8% in control group, p=0.97) • Median time to develop PU was not significantly different between groups: (5.0 days [IQR 3.0 to 8.5] in experimental group versus 8 days [IQR 3.0 to 8.5] in the control group, p=0.182). • An equal number of patients developed a PU Grade II to IV at the pelvic area (hip and sacral) in the experimental group (3.7%) compared to the control group (3.5%) • No significant difference in PU incidence at the heel/ankle between the experimental (1.3%) and the control group (1.9%) 	<ul style="list-style-type: none"> • Lack of a blinded outcome • Limited predictive value of the Braden Scale to assess risk for PU development 	<p>Level of evidence: 1</p> <p>Quality: high</p>

Support Surfaces: data extraction and appraisals

Ref	Type of Study	Sample	Intervention(s)	Outcome Measures & Length of Follow-up	Results	Limitations and comments	
		<ul style="list-style-type: none"> No informed consent <p>Characteristics:</p> <ul style="list-style-type: none"> Approximately 60% sample female Mean age 76.3±14.0 years Approx. 50% incontinent Median Braden score 14.0 15.4% participants in each group had PU grade I on admission (p=0.99 between groups) Mean BMI 23.8±4.65 Approx 27% participants bed-bound and 61.3% chair bound 	<p>with a standard single stage inflation cycle (10 min) and deflation cycle of the air cells (n=312)</p> <ul style="list-style-type: none"> Both mattresses were covered with an identical mattress cover No standard repositioning protocol was used in bed 		<ul style="list-style-type: none"> Study conclusions: an alternating low pressure air mattress with multi-stage inflation/deflation of air cells has no benefit over a standard cycle alternating low pressure air mattress in preventing PUs. 		
J. Johnson, D. Peterson, B. Campbell, R. Richardson, & D. Rutledge, 2011; J. Johnson, D. Peterson, B. Campbell, R. Richardson, & D. N. Rutledge, 2011	Prospective comparative study investigating the prevalence of HAPU in patients cared for on low air loss beds	<p>Participants recruited from 4 units in a community hospital (n=297)</p> <p>Inclusion:</p> <ul style="list-style-type: none"> Inpatient on observation days in 2008 <p>Characteristics:</p> <ul style="list-style-type: none"> first comparison (cardiac renal and medical telemetry units) <ul style="list-style-type: none"> no significant difference in demographics mean age 64-65 years mean length stay 4-6 days mean Braden score approx. 18 Second comparison: (general surgical versus pulmonary unit) 	<p>164 patients were included in survey, of which 133 were allocated to low air loss device</p> <p>The same care staff worked across both units in each of the comparisons</p> <p>Two comparisons:</p> <ul style="list-style-type: none"> Cardiac renal unit with standard beds (n=75) versus medical telemetry with low air loss beds (n=53) general surgical with low air loss bed (n=80) versus pulmonary unit with standard bed (n=89) 	<ul style="list-style-type: none"> Pressure ulcer prevalence observed in four units on three occasions Use of NPUAP staging system Skin assessments conducted by skin nurses and interrater reliability established prior to survey 	<p>PU prevalence did not differ significantly between groups</p> <p>Comparison one: cardiac renal (standard) versus medical telemetry (low air loss) Cardiac unit had lower prevalence HAPU but difference was not significant (1.3% versus 3.8%, p>0.05)</p> <p>Comparison two: medical pulmonary (standard) versus general surgical (low air loss) Medical pulmonary had lower prevalence of HAPU but difference was not significant (3.4% versus 6.3%, p>0.05)</p>	<ul style="list-style-type: none"> No incidences were measured, only prevalence figures Not controlled for differences in patient characteristics No randomization 	Level of evidence: 2 Quality: low

Support Surfaces: data extraction and appraisals

Ref	Type of Study	Sample	Intervention(s)	Outcome Measures & Length of Follow-up	Results	Limitations and comments	
(prevention)		<ul style="list-style-type: none"> ○ Patients on low air loss beds had significantly higher Braden scores (18.96±3.1 versus 17.79±2.9, p=0.013) ○ Patients on low air loss beds had significantly longer length of stay (6.01±7.0 days versus 4.21±3.7, p=0.036) ○ Mean age 64 to 67 years 					
Black, Berke, & Urzendo wski, 2012 (prevention)	Quasi experiment comparing a low air loss bed with microclimate management to an integrated power air redistribution bed for preventing PU	<p>Participants were recruited from a cardiovascular surgical unit in USA (n=52)</p> <p>Inclusion:</p> <ul style="list-style-type: none"> • Likely to be ICU for three days • Not receiving palliative care • No pulmonary or wound issues requiring special beds <p>Characteristics:</p> <ul style="list-style-type: none"> • No significant differences in demographics at baseline • Mean length of stay 7 days, mean length of data collection was 5 days • Mean age 59.1 years • Mean admitting Braden score 11.2 (range 7 to 20) 	<ul style="list-style-type: none"> • Staff training occurred prior to study commencement. • Participants received similar regimens for repositioning and skin care. Participants received either: <ul style="list-style-type: none"> ○ loss bed with microclimate management (n=31) • integrated power air redistribution bed (n=21) 	<ul style="list-style-type: none"> • PU incidence determined through skin assessment every three days • Mean follow up period was 5.7 days • 	<ul style="list-style-type: none"> • Participants on a low air loss bed had significantly less PUs (0% versus 18%, p=0.046) • 	<ul style="list-style-type: none"> • No randomization, blinding, study power calculation • Limited baseline demographics • Concurrent management unclear • Short study period • No interrater reliability 	Level of evidence: 2 Quality: low
Vanderwee, Grypdonck, & Defloor, 2005	RCT evaluating effectiveness of an alternating pressure air mattress for	Participants were recruited in surgical, internal medicine, and geriatric wards in Belgium (n=447)	<ul style="list-style-type: none"> • Participants were randomized to receive either: <ul style="list-style-type: none"> ○ alternating pressure air overlay (Apha-X- 	<ul style="list-style-type: none"> • Daily skin inspection by ward nurses and random checks by researchers • EPUAP classification system used 	Incidence of Category/Stage II or greater pressure injuries <ul style="list-style-type: none"> • no significant difference(p=1.00) between the among individuals cared for either on an active support 	<ul style="list-style-type: none"> • No blinding • Participants had non-equivalent turning protocols because an 	Level of evidence: 1 Quality: moderate

Support Surfaces: data extraction and appraisals

Ref	Type of Study	Sample	Intervention(s)	Outcome Measures & Length of Follow-up	Results	Limitations and comments	
	preventing pressure injuries	<p>Inclusion criteria:</p> <ul style="list-style-type: none"> Aged > 18 years Hospitalisation for ≥ 3 days No existing pressure injury ≥Category/Stage II Body weight <140kg Braden scale score <17 <p>Participant characteristics: Mean age 82 years (interquartile range 77-88) 93% were older than 65 years</p>	<p>Cell®, Huntleigh Healthcare) with no turning protocol (n=148), or</p> <ul style="list-style-type: none"> high specification viscoelastic polyurethane foam mattress (Tempur®, Tempur-World Inc.) with four-hourly repositioning <ul style="list-style-type: none"> Both groups received the same sitting protocol on an air cushion (Airtech®, Huntleigh Healthcare) and asked to stand every 2 hours Both groups received heel elevation using an ordinary cushion 	<ul style="list-style-type: none"> Transparent pressure disk used Interrater reliability for classification (between nurse and researcher) K=0.88 (95% CI 0.78-0.97) 	<p>surface (15.3%) or on a high specification foam mattress (15.6%)</p> <ul style="list-style-type: none"> incidence rate was 1.46 (34/2,371 days) (95% CI 0.98 to 1.97) in alternating pressure air mattress group and 1.66 (35/2,106 days) (95% CI 1.11 to 2.21) in control group No significant difference in time to pressure injury <p>Location of pressure injuries Significant difference in locations of pressure injuries (p=0.003) Alternating pressure group had 73.5% on sacrum, 14.7% on heels, 11.8% other Control group had 54.4% sacrum, 45.7% heels)</p>	<ul style="list-style-type: none"> assumption was made that turning was not required on the alternating pressure mattress 	
Sanada, Sugama et al., 2003	RCT comparing two different alternating air mattresses	<p>Participants were recruited in a hospital in Japan (n=82)</p> <p>Inclusion criteria: Stroke, general surgery or terminally ill person requiring head of bed elevation</p>	<ul style="list-style-type: none"> All participants received 2 hourly repositioning and routine skin care Participants randomized to receive either: <ul style="list-style-type: none"> Single layer air cell overlay (Air Doctor™ Ding Li) with 5-minute alternating cell pressure (n=29), Double-layer air cell overlay (Tricell®, KCI) with 5-minute alternating cell pressure (n=26), or Standard polyester I mattress (Paracare®) (n=27) 	<p>Incidence of Category/Stage I and II pressure injuries</p> <ul style="list-style-type: none"> 	<p>Incidence of Category/Stage II pressure injuries</p> <ul style="list-style-type: none"> Single cell mattress 13.8%, double cell mattress 3.8%, standard mattress 22% <p>Incidence of Category/Stage I and II pressure injuries</p> <ul style="list-style-type: none"> No significant difference between one cell and two cell air mattresses or between one cell mattress and control Pooled alternating air mattresses versus polyester mattress, relative risk 0.29 (95% CI 0.12 to 0.73) 	<ul style="list-style-type: none"> No blinding 24% of participants were lost to follow up Relative risk reported in Medical Advisory Secretariat, Pressure Ulcer Prevention: an evidence-based analysis, Ontario Health Technology Assessment Series 2009 9(2) 1-104 	<p>Level of evidence: 1</p> <p>Quality: low</p>

Support Surfaces: data extraction and appraisals

Ref	Type of Study	Sample	Intervention(s)	Outcome Measures & Length of Follow-up	Results	Limitations and comments	
Manzano et al., 2013	Quasi experiment comparing alternating pressure mattress to alternating pressure air overlay for preventing PU in ICU patients	<p>participants were retrospectively recruited over 5 months in 2001 (overlays) and 2006 (mattresses) in an ICU in Spain (n=221)</p> <p>Inclusion:</p> <ul style="list-style-type: none"> aged over 18 years invasive or non-invasive mechanical ventilations for at least 24 hours in ICU within 24/48h after initiating invasive or non-invasive MV <p>Exclusion:</p> <ul style="list-style-type: none"> Existing PU Body weight > 140 kgs 	<p>Participants received either:</p> <ul style="list-style-type: none"> small-cell alternating overlay (maximum cell height: 6.5 cm and cell cycle time: 6 minutes, standardized protocol for turning every 4 hours using following schedule: semi-Fowler 30°, right-side lateral position 30°, semi-Fowler 30°, and left-side lateral position 30°) alternating replacement mattress: Alternating modus of the Total Duo2®, Hill-Rom Corporate, Bastesville, IN, USA (maximum cell height: 13.5 cm, turning protocol similar as in intervention 1 group) 	<ul style="list-style-type: none"> Incidence of pressure ulcers grade II to IV 	<p>Multivariate analyses:</p> <ul style="list-style-type: none"> risk for developing a pressure ulcer was 0.44 (95% CI: 0.21–0.92), indicating a significantly lower risk for developing a pressure ulcer (cat II-IV) on the replacement mattress compared to the small-cell overlay mattress (p=0.038). 	<ul style="list-style-type: none"> No information on preventive measures when seated. time lag between two interventions is 5 years. no correction possible for unknown differences between two groups Not clear how multivariate analyses was conducted no information on non-blanchable erythema and possible baseline differences 	<p>Level of evidence: 2</p> <p>Quality: moderate</p>
Nixon et al., 2006	RCT to compare the effectiveness of alternating-pressure mattress replacements and alternating-pressure mattress overlays	<p>Participants recruited in 11 vascular, orthopedic, medical, and care-of-elderly wards in UK (n=1,971)</p> <p>Inclusion criteria: Acute or elective patients Existing Category/Stage I or II pressure injury</p>	<ul style="list-style-type: none"> Participants received either alternating air pressure overlay (n=990) or alternating air mattress (n=982) 	<ul style="list-style-type: none"> New Category/Stage II or greater pressure injury Follow up for 30 and 60 days (median 9 days) 	<p>Category/Stage II and greater pressure injury incidence</p> <ul style="list-style-type: none"> No significant difference between alternating air overlay (10.7%, 106/989) and alternating air mattress (10.3%, 101/982, p=0.75) Relative risk 0.96, 95% CI 0.74 to 1.24) No difference in time to develop pressure injury (log-rank test statistic 0.094, p = 0.76). However there were few events, <p>Subjective evaluations 23% of individuals receiving an alternating air overlay and 18.9% of those receiving an alternating air</p>	<ul style="list-style-type: none"> Experiment was not blinded 6% participants lost to follow up ITT analysis Relative risk reported in Medical Advisory Secretariat, Pressure Ulcer Prevention: an evidence-based analysis, Ontario Health Technology 	<p>Level of evidence: 1</p> <p>Quality: high</p>

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Ref	Type of Study	Sample	Intervention(s)	Outcome Measures & Length of Follow-up	Results	Limitations and comments	
					<p>mattress requested a change of support surface, which was significantly more for the overlay group (p=0.02)</p> <p>Adverse events Total of nine incidents, (higher in mattress versus overlay group with all falls associated with mattress, and equivalent cot side incidents (2 in overlay group, 7 in mattress group)</p>	Assessment Series 2009 9(2) 1-104	
Iglesias et al., 2006	RCT to compare the effectiveness of alternating-pressure mattress replacements and alternating-pressure mattress overlays	See paper by Nixon et al., 2006	<ul style="list-style-type: none"> See paper by Nixon et al., 2006 	<ul style="list-style-type: none"> Estimates of restricted mean time to develop a pressure injury Cost and health benefits 	<p>mean time to development of pressure ulcers mattress group took 10.64 days longer to develop a pressure ulcer compared to overlay group (p>0.05)</p> <p>Cost effectiveness</p> <ul style="list-style-type: none"> The mattress was associated with an 80% probability of being cost saving compared with the overlay (for a willingness to pay of zero) The mattress was associated with an 15% probability of being cost saving compared with the overlay (for a willingness to pay of £25 to £30,000) Mattress was associated with a mean reduction in total hospital cost of £283.60 (95% CI – £377.59 to £976.79, p=0.418) <p>Differences in health benefits and total costs for hospital stay between alternating pressure mattresses and alternating pressure overlays were not significant</p>	See paper by Nixon et al., 2006	Good quality economic analysis
Vermette et al., 2012	RCT – prospective study comparing	Participants recruited from medical, surgical, ICU and acute geriatric wards. Country not stated. (n=110)	<ul style="list-style-type: none"> Both groups had identical protocols with repositioning and device check every 2 hrs, sacral 	<ul style="list-style-type: none"> PU incidence within the study period of 2 weeks determined by head to toe assessments 	<ul style="list-style-type: none"> No significant difference in PU incidence was found between the control and study groups (11% versus 4%, p=0.2706) 	<ul style="list-style-type: none"> Experiment was not blinded Cost analysis was limited to the 	Level of evidence: 1

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Ref	Type of Study	Sample	Intervention(s)	Outcome Measures & Length of Follow-up	Results	Limitations and comments	
(prevention)	efficacy of inflated static overlay to a low air loss dynamic mattress	<p>Inclusion:</p> <ul style="list-style-type: none"> • Aged ≥ 18 years • Without existing PU on visual inspection • Weigh <300lb • Informed consent • Moderate to high risk of PU with a Braden score ≤ 14 <p>Characteristics:</p> <ul style="list-style-type: none"> • No statistical differences between groups at baseline • Mean Braden score 11 to 12 • Mean age approx. 77 yrs • More participants in study group had BMI <18 and more in control groups had BMI >25 (p=0.0241) • More study group participants had diabetes (unclear if statistical due to conflicting data in paper) • Matched for bed-ridden/chair ridden status 	<p>moisturizer, minimal raising of bed head, pillow supports.</p> <ul style="list-style-type: none"> • Participants were randomized to receive either: <ul style="list-style-type: none"> ○ micro-fluid static overlay for participants <200lb (n=50) or low-air-loss dynamic mattress with pulsation for participants 200 to 300lb or who required edema management (n=5) or, ○ air inflated static overlay (n=55) 	<p>performed 3 times a week with PUs classified on NPUAP scale</p> <ul style="list-style-type: none"> • Comfort level rated by participants on a 5 point Likert scale 	<ul style="list-style-type: none"> • No significant difference in comfort (90% for control versus 85% for study, p=0.7129) • There was a significant difference in total cost with the air inflated overlay being less expensive (\$13606 versus \$3364, p≤0.001) 	<p>rental or the purchasing of surfaces</p> <ul style="list-style-type: none"> • 	Quality: moderate
Bennett et al., 1998	RCT comparing low air loss bed to a standard bed for preventing pressure injuries	<p>Individuals were recruited in long term and acute care facilities (n=116 randomized, n=26 withdrew, n=98 analyzed)</p> <p>Inclusion criteria: incontinent of urine and/or faeces, bed bound for >16 hours/day Category/Stage II or lower pressure injuries or no pressure injury</p>	<ul style="list-style-type: none"> • All urinary catheters removed in the intervention group, but not the control group • Nursing staff received training regarding bed use by representatives of the manufacturer 	<ul style="list-style-type: none"> • Follow up for 60 days maximum, average follow up was 4-6 days • Nurses and patients in low air loss groups were interviewed about comfort and issues 	<p>Pressure injury incidence</p> <ul style="list-style-type: none"> • New category/Stage II to IV pressure injuries were more frequently observed in low air loss group (8/42) compared to standard care (4/56), but not statistically significantly different (19% vs7%, p=0.11) • New category/Stage I pressure injuries were significantly more frequently observed in low air loss group (6/42) compared to standard care (0/56), (14% vs0%, p=0.008) 	<ul style="list-style-type: none"> • No blinding is reported • Individuals in the study received intervention for varying lengths of time • Comparators were varied • Control group had significantly longer mean 	<p>Level of evidence: 1</p> <p>Quality: low</p>

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Ref	Type of Study	Sample	Intervention(s)	Outcome Measures & Length of Follow-up	Results	Limitations and comments	
		<p>Participant characteristics:</p> <ul style="list-style-type: none"> • Most participants were in acute care • Mean age approx. 80 years <p>Comorbidities included sepsis, malignancy, fractured neck of femur, hypovolaemia, dementia</p>	<ul style="list-style-type: none"> • Individuals were randomized to receive either: • Low-air-loss hydrotherapy bed (Clensicair™, SSI/Hill Rom) with permeable fast drying sheet and use of urine collection device (n = 42), or • Standard bed or foam, air, alternating-pressure mattresses without standardized skin care regimen (n = 56) 		<p>Subjective assessments</p> <ul style="list-style-type: none"> • 24% (n=10) of participants who had a low air loss bed completed an evaluation • 50% rated the bed as comfortable, 40% rated bed as uncomfortable • 47 nurses completed an evaluation, of which 31% believed the bed prevented pressure injuries, 65% believed learning to use the bed was easy and 21% were overall satisfied with the bed <p>Adverse events</p> <p>2/56 individuals in low air loss group developed hypothermia (rectal temp below 97F)</p>	<ul style="list-style-type: none"> • follow up period (4 days vs 6 days, p=0.017) due to more withdrawals from the treatment group (36% vs 3%, p=0.0001) • No ITT analysis with high attrition • Baseline risk assessment status not reported 	
Inman, Sibbald, Rutledge, & Clark, 1993	RCT exploring a low air loss bed for preventing pressure injuries	<p>Participants were recruited in one critical care unit in Canada (n=98)</p> <p>Inclusion criteria:</p> <ul style="list-style-type: none"> • Aged > 17 years • APACHE score > 15 • Expected ICU stay > 3 days 	<ul style="list-style-type: none"> • All participants received 2-hourly turning • Participants were randomized to received: • Low air loss bed described as low friction, low shear, high moisture vapor transmission rate and decreased stresses on skin (KinAir™, Kinetic Concepts Inc.) (n=49) • Standard ICU bed (n=49) 	<ul style="list-style-type: none"> • Visual skin inspection conducted of 13 bony prominences on a daily basis until the participant was spending 6 hours/day walking or until low air loss bed use ceased • Pressure injuries categorized on Shea scale 	<p>Pressure injury incidence</p> <ul style="list-style-type: none"> • More pressure injuries occurred with the standard ICU bed compared with the low air loss bed (51% vs 12%) • Odds ratio of developing a single pressure injury on low air loss bed was 0.18 (95% CI 0.08 to 0.41, p=0.0001). (i.e. about 18% as likely to develop a pressure injury on a low air loss bed as a standard bed) • More participants in the standard ICU bed group experienced multiple pressure injuries compared with the low air loss bed (24% vs 2%) 	<ul style="list-style-type: none"> • Methods of randomization and allocation concealment not reported • 2% loss to follow up were stays in ICU < 3 days • No ITT analysis • 	<p>Level of evidence: 1</p> <p>Quality: low</p>
Clinical question 4: What is the most effective seating support surface for preventing pressure injuries?							
Mossman & Hampton, 2016	Case series reporting efficacy of a support cushion in	Participants were recruited in UK care homes by staff members over a 3-month period (n=10)	<ul style="list-style-type: none"> • Pressure redistribution cushion (Airospring™ AS200 cushion) which is washable and dissipates 	<ul style="list-style-type: none"> • Condition of skin before/after sitting on cushion 	<p>Skin condition</p> <ul style="list-style-type: none"> • 1 participant withdrew due to jaundice requiring end-of-life care 	<ul style="list-style-type: none"> • Selection of participants is unclear and non-consecutive 	<p>Level of evidence: 4</p> <p>Quality: low</p>

