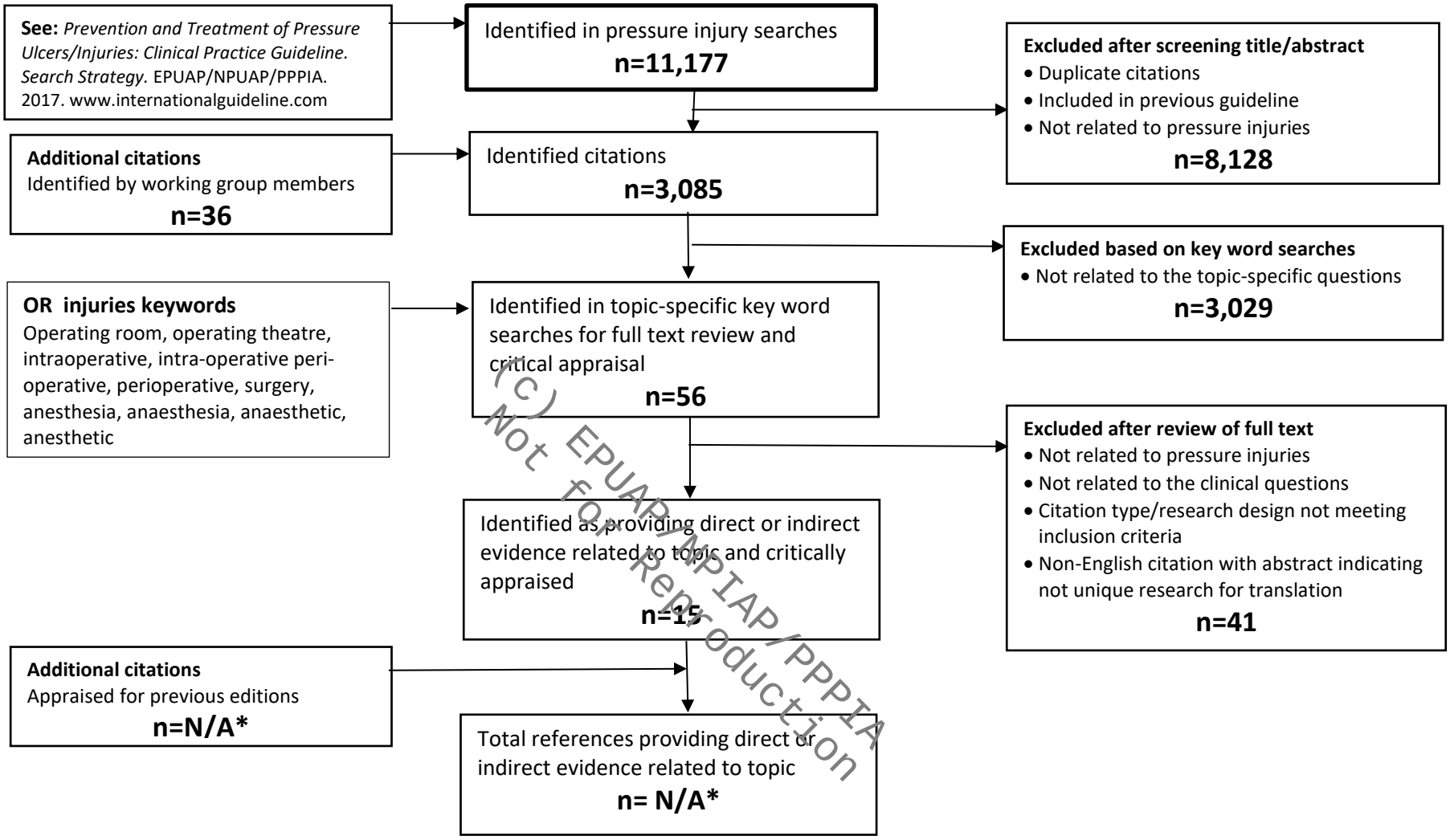
Search results for 2019 International Pressure Injury Guideline: Individuals in the Operating Room



* Recommendations related to all special populations are included in the topics to which the recommendation relates (e.g. support surfaces), and the references supporting these recommendations are included in the search reports for those topics.

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

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 1: What are the unique pressure injury risk factors to consider for individuals in the operating room?							
Lin et al., 2017	Retrospective cohort study investigating risk factors for pressure injury in people undergoing posterior lumbar and/or thoracic surgery	Participants were recruited in one spine service in Singapore (n=209) Inclusion criteria: • Adults having posterior lumbar and/or thoracic spinal surgery on a Jackson table Exclusion criteria: • sedation or local anaesthesia for procedure • Existing pressure injury Participant characteristics:	N/A	• Pressure injury Stage 1 or greater assessed using NPUAP staging system • Skin assessments conducted at immediate postop, 24 hours postop, 48 hours postop • Daily Braden scale score • Multivariate logistic analysis • Risk factors collected: (n=27) including gender, smoking, diabetes, cancer, antiplatelet use, previous skin problems, Braden scale score, myelopathy, radiculopathy, non-specific numbness, spinal deformity, lumbar prolapse, cervical myelopathy, lumbar spinal	**Pressure injury incidence** 23% (48 Category./Stage I PU and 2 Category/Stage II pressure injuries) **Multivariate analysis (5 factors significant)** • Previous skin problems OR not reported, p=0.034 • Myelopathy, OR 4.79, p=0.013 • Spinal deformity, OR 3.31, p=0.010 • Operative time >300 mins, OR 8.12, p=0.005 • Levels of surgery > 4, OR 9.10, p=0.006	• Included in risk chapter, only consider factors specific to operating room • Insufficient number of events • Cutoffs and categorical factors not clearly defined • Unclear if full sample included in analysis	**Level of evidence: 3 (prognostic)** **Quality: low**

Ref	Type of Study	Sample	Intervention(s)	Outcome Measures & Length of Follow-up	Results	Limitations and comments	
				stenosis, spondylolisthesis, spinal metastasis, anterior surgical approach, posterior surgical approach, surgery with fusion, ASA grade, height, weight, BMI, operative time, number of screws, levels of surgery			
Chen, Zhu, Wei, & Zhou, 2018	Retrospective cohort study exploring pressure injury risk factors in people undergoing surgery for hip fracture	Participants were recruited In a tertiary hospital in China (256 (21 missing data) 235 pts study population Inclusion criteria: Adults hip fracture at risk on Braden scale Exclusion criteria: PU on admission, death	N/A	• Skin inspections	**Pressure injury incidence** 31 pts with 37 (13.2%) Stage ≥1 PU **MV analysis** Only Braden scale was a significant risk factor Length of surgery, haemoglobin and albumin were not significant	• Included in risk chapter • Insufficient number of results • Unclear risk factor measurement methods	**Level of evidence: 3 (prognostic)** **Quality: low**
Shaw, Chang, Lee, Kung, & Tung, 2014	Prospective cohort study Exploring risk factors for pressure injury in people having surgery	Participants were recruited in a surgical department in Taiwan (n=297) Inclusion criteria: Adults admitted for first elective procedure under spinal or general anaesthesia >30mins, consent to participate, communicate in Mandarin or Taiwanese Exclusions: pre-existing PU or trauma	N/A	• Logistic regression	**Pressure injury incidence** • Immediately post-operative, incidence was 9.8% • (29 Stage 1 PU) • 30 minutes post-operative, incidence was 5.1% (15 Stage 1 PU) **MV analysis** • Significant factors: Age, type of anaesthesia [general anaesthesia or not], operation position (nonsupine vs supine), type of surgery (orthopaedic vs general), admission Braden score, number of nursing interventions	• Included in risk chapter • Inadequate number of events. • Some PUs resolved within 30 mins	**Level of evidence: 3 (prognostic)** **Quality: low**

Ref	Type of Study	Sample	Intervention(s)	Outcome Measures & Length of Follow-up	Results	Limitations and comments	
					• Not significant: Gender, Heat Lung machine use, Type of surgery (cardiac vs general), Type of surgery (neuro vs general)		
Yoshimura et al., 2015	Retrospective cohort study exploring pressure injury risk factors in people have neurosurgery	Participants were recruited in a neurosurgery department in Japan (n=277) Inclusion criteria: Adults undergoing elective surgery in park bench position who had no pressure injury prior to surgery, with written informed consent Exclusion: repeated surgery or missing risk assessment	N/A	• Multivariate logistic stepwise regression	**Pressure injury incidence** • Incidence was 11% (29 PU Grade 1 and 1 PU Grade 2) **MV analysis** • Presence of perspiration was significant • Surgery length > 6 hours / Core temperature > 38.1C as a hybrid factor was significant (OR 8.45, 95% CI 3.04 to27.46 p<0.001)	• Included in risk chapter • Timing of development of perspiration and PU during surgery is unclear • few risk factors • poor definition of perspiration • data derived cut points	**Level of evidence: 3 (prognostic)** **Quality: low**
Chen, Shen, Xu, Zhang, & Wu, 2013	Retrospective cohort study exploring relationship between perioperative corticosteroids as a risk factor for pressure injuries	Participants were consecutive cardiac patients over one year at one hospital in China (n=286) Inclusion criteria: Adults and children undergoing cardiac or aortic surgery Exclusion criteria: Not admitted to a cardiac ICU post surgery Participant characteristics: • Mean age 46.9±22.1 years (range 2 to 84) • 55.9% male • People who developed pressure injuries were older (p=0.017)	N/A	• Record review, does not report how pressure injuries were assessed • Used NPUAP classification • Logistic regression model	**Pressure injury incidence** • Surgical related pressure injury incidence was 16.4% (95% CI 12.3 to 21.2%) • Category/Stage I pressure injuries 97.9%, Category/Stage II pressure injuries 2.1% • 14.9% developed more than one pressure injury • Most common locations sacrum/coccyx 50.9%, heels 22.8%, tuberosities 910.5%) **MV analysis** 9 factors included in model, two factors significant • Corticosteroids odds ratio 2.808, 95% CI 1.063 to 9.769, p=0.042 • Length of surgery OR 1.005, 95% CI 1.000 to 1.011, p=0.036	• Not eligible for risk section due to study including children • Insufficient events • Unclear numbers with missing data • Method of assessment not reported	**Level of evidence: 3 (prognostic)** **Quality: low**

