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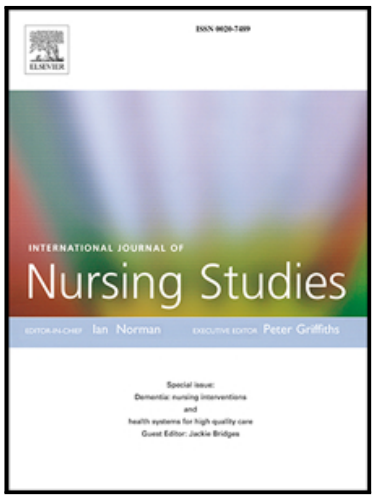

Repositioning for pressure injury prevention in adults: An abridged Cochrane systematic review and meta-analysis.

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TITLE

Repositioning for pressure injury prevention in adults: An abridged Cochrane systematic review and meta-analysis.

AUTHORS

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*This article is based on a Cochrane Review published in the Cochrane Database of Systematic Reviews (CDSR) 2020, Issue 6, DOI: 10.1002/14651858.CD009958.pub3 (see www.cochranelibrary.com for information). Cochrane Reviews are regularly updated as new evidence emerges and in response to feedback, and the CDSR should be consulted for the most recent version of the review.

Abstract

Background: A pressure injury is an area of localised damage to the skin and underlying tissues. Patient repositioning is an important prevention strategy, as those with limited mobility are at increased risk of developing pressure injury.

Objectives: To assess the clinical and cost-effectiveness of repositioning schedules on the prevention of pressure injury in adults.

Design: Systematic review and meta-analysis.

Data sources: The Cochrane Wounds Specialised Register; the Cochrane Central Register of Controlled Trials; MEDLINE (Ovid); Embase (Ovid) and Cumulative Index of Nursing and Allied Health Literature Plus (EBSCO) were searched in February 2019. No restrictions were applied to language or date of publication.

Review methods: Studies were eligible if they were randomised controlled trials including cluster trials, published or unpublished, and undertaken in any healthcare setting that assessed the clinical and/or cost effectiveness of repositioning schedules for prevention of pressure injury in adults. Methodological quality of the studies was independently assessed by three authors. Heterogeneity between studies was assessed using the I^2 statistic, and the pooled risk ratios along with their 95% confidence intervals were estimated using either fixed and random effects models, as indicated. Grading of Recommendations Assessment, Development and Evaluation was used to appraise the certainty of evidence.

Results: Eight eligible trials involving 3,941 participants published between 2004 and 2018 were identified. Trials compared either different repositioning frequencies or positioning regimens. Three trials (1074 participants) compared 2-hourly with 4-hourly repositioning (risk ratio 1.06, 95% confidence interval 0.80 to 1.41; I^2 = 45%). Two other trials (252

participants) compared a 30-degree tilt with a 90-degree tilt (risk ratio0.62, 95% confidence interval 0.10 to 3.97; I^2 =69%).

Only two trials included economic analyses, both amongst nursing home residents. One study estimated the costs of repositioning to be Canadian dollars $11.05 and Canadian dollars $16.74 less per resident per day for the 3-hourly or 4-hourly regimens, respectively, when compared to 2-hourly regimen. The second study reported 3-hourly repositioning using a 30-degree tilt to cost €46.50 (95% confidence interval €1.25 to €74.60) less per patient in nursing time compared with 6-hourly repositioning with a 90-degree lateral rotation.

Conclusion: It remains unclear which repositioning frequencies or positions are most effective in preventing pressure injury in adults. There is limited evidence to support the cost effectiveness of repositioning frequencies and positions.

Registration: Cochrane protocol published in 2012.

What is already known about the topic?

- Pressure injuries are areas of localised damage to the skin or underlying tissue, often over a bony prominence and generally caused by pressure and/or shear.
- Immobility is a major risk factor for the development of pressure injury and is an important component of risk assessment.
- Repositioning is an important strategy that redistributes pressure and is recommended in international pressure injury prevention clinical practice guidelines.

What this paper adds

- The body of evidence on the clinical and cost effectiveness of particular positions and repositioning frequencies for pressure injury prevention in adults is low quality.
- There is a paucity of evidence on the effectiveness of regular repositioning. Given the lack of evidence does not prove a lack of effect, repositioning remains an important pressure injury prevention strategy and recommended by most guidelines.
- Findings from the eight clinical trials and two economic analyses included in this review suggest the evidence to support the use of one particular repositioning frequency and position over another to prevent pressure injuries is low in quality and limited in amount. It remains unclear which position or frequency of repositioning is the most effective in reducing pressure injury development.

Keywords: Pressure ulcer, repositioning, randomised controlled trial, systematic review, meta-analysis, cost-effectiveness

1. Introduction

A pressure injury is an area of underlying tissue damage caused by shear or pressure for a prolonged period, often occurring over bony prominences [2]. While the terms pressure 'ulcer' or 'bed sore' are also used to describe pressure injuries, the term pressure 'injury' is used in this paper in accordance with recent international guidelines [2]. Hospital acquired pressure injuries are preventable adverse events and are associated with increased risk of mortality, significantly higher hospitalisation costs, and longer lengths of hospital stay for patients [3-5].

The results of a recent systematic review and meta-analysis undertaken to describe the global prevalence and incidence of pressure injuries indicated that pooled prevalence of hospital-acquired pressure injuries was 12.8% (95% confidence interval 11.8 to 13.9), with an incidence rate of 5.4 per 10,000 patient days [6]. The most frequently occurring locations of pressure injury identified in this same systematic review were the sacrum, heels, and hips [6]. Costs of pressure injury treatment varies between countries but is considerably higher in developed countries. For example, a cost analysis of 273 hospitals in the United Kingdom showed that pressure injuries cost £750 million [2] per annum resulting in the loss of 26 healthy life years [7]. Estimates based on Australian data suggest that pressure injury treatment costs $1.8 billion Australian dollars annually [8], while in the United States, the national cost of hospital acquired pressure injuries has been estimated at US$26.8 billion per annum [9]. A large proportion of these healthcare costs relate to nursing time associated with the delivery of care [8 10].