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	preventing pressure injuries	<p>Inclusion criteria:</p> <ul style="list-style-type: none"> • Braden score \geq 13 • Intact skin • Chair fast or minimal walking • Aged > 18 years is residing in a hospice or > 65 if in aged care <p>Exclusion criteria:</p> <ul style="list-style-type: none"> • Weigh > 120 kgs • Moisture lesions present <p>Participant characteristics:</p> <ul style="list-style-type: none"> • Age 43-95 years • 80% female • 40% urinary incontinence • 40% had previous PU • 60% able to independently reposition <p>Braden scores ranged from 13 to 22</p>	<p>heat in order to keep skin hydrated</p> <ul style="list-style-type: none"> • Cushion has two covers, one from knitted fabric and a water proof one • Participants used cushion when sitting out of bed • Commenced with 3 hours' duration on cushion, increasing if no erythema present • Long term care patients participated for 4 weeks, hospice patients for 2 weeks 	<ul style="list-style-type: none"> • Length of time on cushion • Repositioning regimen • Cushion comfort 	<ul style="list-style-type: none"> • 8 participants had intact skin at conclusion of trial • 1 participant had blanching erythema for the final 8 days of study (hospice patient) • 2 participants had episodes of blanching erythema but skin remained in tact <p>Length of time on cushion</p> <ul style="list-style-type: none"> • Mean hours on cushion ranged from 3.75 to 13.5 <p>• Author conclusion: A pressure redistribution cushion can decrease skin problems in individuals at moderate risk of PU (however the data doesn't support this conclusion, with 33% of individuals who finished study experiencing a pressure injury)</p>	<ul style="list-style-type: none"> • Informal, non-validated skin assessments by non-blinded staff members who had also recruited participants • Short study with variable time spent on cushion • Other management (e.g. pressure lifts, time spent moving, repositioning) not reported • No control group 	
Meaume, Marty, & Colin, 2017	To assess pressure injury incidence in patients using wheelchairs and at high risk of pressure injury using single- and multi-compartment air cushions	<p>2x prospective observational studies with data collated. Studies completed across 6 centres in France (n=152)</p> <p>Inclusion criteria:</p> <ul style="list-style-type: none"> • Aged 18+ yrs • Living at home or hospitalised • Reduced mobility and/or sensory disturbances and/or history of IT or hip pressure injury • Spending 8+hrs a day in wheelchair 	<p>Group A: Single-compartment air cushion (ROHO single valve – variable profile heights) Participants without significant postural asymmetry n=78</p> <p>Group B: Multi-compartment air cushion (ROHO Quattro – variable profile heights) Participants with significant postural asymmetry n=74</p>	<p>Primary: pressure injury incidence at 35 days determined through daily examination of sacral and coccyx region</p> <p>Secondary: Comfort, balance and ease of use satisfaction levels (ranked on 5-point scale)</p> <ul style="list-style-type: none"> • Adverse events • Technical incidents 	<p>Pressure injury incidence</p> <ul style="list-style-type: none"> • 2.6% (2/78) Single-compartment air cushion • 4% (3/74) Multi-compartment air cushion <p>High levels of satisfaction relating to comfort, balance and ease of use</p> <p>Adverse events</p> <ul style="list-style-type: none"> • 5 adverse events recorded with none related to the cushion • 8 minor technical difficulties relating to use and maintenance of the cushion 	<ul style="list-style-type: none"> • Lack of comparative statistics, despite power calculations • Power calculations wanted 80 in each group – under-powered 	<p>Level of evidence: 4</p> <p>Quality: low</p>

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		<ul style="list-style-type: none"> High or very high pressure injury risk (combination of clinical judgement and Braden score) <p>Exclusion criteria:</p> <ul style="list-style-type: none"> Current pressure injury Malnutrition Life expectancy <6mths 	<p>Other interventions included:</p> <p>Tracking of Braden scores; co-morbidities; type of wheelchair; average sitting time in wheelchair; use of pressure mattress; daily mobility or physiotherapy; level of activity, including pressure-relieving push-ups</p>		<ul style="list-style-type: none"> Author conclusion: Low incidence of pressure injuries for high risk patients using single- or multi-compartmental air cushions recommends the use of these cushions in practice. 		
Collins, 1999	Quasi experiment comparing a pressure reducing armchair with air cushion with a hospital chair	<p>Participants were older adults recruited in an acute hospital (n=1063)</p> <p>Inclusion criteria: Aged over 65 years</p> <p>Participant characteristics: Average age 82 years (range 53 to 100)</p>	<ul style="list-style-type: none"> Participants were receiving either : <ul style="list-style-type: none"> A pressure redistribution seating surface consisting of pressure redistribution foam surround two fluid filled compartments, plus padded arms and tilted positioning (Tansflo®, Karomed Ltd, n= 505), or A standard hospital chair that consisted of a plywood base, foam and vinyl (n=558) Unclear how long sat out of bed for 	<ul style="list-style-type: none"> Pressure injures – unclear how often skin was assessed or how long individuals were followed (average length of stay was 13-16 days) 	<p>Pressure injury incidence</p> <ul style="list-style-type: none"> Participants receiving the pressure redistribution cushion had lower pressure injury incidence (1 versus 9, 0.001% versus 3.4%, p<0.0001) 	<ul style="list-style-type: none"> Very limited information about the participants Time spent sitting out of bed not reported No blinding Wards were followed for 6 months but length of individuals care is unknown 	<p>Level of evidence: 2</p> <p>Quality: low</p>
Geyer, Brienza, Karg, Trefler, & Kelsey, 2001	RCT comparing a foam cushion to pressure redistribution cushions	<p>Participants were recruited in two skilled nursing facilities in US (n=32)</p> <p>Inclusion criteria:</p> <ul style="list-style-type: none"> Older adults Tolerate sitting in a wheelchair for at least six hours each day. 	<p>Participants (stratified by Braden risk score) received either:</p> <ul style="list-style-type: none"> pressure redistributing cushion selected from a range of cushions meeting requirements for immersion, envelopment and 	<ul style="list-style-type: none"> Interface pressure Weekly skin assessments Pressure injuries categorised using NPUAP system Incidence of pressure injuries, days until pressure injury, peak interface pressure 	<p>Pressure injury incidence</p> <ul style="list-style-type: none"> No significant differences between the groups (19% 10/17 foam group versus 40% 6/15 intervention group, p=reported to be nonsignificant) Ischial pressure injuries lower for pressure redistribution cushion group (47% 8/17 versus 0%, p<0.005) 	<ul style="list-style-type: none"> Seating assessment used for selecting the intervention – actual cushions used is not reported 	<p>Level of evidence: 1</p> <p>Quality: low</p>

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Ref	Type of Study	Sample	Intervention(s)	Outcome Measures & Length of Follow-up	Results	Limitations and comments	
		<ul style="list-style-type: none"> Braden score ≤ 18 with combined subscale for activity and mobility of ≤ 5 No sitting surface pressure injury 	moisture management (n=15), or <ul style="list-style-type: none"> 3" convoluted foam cushion (Bioclinic Standard #CE3408; Sunrise Medical, n=17) 		<ul style="list-style-type: none"> Sacral/coccyx/buttock pressure injuries lower for foam group (11.7% 2/17 versus 40%, 6/15, $p < 0.005$) 	<ul style="list-style-type: none"> No significant difference in time spent sitting 	
Brienza et al., 2010	Randomized clinical trial comparing wheelchair cushions for prevention of pressure injuries	Participants recruited from 12 nursing homes in USA (n=232 included, 180 completed study) <p>Inclusion:</p> <ul style="list-style-type: none"> Aged ≥ 65 years Wheelchair use for ≥ 6hrs daily Braden score of ≤ 18 combined Braden activity and mobility score of ≤ 5 No pre-existing PU of ischial area <p>Exclusion:</p> <ul style="list-style-type: none"> Body weight ≥ 113kgs or hip width ≥ 51cm Requiring wheelchair head support Severe orthopedic deformity requiring chair adaption Current use of seating cushion <p>Characteristics:</p> <ul style="list-style-type: none"> Only significant difference at baseline was more participants in the SP group having ability to walk more than 3 metres ($p=0.03$) 	All participants received a seating assessment at study commencement by a seating specialist and provided with a fitted wheelchair. <p>All participants received a skin and risk assessment by a blinded nurse on a weekly basis.</p> Participants were assigned either: <ul style="list-style-type: none"> SP group: skin protection (n=113) receiving an air, viscous fluid and foam or gel and foam cushion (n=113) Foam group: received a 7.6 cm crosscut segmented foam cushion (n=119) 	<ul style="list-style-type: none"> PU incidence over 6 months for PUs near the ischial tuberosities (IT) assessed using NPUAP staging Secondary analysis was performed on combined IT PUs and PUs over the sacrum and coccyx Follow up was 6 months or until PU incidence 	<ul style="list-style-type: none"> The foam group experienced a significantly greater incidence of IT PUs (6.7% versus 0.9%, $p=0.04$) There was no significant difference in incidence of combined IT and sacral PUs (17.6% versus 10.6%, $p=0.14$) that included 29 stage II PUs and 2 stage III PUs Kaplan Meier methods did not demonstrate statistically significant differences in the cumulative incidence of PUs between groups 	<ul style="list-style-type: none"> The study did not control for conditions that may influence PU risk while participants were not in wheelchair Staff awareness of residents' participation in the study may have affected the PU incidence rate Sample was primarily female and white 	<p>Level of evidence: 1</p> <p>Quality: moderate</p>

Support Surfaces: data extraction and appraisals

Ref	Type of Study	Sample	Intervention(s)	Outcome Measures & Length of Follow-up	Results	Limitations and comments	
		<ul style="list-style-type: none"> • Mean age approx. 86 years • >80% sample female; > 90% White • Mean BMI approx. 24 to 25 • Mean Braden score 15.5 Over 85% were incontinent					
Clinical question 5: What reactive support surfaces are effective in treating pressure injuries?							
Girolami, Moore, Haper, Betts, & Woodward, 2014	Compare outcomes of among patients at high risk for pressure injury and for whom high specification foam (HSF) support surfaces was added to either portable recliner or standard hospital bed in addition to standard PU prevention and treatment regimen to historical controls	Participants were recruited in a hospice, longer term care facility and rehabilitation unit in the US (n=44) Inclusion criteria: <ul style="list-style-type: none"> • Impaired activity/mobility as evidenced by need for assistance with ambulation or position changes • Minimum of one comorbidity Exclusion criteria: Not stated Participant characteristics and any baseline differences: <u>Mattress trial (n=44)</u> <ul style="list-style-type: none"> • 35 pre-existing pressure injuries: Category/Stage 1 – 5, Stage 2 – 8, Stage 3 – 12, and Unstageable -3. • Mean age 79 (range 47 – 98) • Mean days on mattress 53 (range 3-120 days) <u>Recliner group (n=33)</u>	<ul style="list-style-type: none"> • Pre-market high specification foam mattress and high specification foam seating support surface for medical grade portable recliner • The products had strategically designed foam segments and indentation force deflection • Concurrent care regimens included skin hygiene, incontinence, repositioning protocols, but unclear if this was the same in all facilities 	<ul style="list-style-type: none"> • Initial visit by phone or in-person interview of patient, if able, or caregiver and every 7-21 days up to 120 days • Factors associated with pre-study equipment: type, fall history, pain, perceptions of comfort, migration, immersion, heel offloading - Factors associated with investigational HSF devices: - Perceptions of comfort, control of migration downward when positioned on equipment, immersion into equipment without hammocking or bottoming out, and heel off-loading • Pre-existing wounds: Initial stage / location noted and subsequent status of wound healing (size, predominant tissue) 	<p>Pressure injury incidence</p> <ul style="list-style-type: none"> • two new-onset pressure injuries developed in high risk patients in the mattress trial • No new pressure injuries developed during the recliner trial. <p>Pressure injury healing with mattress or recliner</p> <ul style="list-style-type: none"> • Of the pressure injuries in the mattress group, 17 healed, 10 improved, seven were unchanged, two deteriorated • Of the 20 pressure injuries in the recliner group, 17 healed and 3 improved. <p>Comfort score</p> <ul style="list-style-type: none"> • Compared to pre-trial, on the trial mattress there was significantly greater ratings of comfort ($z = -3.35$, $p < 0.001$). • Compared to pre-trial, on the trial recliner there was significantly higher ratings for comfort ($z = -4.01$, $p < 0.001$) <p>Migration</p>	<ul style="list-style-type: none"> • Any limitations • Small sample size • convenience sampling • lack of prospective control arm • lack of a validated survey tool to rank comfort, pain, migration, immersion, and heel off-loading • no statistical analysis of pressure injury prevention or healing 	<p>Level of evidence: 4</p> <p>Quality: low</p>

Support Surfaces: data extraction and appraisals

Ref	Type of Study	Sample	Intervention(s)	Outcome Measures & Length of Follow-up	Results	Limitations and comments	
		<ul style="list-style-type: none"> • 20 people had pressure injuries • Mean age 82 (range: 63-97) • Mean Duration 39 days (range 13-66) 		<p>type) documented by assigned nurse on survey tool</p> <ul style="list-style-type: none"> • Staging system used was NPUAP 	<ul style="list-style-type: none"> • Compared to pre-trial, on the trial mattress there was significantly greater migration ($z = -2.83$, $p = 0.00466$), • Compared to pre-trial, on the trial recliner there was significantly higher ratings for migration ($z = -3.62$, $p = 0.003$) <p>Immersion</p> <ul style="list-style-type: none"> • Compared to pre-trial, on the trial mattress there was significantly greater immersion ($z = -2.78$, $p = 0.00544$) • Compared to pre-trial, on the trial recliner there was significantly higher ratings for immersion ($z = -4.01$, $p < 0.001$), <p>Heel offloading</p> <ul style="list-style-type: none"> • Compared to pre-trial, on the trial mattress there was significantly greater heel off-loading ($z = -4.78$, $P = 0.00$) • Compared to pre-trial, on the trial recliner there was significantly higher ratings for heel off-loading ($z = -3.82$, $P = 0.00014$) <p>Author conclusions: high specification foam devices were safe and highly rated by patients and/or caregivers in relation to comfort, migration control, immersion, heel off-loading, pain and falls.</p>		

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Support Surfaces: data extraction and appraisals

Ref	Type of Study	Sample	Intervention(s)	Outcome Measures & Length of Follow-up	Results	Limitations and comments	
Valente, Greenough III, DeMarco, & Andersen, 2012	Retrospective cohort analysis comparing a gel-foam mattress with a power air mattress overlay	<p>Participants were inpatients at a geriatric hospital in USA during the retrospective study period. (n=122)</p> <p>Inclusion:</p> <ul style="list-style-type: none"> Placed on study mattress for at least 10 days during retrospective study time period <p>Exclusion:</p> <ul style="list-style-type: none"> admission or time on mattress of interest <10 days <p>Characteristics:</p> <ul style="list-style-type: none"> All participants on one of the two support surfaces of interest were at high risk of PU (Braden<16) Participants on a gel mattress had significantly (p<0.03) more health problems (9.3±2.2 versus 8.3±2.7) Mean Braden score 12.9 to 13.5 Length of stay was significantly greater for those on the air mattress overlay 83±13.5 days versus 133±16.7 days) Mean age 65 to 69 years Primarily Caucasian 	<ul style="list-style-type: none"> On admission patients were assessed using the Braden Score risk assessment tool Each participant was assigned to either (decision by physician or nurse and not related to this study): <ul style="list-style-type: none"> Gel-foam reactive mattress (n=55) Power Air mattress overlay (alternating a pressure air mattress) (n=67) 	<ul style="list-style-type: none"> PU rates determined by skin assessment PU healing determined by weekly skin assessment The size of each ulcer (length and width) was assessed using paper tape measurements 	<p>Pressure injury incidence</p> <ul style="list-style-type: none"> There was no significant difference in PU incidence between those on the gel-foam mattress and those on the air mattress overlay (25% versus 40%, p=0.118). In the gel-foam mattress group (n=55) there were 63 PUs: 36 on admission, and 27 that developed during stay. In the air mattress overlay group (n=67) there were 110 PUs: 54 on admission and 56 developing during stay <p>Pressure injury healing</p> <ul style="list-style-type: none"> A larger percentage of PUs healed in the air mattress overlay group (42% versus 27%) Overall, of the pressure ulcers that showed healing, the lesions healed at simultaneous rates between groups (mean rate of 31.9 ± 15.4 cm²/week on the gel mattress and 31.3 ± cm²/week on the air overlay) <p>Study conclusions: when controlling for the total amount of time each group spent on the respective mattresses, the efficacy of the gel-foam mattress preventing new PUs equaled or outweighed the benefit of the Power Air overlay</p>	<ul style="list-style-type: none"> Retrospective No randomization Patients were on the gel mattress for longer than the on the power air overlay Assumed no PU would develop in less than 7 to 10 days so exclude these patients 	<p>Level of evidence: 3</p> <p>Quality: low</p>

Support Surfaces: data extraction and appraisals

Ref	Type of Study	Sample	Intervention(s)	Outcome Measures & Length of Follow-up	Results	Limitations and comments	
Cassino, Ippolito, Cuffaro, Corsi, & Ricci, 2013	RCT comparing a gel overlay to a three dimensional, multi-layer macro-porous polyester overlay	<p>Participants were recruited from 8 long term care facilities in Italy (n=72)</p> <p>Inclusion:</p> <ul style="list-style-type: none"> aged > 18 years Braden score between 6 and 14 Norton score between 5 and 12 Category/stage I to IV PU <p>Exclusion:</p> <ul style="list-style-type: none"> No existing PU Infection allergy to overlays, needing additional aids immunosuppressants, antitubercular therapy, AIDS, HCV, pregnancy, terminal diagnosis <p>Characteristics:</p> <ul style="list-style-type: none"> No significant difference in gender, age (mean approx. 85 years) or PU risk scale scores at baseline The 3D overlay group had more PUs of category IV (22.22% versus 6.81%, p =not reported) 	<p>Participants were randomly assigned to receive either:</p> <ul style="list-style-type: none"> 3D, macro-porous polyester, 9mm thick overlay (Aiartex®, Herniamesh srl) (n=35) Gel overlay made of 100% viscoelastic polymer at 15.9mm thick (Akton® Overlay, Action product) (n=37) 	<ul style="list-style-type: none"> Unclear how wounds were measured and surface area calculated Outcome appears to be reduction in percent surface area Outcome of improved, worsened or resolved is reported, but unclear how wounds were categorized Follow up 12 weeks, reports outcome measures at 4, 8 and 12 weeks. 	<ul style="list-style-type: none"> No significant difference between overlays for % wounds unchanged/worsened (45% for 3D, 59.5% for gel p = ns) Approximately 1/3 participants in both groups were suspended from trial, primarily due to worsening of PU No significant difference in wounds resolved in 12 weeks (8.57% for 3D, 13.5% for gel, p =ns) 3D overlay had greater percent reduction in wound surface area (p<0.05) No significant difference in rating for comfort (rating of good or excellent was 40% for 3D overlay and 19% for gel, p =ns) Ease of use (e.g. bed-making) was significantly greater for 3D (p<0.001) 	<ul style="list-style-type: none"> No power calculation Does not report methods of randomization Large drop out, unclear if included in analysis for % surface area Method of wound assessment and categorization is not reported 	<p>Level of evidence: 1</p> <p>Quality: low</p>
<p>Clinical question 6: What active support surfaces are effective in treating pressure injuries?</p> <p>Clinical question 7: When should an active support surface be used to treat pressure injuries?</p>							
Meaume & Marty, 2015	Cohort study investigating effectiveness of an alternating	Participants were recruited in three home health care centers in France (n=92, n=62 had a PU at baseline)	<ul style="list-style-type: none"> All participants received an alternating pressure air mattress (The Sentry by Suntech Medical 	<ul style="list-style-type: none"> Three month follow up period Skin condition examined "regularly" and follow-up 	Per cent participants with worsening of skin at day 90	<ul style="list-style-type: none"> Small study but met sample size calculation requirements 	Level of evidence: 3