Ref	Type of Study	Sample	Intervention(s)	Outcome Measures & Length of Follow-up	Results	Limitations and comments	
Magny et al., 2017	Retrospective study exploring **risks for pressure injury and pressure injury prognostic value**	Participants were recruited in a post-operative unit in France (n=567) Inclusion criteria: • Hip fracture • ≥ 70 years of age Exclusion criteria: • Pathological fracture • Hospitalized when fracture occurred	• N/A	• 6.month mortality • Admission until death or 6 months after surgery • Routine consultation or contacted and interviewed by phone • Secondary end-points: in hospital mortality and 30 days mortality, LOS and complications) • Missing patients were tracked though health care providers, GP	**Pressure injury incidence** • 11.8% pressure injuries, mostly heels (60%) and sacrum (39%). • Severity of the pressure injuries: Category/Stage I (34%, Category/Stage I I (49%), Category/Stage III (9%) and Category/Stage IV (7%). **Risk factors for pressure injuries** • Low serum albumin, chronic atrial fibrillation, coronary artery disease and diabetes • 30 days' mortality (4.1%) and 6 months (14.4%) • Survival rate decreased in the pressure injury group	• Not eligible for risk chapter, no MV analysis • No evaluation of interventions to prevent pressure injuries • No data on the surgery/OR experience	**Level of evidence: 3 (prognostic)** **Quality: low**
Shen, Chen, Xu, Zhang, & Wu, 2015	Retrospective study exploring **relationship between pressure injuries and length of surgery**	Participants were recruited in an operating suite in China (n=286) Inclusion criteria: Cardiac and aortic surgery Exclusion criteria: Not admitted to cardiac intensive care post operatively after cardiac surgery Participant characteristics: • Pediatric and adults, mean age 46.9 years • Male 55.9%	Any Category/Stage II pressure injuries were treated with a hydrocolloid dressing	• Pressure injuries measured and recorded using a tracking and NPUAP staging • Length of surgery defined as time of first incision to wound closure • Demographic data collected from records • Risk factors were documented including medications such as steroids, vasoactive drugs	**Pressure injury incidence** 16.4% (95% CI 12.3%-21.2%) 97.9% of pressure injuries were Category/Stage I Most common locations were sacrum and coccyx (50.9%), heels (22.8%), ischial tuberosities (10.5%) **Covariate analysis for factors associated with pressure injuries** Following factors related to pressure injuries: • Higher mean age (pressure injuries 53.9±16.3 vs no pressure injury 45.5±22.8, p=0.17) • Length of surgery (pressure injuries 259.7±108.9 mins vs no pressure injury 182.6±98.8, p=0.00) • Taking corticosteroids (p=0.46)	• Risk study not eligible for risk section due to no multivariate analysis • Retrospective study relying on medical records • Important risk factors (e.g. Braden Scale) not accessible for some patients	**Level of evidence: 3 (prognostic)** **Quality: low**

Ref	Type of Study	Sample	Intervention(s)	Outcome Measures & Length of Follow-up	Results	Limitations and comments	
					• Disease category (p=0.013) • Non-significant factors were gender, weight, length of cardiopulmonary bypass, intraoperative vasoactive agents, postoperative vasoactive agents • No significant effect for length of surgery in pediatric patients **Author conclusions: for adults, length of surgery is a risk factor for pressure injuries**		
Sasabuchi, Matsui, Lefor, Fushimi, & Yasunaga, 2018	Retrospective observational study **evaluating influence of surgical timing on adverse outcomes including pressure injuries**	Participants were records extracted from a national database spanning 4-year period in Japan (n=208,936) Inclusion criteria: • Surgery for hip fracture • Aged > 65 years Exclusion criteria: • Surgery on day 30 or later • Aged <65 years Participant characteristics: • 22.5% had surgery within 2 days of admission and 77.5% had delayed surgery	N/A	• Review of records • Does not state how pressure injuries were identified or categorized, or timing of their development	**Pressure injury incidence** • More people had pressure injuries in the group that had delayed surgery versus early surgery (1.6% versus 1%, p<0.001) • Early surgery (within 2 days) was significantly associated with pressure injury during hospitalization (odds ratio 0.56, 95%CI: 0.33 to 0.96, p = 0.035)	• Not a prognostic study • Unclear how pressure injuries were assessed • Possibly includes pre-surgery pressure injuries • No other risk factors for pressure injuries were included in modelling	**Level of evidence: 3** **Quality: low**
Hayes et al., 2014	Retrospective case control study to determine the **relationship between time in the OR and hospital-acquired**	Participants were people discharged from surgical services over a 3 year period in a hospital in US (eligible population 33,725 n=931 surgical patients with hospital acquired pressure injuries, all cases matched to 4 controls for total of 4652 participants)	N/A	• Date and time pressure injury first documented • Time in the OR in the 24, 48, and 72 hours prior to incident pressure injury • Braden scores on admission and most	**Pressure injury incidence 2.8%** **Operating room time** • Only 5% of HAPUs occurred within 24 hours of extended (> 4 hours) surgery and 58% occurred after hospital day 5.	• Not eligible for risk section, no multivariate analysis • Potential misclassification when pressure injuries identified	**Level of evidence: 3 (prognosis)** **Quality: low**

Ref	Type of Study	Sample	Intervention(s)	Outcome Measures & Length of Follow-up	Results	Limitations and comments	
	pressure injuries	Case inclusion: (n=931) Documented pressure injuries Case exclusion: Pressure injury documented within 24 hours of admission Control inclusion: (n=3721) Matched to hospital length of stay at time pressure injury documented Characteristics: • Primarily trauma or cardiac surgery • Case patients more likely to be male, older, lower admission Braden scores, and more likely to die during admission or be discharged to long-term acute care hospital.		recent prior to pressure injury documentation • American Society of Anesthesiologists (ASA) score, sex, age, patient weight, year of study	• odds ratios for HAPU occurrence (compared to patients who were not in the OR in the 24 hours prior to a documented pressure injury) were: o 1.1 for <2 hours operating time, o 1.2 for >2 but <4 hours, o 1.6 for >4 but <6 hours o 6.4 for >6 hours in the OR **Author conclusions: Extended surgery is a risk factor for pressure injury**	• Unable to correlate pressure injury location with surgical position • Significant difference in admission Braden score • Did not consider other risk factors	
Kim, Lee, Ha, & Na, 2018	Case control study identifying perioperative **risk factors for post operative pressure injuries**	Participants were recruited over 12 months in a hospital in South Korea. Each case was matched to two controls from the same cohort (2,498 eligible population, n=43 cases, n=86 controls) Inclusion criteria: • Adults undergoing major surgery Exclusion criteria: • Pressure injury on admission • Children	Controls matched for age, sex, surgery and comorbidities	• Method of assessing pressure injuries not reported	**Incidence** • Category/Stage 2 or greater pressure injuries was 1.7% • 79% coccyx;9% heel; 7% occiput; 5% back **Multivariable analysis** • Preoperative albumin (g/dl) OR 0.21, 95% CI 0.05 to 0.82, p=0.025 • Preoperative lactate (mmol/L) OR 1.70, 95% CI 1.07 to 2.71, p=0.026 • Packed RBC transfusion (units) OR 0.99, 95% CI 1.92 to 1.06, p=0.772 • Braden score OR 0.88, 95% CI 0.64 to 1.21, p=0.421	• Not eligible for risk chapter due to study design • Some variables (e.g. Braden scale score) were only measured post-operative • Pressure injuries identified through medical records	**Level of evidence: 3 (prognostic)** **Quality: low**