Clinical guidelines recommend repositioning for the prevention of pressure injuries in at risk patients [2]. Repositioning regimes involve frequency (e.g. 2-hourly), positioning using tilt and/or position (lateral, supine, prone), and are used to redistribute pressure between the

body and support surface [5]. Repositioning is believed to work as a prevention strategy by reducing the duration of pressure on tissues, decreasing tissue hypoxia and thus risk of pressure ulceration [11 12]. However, recommendations for routine repositioning are largely based on findings from small observational studies conducted more than 25-years ago [13].

A systematic review synthesising evidence for effectiveness of repositioning in adults was undertaken. The aim was to assess the clinical and cost-effectiveness of repositioning schedules on the prevention of pressure in adults regardless of risk in any healthcare setting.

2. Materials and methods

2.1. Design

This systematic review is an abridged version based on our 2020 Cochrane review [14] (updated from the original review, published in 2014[15]; the protocol was published in 2012[16]). It followed the recommendations from Preferred Reporting Items for Systematic Review and Meta-Analysis (PRISMA) guidelines for reporting systematic reviews and meta analyses [17].

2.2 Inclusion/exclusion criteria

Publications identified in the search of the five databases were combined and duplicates removed. Randomised controlled trials and cluster-controlled trials cluster-controlled trials were included, regardless of the cluster group (i.e. patient, nurse, hospital). Cross-over trials and quasi-randomised studies were excluded as were all other designs.

All studies were reviewed for eligibility against the population, intervention, comparison, outcomes (PICO) criteria. The population included adult patients admitted to any healthcare or long-term care facility without an existing pressure injury at baseline. Studies where the

only systematic differences were due to varying repositioning frequencies were included. So were the trials comparing *different positions* for repositioning, where the systematic difference between groups were due to such positionings. Studies comparing any repositioning regimen with standard practice, were also included.

The primary outcome measure was the proportion of participants with a new pressure injury (i.e. cumulative incidence) of any stage or location/body region, measured in the study as either primary or as a secondary outcome. Pressure injury stage was defined according to published criteria [2 13], or as defined by study authors. Secondary outcomes included health-related quality of life, procedural pain, patient satisfaction, and costs (e.g. costs of pressure injury prevention, related health practitioner time or visits, costs avoided by pressure injury prevention).

Comparative full and partial economic evaluations conducted within the framework of eligible randomised controlled trials, or cluster-controlled trials reporting information such as estimates of resource use or costs associated with repositioning and a comparator were included as part of the review of health economic evidence. Only health economics studies conducted alongside effectiveness studies were considered.

2.3 Search strategy

Electronic databases searched to identify relevant clinical trials included the Cochrane Wounds Specialised Register of Controlled Trials (; 2019); Ovid MEDLINE; Ovid Embase; EBSCO Cumulative Index of Nursing and Allied Health Literature Plus; and the National Health Service Economic Evaluation Database (2015). All searches were on 12 February 2019. The US National Institutes of Health Ongoing Trials Register, ClinicalTrials.gov, the World Health Organization (WHO) International Clinical Trials Registry Platform and the

European Clinical Trials Register were searched 10 March 2019. To identify economic studies, filters developed by the Centre for Reviews and Dissemination were applied to the Ovid MEDLINE, Ovid Embase, and EBSCO Cumulative Index of Nursing and Allied Health Literature Plus searches (CRD 2013).

The reference lists of included trials, relevant systematic reviews, meta-analyses, and health technology assessment reports were also searched to identify other potentially eligible trials or supplementary publications. Search filters were applied to databases, including the Cochrane Highly Sensitive Search Strategy for identifying randomised trials in MEDLINE; the Ovid Embase filter; and the trial filters which were applied to the Cumulative Index of Nursing and Allied Health Literature Plus searches. No restrictions were applied to language, date of publication, or study setting.

2.4. Study selection

Three review authors independently assessed all titles and abstracts of retrieved citations against the eligibility criteria. Full reports of all potentially relevant trials were retrieved for further assessment of eligibility. Where there were discrepancies, review authors discussed and made decisions by consensus.

2.5. Data collection process and extraction

Data were independently extracted from included studies by three review authors. A specifically designed data collection tool was used to extract information (e.g., author, title, journal title, year of publication, country; healthcare setting; eligibility criteria; sample size; intervention; primary and secondary outcome measures). If data were missing from reports, attempts were made to contact authors. Data were entered into Review Manager 5

software (Review Manager 2014) by one author and a data check for accuracy was performed by two review authors.

2.6. Risk of bias assessment

Two review authors independently assessed the risk of bias of eligible trials using the Cochrane tool for assessing risk of bias [18]. The domains randomisation, allocation concealment, blinding of outcome assessors, and incomplete outcome data were assessed as low risk of bias, high risk of bias, or unclear risk of bias. Overall high risk of bias was defined as if a trial was rated as 'high' for any one of the three key domains.

Assessment of risk of bias is presented in the 'Risk of bias' summary figure that details reviewers' judgements in a cross-tabulation of studies. Where authors did not report validity criteria, these trials were recorded as being at unclear risk of bias. During study selection, data extraction, and assessment of risk of bias, any disagreements between review authors were resolved by consensus or by referral to another review author.

2.7. Data analysis

For measures of treatment effect, effect estimates for dichotomous outcomes (e.g. relative proportions of patients developing pressure injuries during follow-up) are reported as risk ratios with 95% confidence intervals [19]. In the absence of clinical and methodological heterogeneity we conducted a fixed effects analysis. A random effect model was used when heterogeneity exceeded 50%. The Chi-squared and I^2 statistics were used to calculate heterogeneity and reported as the pooled estimate together with its 95% confidence interval. Where appropriate, the data are presented using forest plots. The decision to pool data depended on the availability of outcome data and the assessment of between-trial heterogeneity. Quantitative data were analysed using Review Manager 5 [20].

Where possible, costs relating to implementing pressure injury prevention and treatment strategies (including complications or infections), health practitioner time or visits, duration or costs of hospital stay for pressure injury and associated adverse events were extracted. Where reported, indirect costs to society associated with pressure injury such as lost productivity were also extracted.