Support Surfaces: data extraction and appraisals

Ref	Type of Study	Sample	Intervention(s)	Outcome Measures & Length of Follow-up	Results	Limitations and comments	
	pressure mattress in preventing and healing PU in home care	<p>Inclusion criteria:</p> <ul style="list-style-type: none"> Aged ≥ 18 years Discharged from hospital in previous 3 days High risk of PU defined as Braden scale score < 15 If no PU at baseline, needed to have ≥ 20 hours/day on bed rest and have poor general health, peripheral vascular disease or recent serious neurologic disorder <p>Participant characteristics:</p> <ul style="list-style-type: none"> 52.2% male Mean age 74.7 ± 12 years At commencement, 62/99 had an existing PU, of which most were sacral Almost half of the PU were Category 3 Approx 52% of participants used an alternating pressure mattress in hospital 72.8% urinary continence Mean Braden scale 10.2 ± 3.4 Mean hospitalization time was 4.6 ± 3.7 weeks 	<p>Systems-Tridien that had sequentially de/inflating air cells at a timed interval)</p> <ul style="list-style-type: none"> Patients and family received instructions and training on mattress use 54.3% were fully bedbound and 43.5% used cushions in bed Mean repositioning was 1.8 ± 1.8 times daily 	<p>visits were at 30 and 90 days</p> <ul style="list-style-type: none"> Opinion survey on comfort using a 5 point numerical rating scale Primary outcome was percent of patients with worsening skin condition at 90 days Secondary outcome was worsening PU or onset of new PU in secondary prevention group 	<ul style="list-style-type: none"> Overall rate of worsening skin condition was 13.0% (95% CI 6.2 to 19.9) For individuals with no PU at baseline (primary prevention group), only 1 participant (1/30) had worsening skin For secondary prevention group 17.7% (95% CI 8.2 to 27.3) had worsening skin <p>Per cent participants with a PU at 90 days</p> <ul style="list-style-type: none"> From those with no PU at baseline, 3/30 had a PU at 90 days Of those with a PU at baseline, 20/62 healed in 90 days and 42/62 still had a PU at 90 days <p>Mattress comfort</p> <ul style="list-style-type: none"> Over 95% rated mattress comfort as satisfactory or very satisfactory 	<ul style="list-style-type: none"> No control group Non-blinded outcome assessment Poor reporting of any concurrent care measures Large drop out rate (63% from primary prevention group and 61% in secondary prevention group (62% overall) primarily due to death 	Quality: moderate
Stephen-Haynes & Callaghan, 2017	To examine the effect of using the alternating pressure air mattress for home-care patients at a high risk or	<p>Participants were recruited in a home care setting in the UK (n=100)</p> <p>Inclusion criteria</p> <ul style="list-style-type: none"> Aged over 18 years Lived in own home 	<ul style="list-style-type: none"> Care based on guidance from NICE (2014) and EPUAP et al (2014), local guidelines and staff who are trained to provide care based upon the structured approach 	<ul style="list-style-type: none"> EPAUAP/NPUAP staging system The mattress was used for a total of 5809 days (829 weeks) during the evaluation. The average time using mattress 83 days (range 1-295) 	<p>Pressure injury outcomes</p> <p>Pressure injury improved in 53%, stayed the same for 20% and deteriorated for 5%</p> <p>All deteriorating pressure injuries were in people at end-of-life</p> <p>Skin condition</p>	<ul style="list-style-type: none"> long periods of time when no clinical staff are delivering care The support surface is only one of several interventions that 	<p>Level of evidence: 4</p> <p>Quality: Low</p>

Support Surfaces: data extraction and appraisals

Ref	Type of Study	Sample	Intervention(s)	Outcome Measures & Length of Follow-up	Results	Limitations and comments	
	with pressure injuries	<ul style="list-style-type: none"> High risk of pressure injuries (Waterlow scale), or existing deep pressure injury Required alternating pressure mattress using the NHS trust selection algorithm <p>Participant characteristics:</p> <ul style="list-style-type: none"> Mean age 78.4 years 64% female At the start of the study, 5% had a Category/Stage I pressure injury, 22% had Category/Stage II pressure injury, 21% had a Category/Stage III pressure injury and 5% had a Category/Stage IV pressure injury, 44% had intact skin, 3% were unrecorded 	<p>outlined in the SSKIN bundle.</p> <ul style="list-style-type: none"> Patients were allocated the Dual Professional (IQ Medical) APAM using an NHS trust equipment selection algorithm based upon the NICE (2014) 	<ul style="list-style-type: none"> Unclear how skin evaluation was conducted 	<p>Skin remained the same in 50%, improved in 39% of patient and deteriorated in 7%. 4% did not have an assessment completed.</p> <p>Informal care giver evaluation 77% said experience with moving and handling remained the same, 14% said it improved.</p> <p>Staff evaluation 77% said experience with moving and handling was same, 14% said it improved.</p> <p>Patient comfort evaluation 43% said it was more comfortable, 28% said it was the same and 5% said it was less comfortable. In 17%, they could not compare as this was the first time they had used an alternating pressure air mattress.</p> <p>Author conclusions: Selection of appropriate alternating pressure mattresses should take account of risk factors for the development of pressure ulcers and clinical outcomes</p>	<p>could influence the primary outcome</p> <ul style="list-style-type: none"> Only one model of mattress was reviewed Low pressure feature was not reviewed 	
Fletcher, Harris, Mahoney, Crook, & Moore, 2014	Cohort study demonstrate that the Dolphin FIS provided equivalent pressure ulcer prevention to the existing	<p>n=18</p> <p>Inclusion criteria: patients at very high risk with complex needs</p> <p>Characteristics: 14/18 had existing pressure injuries</p>	Dolphin FIS system mattress given to each patient identified.	<ul style="list-style-type: none"> Mattress was in used between 2 days to 7 months ward staff completed a paper-based evaluation form at start, transfer between wards/units, and end of therapy 	<p>Pressure ulcer incidence Neither of the patients that were pressure injury free went on to develop one.</p> <p>Pressure ulcer healing Of the patients with existing pressure ulcers, two healed, seven improved and five remained static.</p>	<ul style="list-style-type: none"> Small sample with limited reporting of other interventions provided No detail regarding control interventions No formal statistical evaluation 	<p>Level of evidence: 4</p> <p>Quality: low</p>

Support Surfaces: data extraction and appraisals

Ref	Type of Study	Sample	Intervention(s)	Outcome Measures & Length of Follow-up	Results	Limitations and comments	
	standard treatment	Staff also recruited to completed questionnaires			Staff survey <ul style="list-style-type: none"> Staff consistently commented positively on the ease of use 	<ul style="list-style-type: none"> No blinding for assessors Potential bias from industrial support Not clear how skin was assessed No analysis of potential confounders. 	
Ferrell, Osterweil, & Christenson, 1993	RCT exploring the effectiveness of low air loss bed for treating pressure injuries	<p>Participants were older adults recruited in a nursing home (n=84)</p> <p>Inclusion criteria: Trunk or trochanter Category/Stage pressure injury II or greater</p> <p>Exclusion:</p> <ul style="list-style-type: none"> Expected survival < 1 month Planned pressure injury surgery <p>Characteristics:</p> <ul style="list-style-type: none"> Comparable baseline demographics with respect to risk factors Baseline pressure injury surface area comparable between groups 	<ul style="list-style-type: none"> Participants were randomized to receive either: <ul style="list-style-type: none"> Low air loss bed (Kinair™) (n=43), or Convuluted foam overlay on top of standard foam mattress (n=41) All participants received two hourly turning 	<ul style="list-style-type: none"> Follow up 33 days for low air loss and 40 days for foam mattress Wound surface area traced twice per week and area measured using planimetry Complete healing 	<p>Complete healing There was no significant difference between groups for percent of pressure injuries completely healed (LAL 60.4% vs foam 46.3%, p=0.20)</p> <p>Change in wounds surface area</p> <ul style="list-style-type: none"> Low air loss group achieved significant reduction in wound surface area (p=0.0002) Foam overlay group achieved significant reduction in wound surface area (p=0.0004) No clear intergroup-difference is established 	<ul style="list-style-type: none"> A priori sample calculation Study terminated early due to unexpectedly large difference between groups Randomization not reported Blinding not reported ITT analysis No intergroup statistical analysis 	<p>Level of evidence: 1</p> <p>Quality: moderate</p>
Day & Leonards, 1993	RCT exploring difference between a low air loss mattress and a standard foam mattress	<p>Participants were recruited in a hospital in USA (n=77 enrolled)</p> <p>Inclusion criteria:</p> <ul style="list-style-type: none"> Category/Stage II to IV pressure injury Limited mobility 	<ul style="list-style-type: none"> Participants were randomized to receive either: <ul style="list-style-type: none"> Low air loss air suspension bed (Therapulse™, Kinetic Concepts) (n=44) or, 	<ul style="list-style-type: none"> 7 day follow up Mean ulcer size Mean comfort score NPUAP classification nscale 	<p>Change in wound surface area</p> <ul style="list-style-type: none"> There was no significant difference in change in wound size between low air loss bed group and standard foam group (F[1, 78] = 0.35, p>0.05) <p>Comfort score</p>	<ul style="list-style-type: none"> Blinding unclear Unclear if ITT analysis Disproportionate mean ulcer size at baseline 	<p>Level of evidence: 1</p> <p>Quality: low</p>

Support Surfaces: data extraction and appraisals

Ref	Type of Study	Sample	Intervention(s)	Outcome Measures & Length of Follow-up	Results	Limitations and comments	
		<p>Characteristics:</p> <ul style="list-style-type: none"> • Comparable baseline demographics between groups with respect to risk factors • Baseline pressure injury surface area reported to be more severe in a group receiving low air loss bed but analysis accounted for this 	<ul style="list-style-type: none"> ○ Convoluted foam mattress (Geomatt™, SpanAmerica) (n=39) <p>All participants received standardized wound care</p>		<ul style="list-style-type: none"> • Only n=20 in low air loss bed group and n=21 in foam group completed comfort assessment 	<ul style="list-style-type: none"> • Method of randomization and allocation concealment not reported 	
Mulder, Taro, Seeley, & Andrews, 1994	RCT exploring difference between a low air loss mattress and a standard foam mattress	<p>Participants were recruited in 25 nursing homes (n=49 enrolled)</p> <p>Inclusion criteria:</p> <ul style="list-style-type: none"> • Category/Stage III or IV pressure injury <p>Characteristics:</p> <ul style="list-style-type: none"> • Unclear if there was comparable baseline demographics with respect to risk factors • Baseline pressure injury surface area and whether it was comparable between groups was not reported 	<ul style="list-style-type: none"> • Participants were randomized to receive either: <ul style="list-style-type: none"> ○ Low air loss air suspension bed (Therapulse™, Kinetic Concepts) (n=31) or, ○ Convoluted foam mattress (Geomatt™, SpanAmerica) (n=18) • All participants turned two hourly 	<ul style="list-style-type: none"> • 12 week follow up • Pressure injury volume and surface area measured as length x width (x depth) • Reduction in pressure injury category • Weekly wound assessment 	<p>Change in wound surface area</p> <ul style="list-style-type: none"> • Significant reduction in low air loss bed group (p=0.042) • No between group analysis 	<ul style="list-style-type: none"> • ITT analysis • Drop out of 20.4% but unclear from which groups • Disproportionate randomization not explained • Method of randomization and allocation concealment not reported • Unclear if outcome measure was blinded 	<p>Level of evidence: 1</p> <p>Quality: low</p>
Devine, 1995	RCT exploring difference between different alternating pressure air mattresses	<p>Participants were older adults recruited in hospital (n=41)</p> <p>Inclusion criteria:</p> <ul style="list-style-type: none"> • Category/Stage II or greater pressure injury <p>Characteristics:</p>	<ul style="list-style-type: none"> • Participants were randomized to receive either: <ul style="list-style-type: none"> ○ Alternating pressure air mattress with figure-eight shaped cells (Nimbus™ I DFS) (n=22, 14 completed) with 10 minute cycle or, 	<ul style="list-style-type: none"> • 4 week follow up • Pressure injury complete healing • Reduction in pressure injury size • volume and surface area measured as length x width (x depth) 	<p>Complete healing</p> <p>There was no significant difference in percent pressure injuries reaching complete healing between the figure-eight shaped cell mattress (35.7%) compared with the double layer mattress (62.5%) (p=0.17)</p> <p>Change in wound surface area</p>	<ul style="list-style-type: none"> • Unclear if ITT analysis • Drop out of 24% mainly from death or transfer • No blinded outcome measures • 	<p>Level of evidence: 1</p> <p>Quality: moderate</p>

Support Surfaces: data extraction and appraisals

Ref	Type of Study	Sample	Intervention(s)	Outcome Measures & Length of Follow-up	Results	Limitations and comments	
		<ul style="list-style-type: none"> • Mean age 82.5 years (range 69-98) • Comparable baseline demographics with respect to risk factors, except more participants in Airwave™ group were catheterized Baseline pressure injury surface area not reported, but was comparable between groups	<ul style="list-style-type: none"> ○ Alternating air mattress (Pegasus Airwave™) with double layer mattress and 3-cell alternating cycle of 7.5 minutes (n=19,n=16 completed) 	<ul style="list-style-type: none"> • Reduction in pressure injury category • Weekly wound assessment 	There was no significant difference in decrease in pressure injury size between the figure-eight shaped cell mattress (25%) compared with the double layer mattress (42.8%) (p=0.31)		
Russell & Lichtenstein, 2000	RCT exploring difference between different alternating pressure air mattresses used in conjunction with different seating cushions	Participants were older adults (n=141) Inclusion criteria: <ul style="list-style-type: none"> • Category/Stage II or greater pressure injury Characteristics: <ul style="list-style-type: none"> • Mean age 83-84 years • Comparable baseline demographics with respect to risk factors, Baseline pressure injury surface area not reported, but was comparable between groups	<ul style="list-style-type: none"> • Participants were randomized to receive either: <ul style="list-style-type: none"> ○ Alternating pressure air mattress (Huntleigh Nimbus™ 3) used with four hourly turning and an Aura™ seating cushion (n=70) ○ Alternating air mattress (Pegasus Airwave™) with eight hourly turning and a Proactive™ 2 seating cushion (n=71) 	<ul style="list-style-type: none"> • 18 month follow up (length of intervention is not clear) • Pressure injury complete healing • Ulcer healing recorded with camera on weekly basis • Pressure injuries categorized with an “improvement factor” that was based on nurses’ ratings 	Complete healing There was no significant difference in percent pressure injuries reaching complete healing between the mattresses mattress (both 91.5%) (p=0.77)	<ul style="list-style-type: none"> • Unclear if ITT analysis • Drop out about 18% in both groups • Blinded outcome measures • Method of randomization or allocation concealment not reported 	Level of evidence: 1 Quality: moderate
Evans, Land, & Geary, 2000	RCT exploring difference between two types of alternating pressure mattress	Participants were recruited in hospitals and nursing homes in the UK (n=32) Inclusion criteria: <ul style="list-style-type: none"> • Age over 65 years • Category/Stage II or III pressure injury Characteristics:	Participants were randomized to receive either <ul style="list-style-type: none"> • Alternating pressure mattress 1 (Nimbus 3) (n=17) or, • Alternating pressure air mattress for hospital participants (variety of models) or overlay (variety of models) for 	<ul style="list-style-type: none"> • Two week follow up • Absolute and relative reduction in wound surface area • Twice weekly wound planimetry • Subjective assessment of comfort 	Absolute and relative reduction in wound surface area <ul style="list-style-type: none"> • No significant difference between groups Comfort <ul style="list-style-type: none"> • No significant difference between groups 	<ul style="list-style-type: none"> • >80% did not complete follow up • Randomization method unstated • Data collectors were blinded • Unclear if ITT analysis 	Level of evidence: 1 Quality: moderate

Support Surfaces: data extraction and appraisals

Ref	Type of Study	Sample	Intervention(s)	Outcome Measures & Length of Follow-up	Results	Limitations and comments	
		<ul style="list-style-type: none"> Comparable baseline demographics with respect to risk factors Baseline pressure injury surface area comparable between groups 	nursing home participants (n=15)				
L. Russell et al., 2003	RCT exploring difference between an alternating pressure air mattress compared with a static fluid overlay	<p>Participants were recruited in hospitals (n=158)</p> <p>Inclusion criteria:</p> <ul style="list-style-type: none"> Category/Stage I or II pressure injury <p>Exclusion criteria:</p> <ul style="list-style-type: none"> Obese patients (>25 stone) Category/Stage III or greater pressure injuries <p>Characteristics:</p> <ul style="list-style-type: none"> Mean age 80 years Baseline Waterlow score mean 21 Comparable baseline demographics with respect to risk factors <p>Baseline pressure injury surface area reported and comparable between groups</p>	<ul style="list-style-type: none"> Participants were randomized to receive either: <ul style="list-style-type: none"> Alternating pressure air mattress (Huntleigh Nimbus™ 3) multicell with 10 minute cycle (n=83) A static fluid overlay mattress (RIC® static) (n=75) Repositioning was standardized at 4 hourly but additional turning occurred on request 	<ul style="list-style-type: none"> Improved pressure injury condition Hospital length of stay EPUAP classification 	<p>Pressure injury improvement</p> <p>There was no significant difference in percent pressure injuries reaching complete healing between the alternating mattress (72.3%) and a static fluid overlay (74.7%, p=0.74)</p>	<ul style="list-style-type: none"> Unclear if ITT analysis Drop out about 18% in both groups Unclear if blinded outcome measures 	<p>Level of evidence: 1</p> <p>Quality: moderate</p>
Allman et al., 1987	RCT comparing an air fluidized bed to an alternating air mattress	<p>Participants were those undergoing surgery in the UK (n=65)</p> <p>Inclusion criteria:</p> <ul style="list-style-type: none"> Aged > 18 years Surgical patient with expected bed/chair confinement for ≥ 7 days 	<p>Participants were randomized to receive either</p> <ul style="list-style-type: none"> Air fluidized therapy (Clinitron™) with four-hourly repositioning (n=31) or, Conventional treatment defined as two hourly 	<ul style="list-style-type: none"> Mean follow up 13 days (range 4-77 days) Median change in wound surface area as judged from photographs by blinded assessor on a weekly basis Pain Shea classification 	<p>Change in pressure injury surface area</p> <p>There was a mean decrease in surface area (-1.2cm²) in the air fluidized group and a mean increase (+0.5cm²) in the conventional treatment group, which was a significant difference between the medians (95% CI -9.2cm² to -0.6cm², p=0.01)</p>	<ul style="list-style-type: none"> Blinded assessors A priori sample size High rate of drop out (32% in air fluidized bed group and 24% in standard therapy groups) 	<p>Level of evidence: 1</p> <p>Quality: moderate</p>