Ref	Type of Study	Sample	Intervention(s)	Outcome Measures & Length of Follow-up	Results	Limitations and comments	
		Participant characteristics: • Mean age 61 years • Mean BMI 22-23kg/m2 • Primarily organ transplantation patients • Operative position was primarily supine			• Ventilator care OR 0.14, 95% CI 0.10 to 1.92, p=0.140		
Wright, Van Netten, Dorrington, & Hoffman, 2014	Study exploring **risk factors for longer length surgery of the head/neck**	Participants were recruited over 3 year period in an Australian hospital (n=88) Inclusion criteria: Major head and neck resection Operation ≥ 5 hours Exclusion: Pre-existing pressure injury Participant characteristics: • Primarily males • Mean age 61.84 years (range 35-85) • Mean operation time 10.67 hours (5.05-19.33) • People who developed a pressure injury were older (p<0.01) and had longer surgery times (p=0.02)		• Demographics and screening tools completed pre-operatively • Pressure injuries assessed by unknown clinical assessment and recorded in notes	**Incidence** 14.7% (n=13/88) **MV analysis** • Gender OR 1.08 95% CI 0.25 – 4.73, p=0.914 • Age OR 0.91, 95% CI 0.84 to 0.98, p=0.009 • Systemic disease OR 0.32, 95% CI 0.08 to 1.4, p=0.131 • Operative duration, OR 1.007, 95% CI 1.002 – 1.013, p=0.011 **The authors provided recommendation that were not reflective of the study findings, although represent the literature overall**	• Includes a relevant MV analysis • Ineligible for risk section • Insufficient cases • One center	**Level of evidence: 3 (prognostic)** **Quality: low**
Schoonhoven, Defloor, van der Tweel, Buskens, & Grypdonck, 2002	Prospective cohort study	Surgical patients admitted to a teaching hospital in Netherlands (n=208) Inclusion criteria: • Surgery expected > 4 hours • with or without pre-op pressure injuries included		• Pressure injuries developing within 2 days following surgery on skin pressure points during surgery	PU incidence stage 1-4 was 21.2% (44/208) in the first 2 days after surgery. PU incidence stage 2-4 was 10.1% (21/208) A multiple logistic regression analysis using 12 variables (chosen for pragmatic reasons as well as the results	• Included in risk chapter • Time limit for intraoperative PU imposed was based on 'best guess'. Some pressure injuries may have been missed.	**Level of evidence: 3 (prognosis)** **Quality: low**

Ref	Type of Study	Sample	Intervention(s)	Outcome Measures & Length of Follow-up	Results	Limitations and comments	
		• Surgical specialties: cardiac, GI, head and neck oncology, neuro, oncology, orthopaedics, plastics, urology and vascular. Exclusion criteria: • Expected to undergo surgery of >4 hours but actual procedure shorter than 4 hours • Surgical specialties: gynea and trauma Participant characteristics: • 72 female and 136 males, median age 61 years		• Category/Stage 1-4 or closed pressure injury • Risk indicators: Body Mass Index (BMI), malnutrition, type of surgery, method of anesthesia. • Follow-up for 14 days or until discharge, which ever occurred first • Discharge patients had follow-up telephone call on day 14.	of a univariate analysis) indicated that only the length of surgery was significantly associated with the occurrence of PU stage 2-4 (OR 1.01, CI 1.004-1.009)	• Post-operative care may have stopped pressure injury progression of biasing the result • Insufficient number of events	
Rademakers, Vainas, van Zutphen, Brink, & van Helden, 2007	Retrospective cohort study exploring **pressure injury risk factors in hip fracture patients undergoing surgery**	Participants were recruited in a trauma centre in Netherlands (n=722) Inclusion criteria: All hip fracture patients admitted to a level one trauma centre Having hip fracture surgery Exclusion: age <60 years, (multiple) high energy trauma (defined as a fall from higher than ground level, or road traffic accidents), initial conservative treatment, inter-hospital transfer, presence of PUs on admission, pathological fractures and recurrent fractures	N/A	multivariate logistic regression	• Incidence of pressure injuries was 29.6%, 214 Stage ≥2 PU MV analysis • time to surgery >12 hours OR 1.7, 95% CI 1.2 to 2.6, p=0.008 • 4 other factors (not related to surgery setting) were also significant	• Included in risk chapter • Large sample size but limited number of risk factors considered and not based on a conceptual framework (no nutrition or skin moisture factors). In adequate measurement of risk factor. (Record review).	**Level of evidence: 3 (prognosis)** **Quality: moderate**

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Nixon, Brown, McElvenny, Mason, & Bond, 2000	Prospective sequential, double triangular, randomised, blinded, controlled trial	446 general, vascular and gynaecological surgical patients Inclusion criteria: • Scheduled for elective major, general, gynaecological or vascular surgery • ≥ 55 years • Scheduled to undergo surgery of 90' or more. • Position to be supine or lithotomy Exclusion criteria: • Liver, urology and breast surgery • Pressure injury ≥ grade 2a • Pre-operative alternating pressure mattress • Dark skin pigmentation • Skin conditions over the sacrum, buttocks or heels which preclude reliable identification of Grade 1 and grade 2a skin assessments	Participants were randomized to either: • Control group (224): Standard operating table mattress + heel pad. • Experimental group (222): Dry visco-elastic polymer pad (Action Products Inc.) • Warming mattress provision for both groups was standardized.	• Pressure injuries Grade 1-5 (incidence (adapted version of Torrance classification) • General data, data on mobility, Braden Scale, equipment, pre-operative physiological measures, and intra-operative physiological measures. • Follow-up of 8 days	• PU incidence was 15.6% (65/416). • 16% (9/56) were directly associated with the peri-operative period • Multivariate analysis showed the following prognostic factors: o Increased number of hypotensive episodes o increased mean core temperature during surgery, o reduced mobility on Braden scale mobility Day 1	• Not eligible for risk chapter • Results are limited by study design since the hypothesis and sample size were not determined by the prognostic factor study • Local variation in theatre practice • Use of a warm air over blanket for some patients classified as `big majors' • 30 patients dropped out.	**Level of evidence: 2 (prognostic)** **Quality: low**
Al-Ani et al., 2008	Prospective cohort study **comparing the incidence of PU in those who had delayed surgery to those who had surgery within 24 hours**	Participants were recruited from two hospitals in Sweden (n=850, n=744 met inclusion) Inclusion: • undergoing surgery for hip fractures Exclusion:	Time to surgery defined as hours from admission to the ER to the time of operation.	Classification of PUs conducted by a specialist nurse according to EPUAP 1998 guidelines. Analysis included only grade II, III and IV PUs	**Time to surgery** • Median wait time to surgery was 24hrs (range 2.8 to 331 hrs) • 48% had surgery within 24 hours • 74% had surgery within 36 hours • 87% had surgery within 48 hours **Incidence of PU** • Participants who had a >24 hr wait for surgery were more likely to	• Not eligible for risk section • Modeling was based on establishing factors that increased risk of a negative outcome (i.e. not just pressure injuries) and did not include other risk factors	**Level of evidence: 3 (prognosis)** **Quality: low**

Ref	Type of Study	Sample	Intervention(s)	Outcome Measures & Length of Follow-up	Results	Limitations and comments	
		• arrived at hospital <24 hrs after fracture occurred Characteristics: • Mean age 81 years • 73% sample were female • 28% of sample had dementia • 49% cervical fracture, 43% trochanter fracture, 8% subtrochanter fracture • Demographics were not significantly different between time-to-surgery groups			develop a PU (21/359, 6% versus 40/385, 10%, p<0.05) • Participants who had a >36 hr wait for surgery were more likely to develop a PU (31/550, 6% versus 30/194, 15%, p<0.001) • Participants who had a >48 hr wait for surgery were more likely to develop a PU (41/646, 6% versus 20/98, 20%, p<0.001) • After adjusting for age, ASA score, pre-fracture mobility, dementia and duration of surgery, adjusted OR of developing a PU: ○ Delay of >24 hrs OR=2.19 (95% CI 1.21 to 3.96, p<0.01) ○ Delay of >36 hrs OR=3.42 (95% CI 1.94 to 6.04, p<0.001) ○ Delay of >48 hrs OR=4.34 (95% CI 2.34 to 8.04, p<0.001)	• Presence of PU on admission to ER was not reported on considered • Unclear when PU classification was conducted and if there was repeat assessment • Unclear if PU assessments were conducted by nurses blinded to surgery time • Small numbers in the group who waited longer for surgery	
Stahel et al., 2013	Cohort study **comparing an early spinal surgery protocol versus delayed surgery**	Participants were those undergoing spinal surgery in a US hospital (n=112) Inclusion: • aged > 18 years • unstable thoracic or lumbar fracture Characteristics: • Mean age 34 to 36 years • Mean time to surgery significantly (ESG 8.9 hrs, DSG 98.7 hrs) different between groups	• Early spinal surgery group (ESG, n=42): surgery performed within 24 hours • Delayed surgery group (DSG, n=70): surgery for spinal fixation delayed by at least 24 hours, (protocol defined patients for whom delayed surgery was more appropriate)	• Method and frequency of assessment of PU was not reported. • Grade/stage of PU was not reported	• Pressure uclers occured less frequently in the participants who had early surgey (2.4% versus 8.6%, p<0.05)	• Not eligible for risk section, not a prognostic study • Does not report method or frequency of assessment of PU • Other factors that may have influenced findings (e.g. duration of surgery) were not included in a correlational analysis • No confidence intervals	**Level of evidence: 3** **Quality: low**