2.8. Summary of findings and assessment of the certainty of the evidence

The 'Summary of findings' tables provide key information about the certainty of the evidence, the magnitude of the intervention effects, the sum of the available data for the primary outcome and secondary outcomes [21] and an overall grading of the body of evidence related to these outcomes using the Grading of Recommendations, Assessment, Development and Evaluations assessment [15 16]. Grading of Recommendations, Assessment, Development and Evaluations assesses the certainty of a body of evidence as high, moderate, low, or very low, which represents the extent to which one can be confident that an estimate of effect is close to the true effect [16]. The level of certainty is downgraded according to risk of bias, precision of the effect estimate, consistency of individual study results, how directly the evidence answers the question(s) of interest, and risk of reporting and publication biases [22 23].

3. Results

3.1. Study characteristics

The study flow diagram is shown in Figure 1. This search yielded 463 intervention records in addition to 18 records from clinical trial registries, resulting in a total of 305 unique records after duplications removed. Fourteen full-text articles and 18 records from clinical trials registries were retrieved. Eight trials (three from the previous review[1]) were included in this

review, representing a total of 3941 participants. Two of the eight included trials were cluster-controlled trials, and studies were conducted in Europe (n=4)[24-27], North America (n=2) [28 29], and Asia (n=2) [30 31].

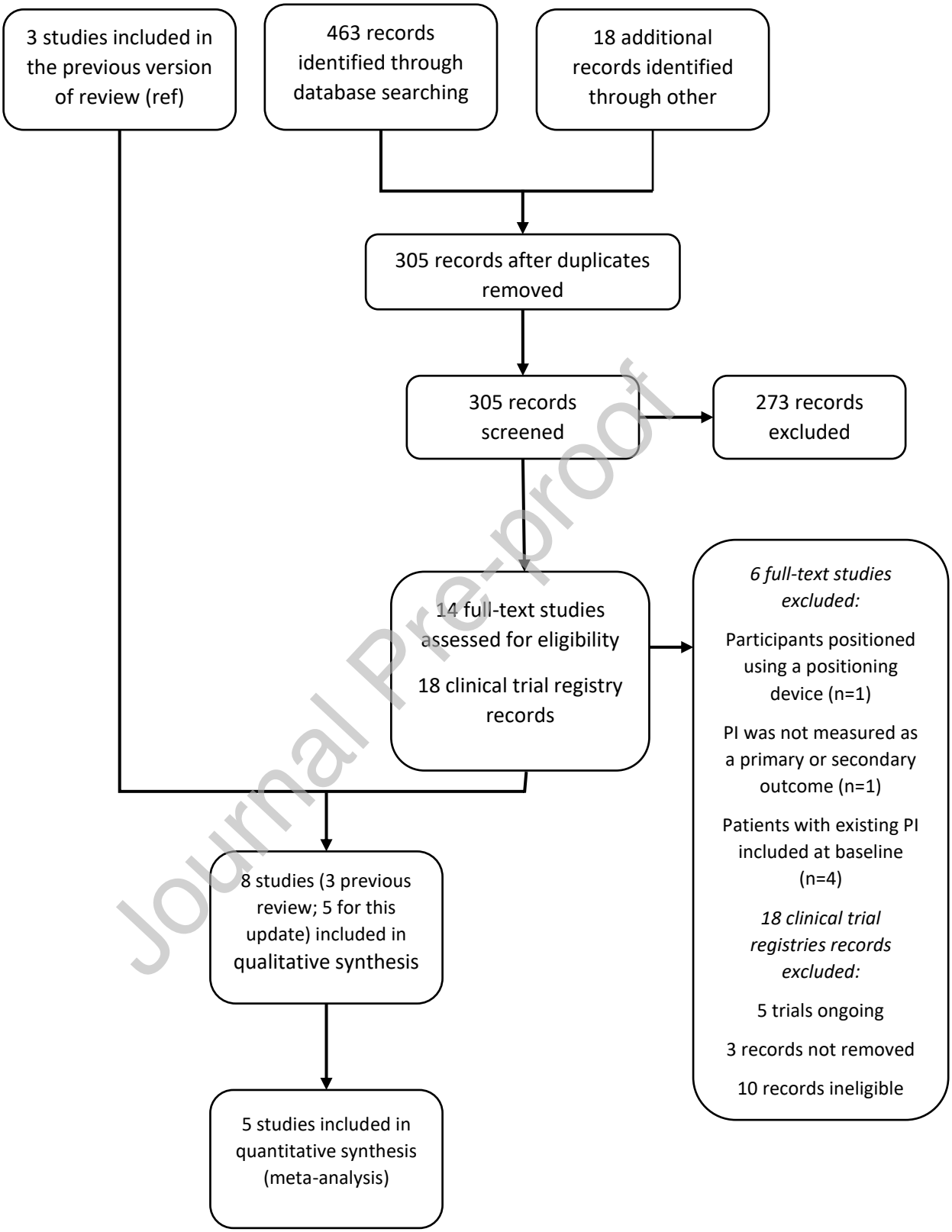

Figure 1. Study flow diagram for clinical studies (undertaken in February 2019)

Three of the eight trials assessed different combinations of repositioning frequencies (2-, 3-, 4- and 6-hourly) [24 25 28] and three compared different tilt positions (30°, 45°, or 90°) [26 27 31].

The Pickham trial assessed whether the feedback provided from a wearable patient sensor would increase turning compliance using a 2-hourly turning regimen with 20° tilt [29]. Zhou 2014 compared a prone position with a standard supine position [30]. Further details regarding the characteristics of included studies are outlined in Table 1.

Electronic searches for this update yielded 237 economic evaluation records. Of these, 236 records were excluded because they did not meet the inclusion criteria. Two economic sub studies met the inclusion criteria [32 33] (Figure 2).