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Ref	Type of Study	Sample	Intervention(s)	Outcome Measures & Length of Follow-up	Results	Limitations and comments	
		<ul style="list-style-type: none"> Pressure injury of any Category/Stage on sacrum, buttocks, trochanter or back <p>Characteristics:</p> <ul style="list-style-type: none"> Primarily Category/Stage III and IV pressure injuries Patients receiving air fluidized had more mobility limitations Baseline pressure injury surface area are not specified but reported as comparable between groups 	turning, heel and elbow protection, alternating pressure mattress (n=34)	<ul style="list-style-type: none"> Repeated measures correlation coefficient (p=0.0001) 	<p>There was a larger difference between the two groups for pressure injuries >7.8cm² in surface area (air-fluidized bed -5.3cm² versus conventional treatment +4.0cm², 95% CI -42.2 to -3.2cm², p=0.01)</p> <p>Improvement in condition</p> <ul style="list-style-type: none"> 71% of air fluidized bed group and 47% of conventional treatment group were rated as being improved in condition (95% CI 1% to 47%, p=0.05) There was a larger difference between the two groups for pressure injuries >7.8cm² in surface area for improvement in condition (air-fluidized 62% versus conventional therapy 29%, 95% CI 1% to 65%, p=0.05) 5.6 fold increase (95% CI 1.4% to 21.7%, p=0.01) greater improvement in air fluidized group <p>Other outcomes</p> <ul style="list-style-type: none"> Protocol adherence was higher with air fluidized bed No difference between group in adverse events Significant reductions in pain with air fluidized bed 		
Munro, Brown, & Heitman, 1989	RCT exploring difference between an air fluidized bed and standard care	<p>Participants were recruited in hospitals (n=45)</p> <p>Inclusion criteria:</p> <ul style="list-style-type: none"> Male Category/Stage II or III pressure injury <p>Exclusion criteria:</p>	<ul style="list-style-type: none"> Participants were randomized to receive either: <ul style="list-style-type: none"> Air fluidized bed (Clinitron™ (n=20) Standard care using an unspecified support surface but reported that sheepskins and 	<ul style="list-style-type: none"> Changed in mean pressure injury surface area 15 day follow up with measures on days 1,3,8 and 15 	<p>Pressure injury improvement</p> <p>There was a statistically significantly greater reduction in mean surface area for air fluidized group compared to standard care group (experimental - 43.5% in surface area versus control group +40%, p=0.05)</p> <p>Patient satisfaction (n=22)</p>	<ul style="list-style-type: none"> Unclear if ITT analysis No blinded outcome measures Randomization and allocation concealment 	<p>Level of evidence: 1</p> <p>Quality: low</p>

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Ref	Type of Study	Sample	Intervention(s)	Outcome Measures & Length of Follow-up	Results	Limitations and comments	
		<ul style="list-style-type: none"> • Obese patients (>250 lb) • Patients at <70% ideal body weight • Category/Stage IV pressure injuries • Serum albumin <2.1g/100mL <p>Characteristics:</p> <ul style="list-style-type: none"> • Comparable baseline demographics not detailed but reported as equivalent with respect to risk factors • Unclear if pressure injury size comparable at baseline 	support devices used (n=25)		<p>No significant difference between air fluidized and standard bed (p=0.067)</p> <p>Pain No significant difference between air fluidized and standard bed (p=0.359)</p> <p>Nursing time Time spent with patients was not significantly difference (p=0.13)</p>	method not reported	
Strauss, Gong, Gary, Kalsbeek, & Spear, 1991	RCT exploring difference between an air fluidized bed and standard care	<p>Participants were in home-based care (n=112 randomized, n=97)</p> <p>Inclusion criteria:</p> <ul style="list-style-type: none"> • Category/Stage III or IV pressure injury • Aged > 16 years • Expected to require hospitalization in future for pressure injury • Expected length of life > 1 year <p>Characteristics:</p> <ul style="list-style-type: none"> • Mean age 63-65 years • Comparable baseline demographics with respect to risk factors <p>Baseline pressure injury surface area not reported and unclear if comparable between groups</p>	<ul style="list-style-type: none"> • Participants were randomized to receive either: <ul style="list-style-type: none"> ○ Air fluidized bed (Clinitron™ (n=58 randomized, 47 analyzed) ○ Standard care (n=54 randomized, n=50 analyzed) • Bi-weekly home visits • Air fluidized bed removed when pressure injury healed to a second stage or better, and reintroduced if the condition worsened again 	<ul style="list-style-type: none"> • Improved pressure injury condition • Photography of wounds assessed by blinded assessors who made an assessment of whether the pressure injury had improved (unchanged, worse, improved) • Shea's classification • Bi-weekly home visits • Days of hospitalization • 36-week follow-up (mean study days 78-81) 	<p>Pressure injury improvement</p> <ul style="list-style-type: none"> • 82-91% of the air fluidized group pressure injuries improved and 62-77% of the standard care group improved • The remaining in both groups had no change <p>Resources</p> <ul style="list-style-type: none"> • Air fluidized group had significantly fewer days in hospital (11.4 vs 25.5 days, p<0.01) • There was a significantly lower cost for care in terms of hospital inpatient resources (\$13,263 vs \$35,736, p<0.05) and physician fees (\$6,646 vs \$12,131, p<0.05) <p>Adverse events Some patients experienced dry skin</p>	<ul style="list-style-type: none"> • ITT analysis • No blinded outcome measures • Allocation concealment not reported • Interrater reliability not reported, but ratings were different between the two groups • Only 53% of participants completed study 	<p>Level of evidence: 1</p> <p>Quality: low</p>

Support Surfaces: data extraction and appraisals

Ref	Type of Study	Sample	Intervention(s)	Outcome Measures & Length of Follow-up	Results	Limitations and comments	
Nixon et al., 2006	RCT to compare the effectiveness of alternating-pressure mattress replacements and alternating-pressure mattress overlays	Participants recruited in vascular, orthopedic, medical, and care-of-elderly wards in UK (n=1,971) Inclusion criteria: Acute or elective patients Existing Category/Stage I or II pressure injury	<ul style="list-style-type: none"> Participants received either alternating air pressure overlay (n=990) or alternating air mattress (n=982) 	<ul style="list-style-type: none"> New Category/Stage II or greater pressure injury Follow up for 30 and 60 days (median 9 days) 	<p>Healing</p> <ul style="list-style-type: none"> There was no significant difference between groups for median time to healing (20 days for each group, p = 0.86). Complete healing between the two groups was also comparable (35% healed in the mattress group and 34% healed in the overlay group) <p>Subjective evaluations</p> <ul style="list-style-type: none"> 23% of individuals receiving an alternating air overlay and 18.9% of those receiving an alternating air mattress requested a change of support surface, which was significantly more for the overlay group (p=0.02) 	<ul style="list-style-type: none"> Experiment was not blinded 6% participants lost to follow up ITT analysis Relative risk reported in Medical Advisory Secretariat, Pressure Ulcer Prevention: an evidence-based analysis, Ontario Health Technology Assessment Series 2009 9(2) 1-104 	<p>Level of evidence: 1</p> <p>Quality: high</p>
Pemberton, Turner, & VanGilder, 2009	Observational pilot study investigating incidence of PU for a low air loss continuous later bariatric bed	n= 21 consecutively admitted patients in a general hospital Inclusion: <ul style="list-style-type: none"> BMI > 35 minimum 3 day stay on support mattress (max 7 days) Participant characteristics: <ul style="list-style-type: none"> mean BMI 51.4 (±10.3) mean age 51.7 years (±14, range 32 to 76) 28% (n=6) had existing PU 57% diabetes mellitus 57% urinary incontinence 43% faecal incontinence 43% neurological impairment 	<p>Low-air-loss, continuous lateral rotation bariatric bed with advanced microclimate technology (TotalCare® Bariatric Plus Therapy System)</p> <p>Participants spent an average of 4.8±2.5 days (range 2 to 8) on the bed surface.</p>	<ul style="list-style-type: none"> PU incidence PU stage (NPUAP criteria) and size (measurement strategy not reported) employee satisfaction on a 4-point Likert scale patient comfort rating (multiple choice questionnaire where 1 = very uncomfortable and 4 = very comfortable) Final outcome measures at day 7. 	<ul style="list-style-type: none"> No new PUs developed PUs (primarily category I) decreased from an average size of 5.2 cm² (±5.2) to 2.6cm² (±5.0) 5 PUs (primarily category I) completely healed, but 3 PUs had no change Mean caregiver satisfaction rating was 3.6 Mean patient comfort rating 3.9 <p>Study conclusion: In patients with a BMI above 35kg/m², a low air loss, continuous rotation bariatric bed was associated with no new PUs and a decrease in PU size for existing PUs after a maximum of 7 days.</p>	<ul style="list-style-type: none"> Small, non-randomised study No statistical significance reported No comparison group No long term follow up (patients stayed on bed for between 2 and 7 days) 	<p>Level of evidence: 4</p> <p>Quality: low</p>

Support Surfaces: data extraction and appraisals

Ref	Type of Study	Sample	Intervention(s)	Outcome Measures & Length of Follow-up	Results	Limitations and comments	
Ward, Fenton, & Maher, 2010	Case series investigating a semi-automated alternating air pressure mattress for treatment of PU	<p>Convenience sample considered at high risk located in 5 hospital wards in Malta (n=60)</p> <p>Inclusion and exclusion not reported</p> <p>Characteristics:</p> <ul style="list-style-type: none"> • 58% sample female • Mean weight 71kgs (range 30 to 110 kgs) • 26.6% considered “vulnerable to” PU and 73.3% considered to be at “elevated risk” <p>65% had existing PU, 75% of which were stage I PU or superficial skin loss.</p>	<ul style="list-style-type: none"> • Participants were nursed on the Alpha Response™ System that comprises a mattress replacement, mattress overlay or seat cushion operated from same pump. • System can be operated as a reactive constant low air mattress, but for this investigation it was operated as an active (alternating) air pump that periodically redistributed pressure by inflating/ deflating beneath the body every 10 minutes 	<ul style="list-style-type: none"> • PU clinical outcomes with PU defined as “improved” or “deteriorated” 	<ul style="list-style-type: none"> • Of the participants who had PU at commencement (n=39), follow-up data for discharge was available for 74% (n=29) • In these participants 69% (n=20) showed improvement in PU at discharge (including 4 participants with stage III and IV PU). • Mean treatment period 19 days. • One wound was reported to deteriorate during the evaluation 	<ul style="list-style-type: none"> • “High risk” was not specified • No randomization and no control group • No interrater checks were performed • Unclear who performed skin observations • Other management of PU was not reported 	<p>Level of evidence: 4</p> <p>Quality: low</p>
Jackson, Chagares, Nee, & Freeman, 1988	RCT comparing air fluidized bed to unspecified controls for healing PU	<p>Participants were recruited in a hospital in US (n=35)</p> <p>Inclusion criteria:</p> <ul style="list-style-type: none"> • At least one Category/Stage III, IV or V pressure injury • above 18 years • ≥14 days of hospitalization <p>Exclusion criteria:</p> <ul style="list-style-type: none"> • Renal disease, fluid restriction, dehydration, heart failure, pulmonary edema • Urinary incontinence or severe diarrhoea • Needing to regularly get in or out of bed 	<p>Participants were assigned (stratified by pressure injury stage):</p> <p>Air fluidized bed (n=15)</p> <p>Non-air fluidized bed (n=20)</p>	<ul style="list-style-type: none"> • Five stage classification system, not named 	<p>Changes in pressure injury</p> <ul style="list-style-type: none"> • Treatment group: 60% in treatment group experienced decrease in ulcer surface area versus 45% in the control group • 40% of treatment group experienced increase in ulcer surface area versus 55% in control group (control group had larger increases) <p>Length of stay</p> <ul style="list-style-type: none"> • Statistically significantly shorter hospital length of stay in treatment group (20 days versus 37.5 days, p<0.05) 	<ul style="list-style-type: none"> • Subjective outcome measures with undefined scales • Unclear how pressure injuries measured • Randomization reported • No blinding • Comparability of populations and treatment unclear 	<p>Level of evidence: 1</p> <p>Quality: low</p>

Support Surfaces: data extraction and appraisals

Ref	Type of Study	Sample	Intervention(s)	Outcome Measures & Length of Follow-up	Results	Limitations and comments	
Clinical question 8: What is the most effective seating support surface for treating pressure injuries?							
Makhsous et al., 2009	Randomized controlled study evaluating wheelchair cyclic pressure relief seating for treating pressure injuries	<p>Participants were in and outpatients recruited from a rehabilitation centre in USA (n=44)</p> <p>Inclusion:</p> <ul style="list-style-type: none"> • SCI • Existing stage II or stage III PU of the sacral or ischial region • Able to independently use a manual or powered wheelchair • Sitting tolerance of 4 hours <p>Exclusion:</p> <ul style="list-style-type: none"> • Degenerative spinal disorder • Injury or surgery to pelvis, hip joint, thigh • Hip contractures • Severe pain, spasms • Concerns regarding concordance <p>Characteristics:</p> <ul style="list-style-type: none"> • No significant difference between groups for demographics • Mean age approx 42 to 44 years • Mean BMI 25.2 • Mean years since SCI injury approx. 3.9 to 6.1 • PU area at commencement: 	<ul style="list-style-type: none"> • All participants received PU treatment by a physician or a trained nurse practitioner. • PU wound care was varied according to individual wound requirements and included silver antimicrobial dressings and NPWT. • Participants were randomized to receive either: <ul style="list-style-type: none"> • Study group: wheelchairs equipped with an individually adjusted automated seat that provided cyclic pressure relief using a protocol of alternating 10 minutes on normal sitting and 10 minutes on off-loading sitting (n=22) • control group: standard wheelchair and participants instructed to perform arm push-ups every 20 to 30 minutes for pressure relief • All subjects sat in wheelchairs for a minimum of 4 hours per day for 30 days 	<ul style="list-style-type: none"> • Wound characteristics were assessed using the PUSH tool twice weekly • Wound dimensions were recorded with digital photography twice a week • Median healing time for a 30% healing relative to initial measurements • The percentage reduction in wound area • Percentage improvement in PUSH score achieved at the end of the trial 	<ul style="list-style-type: none"> • There was no significant difference in overall wound area between groups at the trial end (p>0.05) • The treatment group achieved 30% PU closure significantly faster than the compared with the control group (median 25±2.9 days versus >30 days, p=0.007) • The percentage improvement in PU area was greater in study group (45.0±21% versus 10.2±34.9%, p<0.001) • The percentage improvement in PUSH score was greater in study group (21.9±24.6% versus 5.8±9.2%, p=0.003) • wound closure rate (mm²/day) was significantly faster in study group (21.7±14.6 versus 2.3 ± 20.4, p<0.001) 	<ul style="list-style-type: none"> • Trial short duration • Small sample size • Randomisation and blinding not reported • Unclear of difference on pressure-relief behavior for the participants (e.g. when not in the wheelchair) • Non-equivalent wound care (some participants had moist dressings, others had silver dressing or NPWT) • Nonequivalent PU at baseline – treatment group larger PU therefore favoured for 30% healed outcome 	Level of evidence: 1 Quality: low

Support Surfaces: data extraction and appraisals

Ref	Type of Study	Sample	Intervention(s)	Outcome Measures & Length of Follow-up	Results	Limitations and comments	
		study group 1745.8 ± 1324.9 mm ² versus control 1586.8 ± 1865.0 mm ² , $p > 0.05$ PUs were not significantly different for duration at entry to study					
Other information about seating surfaces/cushions (no evidence on effectiveness in preventing or healing pressure injuries)							
Hollington, Hillman, Torres-Sánchez, Boeckx, & Crossan, 2014	Laboratory study measuring load deflection and hysteresis in 37 seating cushions	37 cushions	Model with simulated loading and measurement	<ul style="list-style-type: none"> N/A 	<p>Tabulated details of 37 cushions</p> <p>Author conclusions: ISO 16840-2:2007 load deflection and hysteresis test can differentiate performance of seating cushions</p>	<ul style="list-style-type: none"> Nil 	Indirect evidence (laboratory study)
Sprigle, 2013	Observational study to document the state of wheelchair cushions after everyday use by identifying signs of wear, fatigue, and failure.	<p>Adult participants were recruited from a rehabilitation hospital (n=141)</p> <p>Inclusion</p> <ul style="list-style-type: none"> participants needed to use a wheelchair as their primary means of mobility <p>Characteristics: 80% of participants had spinal cord injury</p>	<ul style="list-style-type: none"> Each cushion was visually inspected with covers in place and with covers removed (if possible). Additional variables included participant demographics, wheelchair type, and self-reported information about cushion use. 	<p>Cushion inspection</p> <ul style="list-style-type: none"> Cushion cleanliness was based upon a five-point scale ranging from 0 (like new) to 4 (very unclean). Visual signs of wear or damage Cushion Age was defined as the product of cushion age (days) and the daily use (hours). 	<ul style="list-style-type: none"> Cushion age, participant characteristics, and cushion use patterns varied widely. Self-reported ages of cushions spanned from new to 16.25 years (average age = 2.7 years and median age = 2 years). Over 50% of all covers indicated some sign of wear to the fabric, seams, zipper, pocket, or attachment. Damage to fabric and seams were most prevalent 41% of covers on cushions with Age < 12 months showing some sign of damage compared to 56.7% of covers on cushions with Age of 12–36 months and 58.2% of covers on cushions with Age > 36 months ($p = 0.02$) About 40% of foam components with Age < 12 month exhibited permanent deformation, granulation, or stiffness. 	<ul style="list-style-type: none"> Multiple assessors with no formal evaluation of reliability in outcome measures. Heterogeneous sample of patients with 'high end cushions' may not be generalizable data. No clear validated tool to evaluate the cushions 	Indirect evidence (pressure injury not an outcome)

Support Surfaces: data extraction and appraisals

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					and 61% of with Age > 36 months had degradation signs (p=0.059)		
Crane, Winger, & Call, 2016	Laboratory environment Study to compare the interface pressure characteristic of an off-loading wheelchair seat cushion to a flotation style wheelchair seat cushion	Participants were recruited in the US (n=10) Inclusion criteria: <ul style="list-style-type: none"> Adults with chronic Spinal cord injury (SCI) Exclusion criteria: <ul style="list-style-type: none"> Presence of a pressure ulcer hip width > 48 cm Participant characteristics: <ul style="list-style-type: none"> average height 179 ±9 cm average weight 80 ±10 kg, hip width 41 ±4 cm. 	<ul style="list-style-type: none"> Seat pressures were measured, using a pressure mapping system, during five two-minute trials under each of four conditions. Conditions included three configurations of the off-loading seat cushions <ul style="list-style-type: none"> fully-off-loading [C0-off] addition of top-well insert (C2-off) addition of both well inserts (C3-off). comparator flotation style cushion (C3-float) Subjects performed complete pressure relief maneuver between trials.	<ul style="list-style-type: none"> Peak pressure index (PPI) Ischial tuberosity peak pressure dispersion index contact area average pressure The dispersion index is a newer measure that characterizes the percent of pressure distributed under the ischial tuberosities and sacrococcygeal area of the pelvis compared with total pressure under all areas of the seat. 	<ul style="list-style-type: none"> Average pressure ranged from 31 ±13 mmHg (C0-off) to 68 ±37 mmHg (C3-float). Contact area ranged from 2071 ± 33 (C3 float) to 2091 ±25 cm² (C0-off) PPI ranged from 39 ± 18 mmHg (C0 – off) to 97 ± 30 mmHg (C3 – float). Average PPI per configuration were 39 ±18 (C0-off), 61±19 (C1-off), 78 <p>Author conclusions: All metrics indicated that the off-loading cushion reduced PPI, ischial region peak pressure, and dispersion index while not reducing the contact area or increasing the overall average pressure at the buttock-cushion interface – key intrinsic risk factors for pressure ulceration</p>	<ul style="list-style-type: none"> Small sample size Narrow demographic of subjects Lack of universally-accepted interface pressure parameter Did not quantify or assess seated posture characteristics 	Indirect evidence (PU not an outcome measure)
Cho, Beom, Yuk, & Ahn, 2015	To investigate the effects of body mass composition and cushion type on seat interface pressure in patients with SCI and healthy participants	Participants with spinal cord injury (SCI) (n=20) and healthy volunteers (n=20) Inclusion criteria: <ul style="list-style-type: none"> cervical or thoracic level SCI (complete or incomplete) nil pressure injuries in past few months nil surgery on hip joint or femur >90° hip flexion range of motion	Pressure-mapped using the CONFORMat System on 3 cushions and no cushion in 3 different wheelchair postures. Measurements taken for 10 sec Cushions: <ul style="list-style-type: none"> low-priced air cushion (not specifically pressure-related) 	<ul style="list-style-type: none"> Changes of seat interface pressure on cushions in varying postures and across the two sample groups. Body composition factors including weight; BMI; skeletal muscle; body water 	No correlation was found between body composition and seat interface pressure. People with SCI group had higher mean peak pressure with no cushion and with both pressure redistribution cushions	<ul style="list-style-type: none"> Unclear how long spent on cushion – takes time to adjust for appropriate immersion and envelopment Limited postures observed - 20° is insufficient to relieve pressure Non-comparable groups : different 	Indirect evidence (PU not an outcome measure, healthy volunteers)