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Smektala et al., 2008	Prospective cohort study **investigating impact of delayed surgery in older adults with hip fracture**	Participants were recruited from 2002 to 2003 in 268 acute care hospitals in Germany (n=2,916) Inclusion criteria: • aged ≥ 65 • proximal femoral fracture • first fracture event • surgical treatment acute-care admission Exclusion: • multi-trauma or comatose • malignancy • incomplete medical records Characteristics: • 79.7% sample female • Mean age ranged from 81.5 yrs to 82.4 yrs with participants waiting >36 hours significant younger (p=0.009) • > 50% participants had ADA score of III, with those in the lingers surgery wait group being more likely to have higher ASA score	Time to surgery classified as hours from time of fracture event to the time of operation. • 27.5% sample had surgery within 12 hours of fracture • 40.8% had surgery within 12 to 36 hours • 31.7% waited > 36 hours	• The occurrence of a post-operative complication or patient death with one year follow up, of which pressure ulcer was one complication reported • Assessment or classification of PU is not reported	• Incidence of PU was 1.4% • In all patients multi-variate adjusted hazard ratio for PU was 2.08 (95% CI 1.20 to 3.58, p=0.009) • Time to surgery was not significantly associated with PU developed: Multivariate-adjusted OR as a function of time-to-surgery OR=1.33 (95% CI 0.96 to 2.05, p=0.201)	• Not eligible for risk section • Modeling was based on establishing factors that increased risk of a negative outcome (i.e. not just pressure injuries) and did not include other risk factors for pressure injuries • Only patients with comprehensive records maintained for 12 months were included • Method and timing of PU assessment not reported • PU prevention strategies in OP and postoperative are not reported • Does not report identification of PU on admission •	**Level of evidence: 3 (prognosis)** **Quality: moderate**
Lefaivre et al., 2009	Retrospective cohort study investigating **effect of delay to surgery on incidence of PUs**	Participants were admitted to trauma unit in Canada between 1998 and 2001 (n=607) Inclusion: • Aged > 65 years • Isolated fracture proximal femur	Time to surgery defined as hours from admission to the ER to the time of operation.	Method and timing of assessing is not reported. Categories/staging of PU is not reported Delay in surgery was categorised as: • < 24 hours	• Incidence of PU was 13.5% (82/607) • Delay of 24 to 40 hours was not associated with a significant increase in risk of PU (OR 1.23. 95% CI 0.71 to 2.12, p=0.47) • Delay >48 hours prior to surgery was associated with an increased risk of PU (OR 2.29, 95% CI 1.19 to 4.40, p=0.0128)	• Not eligible for risk section • Determination of time of discharge was a limitation • Method of PU assessment and classification is not reported	**Level of evidence: 3 (prognosis)** **Quality: low**

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		Exclusion: Incomplete medical record Characteristics: • Mean age 83.3 years (range 66 to 111) • 79% sample female • 55% trochanter or subtrochanter fracture, 45% femoral neck • Mean time to surgery 33.6±26.18 hrs • Morbidity was 7.9%		• 24 to 48 hours • > 48 hours		• Repeat assessment of PU presence not reported • Blinded assessment is not reported or discussed	
U. G. Nilsson, 2013	Descriptive study **reporting on association between post-operative pain and PU**	Consecutive elective surgery patients at a hospital in Sweden (n=86) Inclusion: • supine position during surgery • aged ≥ 18 years • ASA status I or II • elective surgery under general anesthesia Exclusion: • pre-existing PU • peripheral neuropathy. peripheral vascula disease, paralysis, muscular diseases • BMI < 19 or > 34 Characteristics: • Mean age 48 years (range 18 to 87)	• None	• Pain located on heels, arms or overall, assessed in the post-anesthetic care unit (PACU) on a numerical rating scale (0 to 10) • Heel skin inspection and grading using four grades, conducted in the PACU by the nurse if the patient suffered heel pain	• 85% participants had a Tempur mattress and 15% had an air mattress • Four participants experienced heel pain (range 2 to 5 on NRS). 100% of these participants had a Tempur mattress. • 50% of participants experiencing heel pain had stage I heel PU.	• Not a true risk factor study • Skin assessment was only conducted on participants experiencing pain in PACU, therefore prevalence of heel PU is not accurate	**Level of evidence: 4** **Quality: low**

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		• average surgery duration 151 minutes (range 60 to 560) • 27% of participants experienced preoperative pain					
Primiano et al., 2011	Prospective cohort observational study investigating **risk factors associated with development of PU post-operatively**	Participants were admitted to a trauma academic medical center in from June 2009 to Feb 2010 (n=258) Inclusion: • Aged ≥ 18yrs • same day admission for surgery • expected surgery duration >3hrs • expected inpatient stay ≥24hrs Exclusion: • Pregnancy • Pre-existent PU • 73.3% sample aged between 46 and 75 yrs • 57% sample female • 58% sample White • 97.2% had ASA score of 2 or 3 • 65% surgery lasted 3 to 5 hours • 70% participants has no positioning device, 19.8% had pillow under knees, 8.1% had elevated heels, 2% had wedge foam • Foam table pads with valves were used for 63%	• Duration of surgery • Observation of multiple intrinsic and extrinsic factors	• Presence of new PU within 72 hours of surgery • Assessment pre-intra- and post-operatively, using NPUAP classification system and daily Braden scales scores • Preoperative factors analysed: ○ Age ○ Weight ○ Surgical procedure ○ Incontinence ○ ASA score ○ Nutritional status ○ Blood levels ○ Skin integrity including previous breakdown ○ Alterations in sensation • Intraoperative factors analysed: ○ type of anaesthesia ○ patient temperature ○ temperature devices in OR ○ length surgery	• Incidence of new PU was 8.1% • Variables significantly associated with PU development in chi-square analysis: ○ type of positioning device used in OR (χ^2=7.897, p=0.048) ○ table surface used in OR (χ^2=15.848, p=0.000) ○ postanaesthetic care unit skin assessment score (χ^2=41.652, p=0.000) ○ female gender (χ^2=6.984, p=0.030) • Variables significantly predicting PU development logistic regression multivariate analysis: ○ use of a foam pad on OR table (OR=14.740, p=0.024) ○ Braden score on day 1postoperative (OR=0.783, p=0.003) • 23% of participants who developed a PU (suggests primarily sacral) had their heels elevated (p=ns) • Closed cell foam pad was used for 29% of participants who developed a PU	• Not included for risk factors • single site • confidence intervals not reported • only included surgical • procedures of > 3hr duration • Location of PU not stated • Selection of sample is not reported • Rater reliability and blinding of assessment is not reported	**Level of evidence: 3 (prognosis)** **Quality: low**

Ref	Type of Study	Sample	Intervention(s)	Outcome Measures & Length of Follow-up	Results	Limitations and comments	
		participants and 48% had heated gel pads		○ type of surgical pad/overlay ○ hypotension, hypoxia ○ medications			
Tschannen, Bates, Talsma, & Guo, 2012	Retrospective cohort study **investigating patient-specific and surgical factors in the development of PUs**	Participants recruited from 5 units (3 ICUs; 2 intermediate care) from one hospital (n=3225 surgical patients) Inclusion: • Aged ≥18 yrs • Had a surgical procedure completed during Nov 1, 2007, to Aug 31, 2009 • Admitted to 1 of the 5 study units for >48 hrs. Characteristics: • n=1910 males; n=1315 females • mean age 58.9 yrs; range 18-96 yrs • lost to follow-up and baseline PU not reported	Not reported	Outcome definition: development of ≥1 new Stage 1 or higher hospital-acquired PU. Skin inspected for PU not reported • length of follow-up duration not reported PU definition for regression: ≥Stage 1 NPUAP staging system Statistical methods: Logistic regression	N=383 developed hospital-acquired PUs (no. or grades not reported) No. in final: not reported but assumed complete N=9 risk factors entered into MV analysis: • age; sex; BMI; Braden score at admission; history of diabetes; risk of mortality; use of vasopressors; number of surgeries; total operating room time N=7 risk factors from final model: **BMI:** <.001; 0.97; 0.95-0.98 **History of diabetes** <.001; 1.49; 1.14-1.96 **Use of vasopressors** 0.03; 1.33; 1.03-1.73 **Number of surgeries** <.001; 2.23; 1.45-3.44 **Total operating room time** <.001; 1.07; 1.03-1.11 **Braden score at admission** <.001; 0.89; 0.86-0.93 **Risk of mortality (score 2)** <.001; 2.32; 1.49-3.62 **Risk of mortality (score 3)** <.001; 5.50; 3.58-8.45 **Risk of mortality (score 4)** <.001; 11.15; 7.1-15.5	• Record review • Conceptual framework limited • Strategy for model building based on a restricted conceptual framework	**Level of evidence: 3 (prognosis)** **Quality: low**