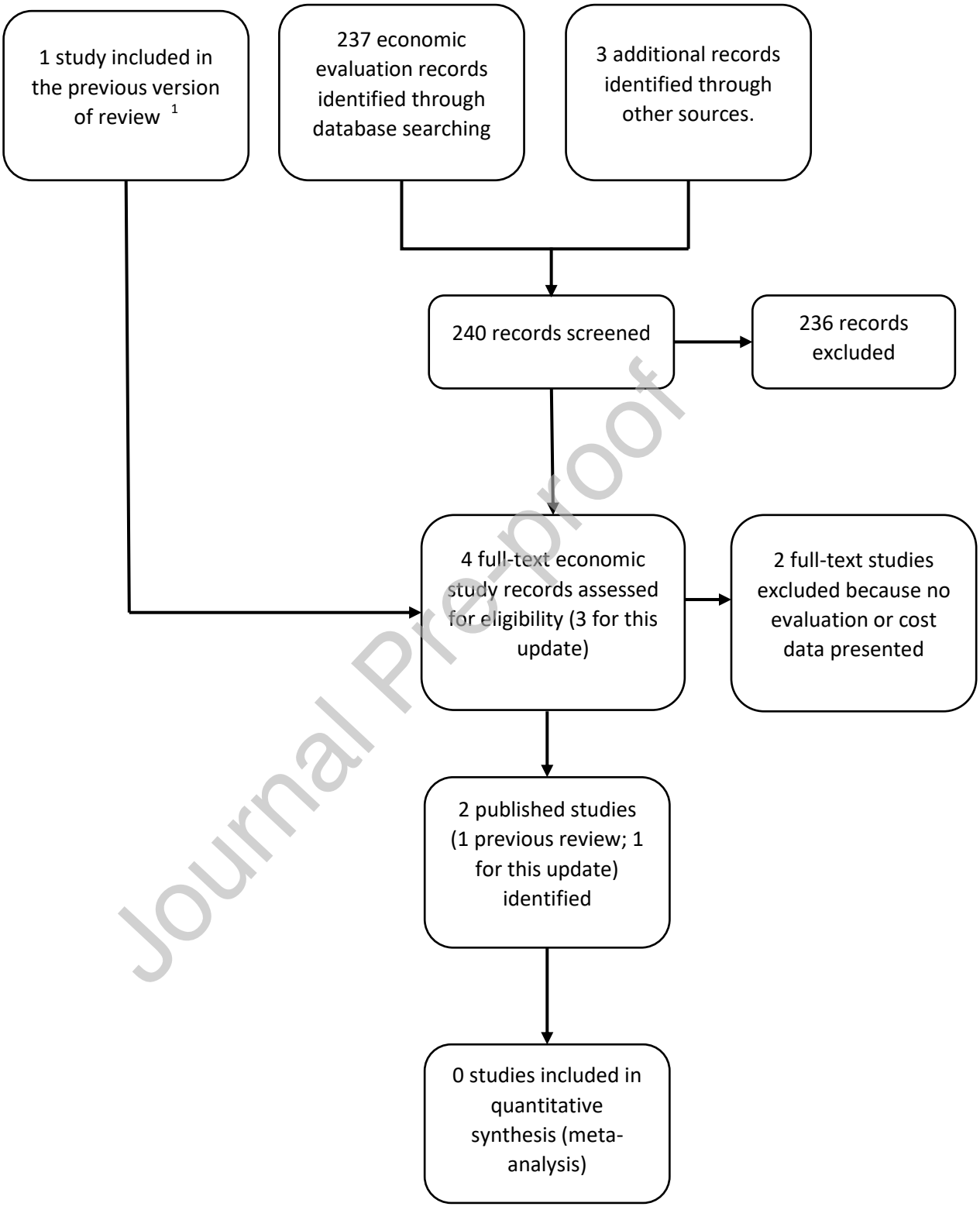

Figure 2 Study flow diagram for economic studies (undertaken in February 2019)

Table 1 Characteristics of included randomised controlled trials (listed in reverse chronological order)

Author, year	Setting and participants	Study design and intervention	Outcomes	
Pickham 2018	Location: Intensive care unit (n=2) in a large academic medical centre in California, USA. Number of participants: n=1312 (intervention: n=659; control: n=653). Inclusion criteria: Critically ill medical, surgical and trauma patients Exclusion criteria: Patients less than 18 years of age; patients with an issue preventing effective sensor adhesion (i.e. a sternal dressing) or known adhesive sensitivity; acuity precluding participation; patient refusal	Study design: pragmatic, investigator-initiated, open-label, single-site, randomised clinical trial. Aims: Assess the clinical effectiveness of a wearable patient sensor to improve care delivery and patient outcomes by increasing the total time with turning compliance and preventing pressure injury s in acutely ill patients. Group A (experimental): Optimal turning: all participants had a sensor applied. Participants received care from nurses who had access to a User Dashboard that provides visual advisories for patient turning, based on data obtained from a wearable patient sensor (Leaf Healthcare Inc). Turning regimen 2-hourly. Group B (control): All participants had a sensor applied. Participants received care from nurses who DID NOT have access to a User Dashboard that provides visual advisories for patient turning. Instead, these participants received standard care practices, patient turning initiated by nurses as necessary. Turning regimen 2-hourly.	Primary outcome: hospital acquired pressure injury Secondary outcomes: Total time with turning compliance. Time points: First 72 hours in ventilator-dependent participants.	Low

Ghezeljeh 2017	Location: intensive care unit in selected government hospitals in Tehran, Iran. Number of participants: n=120 Inclusion criteria: Adults aged ≥ 18 years; no history of ventilator-acquired pneumonia ; hospitalised in intensive care unit; undergoing mechanical ventilation support for 8 hours following hospitalisation; no spinal or unstable pelvic fractures. Exclusion criteria: Patient death; Remaining in selected positions for less than 6 hours over the last 24 hours; history of pressure injury with elevation of head of bed to 45°.	Study design: 3-group randomised clinical trial. Aims: Primary aim was to compare the effect 30° and 45° head of bed tilts on the incidence of ventilator-acquired pneumonia . Incidence of pressure injury was a secondary outcome. Group A: 30° HOB tilt (n = 40). Group B: 45° HOB tilt (n = 40). Group C: routine position (n = 40). Standard care across all groups: Other interventions relative to changing bed sheets, lifting patient rather than dragging, and 2-hourly position changes were performed for participants in all groups.	Primary outcome: unrelated to review outcomes. Secondary outcomes: "the mean probability of pressure injury within 3 days of the analysis of variance test showed that there was no statistically significant difference relative to the mean of the probability of pressure ulcer according to the Braden scale (P = 0.652). Furthermore, none of the patients in the groups suffered from pressure ulcer after 3 days". Time points: participants followed through for 3 days and their skin checked 2-hourly.	High
Manzano 2014	Location: Mixed ICUs (n=2) of a university hospital in southern Spain. Number of participants:	Study design: RCT using 2 groups. Aims: Compare the effectiveness of repositioning every 2 or 4 hours for preventing pressure injury (≥ stage 2) development in intensive care unit	Primary outcome: Occurrence of a new pressure injury (≥ stage 2) at any anatomic site between enrolment in the study and intensive care unit discharge.	Low