Support Surfaces: data extraction and appraisals

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			<ul style="list-style-type: none"> 5cm height low profile ROHO® Quattro® 10cm height high profile ROHO® Quattro® Postures: <ul style="list-style-type: none"> 90° upright position 20° recline 20° forward leaning on support tray 			ages, lower limb muscle tone (people with SCI have reduced lower limb muscle tone and increased body fat)	
Brealey, James, & Hay, 2017	Laboratory study to compare the performance of a range of pressure redistribution cushions to reduce interface pressure on an armchair and an ideal surface.	Convenience sample of consenting health professionals in Australia (n=10) Participant characteristics: <ul style="list-style-type: none"> 20% male, 80% female Male height range of 1.74–1.8 m, weight range of 76–78 kg and BMI range of 23.5–25.6. Female height range of 1.57–1.8 m, weight range of 51–97 kg, and BMI range of 19.36–30.27. 	All the participants sat on the two surfaces: common household armchair and adjustable height, firm chair) and tested each for seven conditions for five minutes: <ul style="list-style-type: none"> Without a pressure redistribution device. Multi-cell air-ROHO® Gel/foam-JAY® Easy, Single cell air-Repose® Dry gel polymer EquaGel® Foam MacMed, Gel-Action 	<ul style="list-style-type: none"> Self-reported comfort (scale 1 to 10) rated at the end of five-minutes Interface pressure readings were provided by the pressure 	<ul style="list-style-type: none"> Foam, single cell air and dry gel cushions were all effective in reducing interface pressure compared to using an armchair alone Findings for the foam/gel cushion showed a possible increase in interface pressure compared to armchair alone. Cushions appeared to be more effective in reducing interface pressure when used on an armchair compared to the firm chair. <p>Conclusions: The chair surface influences the performance of pressure redistribution cushions. Cushions may not perform consistently on non-ideal surfaces.</p>	<ul style="list-style-type: none"> The staff volunteers were small The study only compared two chair surfaces Test rig and measuring device was not possible to map bariatric participants A significant ceiling effect was found from the 200mmHg upper pressure reading limit that impacted results for the control surface 	Indirect evidence (PU not an outcome measure, healthy volunteers) Quality: Low
Vilchis-Aranguren, Gayol-Merida, Quinzano S-Fresnedo, Perez-	Prospective descriptive study exploring influence of support cushions on IP and comfort in people with SCI	Participants were recruited from an SCI service over a 6 month period (n=16, n=2 withdrew) Inclusion criteria:	<ul style="list-style-type: none"> Participants had a personalized thermoformed polypropylene cushion with polyurethane foam covering the base Cushion developed based on anthropometry and 	Outcome measures taken before trial of cushion and then at 2 months Trunk control Evaluated by an expert who assessed ability to remain	<p>Transfer capacity and spasticity no significant differences between cushions (average FIM usual cushion 107.2±17.3 vs trial cushion 110.1±14.0, p>0.05)</p> <p>Pressure redistribution</p>	<ul style="list-style-type: none"> Wide variation in usual cushion types incl 9/16 not using a cushion Very small sample size No randomization of order cushions 	Indirect evidence (PU not an outcome measure)

Support Surfaces: data extraction and appraisals

Ref	Type of Study	Sample	Intervention(s)	Outcome Measures & Length of Follow-up	Results	Limitations and comments	
Zavala, & Galindez-Novoa, 2015		<ul style="list-style-type: none"> Wheelchair users able to transfer and propel chair without assistance Chronic SCI for > 2 years PU free for 6 months No chronic degenerative of cognitive problems Willing to use study cushion for at least 2 months <p>Characteristics:</p> <ul style="list-style-type: none"> 56.25% male average age 31.8 yrs (range 22 to 47) average BMI 25 (range 22to 34) average time in a wheelchair 10.1yrs (range 3 to 26) usual cushions: air filled n=2, no cushion n=9, gel filled n=2, unknown material n=3 <p>all participants had Braden score indicating high risk of PU</p>	<p>made from a mold of the individual</p> <ul style="list-style-type: none"> Participants used cushion in all ADLs for 8 to 16 hours daily for a minimum of 2 months 	<p>seated and react to external stimuli</p> <p>Posture Evaluated using touch examination and observation for angles that may cause asymmetry</p> <p>Interface pressure Pressure mapping, medium pressure of ischiastic tuberosity zone used</p> <p>Spasticity Modified Ashworth scale measuring passive stretching resistance, mscl tone, range of motion (ROM)</p> <p>Ability to transfer, propel and pressure redistribute Functional Independence Measure (FIM)</p>	<p>Average IP significantly improved 72.19±24.24mmHg vs 58.22±27.27mmHg, p=0.012</p> <p>Posture, balance No significant difference No change in FIM scores</p> <p>Satisfaction Patients with less spasticity showed the greatest improvements in satisfaction Patients with higher degrees of spasticity were less satisfied with the cushion</p> <p>Conclusions: a customized wheelchair cushion performs as well or as other cushion types and does not reduce functioning. It may improve IPs</p>	<p>used (i.e. maturation could influence results)</p> <ul style="list-style-type: none"> Primarily non validated outcome measures 	
Ferguson-Pell, Ferguson-Pell, Mohammadi, & Call, 2015	Laboratory study investigating impact force dissipation of support cushions	35 support cushion samples	N/A	<ul style="list-style-type: none"> Tests of cushion impact dampening as required for ISO 16840-2 testing 	<p>The researchers argue that dampening characteristics influence dynamic stability, capacity of cushion to absorb and dissipate energy and reducing loading conditions that increase SDTI risk.</p> <p>The researchers use ISO16840-2 tests to check dampening qualities on 35 different cushions.</p> <p>Results indicated that there was no reliable differentiation in performance</p>	<ul style="list-style-type: none"> Only one sample of each cushion was used Cushion characteristics measured without a user ISO 16840-2 tests are designed to provide characteristics of support surface for 	Indirect evidence (laboratory study, PU not an outcome measure)

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Ref	Type of Study	Sample	Intervention(s)	Outcome Measures & Length of Follow-up	Results	Limitations and comments	
					that could be attributed to the descriptive information about the cushion composition.	use by "typical" adult	
Nakagami, Sanada, & Sugama, 2015	Cross over study investigating effect of an active support cushion on interface pressure (IP) and tissue oxygenation	Healthy volunteers (n=19) Characteristics: <ul style="list-style-type: none"> • Mean age 32.1 ±8.7 • 73.9% Female • Mean body weigh 54±8.8 kg • 5 with BMI < 18.5(kg/m²), 12 with BMI 18.6 to 25.0, 2 with BMI > 25.1 	<ul style="list-style-type: none"> • Participants rested for 10 minutes then sat for 30 minutes on: <ul style="list-style-type: none"> ○ Reactive cushioning system ○ Self-regulating alternating pressure air cell cushion with 35 small air cells (central) and 4 large air cells (sides). Cushion includes bottoming out detectors and air pressure monitoring sensors • At 30 mins participants performed pushups • Cross over experiment with random sequence 	Interface pressure pressure mat Tissue oxygenation <ul style="list-style-type: none"> • near infrared spectroscopy with probe placed on ischial tuberosity • Reactive hyperemia index (RHI) calculated as average peak oxygenation prior to performing push up subtracted from oxygenation just after pushup • Higher value = more severe congestion 	Interface pressure No significant difference between surfaces for peak IP at ischial trochanters (p=0.426 at right and p=0.975 at left) Contact area IP significantly lower in alternating support cushion group vs reactive cushion (p=0.006) Tissue oxygenation RHI significantly higher in reactive cushioning system (p=0.003)	<ul style="list-style-type: none"> • Recommended time for pushups for SCI is 15 minutes, results may not reflect clinical use • Reactive cushion was not described • Consideration to the BMI differences was not reported • 	Indirect evidence (healthy volunteers, PU not an outcome measure) Quality: low
Lee, Park, Jung, & Lee, 2016	to evaluate pressure redistribution when using different seating cushions	Healthy volunteers in South Korea (n=40) Exclusion criteria: <ul style="list-style-type: none"> • sitting problems • hearing, vision, or cognitive impairments that would interfere with assessments Participant characteristics: <ul style="list-style-type: none"> • Age range 18 to 90 years 	<ul style="list-style-type: none"> • Participants sat on a firm surface: <ul style="list-style-type: none"> ○ without a cushion ○ on a 5 cm high gel cushion ○ on a 7 cm high air cushion ○ on a 5 cm high memory foam cushion • Participants kept chins tucked, spines straight, hands on thighs, and pelvis neutrally positioned with flexed hips, knees, and ankles 	<ul style="list-style-type: none"> • Pressure mapping 	For all ages, mean pressure value and peak pressure were higher when on a firm surface without a cushion and on an air cushion compared to other conditions	<ul style="list-style-type: none"> • Limited reporting • Healthy volunteers without sitting problems • Time spent seated on cushions not reported • Participants maintained a specific positioning when seated • 	Indirect evidence (healthy volunteers, PU not an outcome measure)

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			about 90 degrees and feet flat on the floor				
Call, Hetzel, McLean, Burton, & Oberg, 2017	Case series study exploring effect of wheelchair cushions on tissue thickness over bony prominence measured by MRI	Volunteers with SCI in USA (n=10) plus one able body volunteer (n=11 total) Participant (SCI cohort) characteristics: <ul style="list-style-type: none"> • Mean time since injury 18.17 years • Mean weight 65.4 kgs • 60% professional athletes and 40% active people • Relative level of atrophy was medium • 40% of participants had no muscle tissue at trochanters 	Participants sat supported in a suspended position in wheelchair on cushions in the MRI machine, different support configurations were used Two cushions were used – air cell cushion and a pressure offloading cushion	MRI measuring tissue thickness over trochanter, ischial tuberosity and sacrum <ul style="list-style-type: none"> • Pressure mapping 	<ul style="list-style-type: none"> • Average soft tissue compression under the ischial tuberosity was approx 3cm in unloaded state, 2cm with off loading cushion and 1cm with air cell cushion • Strain was significantly less with the offloading cushion than air cell cushion (p<0.001) <p>Author conclusions: There is higher tissue strain sitting on an air cell cushion compared with an offloading cushion, suggesting reevaluation of best practice is required</p>	<ul style="list-style-type: none"> • Participants were primarily professional athletes 	Indirect evidence (PU not an outcome measure)
Wu, Garber, & Bogie, 2015	Repeated measures patient survey exploring satisfaction with an alternating pressure air cushion	Participants were individuals with spinal cord injury (SCI) recruited by unreported methods (n=12) Characteristics:	<ul style="list-style-type: none"> • Participants used the Airpulse SK[®] air cushion for six repeated two week periods over 18 months • Trials conducted in home setting Cushion has generic cell layout and standardized cycle of 3min inflation/deflation 	<ul style="list-style-type: none"> • Quebec User Evaluation of Satisfaction with Assistive (QUEST) and QUEST2.0b at conclusion of study • QUEST2.0b was used to evaluate degree of satisfaction with dimensions, weight of device, ease of adjusting device, safety/security, durability, ease of use, comfort and effectiveness in meeting needs • Survey was delivered 6 times over 18 months 	<ul style="list-style-type: none"> • 92% of participants were quite satisfied or very satisfied with overall use of cushion • One participant was unsatisfied with cushion due to safety concerns as the cushion altered center of gravity in a manual wheelchair <p>Author conclusions: individuals with SCI are satisfied with using this alternating air cushion</p>	<ul style="list-style-type: none"> • Very small sample size • Not clear how participants were selected • Survey tool adapted • Short-term use of 6 x 2week periods over 12 months • No evidence of efficacy in preventing PUs 	Indirect evidence (PU not an outcome measure)

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Ref	Type of Study	Sample	Intervention(s)	Outcome Measures & Length of Follow-up	Results	Limitations and comments	
Lustig, Levy, Kopplin, Ovadia-Blechman, & Gefen, 2017	Laboratory research (computational modeling and hemodynamic measures) to determine biomechanical responses to buttock tissues from toilet seats	Finite modeling One participant was analysed for pressure mapping	<ul style="list-style-type: none"> Finite modeling considering weightbearing on a toilet Six variations of toilet types were explored, a thicker, wider toilet seat with three different types of cushioning and a thinner, less wide seat with the same 3 different types of cushion 	Tissue oxygenation <ul style="list-style-type: none"> 	<ul style="list-style-type: none"> Tissue oxygen levels decreased immediately on sitting on either seat type After reaching a minimum value, a moderate decline compared to immediate values was seen Cushions reduced the peak interface pressures <p>Author conclusions: Peak stress was comparable to non-toilet seats, with cushioning reducing peak pressures</p>		Indirect evidence (PU not an outcome measure, finite modeling)
Levy, Kopplin, & Gefen, 2014	Observational study to measure stiffness and mechanical stressors on air-cell cushion versus foam cushion	One paraplegic subject in a laboratory setting in the US	N/A	<ul style="list-style-type: none"> Stiffness and mechanical stressors in two cushions using paraplegic subject for anatomical matching Measurements using MRI in muscle, skin and fat 	Author conclusions: Air is superior to foam in immersion to reduce mechanical stressors and potentially pressure injuries in people with spinal cord injury	<ul style="list-style-type: none"> Findings based on simulation and potential variation in anatomy/ tissue tolerance Possible errors with computational modelling Further trials needed Investigator involved with company 	Indirect evidence (laboratory study)
Tasker, Shapcott, Watkins, & Holland, 2014	Observational study to investigate the effect of seat shape on the risk of pressure injuries using discomfort and interface pressure measurements.	participants were recruited with intact neurological sensation (n=30) Inclusion criteria: <ul style="list-style-type: none"> Age 18-65years Sensation was normal in the buttocks/thigh area Exclusion criteria: <ul style="list-style-type: none"> pre-existing PIs or skin problems in the buttocks/thigh area Participant characteristics:	Participants (n=30) tested at three sessions: <ul style="list-style-type: none"> At the first session, all participants sat on the flat cushion (Shape X) for baseline measurements. At the second and third session, all participants sat on the shape A and shape B cushion, respectively. A minimum 2-day wash out period between three sessions, aim at 	<ul style="list-style-type: none"> Evaluation of discomfort at 1, 10, 20 and 30 min with discomfort VAS line marked with "extreme comfort" to "extreme discomfort". IPs measurement using pressure mapping device 	<ul style="list-style-type: none"> The estimated reduction of transformed discomfort for Shape B compared to Shape A is 0.95 ($p < 0.001$) [0.60 for Shape A (95%CI 6.3-7.3 at 30min, $p < 0.001$) and 1.55 for Shape B (95%CI 5.1-6.4 at 30min, $p < 0.001$) compared with X (95%CI 7.1-8.1 at 30min)]. Pearson's correlation coefficient between hip width and discomfort at 1, 10, 20 and 30 min revealed a significant ($p < 0.05$) negative correlation with relatively consistent values of -0.39, -0.48, -0.37 	<ul style="list-style-type: none"> The study tested IP and discomfort for 30 able-bodied participants. The targets are not patients 	Indirect evidence (laboratory study with healthy volunteers)

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Ref	Type of Study	Sample	Intervention(s)	Outcome Measures & Length of Follow-up	Results	Limitations and comments	
		<ul style="list-style-type: none"> • Age 26-30 years • 56.66% Female • Weight 70.6-80.7 kg • Height 176-177 cm • BMI 22.54-26.05 • Hip width 39-42 cm • Upper leg length 44-47.5 cm 	<ul style="list-style-type: none"> • ensuring no any residual discomfort . • All participants wore a cotton trousers to ensure a consistent interface . • A footrest block with an integrated weighing scale was assembled to support the participant's feet • The participant's backrest angle set at 10° reclined from vertical. 		<p>and -0.40, respectively.</p> <ul style="list-style-type: none"> • IP results at 30 min on Shape A (18.37±7.29) and on shape B (15.31±6.54), on Shape X (27.35±9.4) ($p < 0.05$). <p>Author conclusions: IP and discomfort could surrogate measures for PU risk when use cushions.</p>		
McClure, Nieves, & Kirshblum, 2014	Cross sectional survey to determine whether those individuals at risk for the development of pressure ulcers (i.e. persons with SCI who are primarily wheelchair users) are using a prescribed wheelchair cushion while traveling	<ul style="list-style-type: none"> • Number of participants: 42 • Clinical setting: outpatient SCI rehabilitation • Country: New Jersey, US (It is not clear in the article) • Inclusion criteria: to complete the survey included using a wheelchair as their primary means of mobility and being between the ages 18 and 75 years old. Participants who could not write the responses on their own completed the questionnaire verbally with an approved study personnel who recorded their responses. • Exclusion criteria: None • Participant characteristics: • The mean time post injury of 10.4 years (range of 1-42 years post injury) 	Usually N/A	<ul style="list-style-type: none"> • This is a survey. 	<ul style="list-style-type: none"> • All of the participants utilized a prescribed wheelchair cushion when seated in their wheelchair. • 27 (64.3%) of the subjects reported transferring to a motor vehicle seat and 15 (35.7%) subjects reported always traveling in their wheelchairs (with their cushion). Of the 27 subjects who transferred to a motor vehicle seat, 25 (92.6%) reported not using a specialty cushion when sitting on the motor vehicle seat. • 23 subjects reported traveling on an airplane and 19 (82.6%) reported not sitting on a prescribed specialty cushion with only four (17.4%) subjects reporting using a specialty cushion when traveling by commercial airline. • Of the 42 participants, 21 (50%) reported that they had been pressure mapped in their own wheelchair cushion in their own wheelchairs. Two 	<ul style="list-style-type: none"> • Further studies should be undertaken to examine barriers to cushion use as well as further studies are needed to determine appropriate pressures while traveling in either a motor vehicle or on a commercial airline seat to appropriately educate patients to prevent pressure ulcer formation. 	Level of evidence: Indirect (PU not an outcome)

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Ref	Type of Study	Sample	Intervention(s)	Outcome Measures & Length of Follow-up	Results	Limitations and comments	
		<ul style="list-style-type: none"> 22 participants had tetraplegia and 20 had paraplegia; 40% of the sample reported having a complete injury, 53% an incomplete injury and the remainder (7%) unsure. 			<p>participants (4.7%) did not respond and only one participant reported being pressure mapped in their car seat. 25 (59.5%) stated that they had a history of PI and 3 of those participants related that development of the PI specifically from sitting either on a motor vehicle seat (two subjects) or from an airline seat (one subject).</p> <ul style="list-style-type: none"> Of the participants who transferred onto the vehicle seat, 55.5% reported a history of PI (15 of the 27 respondents), whereas 66% of participants who did not transfer reported developing a PI. In terms of performing weight shifts, no significant difference, as 66.7% of the participants who sat on the motor vehicle seat versus 60% of the participants who sat on a prescribed wheelchair cushion reportedly performed them. <p>Author conclusions: Persons with SCI, who are primary wheelchair users, do not utilize a prescribed wheelchair cushion when seated in a MV or airplane seat.</p>		
Thorne et al, 2009	Observation survey investigating the impact of a gel pad on interface pressure when in supine position	<p>Participants were recruited from medical and surgical wards in a Canadian hospital (n=60)</p> <p>Inclusion:</p> <ul style="list-style-type: none"> Aged ≥ 18 years Low to moderate risk of PU based on Braden score of 10 to 18 	<ul style="list-style-type: none"> Participants acted as own comparison unit between first and second sessions with 2 hour rest period between sessions For both sessions participants were in supine position with 30° bed head elevation 	<ul style="list-style-type: none"> Participants had IF pressure mapping mat placed underneath the buttock region and pressure readings taken at 5 minute intervals for 20 minutes Mean value of the 4 readings was used for analysis 	<ul style="list-style-type: none"> For the majority of participants (n=55) there was no significant increase or decrease in the interface pressure between no gel mat and gel mat present. For 3 participants there was a significant reduction in interface pressure (more than -73.55mmHg) associated with the gel pad. 	<ul style="list-style-type: none"> Indirect outcome measure Participants did not have high risk of PU Not blinded Unclear whether the gel pad was covered (i.e. micro climate) 	Indicate evidence (PU not an outcome measure)