Ref	Type of Study	Sample	Intervention(s)	Outcome Measures & Length of Follow-up	Results	Limitations and comments	
Connor, Sledge, Bryant-Wiersema, Stamm, & Potter, 2010	Prospective cohort study **examining peri-operative factors predictive of PUs in patients undergoing urologic surgical procedure**	Participants recruited from academic center with urologic-specific OR and inpatient urologic surgery unit (n=538) Inclusion: • English speaking adults • Undergoing scheduled inpatient urologic surgical procedures • Admitted for ≥24 hrs of post-operative care Exclusion: • Pre-existing PU or open skin wound on dependent areas subject to pressure during surgery Characteristics: • n=379 (76%) males; n=119 (24%) females • mean age 58.9 (SD 12.66) yrs; range 20-89 yrs • N=40 enrolled patients excluded • Sample without baseline PU	• When a patient arrived in the post-anesthesia recovery room (PAR), a data collector determined the manner in which patient positioning in OR and turned the patient away from the side that was dependent during surgery. • Minimum 10 min wait before visually inspecting and palpating the skin to determine presence of pressure and/or actual skin breakdown.	• Outcome definition: development of new PU in the PAR. • Skin inspected for PU pre-operatively and post-operatively (PO) when patient arrived to PAR, and PO daily until PO day 3 • mean length of follow-up not reported • PU definition for regression: development of new ≥grade 1 PU NPUAP staging system • Statistical methods: Binary logistic regression with multiple predictors	N=25 (5%) developed Stage 1 PUs No in final: n=498 (assumed) Multivariate analysis N=8 risk factors entered into MV analysis: • Braden scores (pre- and post-op); length of surgery; length of anesthesia time; time BP <50 mmHg diastolic; BMI; position; type of fluids on table surface; type of support device used intra-operatively. N=2 significant risk factors from final model: **BP <50:** 0.046; 1.007; 1.000-1.014 **Perfusion time (anesthesia):** 0.038; 1.005; 1.000-1.010	• Insufficient number of events	**Level of evidence: 3 (prognosis)** **Quality: low**
Clinical question 2: What are the unique pressure injury prevention strategies for individuals in the operating room?							
Support surfaces in the operating room							

Ref	Type of Study	Sample	Intervention(s)	Outcome Measures & Length of Follow-up	Results	Limitations and comments	
Kirkland-Walsh, Teleten, Wilson, & Raingruber, 2015	Aim of study was **compare four different surfaces used in the operating room**	Participants were healthy volunteers in US (n=49) Inclusion criteria: • Hospital staff with various BMIs • Have 30 minutes available to participate • Agreed to have pressure mapping Participant characteristics: Healthy volunteers	Four OR table surfaces were tested for pressure re distribution: • standard three-layer viscoelastic memory foam surgical table • air-inflated static seat cushion under the sacral area placed on standard surgical table • a two-layer OR surface consisting of a top layer of nonpowered self-contouring copolymer gel and a bottom layer of high density foam, and 4 • a fluid immersion simulation surgical surface	• Participants would lie flat on a surface being tested for 5 minutes before any pressure mapping measurements were taken. • Measurements were then taken at 3 and 30 minutes	• Outcomes of testing these surfaces revealed that fluid immersion surfaces provide the lowest interface pressure in sacral areas. • Average sacral interface pressure was significantly lower with fluid immersion compared with other three surfaces (p=0.004) • Average sacral interface pressure ranged from 23.9mmHg (air inflated) to 22.1 mmHg (fluid immersion) between the four surfaces • All support surfaces had significantly different peak sacral interface pressures, except fluid immersion vs air inflated	• Limitations= • All recruits were healthy volunteers • This study was limited to testing pressures and contact areas of the sacrum and not any other at risk areas of the body • All surfaces tested were from different manufacturers and there is the potential that pressure redistribution properties may not be standard across different manufacturers	**Indirect evidence (PU not an outcome measure)**
Grisell & Place, 2008	Blinded RCT **comparing different facial pillow in prone position for prevention of pressure injuries in the OR setting**	Participants were consecutive patients admitted for elective surgery requiring prone position at a surgery in the USA (n=66) Inclusion: • elective thoracic and/or lumbar surgery requiring prone positioning • aged 18 to 65 yrs Exclusion: • existing facial ailment including redness, inflammation, rash, graze, bruising	• All participants were positioned using standard prone positioning. • Patients were randomized to receive different facial pillows: ○ Orthopedic Systems Inc (OSI) disposable polyurethane foam positioner (n=22) ○ Dupaco Prone View® Protective Helmet System disposable polyurethane foam head positioner (n=22)	• Facial tissue pressures were measured at the patient's forehead and chin at time 0, 5, 15, and 60 minutes of positioning • The integrity of skin was recorded and classified using NPUAP system staging at the end of surgery	• 10 patients positioned on the OSI positioner developed PUs (eight stage I PUs and two stage II PUs) • No patients from the other two groups showed any evidence of PUs • The pressure measurements for the Dupaco Prone View® were lower at all of the time points for both the forehead and the chin in comparison to the OSI and the ROHO (p<0.05) • Forehead pressures were significantly less for the ROHO compared with the OSI (p<0.05)	• Patients were not stratified by age, race, or gender and existing risk factors for PU not reported • Risk of PU on entry to study not reported • Length of time in position not recorded (procedures last from 1 to 12 hours)	**Level of evidence: 1** **Quality: low**

Ref	Type of Study	Sample	Intervention(s)	Outcome Measures & Length of Follow-up	Results	Limitations and comments	
		• history of increased intraocular pressure or glaucoma • major language not English Characteristics: • surgery times varied from 1 to 12 hours and not reported • no demographic data reported	○ ROHO Group neoprene air filled bladder dry flotation device (n=22)				
Nixon, McElvenny, Mason, Brown, & Bond, 1998	RCT comparing a standard table mattress to a viscoelastic polymer pad	Individuals undergoing elective major general, gynecological, or vascular surgery in UK (n=446) Inclusion: • aged 55 years or above • surgical procedure was planned to be at least 1.5 hours in length	Participants received either: a viscoelastic polymer pad or a standard table mattress	New pressure injuries	The pressure ulcer incidence in the viscoelastic polymer pad group (11%) was significantly lower than in the standard mattress group (20%) (OR = 0.46; 95% CI 0.26 to 0.82; p = 0.010)		**Level of evidence: 1** **Quality: High**
Feuchtinger, de Bie, Dassen, and Halfens (2006)	RCT comparing visco elastic foam overlay to a water-filled mattress in the OR	Participants recruited in operating room (n=175) Inclusion criteria: • individuals undergoing cardiac surgery • aged at least 18 years, • minimum of 1.5 hours on the operating table	Participants received either: • 4 cm thermoactive viscoelastic foam overlay combined with a water-filled warming mattress during surgery, or • a water-filled warming mattress was used	New pressure injuries	non-significant increase in pressure ulcers in the intervention group compared with the control group (17.6% versus 11.1%, p = 0.22)		**Level of evidence: 1** **Quality: moderate**
Russell & Lichtenstein, 2000	RCT comparing alternating air mattress to gel mattress in operating room	Participants recruited in operating room (n=198) Inclusion criteria: • aged 18 years and older	Participants received either: • alternating pressure air mattress (a multi-segmented pad with more than 2,500 air cells		pressure ulcer incidence of 7% in the control group and 2% in the intervention group (p=0.17) (Level 2 study).		**Level of evidence: 1** **Quality: Low**

Ref	Type of Study	Sample	Intervention(s)	Outcome Measures & Length of Follow-up	Results	Limitations and comments	
		• anesthesia time of four hours or more • undergoing cardiothoracic surgery	enclosed in a waterproof cover) during and after surgery, or • gel mattress during surgery and a standard mattress after surgery				
Aronovitch, Wilber, Slezak, Martin, & Utter, 1999	RCT comparing alternating air mattress to gel mattress in operating room	Participants recruited in operating room (n=217) Inclusion criteria: • Individuals aged 18 years and older • anesthesia time of four hours or more	Participants received either: • alternating pressure air mattress (a multi-segmented pad with more than 2,500 air cells enclosed in a waterproof cover) during and after surgery, or • gel mattress during surgery and a standard mattress after surgery (control)		pressure ulcer incidence of 8.7% in the control group and no pressure ulcers in the intervention group ($p < 0.005$)		**Level of evidence: 1** **Quality: Low**
Wu, Wang, Lin, Liu, & Chao, 2011	Quasi experiment investigating **prone positioning as a risk for pressure injuries**	Participants were recruited in a spinal unit in Taiwan (n=30) Inclusion: • spinal surgery • expected surgery duration ≥ 3 hrs • prone positioning Exclusion: • emergency surgery • vascular disease • diabetes • Braden score <18 Characteristics: • Mean age 57.2±19.6 years • Mean weight 62.3±10.5kgs	Participants received either: • 10cm thick high density foam (HDF) • 2cm thick viscoelastic pads(VP) (high specification) Each participant had VP on the left side of the chest and iliac crest and HDF padding on the right side	• Interface measurement prior to starting surgery • Presence of PU as defined by NPUAP classification observed 30mins following surgery and if PU present then again in 24hrs and 48hrs	• Immediately after surgery 75% of participants had nonblanchable skin redness on iliac and chest pressure points (73% of VP pressure points, 77% of HDF pressure points). • At 30mins post-operative overall incidence of PU was higher in HDF group, but not difference was not significant (10% versus 5%, OR=0.47, 95% CI 0.11 to 1.99, p>0.05) • One stage II PU in VP group after 48 hrs • Interface pressure was significantly lower (p<0.001) with VP pad • Univariate analysis of risk factors for PU at 30mins	• 48 hours follow up • small sample size • Side that the pad was placed not randomized • Blinding of assessor and statistician not reported • Not designed for the null hypothesis	**Level of Evidence: 2** **Quality: moderate**