	n=329. Inclusion criteria: Critically ill adults; no pressure injury at intensive care unit admission; received invasive mechanical ventilation for at least 24 hours between February 2009 and January 2011. Exclusion criteria: Pregnancy; < 18 years; not being on an alternating air-pressure mattress (due to lack of availability); weight greater than 140 kg or less than 45 kg (as per alternating air-pressure mattress specifications); refusal to consent; mechanical ventilation for more than 48 hours before enrolment in the study; and inclusion in a related trial.	patients under mechanical ventilation. Secondary aims: compare clinical outcomes relative to motility, intensive care unit and hospital length of stay , mechanical ventilation duration, adverse/safety events, and nursing workload. Group A: 2-hourly repositioning (n = 165). Group B: 4-hourly repositioning (n = 164). Standard care across all groups: All participants had the same alternating air-pressure mattress . Standard sedation and analgesia consisted of fentanyl plus propofol or midazolam. The weaning protocol included the daily interruption of sedatives and spontaneous awakening trials.	Secondary outcomes: unrelated to review outcomes. Time points: follow-up for 24 hours.	
Zhou 2014	Location: intensive care unit (n=1) in Beijing, China Number of participants: n=116	Study design: 2-armed randomised controlled trial with a 28-day follow-up period Aims: Examine the effects of prone positioning on the occurrence of pressure injury (secondary outcome).	Primary outcome: unrelated to review outcomes Secondary outcomes: occurrence of pressure injury Time points: daily for up to 72 hours	Unclear

	Inclusion criteria: - Exclusion criteria: - unclear, details not available from translation.	Group A (intervention): Prone position for 10 hours, alternating 4 to 6 hours supine, and then repositioned in the prone position for another 10 hours. Group B (control): Supine position with standard care		
Bergstrom 2013	Location: Nursing homes in the US (n=20) and Canada (n=7) Number of participants: n=967 Inclusion criteria: Nursing home residents; aged ≥65 years; no exiting pressure injuries; Braden scale either moderate (13 to 14) or high (11 to 12); limited mobility (≤ 3 on Braden subscale of mobility). Exclusion criteria: individuals deemed not competent to provide consent.	Study design: randomised controlled trial Aims: Determine the effectiveness of 3 repositioning (turning) schedules (2-, 3-, 4-hourly) for prevention of pressure injury in nursing home residents Group A: repositioning every 2 hours/± 30 minutes of scheduled time: (n = 335) Group B: repositioning every 3 hours/± 30 minutes of scheduled time: (n = 333) Group C: repositioning every 4 hours/± 30 minutes of scheduled time: (n = 299) Standard care across all groups: all groups repositioned on high-density foam mattresses.	Primary outcome: pressure injury s on sites susceptible to pressure when lying in bed (coccyx or sacrum, trochanter, heel) weekly. Stage 1 pressure injury identified on 2 consecutive days excluded false positives caused by reactive hyperaemia. Secondary outcomes: none reported. Time points: weekly follow-up for 3 weeks (21 days).	Unclear
Moore 2011	Location: Long term aged facilities (n=12) in Ireland Number of participants:	Study design: 2-arm cluster-controlled trial with a 4-week (28-day) follow-up period	Primary outcome: incidence of all pressure injuries during a 28-day period	High

	n=213 Inclusion criteria: • Inpatient in a long-term geriatric facility • Over 65 years of age • At risk of pressure injury development using the activity and mobility components of Braden scale • No pressure injury at time of recruitment to study • No medical condition that would preclude the use of repositioning • Consent Exclusion criteria: • Patients with existing pressure injury	Aims: Examine whether repositioning using 30° tilt and 3-hourly repositioning reduces the incidence of compared with usual care. Group A: 30° tilt (n = 99 participants randomised, 99 analysed) Group B: Usual care (n = 114 participants randomised, 99 analysed) Group C: Co-interventions: participants in both groups nursed as per planned care regarding nutritional regimens, toileting, changing of incontinence pads, preparation for feeding, and pressure redistribution devices on chairs. Repositioned every 2- to 3-hours during the day.	Secondary outcomes: Economic outcomes: • Mean daily nurse time for repositioning • Nurse time cost per patient • Cost of patient free of pressure injury • Projected annual cost Time points: weekly follow-up over 4 weeks	
Defloor 2005	Location: Wards (n=32) across nursing homes (n=11) in Flanders, Belgium	Study design: 5-armed cluster-controlled trial with a 4-week (28-day) follow-up period Aims: Investigate the effect of 4	Primary outcome: incidence of a pressure injury (any stage) during a 28-day period. Secondary outcomes: unrelated to	High

	Number of participants: n=838 Eligibility criteria: • Geriatric residents with a Braden score of < 17 or a Norton score of < 12 • Informed consent of the patient/family • No pressure injury at time of recruitment to study Exclusion criteria: • none stated, but total of 1114 people excluded.	different preventative regimens involving either frequent turning (2- to 3-hourly) or use of pressure-reducing mattress in combination with less frequent turning (4-to 6-hourly). Group A: 2-hourly turning regimen on standard mattress (n=65) Group B: 3-hourly turning regimen on standard mattress (n=65) Group C: 4-hourly turning regimen on viscoelastic polyurethane (pressure-relieving) mattress (n=67) Group D: 6-hourly turning regimen on viscoelastic polyurethane (pressure-relieving) mattress (n=65) Alternating turning positions: semi-Fowler's with feet elevated 30° alternating with 30° lateral rotation, pillow placement under back from shoulder on standard mattress. Specified sitting position: intervention group sitting periods were recorded but not standardised; participants sat on thick air cushions. Backrest tilt on chair, legs on footrest, but heels not supported. Cushion for back. Group 2 control: n=576	review outcomes. Time points: twice weekly for 4 weeks (28 days).	
Young 2004	Location: medical ward of an acute general	Study design: randomised controlled trial (groupings for allocation not	Primary outcome: incidence of non-blanchable erythema during a 24-hour	High

	hospital in Wales. Number of participants: n=46 Inclusion criteria: • Elderly patients • At risk of developing a pressure injury using Waterlow score • Able to lie in 30° tilt position • Given informed consent • No existing pressure injury • Caucasian Exclusion criteria: not stated	reported) with a 24-hour follow-up period. Aims: Examine the effects of the 30° tilt in reducing non-blanchable erythema Group A (intervention): Repositioning using 30° tilt (left side, back, right side, back) 2- to 3-hourly overnight, 2- to 3-hourly during the day. Sacrum and heels free from contact with support surface. Group B: 90° lateral and supine positions 2- to 3-hourly overnight, 2- to 3-hourly during the day. Standard care across all groups: support mattress: low air loss mattress or alternating air pressure mattresses.	period. Secondary outcomes: not stated Time points: 1, at 24 hours