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Ref	Type of Study	Sample	Intervention(s)	Outcome Measures & Length of Follow-up	Results	Limitations and comments	
		<ul style="list-style-type: none"> Able to sit in 30° supine position 75 to 120 lb body weight <p>Exclusion:</p> <ul style="list-style-type: none"> Agitation or need for restraint Incontinence Palliative care Cellulitis or dermatological condition of buttocks, lower back or upper thigh Existing PU Chest tubes, nephrostomy tubes or NGT Unable to sit in required position <p>Characteristics:</p> <ul style="list-style-type: none"> 57% sample male Mean age 72.6 years Mean BMI 25.68±5.80 for men and 24.53±5.81 for women 	<p>Comparison conditions:</p> <ul style="list-style-type: none"> First session: no gel mat <p>Second session: 18x18x1 inch gel pad between mattress and pressure mapping mat</p>	<ul style="list-style-type: none"> Skin assessment was conducted before and after each session 	<ul style="list-style-type: none"> For 2 participants there was a significant increase in interface pressure (more than 68.77mmHg) There was no significant difference in skin assessments before and after using the gel pad. <p>Study conclusions: the benefit of using a gel pad while in a 30° supine position in bed is uncertain as there is no significant difference observed in interface pressure.</p>	<ul style="list-style-type: none"> Participants were positioned for only 20 minutes so it is unclear if skin assessments would have been different over longer period of time 	
Williams, Leslie, Bingham, & Brearley, 2011	Quasi-experimental (cross-over design in two phases) investigating interface pressure between buttock and different seating	<p>Participants were recruited from an ICU (22-bed ICU on a closed unit in tertiary- referral hospital in Australia (phase 1 n=18, phase 2 n=20)</p> <p>Inclusion:</p> <ul style="list-style-type: none"> impaired mobility scheduled to be sitting out of bed in the regular ICU chair <p>Exclusion:</p>	<p>Phase 1:</p> <ul style="list-style-type: none"> All participants were positioned on 3 different seating surfaces (non-random because of availability of surfaces) for at least 30 minutes (except for one patient who had to put back in bed within minutes after starting. Phase 1: three seat surfaces were: 	<ul style="list-style-type: none"> Interface pressures at the buttock-seat interface (excessive pressures (≥200 mm Hg)) A Force Sensing Array (FSA version 4.0) pressure mapping system (Wista Medical Ltd, Winnipeg, Canada) with a single standard 45x45-cm pressure map The period of 5 	<p>Phase 1</p> <ul style="list-style-type: none"> In participants with pressure maps showing excessive pressures (≥200 mm Hg): 46% of pressures recorded for the regular chair were higher than pressures for the gel chair, and on 11% of maps, the pressures were similar for the regular and gel seating surfaces (z = 2.0, P = .04) Participants in alternative chair had significantly fewer excessive seating interface pressures compared with the regular chair 	<ul style="list-style-type: none"> Not clear how drop-out was handled in analyses (patients were measurements could not be completed (phase 1: n=1 -reason hypotension; phase 2)+ some participants (number not 	Indicate evidence (PU not an outcome measure)

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	surfaces in ICU patients	<ul style="list-style-type: none"> unsuitable for sitting out of bed severe diarrhea able to bear weight (could sit on a regular high-back chair) <p>Characteristics:</p> <p>Phase 1</p> <ul style="list-style-type: none"> Median age 66 (59-73), female participants (28%), mean BMI 27 (5), worst APACHE II score in first 24h 17 (16-19), mean Braden score 12 (2), median number of days in ICU 14 (8-24) <p>Phase 2</p> <ul style="list-style-type: none"> Median age 62 (51-75), female participants (55%), mean BMI 27 (6), worst APACHE II score in first 24h 20 (17-23), mean Braden score 12 (2), median number of days in ICU 17 (12-30) 	<ul style="list-style-type: none"> Regular chair with single cushion (TotalLift-II trolley chair, Wy'East, Clackamas, Oregon) Alternative chair with 4 separate cushions (Hausted APC, SterisCorp, Mentor, Ohio) Regular chair with gel overlay Phase 2: two seating surfaces were: <ul style="list-style-type: none"> Regular chair with single cushion (TotalLift-II trolley chair, Wy'East, Clackamas, Oregon) Alternative chair consisting of three cushions (back rest, cushion under buttocks, and cushion under legs) made from combination of high and low-density foam 	<p>to 29 minutes of sitting out of bed was used</p> <ul style="list-style-type: none"> System was calibrated with an autocalibrator specific to the system Seating protocol was used 	<ul style="list-style-type: none"> Participants in the alternative chair had significantly fewer excessive pressures when compared with the gel overlay alternative chair lacked the practical utility of the regular chair (difficult to transfer participants and limited adjustment options for supporting the patient) Gel overlay did not reduce interface pressures <p>Phase 2</p> <ul style="list-style-type: none"> 55% (n=11) of the patients had seating interface pressures of 200 mm Hg or greater, and of these 10 participants (93%) had fewer episodes of excessive pressures on the new surface ($P < .001$). The remaining 9 participants, seating interface pressures were lower than 200 mm Hg. Among patients who had pressures of 150 to less than 200 mm Hg, 40% had fewer episodes of higher interface pressure with the new surface than with the regular surface ($P < .001$). 	<p>reported) were too tall to be seated in alternative chair</p> <ul style="list-style-type: none"> Outcome measures were not clearly described Competitors not always clearly described Materials of seating surfaces (foam) not clearly described 	
Gil-Agudo et al., 2009	Biomechanical study investigating the impact of different seating cushions on interface pressure	<p>Unclear from where participants were recruited. Appears to be a Spanish trial (n=48)</p> <p>Inclusion:</p> <ul style="list-style-type: none"> Aged 18 to 65 years Complete cervical or thoracic SCI No PU in preceding month 	<ul style="list-style-type: none"> All cushions were covered with their own cover with a protective non-skid, flameproof inner layer and a breathable, elastic outer layer All participants acted as own controls and were seated on the following cushions for 15 minutes 	<ul style="list-style-type: none"> Participants had IF pressure mapping mat placed underneath the buttock region and pressure readings taken at 1.5 minute intervals for 15 minutes Mean value of readings was used for analysis 	<ul style="list-style-type: none"> Cushion 3 (dual compartment cushion with two chambers simulating ergonomic seating base) had the lowest mean interface pressure distribution (34.9 mmHg versus 38.5 to 41.9mmHg for other three cushions, $p < 0.05$) Cushion 4 (gel and firm foam) had the highest interface pressure distribution 	<ul style="list-style-type: none"> Indirect outcome measure Participants did not have high risk of PU No skin assessments 	Indicate evidence (PU not an outcome measure)

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		<ul style="list-style-type: none"> No surgical resection of pelvis or femur Passive hip flexion range of at least 90° <p>Characteristics:</p> <ul style="list-style-type: none"> 79% sample male Mean age 42±17 years Mean weight 67.6±18.6 kgs Mean BMI 23.3±6.0 Mean Braden scale 13.0±2.4 	<p>in wheelchairs. Washout period between cushions was not reported.</p> <ul style="list-style-type: none"> Seating cushions: Cushion 1: single compartment low profile cushion Cushion 2: single compartment high profile cushion Cushion 3: dual compartment cushion with two chambers simulating ergonomic seating base Cushion 4: gel and firm foam cushion 		<p>Study conclusions: a dual compartment cushion with two chambers simulating ergonomic seating base has the most favorable profile when considering interface pressure over 15 minutes sitting time.</p>		
Other information about active support surfaces (no evidence on effectiveness in preventing or healing pressure injuries)							
Ogawa, Mori, Noguchi, Nakagami, & Sanada, 2015	<p><u>Study 1</u> Observational study investigating force and body shift associated with elevated head of bed (HOB)</p> <p><u>Study 2</u> Cross over RCT exploring effectiveness of an alternating pressure air mattress</p>	<p><u>Study 1</u> Participants were healthy volunteers recruited at a university (n=14)</p> <p>Inclusion: Aged over 20 years</p> <p>Exclusion: Skin disease, contact dermatitis caused by medical tape</p> <p>Characteristics:</p> <ul style="list-style-type: none"> Mean age 27.9±3.4 years Mean height 1.64±0.08 m 3 participants had BMI <18.5 (kg/m²), 10 with BMI 18.5 to and 1 BMI >25 	<p><u>Study 1</u></p> <ul style="list-style-type: none"> APAM with three layers of air cells set at 3.5kPa for alternating weight bearing Room temperature at 27°C and humidity maintained at 60±10% No sheets or pillows used and participants wore 100% cotton <p><u>Study 2</u> Cross over RCT in which participants tested:</p> <ul style="list-style-type: none"> same mattress as per study 1, and 	<p><u>Study 1 and 2</u> IP pressure measured using three sensors placed at upper thoracic vertebra, lower thoracic vertebra and mid-point of left thigh Discomfort during elevated HOB measured using a 10-point VAS with discomfort defined as "pushing and pulling feeling" Body shift measured using two laser scanners attached to bedframe at shoulder and heel points</p> <ul style="list-style-type: none"> HOB angle calculated using an accelerometer 	<p><u>Study 1</u></p> <ul style="list-style-type: none"> Start of pulling feel in upper body: <ul style="list-style-type: none"> angle 42±10.4°, upper thoracic: IP 19.2±4.3mmHg and shear 1.7±1.4N lower thoracic: IP 25.5±6.0mmHg and shear 2.7±1.4N Intolerable upper body pulling feeling: <ul style="list-style-type: none"> angle 60±7.6°, upper thoracic: IP 19.8±6.3mmHg and shear force 3.4±1.8 lower thoracic IP 32.7±9.2mmHg and shear force 5.3±3.6N Start of pulling feel in lower body: <ul style="list-style-type: none"> angle 24±17.5° though: IP 19.1±5.2mmHg and shear force 2.1±2.1N 	<ul style="list-style-type: none"> No randomization methods reported in study 2 Consideration to the BMI differences was not reported No consideration to extraneous factors e.g. moisture, body temperature 	Indirect evidence (healthy volunteers, PU not an outcome measure)

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Ref	Type of Study	Sample	Intervention(s)	Outcome Measures & Length of Follow-up	Results	Limitations and comments	
	(APAM) in promoting comfort	<p><u>Study 2</u> Participants were healthy volunteers recruited at a university (n=27)</p> <p>Inclusion: Aged over 20 years</p> <p>Exclusion: Skin disease, contact dermatitis caused by medical tape</p> <p>Characteristics:</p> <ul style="list-style-type: none"> • Mean age 26.3±3.0 years • Mean height 1.65±0.08 m • 5 participants had BMI <18.5 (kg/m²), 19 with BMI 18.5 to and 3 BMI >25 	<ul style="list-style-type: none"> ○ new mattress with air cells divided in 4 to 6 zones, a low friction layer on top of mattress and control of air-cell pressure in the body weight supporting layer, visco-elastic foam at the hinge point 		<ul style="list-style-type: none"> • Intolerable pulling feel in lower body: <ul style="list-style-type: none"> ○ angle 60±13.4° ○ thigh: IP 25.3±6.0mmHg and shear force 3.5±2.4N <p><u>Study 2</u></p> <ul style="list-style-type: none"> • VAS for discomfort was significantly lower for the new mattress at all HOB elevations • Maximum values of external force and IP during HOB elevation were lower for all values (except IP at thighs) for the new mattress 		
Yim, Clark, Gray, Stephen-Haynes, & Jeffery, 2014	Letter to editor related to alternating pressure air flow mattresses	N/A	N/A	N/A	<p>Safety issues highlighted:</p> <ul style="list-style-type: none"> - Risk of death from fire associated with dynamic air flow mattresses, overlays and cushions - If the dynamic air flow surface is punctured by an ignition source, the pump works harder to deliver air, which in turn further fuels a fire - Safety advice includes: not smoking in bed, not having candles or hot electrical equipment nearby/on bed, not using an electric blanket with a dynamic air flow support surface, fire retardant bedding, smoke detection systems in the room. 	<p>Supporting source: Greater Manchester Fire & Rescue Service. Crown c2014.</p> <ul style="list-style-type: none"> • Dynamic Air Flow Pressure Relieving Mattress, 2014. 	Indirect evidence (letter to editor, PU not an outcome measure)
Chai & Bader, 2013	Evaluate the performance of a prototype mattress using	<p>Include the following information:</p> <ul style="list-style-type: none"> • Number of participants: 12 	<p>Prototype mattress with one section providing alternating pressure (AP) support between sections</p>	<ul style="list-style-type: none"> • Interface pressure before and after test sessions at four different head of bed 	<p>Outcome 1 Maximal internal pressures in the sacral area depended on BMI. Linear regression generated four linear models,</p>	<p>Limitations:</p> <ul style="list-style-type: none"> • Sample limited to young healthy volunteers; 	Indirect evidence (PU not an outcome measure)

Support Surfaces: data extraction and appraisals

Ref	Type of Study	Sample	Intervention(s)	Outcome Measures & Length of Follow-up	Results	Limitations and comments	
	interface pressure and transcutaneous gas tensions	<ul style="list-style-type: none"> Clinical setting: Biomechanical Lab at Queen Mary university of London UK Inclusion criteria: Volunteer subjects of various morphologies Exclusion criteria: History of skin related conditions Healthy subjects	providing low pressure support	angles (0 degrees to 60 degrees), each of which lasted 30 minutes. <ul style="list-style-type: none"> Transcutaneous gas tensions (TcPO₂ / TcPCO₂) measured continuously throughout test period at mid-sacrum and control site at right scapula (TcPO₂ only) 	corresponding to each of the HOB angles, that were statistically significant at the 1% level. The mean values were lowest in the horizontal position (HOB 0 degrees) and highest for HOB 60 degrees. Outcome 2 <ul style="list-style-type: none"> Three categories of skin response to applied loading emerged: TcPO₂ levels at sacrum and scapula similar at all four HOB angles for about 50% of test conditions In 35% of test conditions, skin response revealed distinct perturbations in TcPO₂ associated with the A-P profile in the mattress, for example, a compromised TcPO₂ level at HOB 60 degrees In a few cases, there was elevation of TcCO₂ at HOB 60 degrees Author conclusions: In the majority of test conditions, the internal support produced sacral TcPO₂ levels similar to those at the control site or fluctuated at levels adequate for tissue viability. In a few cases, when the HOB was elevated to 60 degrees, TcPO₂ dropped or TcPCO₂ rose to levels that could compromise tissue viability. Interface pressures rarely exceeded 60 mmHg.	needs to be repeated with bed-bound and / or wheelchair-bound individuals <ul style="list-style-type: none"> Use of interface pressure alone is inadequate to in assessing individual risk of tissue compromise since it does not accommodate for variability in morphology, BMI, and other intrinsic factors 	outcome measure)
Butler et al., 2015	Observational study comparing a non-powered mattress to	Healthy volunteers (n=20) Participant characteristics: <ul style="list-style-type: none"> Age range 18 to 65 years 	The intervention and experimental conditions are poorly described. The OxyMat™ non-powered mattress system	Tissue oxygen saturation measured using near infrared spectroscopy at pressure sensitive anatomical locations	Oxygen saturation in supine <ul style="list-style-type: none"> OxyMat had higher oxygen saturation levels at scapula (86.81% versus low air loss 84.98% and alternating 85.55%) 	<ul style="list-style-type: none"> No description of experiment Features of the comparative 	Indirect evidence (PU not an outcome measure)

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	active mattresses for tissue oxygen saturation	Co-morbidities included diabetes, respiratory disease and quadriplegia	was compared to an alternating pressure mattress and a low air loss mattress	<ul style="list-style-type: none"> Measurements taken after 30 minutes in supine and 30 minutes in 30° incline 	<ul style="list-style-type: none"> OxyMat had higher oxygen saturation levels at sacrum (95% versus low air loss 88.7% and alternating 95%) OxyMat had higher oxygen saturation levels at ischium (94.59% versus low air loss 86.41% and alternating 89.78%) OxyMat had higher oxygen saturation levels at heels (53.39% versus low air loss 50.07% and alternating 44.79%) <p>Other findings</p> <ul style="list-style-type: none"> Results were similar for 30° incline Reports that interface pressure is lower with OxyMat, but the details are not reported Reports that OxyMat is associated with improved sleep due to noise reduction from being non-powered, but no data reported 	<p>mattresses are unreported</p> <ul style="list-style-type: none"> PU not an outcome measure Authors are inventors and investors in the product Inadequate details to assess the quality of research 	
Korniewicz, Siegel, Fajardo, & El-Masri, 2011 (prevention)	Open label quasi-experimental trial investigating a low air loss surface with advanced microclimate technology	<p>Participants recruited from a surgical ward and undergoing elective orthopaedic or neurological surgery in USA (n=99)</p> <p>Inclusion:</p> <ul style="list-style-type: none"> Weight >70lb and <500lb Admitted for surgical procedure Remain in bed for at least 2 days <p>Exclusion:</p> <ul style="list-style-type: none"> Traction Mechanical ventilation Spinal injuries 	<ul style="list-style-type: none"> Hill-Rom (company providing beds) representative conducted training sessions in the ward prior to study Participants were randomly assigned to either: <ul style="list-style-type: none"> Control group: VersaCare AIR (n=38) Study group: VersaCare P500 with advanced microclimate technology that manages heat and moisture (n=61) 	<ul style="list-style-type: none"> Prevention of pressure ulcers (?) Braden score changes Data was collected daily from the patient's electronic medical record 	<ul style="list-style-type: none"> Clinical effectiveness parameter not reported Study group had significantly longer bed confinement 6.44±3.23 versus 5.26±2.13 days, p=0.028) Multivariate analysis indicated that the VersaCare P500 bed accounted for 24.5% of variance in Braden scores 	<ul style="list-style-type: none"> Open-label design Data was retrieved from electronic medical records Study did not directly measure the influence of the mattresses on Pus Braden scale scores limited outcome parameter 	Indirect evidence Quality: low

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		<ul style="list-style-type: none"> Existing stage IV PU Terminal condition <p>Characteristics:</p> <ul style="list-style-type: none"> No significant differences in baseline demographics Mean age 59.55±14.96 years 51.5% Hispanic, 10% White, 38% Black 61.6% had a previous history of PU 17.2% diabetics 67% had a Braden score indicating at risk of PU 					
Other information about reactive support surfaces (no evidence on effectiveness in preventing or healing pressure injuries)							
Bergstran d, Källman, Ek, Engström, & Lindgren, 2015	Cross sectional study exploring the interaction between interface pressure, pressure-induced vasodilation and reactive hyperemia with different mattresses	<p>Participants were recruited at a University hospital in Sweden (n=115)</p> <p>3 groups:</p> <ul style="list-style-type: none"> healthy young (age 22-64yrs) n=42 healthy old (age 65+ yrs) n=38 inpatients (age 65+ yrs) n=35 <p>Exclusion criteria:</p> <ul style="list-style-type: none"> body temp >37.5°C tissue damage at sacrum 	<p>For each mattress, each group spent:</p> <ul style="list-style-type: none"> 15 mins side-lying on first mattress (2 mins for subsequent mattresses) 10 mins on back 10 mins lying on side <p>Mattresses:</p> <ul style="list-style-type: none"> standard mattress (Optimal M3, polyurethane foam, 50kg/m3) foam pressure mattress (Pentaflex, polyurethane foam, 50-52 kg/m3) viscoelastic foam + air static mattress (Flexible Therapy System, Arjo Huntleigh) 	<ul style="list-style-type: none"> mean sacral pressure peak sacral pressure blood flow at 1mm, 2mm and 10mm at sacral region <p>Measurements taken at following times:</p> <ul style="list-style-type: none"> baseline during 15/2 min acclimatization whilst in side-lying during period in supine post-load measurement after 10 mins back on side 	<ul style="list-style-type: none"> Viscoelastic+air mattress had the lowest local probe pressure, lowest sacral average pressure and lowest sacral peak pressure compared with all other mattresses (p<0.0005) No differences in blood flow found between the groups Greater proportion of participants lacked pressure-induced vasodilation at 2mm and 10mm on viscoelastic + air mattress than on alternating mattress (39% vs 20% at 2mm, 56.9% vs 35.1% at 10mm) Blood flow response during post-load was larger at 10mm compared with 1mm and 2mm depths 	<ul style="list-style-type: none"> Study was under-powered due to difficulties recruiting at-risk participants (inpatient group) with a skewed number of healthy participants 	Indirect evidence (PU not an outcome measure)