Ref	Type of Study	Sample	Intervention(s)	Outcome Measures & Length of Follow-up	Results	Limitations and comments	
		• 6.7% had BMI <18, 26.7% had BMI 18 to 24, 53.3% participants had BMI of 24 to 29, 13.3% had BMI >30 • Mean Braden scale 20.8±1.2 • Mean operative time 285.4±73.4 mins			○ Female gender (OR=0.04, 95% CI 0 to 0.79, p<0.05) ○ BMI < 18 (OR=21.40, 95% CI 4.11 to 111.51, p<0.05) ○ Body weight <50kgs (OR=18.57, 95% CI 4.06 to 85.03, p<0.05)		
Defloor & De Schuijmer, 2000	Quasi experiment with healthy volunteers to measure interface pressure of different OR support surfaces	Healthy volunteers (n=36) BMI range 18.3 and 42.6 kg/m^2	Four intraoperative positions Five operating table mattresses: A: gel mattress B: foam mattress 70-75g/m2 C: polyester viscoelastic foam, 6cm thick D: polyester viscoelastic foam, 7cm thick E standard foam, 4cm thick	•	• Interface pressure was higher on standard operating-table mattress than on the other types of mattresses for all positions (p<0.01) • pressure was most reduced on viscoelastic foam mattresses, compared to foam mattresses and gel mattresses	•	**Indirect evidence: Interface pressure**
Scott, Baker, Kelly, Stoddard, & Leaper, 1999	Observation study exploring interface pressure for four different operating room mattresses	Participants were healthy volunteers (n=25) Participant characteristics: Mean age 35.5 years Mean BMI 25.9	• Four foam mattresses: ○ A: 33-36km/m^3 foam density, hardness 130-160 Newtons, severe class rating, neoprene cover ○ B: 52-56kg/m^3 foam density, hardness 210-260 Newtons, very severe class rating, nylon/polyurethane cover, convoluted structure ○ C: 46-50kg/m^3 foam density, hardness 110-	• Pressure map measuring sacral interface pressure • Mean maximum pressure (mmH)	• Positioning contributed to interface pressure, with Lloyd Davies position being 9.5% to 14.2% higher interface pressure • Mattress A had significantly lower mean interface pressure (p<0.001) • In supine position, mattress D had the lowest interface pressure • In Lloyd Davies position, mattress A had the lowest mean interface pressure • Underweight individuals experienced significantly higher maximum interface pressures, but	• Healthy volunteers	**Indirect evidence: Interface pressure**

Ref	Type of Study	Sample	Intervention(s)	Outcome Measures & Length of Follow-up	Results	Limitations and comments	
			140 Newtons, very severe class rating, molded ○ D: 52-56kg/m³ foam density, hardness 210-260 Newtons, very severe class rating, neoprene cover • Mattresses were trialed in supine and Lloyd Davies positions		for average interface pressure, increase with increase in BMI		
Positioning in the operating room							
Furuno et al., 2014	Retrospective case series investigating **positioning related complications in patients undergoing surgery with cerebello-pontine angle lesions**	Participants were individuals undergoing surgery for cerebello-pontinangle lesions over 7 years in one center in Japan selected by unspecified methods (n=71 participants) Inclusion criteria: Undergoing surgery for cerebellopontine angle lesions Exclusion criteria: • None identified • Repeat surgeries excluded from analysis Participant characteristics: • Mean age 57 years (range 16 to 81) • Mean operative duration 608 minutes (range 210 to 1060)	• Participants were placed in supine position then trunk rotated to lateral position on 30° to 60° angle toward unaffected side • In some cases (n=note reported) a low resilience foam was used to reduced interface pressure at axilla • In the last 4 cases a viscoelastic foam was used in the axillary region which provided additional support to axilla and low back	• Pressure injuries were measured and assessed using the National Pressure Ulcer Advisory panel classification • Interface pressure at axilla region and great trochanter	• Overall pressure injury incidence 34/71 (47.9%) • 22 (30.98%) developed a Category/Stage I pressure injury and 12 (16.9%) developed Category/Stage II pressure injury • Low resilience foam was associated with a 59% reduction in interface pressure at the axilla (116mmHg to 48.2 mmHg) • No pressure injuries occurred when the viscoelastic foam was used (4 cases) **Author conclusions: Positioning of the head using the sub-occipital approach can put excess loads on the trunk and neck resulting in complications, one of which is pressure injury**	• Pressure of pressure injury at baseline not reported • Minimal participant data collected • No clear comparison between different support surfaces used • Anatomical location of pressure injuries not reported • No limitations identified	**Level of evidence: 4** **Quality: low**

Ref	Type of Study	Sample	Intervention(s)	Outcome Measures & Length of Follow-up	Results	Limitations and comments	
Guo et al., 2017	To identify if curvilinear spine position increase contact area and reduces interface pressure whilst patients are on an operating table	Healthy volunteers recruited in a teaching hospital in China (n=145) Inclusion criteria: aged between 18 to 60 years Exclusion criteria: Joint dysfunction Edema Participant characteristics: • Mean height 167±6.32cm • Mean body weight 59±8.09 kg • Average BMI 21.24±2.36kg/m^2	• Pressure-sensing pad placed on operating table • Participants self-positioned on operating table with sacrum at the center of pressure-sensing pad in the supine and curvilinear supine • Positions • Head of bed elevated to 15° and leg support lowered to 10°	• Contact areas between body and table • Peak pressures at occiput, scapula, sacrum, calf and heel • Highest and mean pressure recorded at particular areas of body • Angles of bed • Patient comfort • Data was recorded at 3 minutes after lying on table and again at various times when angles of bed were altered.	• No significant difference in occiput or scapula interface pressure in supine position compared to curvilinear spinal positions • Median interface pressure was higher in supine position for: Sacrum: 41.4 mmHg vs 38.90 mmHg, p<0.001 Heel: 48.0 mmHg vs 42.50 0mmHg, p<0.001 • Median interface pressure was higher in curvilinear supine position for: Calf: 24.1 mmHg vs 33.50 mmHg, p<0.001 • Curvilinear supine position provided a greater median contact area compared to the supine position (2454.84 vs 2764.52, p<0.001) • Patient comfort was high in curvilinear supine position (median 3 versus median 4, p<0.001) **Author conclusions: Raising head of bed 30 increased contact area and interface pressure. Curvilinear supine position increases contact areas to provide support for bony prominences**	• All participants were healthy volunteers and not surgical patients with the effects of anesthesia or comorbidities	**Indirect evidence (healthy volunteers)**
Heel pressure injuries in the operating room							
Donnelly, Winder, Kernohan, & Stevenson, 2011	RCT **comparing complete offloading to standard care for prevention of heel PUs in post-operative patients**	Participants were recruited from a fracture trauma unit in Ireland (n=239, n=227 completed study) inclusion: • Aged > 65 years	• Participants were randomized to receive either: ○ heel elevation achieved using a commercial device (Heelift® Suspension Boot) plus pressure-redistributing	Primary outcome: • Number of new category 1 or greater PUs on heels or other sites assessed daily for signs of tissue discoloration or ulceration (skin	**Effectiveness in preventing PU** • Significantly fewer PUs in any anatomical location in heel elevation group (7% versus 26%, p<0.001) • Significantly fewer patients in the heel elevation group developed a	• Potential observer bias due to non-blinding; however, all pressure damage was confirmed by a blinded assessor • Half of the subjects had support surface upgraded by nursing	**Level: 2 Quality: moderate**