Abbreviations: US, United States

3.2. Risk of bias assessment

Figure 3 summarises risk of bias across included studies. All trials were assessed as being at high risk of bias in at least one domain [17-24]. The risk of bias was unclear for at least one domain for all but three studies [17 20 24].

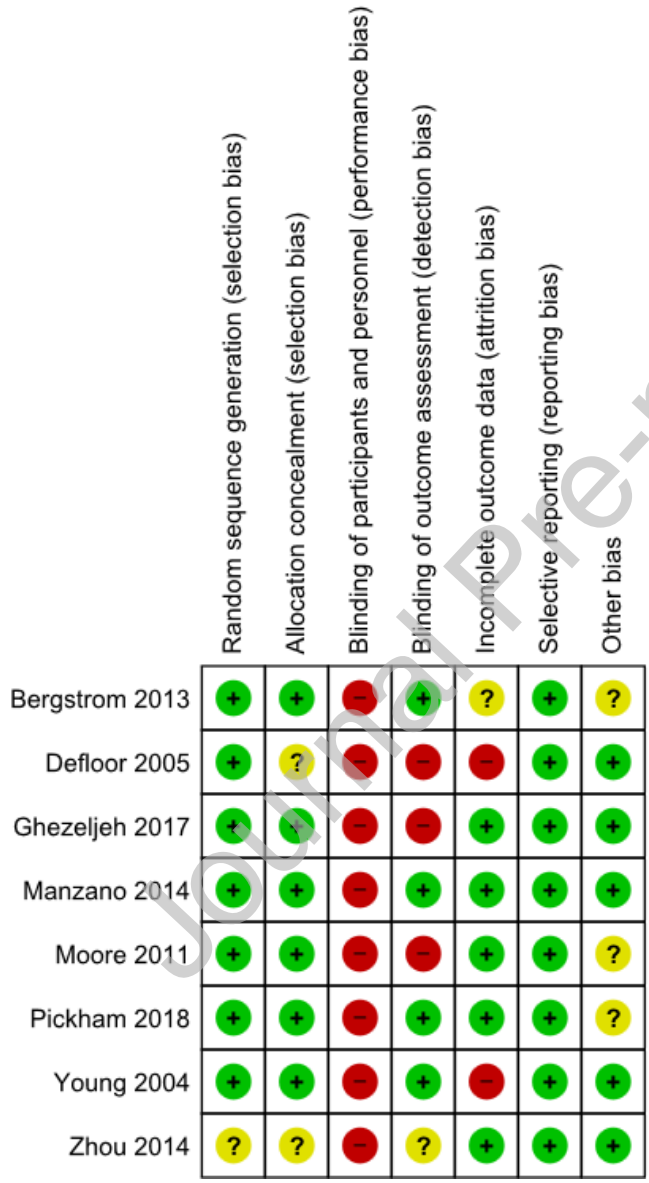

Figure 3: Risk of bias summary for the 8 included studies
(Colour coding: Green=low risk; Yellow=unclear risk; Red=high risk)

3.3. Frequency of repositioning

Data from four trials with 2870 participants compared 2-hourly versus 3-hourly positioning [24 25 28 29] were included. Data from the two trials were unable to be pooled due to high statistical heterogeneity (I^2 = 77%) [25 28]. There were no differences in the risk of pressure injury for 2-hourly versus 3-hourly frequencies in either study (risk ratio 4.06, 95% confidence interval 0.87 to 18.98 and risk ratio 0.90, 95% confidence interval 0.69 to 1.16, respectively), and the certainty of evidence is low [28] to very low [25].

Figure 4 shows a forest plot including three trials comparing 2-hourly with 4-hourly repositioning (1074 participants) (fixed-effect; I^2 = 45%, pooled risk ratio 1.06, 95% confidence interval 0.80 to 1.41) [24 25 28]. It is uncertain whether 2-hourly repositioning compared with 4-hourly repositioning used in conjunction with any support surface increases or decreases the incidence of pressure injury, and the certainty of evidence is very low due to high risk of bias.

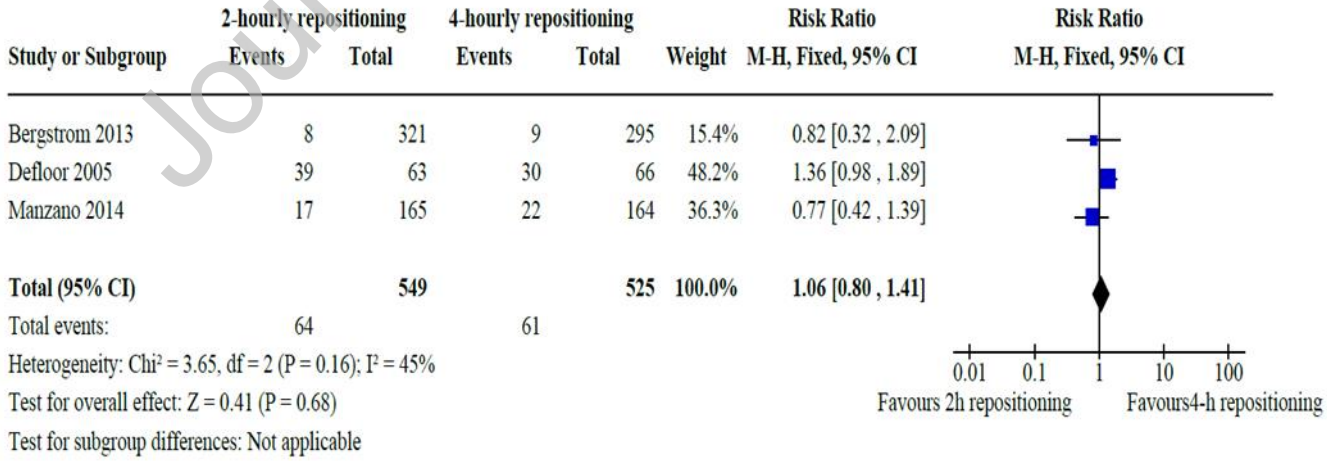

Figure 4: Pressure injury occurrence (stages 1-4), 2-hour versus 4-hourly positioning on any support surface