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			<ul style="list-style-type: none"> alternating air mattress (Autologic 200, Arjo Huntleigh) using a 10 min cycle 				
Rothenberger et al., 2014	To evaluate the effects of different types of reactive pressure relief mattresses with regards to skin perfusion and haemoglobin over vulnerable sites	<p>Cohort cross-over study using healthy hospital staff (n=25)</p> <p>Exclusion criteria:</p> <ul style="list-style-type: none"> Smoking Vascular disease Diabetes mellitus Arterial hypertension Perfusion-altering medication 	<p>Measurements taken at sacral region and heel region whilst lying in supine. Measurements taken after 5 mins in set supine position</p> <p>Three mattresses used:</p> <ul style="list-style-type: none"> standard foam mattress (Universalmatratze Nr) viscoelastic foam mattress (Wulff Viskogelastische Antidekubitusauflage) air-fluidised bed (Clinitron Air Standard Nr) hard lateral transfer mat for control measurement (Samarit Medizintechnik) 	<ul style="list-style-type: none"> Primary: Blood flow velocity Relative amount of local haemoglobin at a 2mm depth Taken after 5 mins on each surface with baseline measurement on hard lateral transfer mat Microcirculation assessed using Oxygen to See (O2C) doppler flowmetry for blood flow velocity 	<ul style="list-style-type: none"> Sacral Region: Significantly higher velocity of blood flow on all the mattresses compared to the transfer mat. No significant difference of local haemoglobin on any surface at the sacral region. Heel region: Significantly higher velocity of blood flow and local haemoglobin on the air-fluidised bed only compared to the other mattresses and the lateral transfer mat 	<ul style="list-style-type: none"> Excessive pressure can cause false readings – it was noted that participants could feel the probe when on the lateral transfer mat Only focuses on healthy participants Measurements taken after only 5 mins but often people at risk are lying for much longer 	Indirect evidence (laboratory study with healthy volunteers)
Low, Chua, Lim, & Yeow, 2017	Comparing the body contact pressure profiles of a latex and polyurethane mattress	<p>20 young healthy participants (10 men, 10 women).</p> <p>No history of back, shoulder or neck pain for the past month</p>	<p>The participants had to adopt 3 different postures on each mattress: lying on the back, on the side and the front (freefaller posture)</p>	<p>With a pressure map sensor: Average peak body contact pressure in each region and the average body contact.</p> <p>A paired t test was used to compare the mean peak body contact pressures between the 2 mattresses in each posture</p>	<ul style="list-style-type: none"> The latex mattress had a higher proportion of body surface area (90.9%-96.1%) in the range of 0 to 0.6 psi across all 5 identified regions compared with the polyurethane foam mattress (82.1%-91.8%) The polyurethane foam mattress had a higher proportion of body surface area (7.4%-14.9%) in the range of 0.6 to 1.2 psi compared with the latex mattress (3.7%-9.5%). Back posture: The peak pressures at the back torso and back buttocks were 	<ul style="list-style-type: none"> Measurement was only for 6 min. Polyurethane foam needs more time to adapt to the body contours. This is confirmed by the body surface area which is higher in the latex mattress group 	Indirect evidence (healthy volunteers)

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					<p>significantly lower, by 26.1% (P b .001) and 28.4% (P b .001), respectively, for the latex mattress compared with the polyurethane foam mattress.</p> <ul style="list-style-type: none"> • Side posture: the mean peak body contact pressures at the side torso and side buttocks were significantly lower, by 35.1% (P b .001) and 28.2% (P b .001) for the latex mattress, relative to the polyurethane foam mattress. • Front posture: The mean peak body contact pressure at the front torso was significantly lower, by 30.9%(P b .001) for the latex mattress, comparison with the polyurethane foam mattress. 	<ul style="list-style-type: none"> • Sample of healthy volunteers, very little information about the patient characteristics and recruitment. • No conclusions can be drawn about PU prevention and PU development. 	
Lai & Guo, 2015	Observational study using 3D FE models to establish guidelines for optimal mattress support shape design and to construct an integral mattress evaluation platform and verify the effectiveness of passive mattresses compared to standard	<p>Participants were healthy volunteers recruited in Taiwan (N=30)</p> <p>Inclusion criteria: healthy adults, avoid exercise and caffeinated beverages before experiment</p> <p>Exclusion criteria: participants suffering from diabetes, skin conditions or cardiovascular disease.</p> <p>Participant characteristics:</p> <ul style="list-style-type: none"> • Statistics reported by gender • Mean age between 28 and 31 years • Mean height between 158.43± 5.92cm and 170.75 ± 4.49cm 	<p>Both control and comparison group were observed in the same way:</p> <ul style="list-style-type: none"> • Participants rested for 15 minutes before measurement. • Participants maintained a comfortable supine position for 30 minutes on the mattress. During this time, measurements of buttock pressure, sacrum blood flow and temperature were recorded. • returned to baseline conditions for 15 minutes • Repeat measure 	An LDF probe, temperature sensor and pressure sensors were used to measure at 1min and 30 min.	<ul style="list-style-type: none"> • The new passive mattress was found to provide a more even body pressure distribution (relative disparity of - 0.7%) than the standard mattress(12%). • The new passive mattress was found to provide better assisted subcutaneous blood flow (relative disparity of 18.78%) than the standard mattress(2.32%). • Relative skin temperature change in both mattresses increased significantly over time.(P=0.0001) 	<ul style="list-style-type: none"> • measure depth reliability problems of available LDF measuring techniques • The study did not investigate the subject's subjective evaluation (e.g. Visual Analog Scale or Kansei engineering process) 	Indirect evidence (healthy volunteers)

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	hospital mattresses	<ul style="list-style-type: none"> • Mean weight between 55.14 ± 8.3kg and 72.83 ± 11.08kg • Mean BMI between 24.99 ± 3.77 and 21.88 ± 2.49 					
Jin, Bo, Qiuyue, & Wuyong, 2014	Observational study to investigate the effectiveness of a sheepskin mattress on interface pressure at the back, sacrum and heel regions	<p>Cohort cross-over study conducted with healthy volunteers in China (n=18)</p> <p>Inclusion criteria:</p> <ul style="list-style-type: none"> • Healthy • Aged 20-27 yrs <p>Exclusion criteria:</p> <ul style="list-style-type: none"> • BMI>24.5 • Back pain 	<p>Control 1: control mattress (3cm thick coir mat)</p> <p>Control 2: standard hospital mattress (foam and 3cm thick coir mat)</p> <p>Treatment 1: control mattress + sheepskin overlay</p> <p>Treatment 2: standard hospital mattress + sheepskin</p> <p>Treatment 3: air mattress (air/strips with 10cm intervals) + control mattress</p>	<ul style="list-style-type: none"> • Interface pressure measurements using the mFLEX pressure mapping system: <ul style="list-style-type: none"> ○ peak pressure ○ average pressure ○ contact area • Measurements taken whilst lying in supine with a 10 sec interval recorded at a random point within a 6 minute period. 	<p>Interface pressure</p> <ul style="list-style-type: none"> • Sheepskin significantly reduced peak pressure with both the control mattress and the standard hospital mattress (control 7.0mmHg, p=0.02, standard hospital mattress 8.8mmHg, p=0.01) • Sheepskin significantly reduced average pressure with both the control mattress and the standard hospital mattress (control 9.30mmHg, p<0.0005, standard hospital mattress 2.0mmHg, p=0.01) • When comparing air mattress with the sheepskin the sheepskin provided reduced peak pressure by 6.8mmHg (p= 0.031), reduced average pressure by 8.8mmHg (p<0.0005) and increased contact area by 435.2cm² (p<0.0005). <p>Contact area</p> <p>Sheepskin significantly increased contact area with both the control mattress and the standard hospital mattress (control 646.1cm², p<0005, standard hospital mattress 395.6cm² p<0.0005)</p>	<ul style="list-style-type: none"> • Without brands of mattresses provided it is difficult to determine the appropriateness of their use in the study, particularly the air mattress • Study sample not representative of the people most likely to need pressure injury prevention – very young and healthy • Coir mattress is very thin and not very supportive 	Indirect evidence (healthy volunteers)
Peterson, Healey, Jacobus Visser, Crombie, & Ledet, 2016	Laboratory study to parametrically evaluate interface array sizes, shapes and patterns	<ul style="list-style-type: none"> • Finite Element Analysis using a previously validated finite element model adapted to predict the effect of support geometries on superficial and deep tissue pressures. 	Not applicable	<p>Pressure mapping:</p> <p>Pressure mapping was utilized to measure seat interface pressures as volunteers sat on different interface support arrays</p>	<p>Finite element analysis</p> <p>Maximum superficial tissue pressures occurred over the individual supports of the support array and maximum deep tissue pressures occurred at the ischial tuberosity</p>	Only evidence from lab with a phantom	Indirect evidence (lab study)

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	for dynamic support surfaces to optimize pressure redistribution to prevent pressure injuries	<ul style="list-style-type: none"> Anatomical phantom testing: An anatomical phantom was fabricated to measure the deep pressures adjacent to the ischial tuberosities and the sacrum using manometers for different support array configurations while being loaded in a mechanical testing machines 			<p>Anatomical phantom testing Deep pressures array with the anatomical phantom. The magnitudes of pressure were consistently greatest at the center of the ischial tuberosities.</p> <p>Pressure mapping</p> <ul style="list-style-type: none"> Peak pressures were always located at the ischial tuberosities. Pressures were highest at the location where the supports contacted the user and were lowest in the unsupported regions (the gaps between supports). In all regularly spaced arrays (rows and columns) of longitudinal cylinders, axial cylinders and spheres, there was hammocking, or high pressure between supports. <p>Conclusions: Hammocking of tissues between supports results in high pressures, even in areas that are unsupported. This is a potential shortcoming of existing dynamic support surfaces</p>	supports and the pattern of the array.	
Hui, Feng, Wong, Ng, & Lin, 2017	To investigate the main and cross-over effects among BMI, body position, and supporting material properties on pressure	<p>Study was conducted with healthy individuals in Hong Kong (n=10)</p> <p>Inclusion criteria:</p> <ul style="list-style-type: none"> Able-bodied Asian adults <p>Exclusion criteria:</p> <ul style="list-style-type: none"> Not stated 	<ul style="list-style-type: none"> Interfacial pressures were measured in lying and sitting positions on four different thickness of two different types of foam. In the lying position the interface pressure was measured between the subject and the 	<ul style="list-style-type: none"> Reduction of pressure in percentage at various positions, reduction % = $\frac{[\text{Pressure (without foam)} - \text{Pressure (with foam)}]}{\text{Pressure (without foam)}} \times 100\%$ Material stiffness (compression modulus): measured using a tensile tester, when the sample 	<p>Reduction of pressure</p> <ul style="list-style-type: none"> Regardless of density and thickness of foam at head, shoulder, and in sitting position, there is increased pressure reduction from BMI-1 group to BMI-2 group. At hip, there is decreased pressure reduction from BMI-1 to BMI-2 group although there is increased pressure 	<ul style="list-style-type: none"> Limitation - limited amount of sample data for analysis Comments: In future research, - additional groups of people should be added 	Indirect evidence (laboratory study with healthy volunteers)

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	relieving performance.	Participant characteristics : <ul style="list-style-type: none"> • 8 females, 2 males • Three BMI groups: Normal: 18.5 – 22.9 Marginal heavy: 23-24.9 Heavy: 25 – 29.9 	supporting material at five body positions (head, shoulder, hip, lower leg, heel). Measurement of the interface pressure without sample material served as control. <ul style="list-style-type: none"> • In the sitting position, the pressure mat was placed between the hip and a piece of the sample material (30 cm x 40 cm). Measurement of interface pressure without sample material served as the control. 	was compressed 0% to 90% of its thickness <ul style="list-style-type: none"> • Pressure relieving (%) at various body positions 	reduction from BMI-2 group to BMI-3 group. <ul style="list-style-type: none"> • Beyond 3.81 cm thickness of low density foam, there is relatively high pressure reduction regardless of BMI or body position. • Interface pressure was significantly reduced regardless of BMI group, body position, and foam thickness except high density foam placed under lower leg. <p>Materials stiffness (compression modulus) Compression modulus of low density PU foam lower than high density foam at three stages of extensions There is low stress for extension of foam material from 10% to 80%.</p> <p>Pressure relieving (%) at various positions The foam density, K2 modulus, K3 modulus values were significant factors for pressure relieving performance in all positions regardless of BMI.</p>	- other supporting materials, such as 3-D spacers with various constructions and thicknesses, should be added -	
Worsley, Parsons, & Bader, 2016	Observational study evaluating biomechanical and physiological responses to a fluid immersion simulation mattress	Participants were healthy volunteers (n=17) Characteristics: <ul style="list-style-type: none"> • Mean age 60 years (range 24 to 81) • BMI range 20.3 to 32.5kg/m² 	<ul style="list-style-type: none"> • In laboratory settings at 20°C the following protocol was followed: <ul style="list-style-type: none"> ○ 15 min laying for baseline measure of gas responses ○ Mattress configuration to one of three randomly allocated postures (supine, high 	<ul style="list-style-type: none"> • Transcutaneous oxygen and carbon dioxide gas responses recorded using gas tension electrode continuously at the sacrum during test condition • Results normalized to baseline and then categorized as Category 	<p>Gas response</p> <ul style="list-style-type: none"> • 82% participants exhibited a Category 1 or Category 2 response during all test postures • 17% had Category 3 response in all test conditions • 1% had Category 3 response in lateral lying with low immersion (participant had low BMI) 	<ul style="list-style-type: none"> • Small trial with healthy volunteers 	Indirect evidence (healthy volunteers, PU not an outcome measure)

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			sitting, lateral tilt) using bed frame control and (for tilt) pillow support ○ Maintain posture for 10 mins ○ Repeat in other postures until all three postures tested • Above protocol was repeated for low, medium and high immersion	1 (minimal change in both TcPO ₂ and TcPCO ₂), Category 2 (>25% decrease in TcPO ₂ and minimal change in TcPCO ₂) or Category 3 (>25% decrease in TcPO ₂ and >25% increase in TcPCO ₂) • Interface pressure and microclimate measured mid-point of test condition • Comfort rated by participants using a 5-point verbal scale	Interface pressure and microclimate • Peak pressure was lower under sacrum than the rest of the body (median 21-27mmHg at sacrum) but not significantly different based on immersion or posture • Supine and high sitting temperature at sacrum ranged between 30.1 to 30.6°C and relative humidity ranged between 42.3 to 44.5% • Lateral tilt temperature at sacrum decreased by 1.7 to 2.5°C and relative humidity decreased by 3.3 to 5.35% Comfort • Low and medium immersion was rated comfortable by 71% • Comfort was significantly lower in high immersion and bottoming out occurred Author conclusion: fluid immersion simulation mattress provides pressure redistribution with maintenance of high tissue perfusion over sacrum for individuals with normal to high BMI		
Duetzman et al., 2015	To assess peak sacral pressure before and after use of a liquid-based pad and compare results between healthy participants	2-phase single-centre cohort study Phase 1 - healthy volunteers from local office block Phase 2 - patients with a SCI on a hospital ward in America Phase 1 n=12 Inclusion criteria: - age 18-65 yrs	Pressure-mapped whilst in supine on a mattress for 15 mins with and without pad Liquid Pad – PURAP liquid pad Phase 2 participants were on either Accumax mattress (reactive air/foam,	Primary: - average peak pressure over 15 min - average peak pressure over first minute - average peak pressure over last minute Secondary: comfort of pad	Use of pad significantly decreased mean sacral pressures in both phases (32% (range 19-46%) in phase 1; 23% (range 11-42%) in phase 2) No correlation between BMI and decrease in peak pressure (Pearson's r=0.23, p=0.18)	• Phase 2 participants were on average twice as old as Phase 1 participants • Small sample sizes in both phases • Potential observer bias	Indirect evidence (PU not an outcome measure, healthy volunteers)

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	and patients with a SCI	<p>- BMI 18-40</p> <p>Exclusion criteria:</p> <ul style="list-style-type: none"> - serious medical condition - recent weight loss (BMI reduction > 20% in last 3 mths) - inability to consent - pregnant - prisoner <p>Phase 2 n=10</p> <p>Inclusion criteria:</p> <ul style="list-style-type: none"> - SCI with surgery on the spine in the last week - age 18-80 yrs - BMI <25 <p>Exclusion criteria:</p> <ul style="list-style-type: none"> - inability to consent - pregnant - prisoner 	Hill-Rom) or P500 mattress (active air, Hill-Rom) based on clinical need and availability and were asked to be as mobile as they would be if not in the study		<p>In both phases, pressure over time increased without the pad but remained stable with the pad (Wilcoxin, $p < 0.001$ for both phases)</p> <p>70% noted an increase in comfort, 30% no change in comfort, 0% noted a decrease in comfort</p> <p>AUTHOR CONCLUSION: Use of the pad may be beneficial in circumstances when mattresses cannot be employed to reduce sacral peak pressure and aid prevention of pressure injuries.</p>	<p>may result in increased reporting of comfort changes</p> <ul style="list-style-type: none"> • Further research indicated to look at pressure injury incidence or healing to incorporate factors such as sweating or incontinence against the pad. • Unclear if study used only the liquid pad from the PURAP cushion or the whole cushion 	
Turnage-Carrier, McLane, & Gregurich, 2008	Quasi-experimental investigating interface pressure between occiput and different support surfaces in children	<p>Participants were recruited from an inpatient level II hospital nursery (n=13, n=11 completed study)</p> <p>Inclusion:</p> <ul style="list-style-type: none"> • healthy premature infants of post-menstrual age (PMA) 35 to 37 weeks • feeding and gaining weight • in an open crib • within 1 to 3 weeks of discharge • no history or diagnosis of a skin disorder <p>Exclusion:</p>	<ul style="list-style-type: none"> • All participants were positioned on 5 different support surfaces in a random order for 3 to 5 minutes. • The 5 bed surfaces were: <ul style="list-style-type: none"> ○ Standard crib mattress with 2.75" foam overlay ○ Standard crib mattress without foam overlay ○ Gel pillow ○ Gel mattress ○ Water pillow – 288mL water • Crib blanket was placed over the standard crib 	<ul style="list-style-type: none"> • Interface pressures obtained under the occiput using an interface (IF) pressure evaluator and recorded in mmHg • Three measurements were taken on each surface 	<ul style="list-style-type: none"> • No significant differences between the readings for participants • A significant difference in the mean of the IF pressures between each mattress and the standard crib mattress was established ($p < 0.001$) • Mattress with foam overlay had the lowest IF pressure (mean 31mmHg) and standard mattress had the highest IF pressure (86.9mmHg) <p>Study conclusions: A foam mattress overlay is associated with lower occipital IF pressure in babies</p>	<ul style="list-style-type: none"> • Infant movement could alter interface pressures • Observable differences in head shape could have influenced the IF pressures 	Indirect evidence (PU not an outcome measure)