Ref	Type of Study	Sample	Intervention(s)	Outcome Measures & Length of Follow-up	Results	Limitations and comments	
		• Fractured hip in previous 48 hours Exclusion: • Existing heel pressure damage • History of previous PU • Considered unsuitable by research team or no consent Characteristics: • Mean age 80 yrs • Mean Braden score 15 • low prevalence of peripheral vascular disease and diabetes • Approximately 1/3 sample were at moderate to high risk of malnutrition • No differences between groups in types of injury or time taken to get to hospital • Significantly more of the control group waited >72 hours between injury and surgery (p=0.0009) • Significantly more of the heel elevation group had surgery of > 2 hrs duration (p=0.034)	support surface (n=120, 9 withdrew) ○ standard care that included a pressure-redistributing support surface (n=119, 3 withdrew) • Pressure redistribution support surfaces included cut foam mattresses, alternating mattresses and mattress overlays selected according to individual needs.	temperature, induration, oedema, pain, itching) with all skin damage photographed and confirmed by a blinded skin viability nurse who categorized damage on NPUAP scale Secondary outcomes: • Participant opinion assessed via questionnaire • Concordance with an offloading device	PU on ankles, feet or heels (0 versus 29, p<0.001) • Control group more likely (p=0.001) to suffer pressure damage at all time points. **Acceptability and concordance** • The heel elevation device was rated: ○ comfortable by 59% participants ○ interfering with sleep by 32% participants ○ adversely affecting movement in bed by 41% participants • Reasons for poor concordance included weight and bulk (36%), heat (31%) and discomfort (24%). **Adverse events** 45 adverse events (no significant association between the groups and adverse events, p=0.691)	staff (protocol violations) • Duration of time spent in bed/days treatment was not reported • Study failed to recruit *a pirori* sample size for clinical significance	
Malkoun, Huber, & Huber, 2012	Cross-over quasi-experiment **investigating interface pressure at the**	Consecutive subjects were recruited from an outpatient vascular laboratory (n=116) Characteristics: • mean age 56yrs ±18.3	• Comparison of interface pressures for: ○ Action® Heel Support ○ Oasis Elite viscous elastic gel (VEG) heel block	• Interface pressure reading at four anatomical sites using XSensor® X3 pressure mapping system	• Offloading devices (Oasis block and prototype) generated significantly (p<0.0001) less pressure at heel compared to the other devices/surfaces.	• No blinding	**Indirect evidence Quality: low**

Ref	Type of Study	Sample	Intervention(s)	Outcome Measures & Length of Follow-up	Results	Limitations and comments	
	heel and Achilles tendon of different offload devices in the OR setting	• mean weight 78.1kg±14.5 • mean BMI 27.3±4.7	○ Action® Overlay VEG mat ○ Prototype leg elevation device, Viater® Medical ○ Regular theatre table	• Measurements were taken 2 minutes after the device was put into place • Measurements were taken at the heel, Achilles tendon, lateral malleolus, and calf	• Prototype device and Oasis block median pressure 0 mmHg at heels • Theatre table and the Action® VEG mat median pressure 0 mmHg at Achilles tendon but 193.2 mmHg and 174.8 mmHg respectively at heel • Prototype device applied significantly (p<0.0001) less pressure to the Achilles tendon than the Action® heel support or Oasis block • Prototype device significantly (p<0.0001) less pressure at lateral malleolus than Oasis block or Action		
Clinical question 3: What are the unique pressure injury treatment strategies for individuals in the operating room?							
No specific studies identified							
Additional topics							
Outcomes for surgery and influence of pressure injuries							
Ireland, Kelly, & Cumming, 2015	Cross sectional study investigating **factors associated with length of stay for patients with hip fracture**	All Australian Dept Veterans' Affairs (DVA) registered hospitalizations for hip fracture from 07/08 to 07/09 (n=2,552) Characteristics: • Classified as being admitted from community dwelling or residential aged care (RAC) facilities (27.7%) • Comorbidities and complications were comparable between	N/A	Adverse events following hospitalization for hip fracture	• 14.4% of participants had a diagnosis of skin ulceration (14.5% for community dwelling and 14% for RAC dwelling) • Skin ulceration increased acute phase length of stay for hip fracture significantly by mean 5.4 days (95% CI 3.4 to 7.5, p<0.001) for community dwelling patients and by mean 3.2 days (95% CI 1.4 to 5.3, p<0.001) for RAC dwelling patients • Skin ulceration increased total hospital length of stay for hip fracture significantly by mean 5.6	• No multivariate logistic analysis or control for pre-existing comorbidity and age or effects of multiple adverse events • Relies of database records and linkage of hospital records to DVA databases	**Level of evidence: 4** **Quality: low**

Ref	Type of Study	Sample	Intervention(s)	Outcome Measures & Length of Follow-up	Results	Limitations and comments	
		community dwelling and RAC dwelling participants (except for dementia and respiratory infection)			days (95% CI 4.0 to 7.4, p=not sig) for community dwelling patients and by mean 3.7 days (95% CI 1.7 to 5.9, p<0.001) for RAC dwelling patients **Study conclusions: Acquiring a pressure injury following admission for hip fracture is associated with a significant increase in length of stay**		
Mariconda et al., 2015	Prospective observational study investigating **outcomes for patients following hip fracture**	Consecutive patients with fractured hip admitted in a 15-month period (n=568 meeting inclusion criteria) Inclusion criteria: • Aged ≥ 50 years • Low energy trauma Exclusion criteria: • Pathological fracture • Conservative managment Participant characteristics: • Mean age 78.3 yrs (range 50 to 105) • 77.3% sample was female • Mean BMI 25.3 (range 15.2 to 44.4) • 20.8% had dementia • Mean MMSE 21.7 • 70.1% had full mobility prior to fracture (walk unaccompanied without aids)	Surgical correction of fractured hip Follow up 12 months	Multivariate analysis Considering patient demographics, surgical variables, fracture classification, length of stay, complications and mortality	• PU following fracture of the hip was inversely related to the MMSE score (odds ratio (OR) 0.90; 95% CI 0.87 to 0.94, p<0.001) and to surgery performed within 72 hours (OR 0.53, 95% CI 0.30 to 0.93; p=0.028). • PU following fracture of the hip was directly associated with ASA grade (OR 2.41, 95% CI 1.40 to 4.14, p=0.001)	• Patients lost to follow up (n=16) were excluded from analysis • Minimal analysis presented for PU	**Level of evidence: 4** **Quality: high**
Mehaffey et al., 2017	Cross sectional study to determine	Participants were a taken from the National Inpatient Survey conducted in 1050	NA	• Record review • Unclear how pressure injuries	**Pressure injury incidence** 29.4%	• retrospective design relying on records	**Level of evidence: 4**

Ref	Type of Study	Sample	Intervention(s)	Outcome Measures & Length of Follow-up	Results	Limitations and comments	
	whether the pressure injures increase mortality in patients undergoing major vascular procedures	hospitals in the US (n=538,808 people, n=16,000 with pressure injury) Inclusion criteria: Aged above 18 years Exclusion criteria: • Patients with ruptures aneurysms were excluded Participant characteristics: There were significant differences between people with and without pressure injury in almost all variables including demographics, comorbidities and surgical factors (e.g., type of surgery)		were identified and evaluated	**Clinical outcome (pressure injury vs no pressure injury)** • Death (6.3% vs 2.7%,p<0.001) • Length of stay (17±0.14 vs 6.6±0.13, p<0.001) • Place of discharge (p<0.001) • Wound complication (6.1% vs 4.2%, p<0.001) • Infection complications (2.4%cvs 1.1%, p<0.001) • Cardiovascular complications (4.5% vs 4.1%, p=0.002) • Systemic complications (0.8% vs 0.7%, p=ns) • GIT complications (0.5% vs 0.8%, p<0.001) • Procedural complications (2.9% vs 2.6%, p=0.01) • Neurological complications (18.2% vs 8%, p<0.001) **Author conclusions: Presence of a pressure injury is indicative of a poor clinical outcome for individuals undergoing major vascular procedures.**	• The database is lacking data on clinical granularity and no details on treatment interventions • Data may not be directly translatable to individual centers • Unclear whether pressure injury preceded factors or vice versa	**Quality: high**
Prevalence studies							
L. Nilsson et al., 2016	Prevalence survey **identifying rate of adverse events including PU in surgical patients**	Random sample of 20 to 40 records each month were reviewed in 63 Swedish hospitals covering a 12 month period (n=19,141 reviewed, n=3301 were surgical patients, corresponds to 1.6% national surgical records) Inclusion criteria:	All hospitals had their own review teams consisting of clinicians from different backgrounds who discussed each adverse event	Adverse events were categorized based on type (including PU Category/Stage 2 to 4) Adverse events were categorized by severity based on level and type (temporary or permanent) of harm to patient	**Adverse events** 15.4% (n=507) of admissions experienced at least one adverse event 37.5% (n=247) adverse events were considered non-preventable **Pressure ulcer incidence** • All age groups: 6.1% (n=31) • Aged 18 to 64 years: 1.1% (n=2)	• Relied on medical record data • No interrater reliability conducted for identifying or categorizing adverse events • Did not include having a surgical procedure in the protocol –	**Level of evidence: 4** **Quality: low**