Bergstrom et al.[28] compared repositioning regimens using 3-hourly (n = 209), and 4-hourly (n = 198) frequencies, with all participants being nursed on high-density foam mattresses. There was no significant difference in pressure injury incidence between with 3-hourly compared with 4-hourly repositioning regimens (risk ratio 0.20, 95% confidence interval 0.04 to 0.92), and the certainty of evidence is low.

Defloor et al.[25] compared the number of new pressure injuries of any stage in participants being nursed on viscoelastic foam mattresses receiving 4-hourly repositioning compared with those receiving 6-hourly repositioning [25]. There was a reported 27% reduction associated with 4-hourly repositioning (risk ratio 0.73, 95% confidence interval 0.53 to 1.02), however the certainty of evidence was very low due to high risk of bias. Finally, Pickham et al.[29] compared a 2-hourly turning regimen using a 20° tilt with "standard care", and participants in the intervention group developed fewer pressure injuries compared to the control group (risk ratio 0.28, 95% confidence interval 0.10 to 0.75), with moderate certainty of evidence [29].

3.4 Different positions for positioning

Data from four trials with 495 participants were included that compared different positions for positioning [26 27 30 31] . Figure 5 shows the forest plot results of two trials comparing 30° and 90° tilts (pooled risk ratio 0.62, 95% confidence interval 0.10 to 3.97) [26 27]. Overall, there was no clear difference in occurrence of stage 1 or 2 pressure injuries (persistent erythema) between the degree of tilting and the certainty of evidence is very low due to high risk of bias.

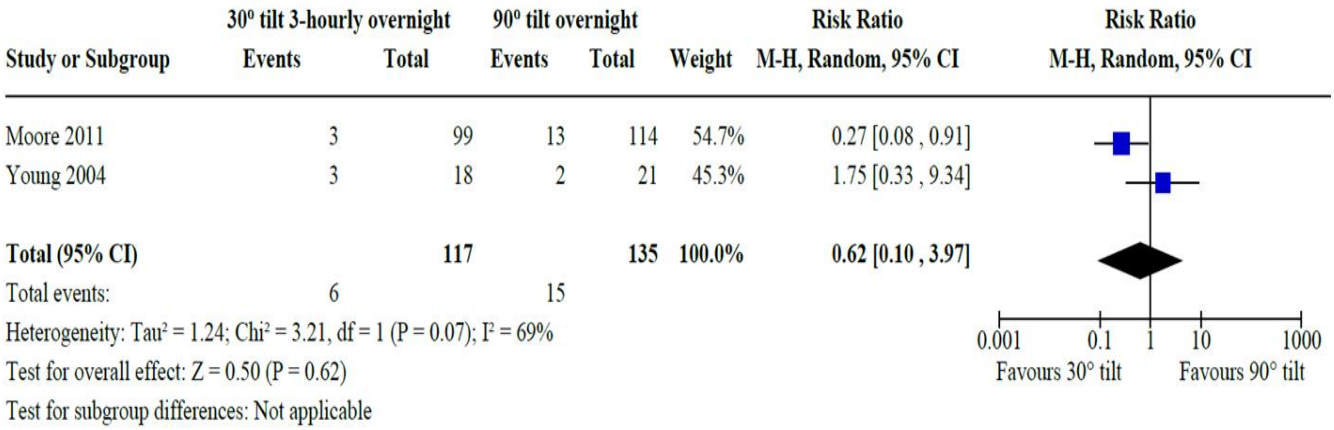

Figure 5: Pressure injury occurrence (stages 1-4), 300 tilt overnight versus 900 tilt overnight

There were two other trials undertaken in intensive care unit settings that included 236 participants, however their results could not be pooled due to the differences in tilt and repositioning regimens. Ghezeljeh et al. [31] compared the use of 30° 2-hourly head-of-bed tilt with a 45° 2-hourly head of bed tilt and "standard care" in three randomised groups [31]. For the outcome of pressure injury, the authors stated that none of the patients who were recruited in this study developed pressure injuries. The certainty of evidence is low. Zhou et al.[30] compared the effects of prone positioning (intervention) versus supine positioning on the development of pressure injury. The occurrence of stage 1 pressure injury was higher in intervention participants, but there was no clear difference in the risk of stage 2 pressure injury between the two groups (P > 0.05). However, the authors presented no numerical data and the certainty of evidence is low due to high risk of bias.

3.5. Economic outcomes

A within-trial cost-minimisation analysis undertaken alongside Bergstrom et al. compared the costs of 3-hourly (n = 326) and 4-hourly (n = 295) repositioning to a 2-hourly (n = 321) repositioning schedule [33]. In Canadian dollars, the cost of repositioning was estimated to be $11.05 lower per resident per day for the 3- hourly regimen or Canadian dollars $16.74 lower per resident per day for the 4- hourly regimen, compared to the 2-hourly regimen. The estimates of economic benefit were from the perspective of the Ontario Ministry of Health and Long-Term Care and were driven primarily on the value of freed nursing time. The analysis assumed 2-, 3-, or 4-hourly repositioning was associated with a similar incidence of pressure injury based on the trial findings [28].