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		<ul style="list-style-type: none"> Supplemental oxygen Apnea, bradycardia, active infection, cardiopulmonary disease, congenital abnormality, skin disorder, trauma, hydrocephaly, cephalohematoma, caput succedaneum or birth injury of head/neck. <p>Characteristics:</p> <ul style="list-style-type: none"> Mean age 30.2 gestational weeks, mean PMA 36.1 weeks Mean weight 2556.9g 	mattress, the gel mattress and the foam overlay and a new disposable cover was placed over the gel pillow.				
Posada-Moreno et al., 2011 (micro climate)	Quasi-experimental study investigating the effect of different mattress coverings on skin surface temperature	<p>Participants were healthy volunteers. Participants acted as own controls. (n=31)</p> <p>Characteristics:</p> <ul style="list-style-type: none"> Not taking medications No known pathology or illicit drug use Mean age 24.83±2.38 yrs (range 19 to 29) 55% sample female 	<p>Temperature of examination room controlled between 22 and 25°C</p> <ul style="list-style-type: none"> Participants lay without motion in the supine position in contact with three different mattress surfaces The same standard foam cushion was used and the surface cover was varied: <ul style="list-style-type: none"> Cover 1: conventional cotton cover Cover 2: conventional cotton cover with small plastic film underneath Cover 3: plastic protective case 	<ul style="list-style-type: none"> Baseline temperature measured at axilla Skin temperature measured at 7 areas (sacrum, right and left scapula, right and left elbow, right and left calcaneus) Temperature measurements were taken every minute for the first 15 min, followed by a measurement at 30 min, 45 min and then every minute until 60 minutes. 	<ul style="list-style-type: none"> Skin temperature dropped at most thermometer points for all types of cover compared with baseline (p<0.001 for most body points and covers) Plastic covering produced a larger increase in local temperature at all extremities 	<ul style="list-style-type: none"> Small sample of young adults with no pathology Baseline temperature was taken at axilla and study measures were taken at extremities, therefore drops in temperature from baseline should be expected 	Indirect evidence

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Ref	Type of Study	Sample	Intervention(s)	Outcome Measures & Length of Follow-up	Results	Limitations and comments	
Futamur a, Sugama, Okuwa, Sanada, & Tabata, 2008 (potential adverse effects)	Quasi-experimental investigating impact of an automated turning ability in a low air-cell mattress on heart rate	n= 10 bedridden women with verbal communication difficulties	<ul style="list-style-type: none"> Participants were nursed on the NEO® air cell mattress. The air cell mattress has an automatic turning function in which two inflation cells aligned parallel to the patient at either side of the bed alternatively inflate to incline the body. Participants acted as own controls for two study periods: <ul style="list-style-type: none"> Control period: 1-week in which air cell mattress was used without the automated turning function and repositioning was performed by staff Experimental period: 1-week during which the automated turning function of the air-cell mattress was applied at night 	<ul style="list-style-type: none"> Degree of comfort High frequency(HF) components of heart rate (parasympathetic activity) variability measured via insitu electrodes providing measures overnight 	<ul style="list-style-type: none"> No significant differences in the HF component associated with automated turning were observed in 5 of the participants Significant increases in the HF component were observed in 3 participants associated with the automated turning 2 participants with the lowest body mass index values exhibited a significant reduction in the HF component during the automated time period Study conclusions: automated tilting bed does not appear to significantly influence HF components of heart rate in most participants. 	<ul style="list-style-type: none"> The relationship between HF heart rate and comfort is not established The relationship between HF heart rate and PU risk is not established 	Indirect evidence Quality: low

Additional evidence from systematic reviews to support discussion

Ref	Type of Study	Types of studies	Types of participants	Intervention(s)	Results	Limitations and comments	
McInnes et al., 2015	Systematic review exploring the effectiveness	59 RCTs and quasi-RCTs included <ul style="list-style-type: none"> Only 49% of trials reported method of randomization and 34% 	Constant low pressure support surfaces (e.g. standard foam; high specification foam; fiber-	Incidence of new PUs measured using objective clinical outcome measures	Standard foam hospital mattress compared with high specification foam mattresses (5 trials, 0 new since 2014 guideline)	<ul style="list-style-type: none"> All the trials reported in this review that meet the guideline inclusion criteria 	Quality: high

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	<p>of support surfaces in preventing pressure ulcers</p>	<p>reported allocation concealment.</p> <ul style="list-style-type: none"> • Only 20 trials reported that there was blinded outcome assessment, only 47% adequately addressed incomplete data. • 69% of trials reported baseline comparability and 66% reported measuring outcomes at the same time. 	<p>filled; air, water or bead filled; sheepskins) compared to each other or to high tech support surfaces (alternating pressure, air-fluidized, low-air-loss)</p> <p>Overlays Turning beds/frames Seating cushions Limb protectors</p>	<p style="text-align: center; opacity: 0.5; font-size: 2em; transform: rotate(-30deg);"> (c) EPUAP/NPIAP/PPPIA Not for reproduction </p>	<p>Risk ratio (RR) 0.40, 95% CI 0.21 to 0.74, p=0.004</p> <p>High specification foam mattresses compared with each other Insufficient evidence to select one type over another</p> <p>Other constant low pressure surfaces compared with one another Insufficient evidence to select one type over another</p> <p>Sheepskin versus no sheepskin for preventing all Categories of PU (3 trials, 0 new since 2014 guideline) RR 0.48, 95% CI 0.36 to 0.64, p<0.0001</p> <p>Alternating pressure versus standard mattresses (2 trials, 0 new since 2014 guideline, high risk of bias) RR 0.31, 95% CI 0.17 to 0.58, p=0.0002)</p> <p>Alternating pressure versus constant low pressure surfaces Silicore vs foam overlay, 4 trials (none since 2014 guideline) Relative risk (RR) 0.91 95% CI 0.72 to 1.16, p=ns</p> <p>Author conclusions: For people at high risk of developing PU higher-specification foam mattresses rather than standard hospital foam mattresses should be used. Relative merits of higher-tech constant low-pressure and alternating-pressure for prevention of PU are unclear.</p>	<p>have been included in the guideline.</p> <ul style="list-style-type: none"> • Most of the studies in the review are at moderate to high risk of bias • Two previous versions of this review are included in the guideline and the conclusions have not change in this updated version (there is 6 new trials) 	
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<p>McInnes, Jammali-Blasi, Bell-Syer, & Leung, 2018</p>	<p>Systematic review exploring the effectiveness of support surfaces in treating pressure ulcers</p>	<ul style="list-style-type: none"> • Included only RCTs, generally of low quality • Includes 5 studies on reactive support surfaces (all early studies, only 1 included in the guideline) • Includes 9 studies on active support surfaces (all early studies, not included in the guideline) 	<ul style="list-style-type: none"> • Low tech support surfaces vs any comparison • High tech support surfaces vs any comparison 	<p>Healing of pressure injuries</p>	<p>Water mattress overlay vs low tech mattress no significant difference for healing pressure injuries in 4 weeks RR 0.93, 95% CI 0.63 to 1.37)</p> <p>Low air loss bed vs low tech mattress overlay No significant difference in pressure injury healing in older adults in 33 to 40 days RR 1.30, 95% CI 0.87 to 1.96, p=0.20</p> <p>Alternating pressure mattress vs control</p> <ul style="list-style-type: none"> • no significant difference for complete healing pressure injuries in 4 weeks: RR 0.57, 95% CI 0.26 to 1.27, p=0.17 • No significant difference in decrease in pressure injury size over 4 weeks: RR 0.58, 95% CI 0.21 to 1.65, p=0.31 • No significant difference in complete healed pressure injuries at 18 months RR 0.99, 95% CI 0.90 to 1.09, p=0.77 <p>Alternating pressure mattress vs air filled mattress No significant difference in proportion of people with complete pressure injury healing: RR 5.50, 95% CI 0.73 to 41.44, p=0.098</p>	<ul style="list-style-type: none"> • All the studies in the review are at moderate to high risk of bias • 	<p>High</p>
<p>Demarré et al., 2013</p>	<p>Pooled analysis of results from two different RCTs to compare the</p>	<p>Include the following information:</p> <ul style="list-style-type: none"> • Number of participants: Data were pooled (N=617) from an RCT 	<p>The main differences among the three groups were: 1) type of support surface, 2) air cell pressures, 3) method of inflating and deflating the air cells, 4) use of a sensor, and</p>	<ul style="list-style-type: none"> • When/how/ by whom pressure injuries/other outcomes were measured - In both studies, skin assessment was performed 	<p>Outcome 1 Cumulative incidence of all pressure ulcers: - No significant differences in PU development were found between patients on the APAM overlay and those</p>	<ul style="list-style-type: none"> • Limitations: - Lack of randomization within the pooled sample, which can lead 	<p>Quality: high</p>

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<p>effectiveness of multi-stage and one-stage alternating low pressure air mattresses (ALPAM) and alternating pressure air mattress (APAM) overlays in preventing pressure ulcers among hospitalized patients</p>	<p>of patients at risk of pressure ulcer allocated to multi-stage ALPAM (n=252) or one-stage ALPAM (N=264) and a second RCT of patients also at risk of pressure allocated to APAM overlay (N=101)</p> <ul style="list-style-type: none"> • Clinical setting <ul style="list-style-type: none"> - APAM study: 1 of 19 surgical, medical, and geriatric wards in a convenience sample of seven Belgian hospitals - ALPAM study: Eight geriatric wards and 17 medical wards in five Belgian hospitals • Country: Belgium for both studies • Inclusion criteria: <ul style="list-style-type: none"> - Braden score < 17 - Admitted to a geriatric or internal medicine ward • Exclusion criteria: <ul style="list-style-type: none"> - No pressure ulcer of any category / stage at start of study • Participant characteristics and any baseline differences <ul style="list-style-type: none"> - Median age was 80 years - 60.1% were female 	<p>5) preventative measures at the heels.</p> <p>APAM: overlay, steep / single-staged inflation – deflation, all cells except three at the head zone (continuous low pressure) alternated inflation-deflation, no heel off-loading</p> <p>One-stage ALPAM: mattress replacement, steep inflation – deflation of air cells, all air cells alternated, mattress manually adjusted to patient's weight with external control unit, no heel off-loading</p> <p>Multi-stage ALPAM: Mattress replacement, air cells gradually inflated and deflated, air cells at spine and sacrum alternated, sensor at sacrum continuously measured weight distribution and adjusted pressure in the cells, air cells at head and heels had continuous low pressure, no heel off-loading</p>	<p>by the ward nurses on a daily basis</p> <ul style="list-style-type: none"> • Staging system used: NPUAP / EPUAP (2009) • Follow up period: For 14 days after study inclusion 	<p>on one-stage ALPAM (OR = 0.40; 95% CI [0.14, 1.10])</p> <ul style="list-style-type: none"> - Fewer severe PU developed in multi-stage ALPAM group compared with APAM overlay group (OR=0.08; 95% CI [0.01, 0.83]). - No difference in incidence of superficial PU among three study groups. - More PU developed in higher risk patients, with Braden scores between 6 and 9, than in patients with braden score between 15 and 16 (OR 5.23; 95% CI [1.67, 16.32]) <p>Outcome 2 Median time to develop a pressure ulcer was 8 days (IQR=4.00-12.25).</p> <p>No difference in time to ulcer was found among the three groups.</p> <p>Probability of remaining ulcer free did not differ among the three groups.</p> <p>Conclusion: A multi-stage ALPAM was more effective than an APAM overlay at reducing PU incidence.</p>	<p>to unequal distribution of baseline characteristics</p> <ul style="list-style-type: none"> - Use of cut-off Braden score of 17 - time lapse of 7 years between APAM overlay study and ALPAM study. - Absence of twice daily re-assessment of non-blanching erythema - Lack of blinded skin assessment <ul style="list-style-type: none"> • Any comments on results, design, funding, conflict of interest, power • Comment • Further research is needed to confirm these results
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		<ul style="list-style-type: none"> - Most frequent admission diagnoses: neurological (25.9%), rehabilitation disorders (23.4%), and pulmonary disorders (17.9%) - Median Braden score 14 (IQR = 12-15). - Significantly older patients (P=.03) in APAM group (Mdn = 81) - More APAM patients care for in the geriatric wards 					
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Table 1: Level of Evidence for Intervention Studies

Level 1	Experimental Designs <ul style="list-style-type: none"> • Randomized trial
Level 2	Quasi-experimental design <ul style="list-style-type: none"> • Prospectively controlled study design • Pre-test post-test or historic/retrospective control group study
Level 3	Observational-analytical designs <ul style="list-style-type: none"> • Cohort study with or without control group • Case-controlled study
Level 4	Observational-descriptive studies (no control) <ul style="list-style-type: none"> • Observational study with no control group • Cross-sectional study • Case series (n=10+)
Level 5	Indirect evidence: studies in normal human subjects, human subjects with other types of chronic wounds, laboratory studies using animals, or computational models

Table 2: Levels of evidence for diagnostic studies in the EPUAP-NPUAP-PPPIA guideline update

Level 1	Individual high quality (cross sectional) studies according to the quality assessment tools with consistently applied reference standard and blinding among consecutive persons.
Level 2	Non-consecutive studies or studies without consistently applied reference standards.
Level 3	Case-control studies or poor or non-independent reference standard.
Level 4	Mechanism-based reasoning, study of diagnostic yield (no reference standard). Low and moderate quality cross sectional studies.

Table 3: Levels of evidence for prognostic studies in the EPUAP-NPUAP-PPPIA guideline update

Level 1	A prospective cohort study.
Level 2	Analysis of prognostic factors amongst persons in a single arm of a randomized controlled trial.
Level 3	Case-series or case-control studies, or low quality prognostic cohort study, or retrospective cohort study.

APPRAISAL FOR STUDIES PROVIDING DIRECT EVIDENCE (i.e. ELIGIBLE FOR SUPPORTING AN EVIDENCE-BASED RECOMMENDATIONS)

Each criteria on the critical appraisal forms was assessed as being fully met (Y), partially met or uncertain (U), not met/not reported/unclear (N), or not applicable (NA). Studies were generally described as high, moderate, or low quality using the following criteria:

- High quality studies: fully met at least 80% of applicable criteria

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- Moderate quality studies: fully met at least 70% of applicable criteria
- Low quality studies: did not fully meet at least 70% of applicable criteria

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CROSS SECTIONAL/SURVEY/PREVALENCE STUDIES/OBSERVATIONAL

Endnote ID	Author/year	Focused question	Sampling method	Representative sample	States number invited participants	Clear outcome measures	Valid reliable outcome measurement	Comparable results for multiple sites	Confounders identified and accounted for	Minimal bias	Reliable conclusions	Level of evidence	Quality
10741	Lee et al., 2016	Y	N	N	Y	Y	U	N/A	N	U	U	Indirect evidence	low
3105	Fletcher et al., 2014	Y	N	N	N	Y	U	NA	N	U	N	4	low
16282	Fletcher et al., 2016	N	N	N	N	N	U	Y	Y	Y	U	4	low
16210	Gleeson, 2016b	Y	N	N	N	N	N	NA	N	N	N	4	low
8834	Gleeson, 2015b	N	N	N	N	N	U	NA	N	N	N	4	low
15197	Meaume et al., 2017	Y	Y	Y	N	Y	Y	U	Y	Y	Y	4	High
3160	Newton, 2014	Y	U	Y	Y	N	N	U	N	U	U	4	low
16831	Stephen-Haynes & Callaghan, 2017	Y	N	N	N	Y	Y	NA	N	Y	N	4	Low

RCTS

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Endnote ID	Author/year	Focused question	Assignment randomised	Adequate concealment method	Subjects and investigators blinded	Groups comparable at commencement	Only difference btw groups was treatment	Valid, reliable outcome measure	% drop out in study arms is reported and acceptable	Intention to treat analysis	Comparable results for multiple sites	Minimal bias	Reliable conclusions	Level of evidence	Quality
14653	Sauvage et al., 2017	Y	Y	Y	N	Y	Y	Y	N	Y	NA	Y	Y	1	moderate
8923	Ozyurek & Yavuz, 2015	Y	Y	Y	U	Y	Y	Y	U	U	N	Y	U	1	moderate
15109	M. van Leen et al., 2018	Y	Y	U	N	Y	Y	Y	Y	U	U	Y	Y	1	low
1434	M. Van Leen et al., 2013	Y	Y	Y	N	Y	N	Y	Y	Y	NA	Y	Y	1	high
14738	Park & Park, 2017	Y	Y	N	N	Y	Y	Y	Y	Y	NA	Y	Y	1	moderate
7811	Ricci et al., 2013	N	U	U	U	Y	Y	Y	Y	N	U	U	U	1	Low

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CASE SERIES

Author/year	Focused question	Participant characteristics reported	Inclusion criteria defined	Consecutive recruitment	Participants entered at same disease stage	Intervention clearly reported	Outcomes relevant and defined	Valid, reliable outcome measurement	Per cent drop out reported and acceptable	Estimates of random variability	Comparable results for multiple sites	Minimal bias	Reliable conclusions	Level of evidence	Quality
12864 Mossman & Hampton, 2016	Y	Y	Y	N	N	N	Y	U	NA	N	U	N	N	4	low
3048 Girolami et al., 2014	N	Y	Y	U	U	N	Y	N	N	N	U	N	N	4	Low

COHORT STUDIES

Author/year	Focused question	Comparable source populations	States number invited	Likelihood of outcome at enrollment considered	Per cent drop out in study arms is reported	Comparison btw drop outs and participants	Clear outcome measures	Assessment blinded, or discuss potential bias	Valid, reliable assessment with supporting	More than one measure of exposure	Confounders identified and accounted for	Provides confidence intervals	Minimal bias	Reliable conclusions	Level of evidence	Quality
13724 Serraes & Beeckman, 2016	Y	Y	Y	Y	Y	N	Y	N	Y	Y	N	Y	Y	U	3	Moderate
9353 Meaume & Marty, 2015	Y	Y	Y	Y	Y	N	Y	N	U	U	Y	Y	Y	U	3	Moderate
8831 Emejulu et al., 2015	Y	U	N	N	N	N	Y	N	U	U	N	N	U	Y	3	Low

QUASI EXPERIMENTAL STUDIES

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Author/year	Focused question	Subjects and investigators blinded	Groups comparable at commencement	Only difference btw groups was treatment	Valid, reliable outcome measurement	Per cent drop out in study arms is reported and acceptable	Intention to treat analysis	Comparable results for multiple sites	Minimal bias	Reliable conclusions	Level of evidence	Quality
6691 Vilchis-Aranguren et al., 2015	Y	N	Y	Y	N	Y	N	N/A	N	U	indirect	low

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SYSTEMATIC REVIEWS FOR DISCUSSION

RATING CRITERIA:	
1	Partial yes: states review question, search strategy, in/exclusion criteria and risk of bias were a-priori; full yes: meta-analysis/synthesis plan, investigation of heterogeneity and justification for protocol deviation
2	Partial yes: At least 2 databases, provides keywords and search, justifies publication restrictions; full yes: searched reference lists of included studies, searched trial registries, consulted experts in field, searched grey literature, search within 24 months of review completion
3	At least two reviewers independently agreed on selection of studies to include or reviewers achieved 80% agreement on a sample of studies
4	Either two reviewers did data extraction and had >80% agreement, or two reviewers reached consensus on data to extract
5	Partial yes: list of all relevant studies that were read and excluded; full yes: every study that was excluded is independently justified
6	Partial yes: described populations, interventions, comparators, outcomes and research design; full yes: detailed descriptions of same plus study setting and timeframe for follow-up
7	FOR RCTS Partial yes: appraised risk of bias from unconcealed allocation and lack of blinding; full yes: appraised risk of bias on true randomisation, selection of reported result from multiple measurements/analyses
	FOR non randomised studies: Partial yes: appraised confounding and selection bias; full yes: appraised methods to ascertain exposures and outcomes, selection of reported result from multiple measurements/analyses
8	Must include reporting of the source of funding of individual studies, or reports that the reviewers considered this even if individual funding sources aren't listed in review

Endnote ID	Author/year	PICO research question and inclusion criteria	Explicitly states a-priori protocol ¹	Rationale for selection of study designs	Comprehensive search ²	Duplicate study selection ³	Duplicate data extraction ⁴	Excluded studies listed ⁵	Adequate description of included studies ⁶	Risk of bias assessed ⁷	Source of funding reported ⁸	Appropriate meta-analysis including weighting and adjustment for heterogeneity	Meta-analysis considers risk of bias of studies	Discussion consider risk of bias of studies	Assessment of publication bias if quantitative analysis is done	Potential conflicts of interest of authors reported and managed	Review Quality
10800	McInnes et al., 2015	Y	Y	N	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	High
9669	Folan, Downie, & Bond, 2015	Y	N	N	Y	Y	Y	N	Y	Y	N	NA	NA	Y	N	Y	Exclude
17850	McInnes et al., 2018	Y	Y	N	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	High

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