Ref	Type of Study	Sample	Intervention(s)	Outcome Measures & Length of Follow-up	Results	Limitations and comments	
		Patients aged ≥ 18 years In-hospital stay of ≥ 24 hours Participant characteristics: 49% female Median age 67 to 68 years(range 18 to 100)		Adverse events were categorized as not preventable, probably not preventable, probably preventable or preventable	• Aged ≥ 65 years: 8.8% (n=29) • Significantly more likely in older cohort (p<0.001) • Women more likely to experience PU than men (p<0.03)	researchers assumed the random sampling would represent OR patients • Unclear how PU was identified and whether PU on admission was included	
Bulfone, Marzolil, Wuattrin, Fabbro, & Palese, 2012	**Prevalence study**	Operating theatres in a teaching hospital (North Italy) Inclusion/exclusion criteria: • Participants who underwent major surgery • on the operating table for > 2 hrs and observable for at least 6 days post-op. (n=102) • Excluded: transferred to ICU or other hospitals after surgery	N/A	• Pressure ulcers were graded as per NPUAP classification • Clinical inspection	• Overall Incidence during intraoperative period: 13/102 (12.7%) • During general surgery: 4/13 (38.4%) During vascular surgery: 2/13 (15.3%)		**Level of evidence: 4**
Bry, Buescher, & Sandrik, 2012	**Prevalence study**	Urban trauma unit (USA) Inclusion/exclusion criteria: • General and critical care admissions over 12 to 17 months (only adult patients) • paediatric, obstetric, and psychiatric units Participant characteristics: • Mean age 67.3 years • 74.4% patients were black, 5.8% Hispanic, 8.5% white	N/A	• HAPU was reported by nursing staff to the researchers who then assessed and staged PU • Clinical inspection • No information about PU staging system reported ○ SDTI 45% ○ Stage II PU 14.6% ○ Stage III PU 20.7% ○ Unstageable PU 19.5%	• Average incidence rate for at least one HAPU in a patient: ○ Critical care: 5.0 per 1000 patient days ○ General hospital: 1.1 per 1000 patient days ○ Facility: 1.5 per 1000 patient days • 82 patients with at least 1 HAPUs were identified within study period.	• Single centre data absent of comparison group • No direct observation on management strategies • Lack of information about HAPUs identified	**Level of evidence: 4**

Ref	Type of Study	Sample	Intervention(s)	Outcome Measures & Length of Follow-up	Results	Limitations and comments	
Haleem, Heinert, & Parker, 2008	**Database review prevalence study**	Participants were a consecutive cohort of those admitted to one hip fracture unit in the UK under one clinician. (n=4654) Participant characteristics: • Mean age was 76.6yrs for those without PU and 82.1yrs for those with PU (p<0.001)	N/A	• Data base review • PU was defined as any break in the skin (stages II to IV) on buttocks, heels or sacral region.	• Incidence of PU 3.8% • Participants with PU had a significant longer time from admission to surgery (37.7hrs versus 27.6 hrs, 95% CI 17.36 to to 2.84, p<0.0067) No significant difference between duration of anaesthesia between those with and without PU (p=0.16)	• Broad definition of PU and method of identification is not reported • All participants received Standardized management	**Level of evidence: 4**
Lumbley, Ali, & Tchokouani, 2014	Retrospective record review study **reporting characteristics of individuals developing pressure injury during surgery**	Participants were individuals who underwent surgery in a 6 year period at one medical center in US (n=812 pressure injury cases, 222 met inclusion criteria) Inclusion criteria: • Experienced a pressure injury deemed to be related to intraoperative period • Aged < 80 years • Surgery > 2 hours Participant characteristics: 68% male Average age 57.5 years (range 18-80) 68.5% white, 6.8% African American, 20.3% race unknown	NA	• Pressure injury noted in medical record • Also collected demographic, diagnostic and medical data from records	• Mean surgical time was 3hrs 55mins (range 2 to 16), with 94 incidents in the 2-4 hour range and 38 in the 4-6 hour range • Comorbidities were varied including hypertension (n=67), cardiac disease (n=62), diabetes (n=55), respiratory disease (n=49), cancer (n=31), malnutrition (n=23) • Intraoperative position was most often supine (n=189), prone (n=17) and lateral (n=11) • Surgical type was most often abdominal (n=98), non-cardiac thoracic (n=37), orthopedic (n=33), trauma/burn (n=32) • Pressure injury location was most often coccygeal/sacral (n=86), buttocks (n=45), penile (n=16), heels (n=12) and scrotal (n=12) **Author conclusions: supine abdominal surgery of 2-4hours duration is most associated with pressure injuries**	• Rationale for case length inclusion was that a case < 2 hours is not sufficiently long to lead to a pressure injury • Unclear how pressure injuries were deemed to be related to intraoperative period • Relied on medical record data • No MV analysis or comparator group • Single center study • No pressure injury severity reported • Large amounts of missing data	**Level of evidence: 4** **Quality: low**

Additional evidence from systematic reviews to support discussion

Ref	Type of Study	Sample	Intervention(s)	Outcome Measures & Length of Follow-up	Results	Limitations and comments	
Madrid et al., 2016	Systematic review investigating **active body warming systems for decreasing perioperative hypothermia**	The systematic review included only one RCT that reported PUs. The included RCT was conducted in a UK operating room (n=338 participants) Inclusion criteria: • RCTs assessing efficacy of perioperative warming systems • RCTs that included adults undergoing scheduled surgery where hypothermia was not intended • Participant characteristics: (in the single included RCT) • Mean age 68 years • Undergoing elective surgery • Mean surgery duration was approx. 112 mins • Regional or general anesthesia	Participants received either • Forced air warming device plus warmed IV fluids. Temperature setting, duration and anatomical location not reported (n=161) or • Standard care consisting of normal ambient temperature, minimal patient exposure, warmed blankets and warmed IV fluids at clinical discretion (n=163)	Pressure ulcers (not state how these were identified or assessed)	There was a non-significant reduction in risk of PU associated with active body system warming RR 0.54, 95% CI 0.25 to 1.17, p=0.12	• Study was considered to be at moderate risk of bias. It was randomized and non-blinded • Identification and assessment of PUs not reported (i.e. unclear if Category/Stage I included) • No meta-analysis in this review	**Quality: moderate**

Table 1: Level of Evidence for Intervention Studies

Level 1	**Experimental Designs** • Randomized trial
Level 2	**Quasi-experimental design** • Prospectively controlled study design • Pre-test post-test or historic/retrospective control group study
Level 3	**Observational-analytical designs** • Cohort study with or without control group • Case-controlled study
Level 4	**Observational-descriptive studies (no control)** • 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
- Moderate quality studies: fully met at least 70% of applicable criteria
- Low quality studies: did not fully meet at least 70% of applicable criteria

CROSS SECTIONAL/SURVEY/PREVALENCE STUDIES/OBSERVATIONAL

Endnote ID	Author/year	Focussed 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
6695	Ireland et al., 2015	Y	Y	U	U	Y	U	N	N	U	Y	4	low
11029	L. Nilsson et al., 2016	Y	N	U	N	Y	N	U	N	Y	U	4	Low
9506	Mariconda et al., 2015	Y	Y	Y	Y	Y	U	N/A	Y	Y	Y	4	high
3000	Lumbley et al., 2014	Y	Y	U	Y	Y	U	NA	N	Y	N	4	Low
14087	Mehaffey et al., 2017	Y	Y	Y	Y	Y	Y	Y	Y	U	Y	4	High
17859	Sasabuchi et al., 2018	Y	Y	Y	Y	Y	U	U	N	Y	Y	4	Moderate

CASE SERIES

	Author/year	Focussed question	Participant characteristics reported	Inclusion criteria defined	Consecutive recruitment	Participants entered at same disease stage	Intervention clearly reported	Outcomes relevant and defined apriori	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
2867	Furuno et al., 2014	N	N	Y	U	U	N	Y	Y	NA	N	NA	N	N	4	Low

PROGNOSTIC STUDIES

	Author/year	Adequate description of baseline characteristics	Satisfactory study attrition	Clear outcome measures/prognostic factors	Range of prognostic factors/confounders measured identified	Method of measuring prognostic factor is reported, valid and reliable	Same method of measure of prognostic factor for all	Continuous variables or appropriate cut offs	Percent participants with complete data acceptable	Appropriate imputation method	Confounders/prognostic factors accounted for in analysis	Selective reporting avoided	Adequate sample size (10 PIs per factor)	Level of evidence	Quality
6407	Hayes et al., 2014	Y	U	Y	N	Y	Y	Y	Y	NA	N	N	Y	3 (prognostic)	Low
14698	Lin et al., 2017	Y	U	Y	Y	U	Y	N	U	NA	Y	N	U	3 (prognostic)	Low
14839	Magny et al., 2017	Y	Y	N	Y	U	U	U	U	NA	N	U	Y	3 (prognostic)	Low
8855	Shen et al., 2015	Y	Y	Y	N	N	U	N	U	NA	N	Y	Y	3 (prognostic)	Low
17628	Kim et al., 2018	Y	Y	Y	Y	Y	U	U	U	NA	Y	U	N	3 (prognostic)	Low
17196	Wright et al., 2014	Y	U	N	Y	U	U	U	U	NA	Y	U	N	3 (prognostic)	Low
1302	Chen et al., 2013	N	U	Y	N	U	U	Y	U	NA	Y	U	N	3 (prognostic)	Low

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
10806	Madrid et al., 2016	Y	Y	N	Y	Y	Y	Y	Y	Y	Y	NA	NA	Y	NA	Y	High
14274	Chen, Shen, Liu, & Liu, 2017				N			N		N		N		N	Y		Exclude
14421	de Oliveira et al., 2017				N			Y		Y		NA		N	Y		Exclude

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