Moore et al. [32] performed a cost-effectiveness analysis based on data from their cluster-controlled trial [26], comparing the nursing time cost of 3-hourly repositioning using a 30° tilt with standard care (6-hourly repositioning with a 90° lateral rotation) among nursing home residents. The authors estimated 3-hourly repositioning using a 30^{o} tilt to cost €46.50 (95% confidence interval €1.25 to €74.60) less per patient in nursing time compared with 6-hourly repositioning with a 90-degree lateral rotation. Consequently, based on the trial findings and subsequent economic evaluation, the authors concluded that the 30° tilt 3-hourly regimen was less costly in terms of nurse time (as well as more effective in reducing the incidence of pressure injuries in their trial) than the standard care of 6-hourly repositioning with a 90° lateral rotation (Moore 2011[26]; 2013[32]).

4. Discussion

The objective of this updated review was to assess the clinical and cost effectiveness of repositioning regimens on the prevention of pressure injury in adults regardless of risk in any setting. This review included data from eight clinical trials and two economic analyses with a total of 3,941 participants. The Grading of Recommendations, Assessment, Development and Evaluations assessment judged the certainty of evidence for effectiveness of repositioning frequencies, and positions as low or very low certainty, with serious risk of bias related to lack of blinding and imprecision. Therefore, it was not possible to draw reliable conclusions as to whether one particular repositioning frequency or position is more effective in pressure injury prevention.

In this review, one study reported the cost of nursing time for repositioning to be lower when patients were more frequently positioned with a lower tilt regimen (i.e., more frequent turning required less nursing time [32]). The result of the other economic sub study [33] suggested that less frequent repositioning used in combination with viscoelastic mattresses was more cost-effective primarily in terms of nursing time. Nonetheless, with only two within trial economic evaluations included in this review, both in nursing home residents, these results are at best inconclusive and unlikely to be generalisable. Therefore, understanding which repositioning regimen provides optimal value is an important area for further research.

4.1. Limitations of included studies

Overall, limitations of included studies diminished the completeness and applicability of evidence. Trials were conducted in developed nations [24-27], and five were undertaken in

acute care settings [24 27 29-31], limiting the extent to which findings can be generalised to lower-income and non-acute care settings. All trials had small samples and thus were underpowered to detect treatment effects, the focus of interventions varied, and no study examined outcomes such as participant pain, quality of life, or patient satisfaction. Inconsistent follow-up periods and variation in the types of support surfaces used across the included trials also limits generalisability.

Assessment of risk of bias identified limitations relative to blinding. Difficulty in blinding outcome assessors to the intervention was particularly concerning and a serious limitation in three trials [25 26 31]. The certainty of the evidence was assessed as low or very low for most of the included trials. Studies were downgraded due to small samples with consequent imprecision, lack of allocation concealment and/or blinding of personnel and outcome assessors. These results are consistent with others' assessment of the evidence for frequencies of repositioning and repositioning positions [36-38]. Findings from a recently published systematic review by Avsar et al [36] concluded that the evidence for turning and repositioning schedules remains inconclusive [36]. While Asar et al. [36] similarly examined the effects of different repositioning regimens, there are some differences between their review and the current review: Asvar et al.[36] included before-and-after design studies and descriptive studies as well as randomised controlled trials and cluster-controlled trials, and outcomes of patient preferences rather than health-related quality of life outcomes. The current review considered data derived from only randomised controlled trials and cluster-controlled trials, and included health-related quality of life, procedural pain, and patient satisfaction.

4.2. Strengths and limitations of this review

We conducted a rigorous and comprehensive systematic literature search that was reproducible. This review was guided by clearly defined, prespecified procedures to prevent potential bias in the review process and all evidence that could be obtained in the review was considered, including one study that was not published in English [30]. Nevertheless, we may have missed trials published in journals that were outside our search strategy. We had planned to undertake a sensitivity analysis to test the robustness of the results based on those lost to follow-up, but, due to the low volume and quality of the evidence and the inability to draw any conclusions, a sensitivity analysis would not have aided understanding. That these meta-analyses included only two to three studies is a limitation of this review. Further, it is possible this review is subject to cultural bias; six of the included trials were conducted in developed nations, thereby limiting the generalisability of findings to lower-income settings.

4.3. Implications for clinical practice

There is currently insufficient evidence to recommend one repositioning regimen in preference to another. Repositioning per se is recommended in all clinical practice guidelines [2 39 40], though implementation is probably variable and highly dependent on the available resources. More recent clinical practice guidelines no longer advocate repositioning patients every two hours [2]. Rather, guidelines recommend that the patient's level of activity and ability to reposition themselves should guide health professionals' decision-making regarding frequency and amount of assistance for repositioning [2]. This seems like a very common-sense approach and reflects more patient-centred, individualised care.

4.4. Implications for research

To address the methodological limitations identified in included trials, researchers must ensure transparency of research process and adhere to the Consolidated Standards of Reporting Trials statement for reporting randomised controlled trials [41]. To minimise the sources of bias, researchers need to ensure rigorous processes in research design and execution of allocation concealment, randomisation, blinding, and participant attrition [42]. For instance, having assessors who are blinded to the outcome. If cluster-controlled trials are used, researchers need to also consider the potential for bias relative to participant selection, baseline comparability, analysis, and loss of clusters [18].

Further research is needed relative to: repositioning frequencies and optimal positioning; use of manual repositioning regimens and electronic repositioning aids; effects of repositioning in high-risk patient populations (e.g. spinal cord injury); effects of position sensors on repositioning regimens; use of pressure sensor technologies to map pressure in relation to different tilt angles during repositioning; use of repositioning monitors to quantify patient repositioning while in bed; economic costs (including incremental costs) of pressure injuries; and economic and social impacts of pressure injuries on patients' health-related quality of life using valid and reliable measures. However, a properly conducted trial will be challenging to plan, fund and deliver and will likely require a repositioning intervention that is complex. Thus, it is unlikely to be as a simple as a 2-hourly versus 4-hourly repositioning regimen because patients' clinical conditions need to be considered.

5. Conclusions

These review findings suggest a lack of robust evaluations of repositioning frequency and positioning for pressure injury prevention and uncertainty about their clinical and cost

effectiveness. Nonetheless, we cannot conclude that these interventions are ineffective as all comparisons are underpowered. This lack of quality trials reflects the challenges in undertaking research focused on repositioning for pressure injury prevention. The growing body of evidence on the aetiology of pressure injuries helps explain the mechanism of action of repositioning as one strategy that makes theoretical sense.

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Conflict of interest

The authors declare they have no conflict

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