Document cover sheet

Assessment report: Bed frames for adults in acute settings

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EAG sign-off: Hayden Holmes

Version number	**Brief description of changes**	**Author/reviewer (e.g. J Smith)**	**Date (DD/MM/YY)**	**Date sent to NICE (if applicable)**
V1.0	First draft of LSA report	YHEC	12.11.2024	12.11.2024
V2.0	Second draft of LSA report	YHEC	28.11.2024	28.11.2024
V3.0	Post consultation feedback. Minor clarification changes	YHEC	17.11.2024	17.11.2024
V4.0	Post draft guidance consultation feedback. Minor clarification changes on page 156	YHEC	27.05.2025	23.05.2025

NATIONAL INSTITUTE FOR HEALTH AND CARE EXCELLENCE

Early Value Assessment

[GID-HTE10050] - Bed frames for adults in acute settings

External Assessment Group report

Produced by: York Health Economics Consortium (YHEC)

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Purpose of the assessment report

Late-stage assessment forms part of NICE's new lifecycle approach to technology evaluation, that ensures NICE can look at any technology at any stage across the product lifecycle. This external assessment report is part of the late-stage guidance process described in the Late-Stage Interim Methods and Process Statement (2024). NICE has commissioned this work and provided the template for the report. The report forms part of the papers considered by the Committee when it is making decisions about the late-stage assessment.

Declared interests of the authors

Description of any declared interests with related companies, and the matter under consideration. See NICE's Policy on managing interests for board members and employees.

None

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Responsibly for report

The views expressed in report are those of the authors and not those of NICE. Any errors are the responsibility of the authors.

EAR Amendments

The original EAG report was submitted to NICE on 28th November 2024. Since that submission, changes have been made to respond to correct errors or provide further clarifications. The changes are summarised in the table below.

Location in report	**Edit made**
Throughout	Minor grammatical changes.
Table 4.1, Section 5.1, Section 5.2, Section 5.3, Table 5.1	Inclusion of Lustig 2020.
Table 4.1, Section 5.1, Section 5.2, Section 5.3, Table 5.1	Inclusion of Budarick studies.
Table 2.1, Table 2.2, Table 2.3, Table 2.4, Table 2.5, Table 2.6, Table 2.7	Updated tables to include additional features based on the company's responses.
Table 2.8	Updated the groups of people who may benefit from the feature to include caregivers for some of the features.
Section 2	Removed the second bullet point from the first bullet list in this section on Acella Therapy
Section 7	Updated outcomes to incidents throughout.
Table 7.1	Added further details to the assumption about generic features reducing clinical outcomes. Updated the discussion point for the training cost assumption.
Section 7.2.6	Details on 10% reduction and rationale added.
Section 7.2.10	Scenario using alternative falls data added.
Section 7.3.1	Explanation for the inclusion of bed exit alarm efficacy added.

Section 7.3.3	Scenario analysis results added.
Section 7.3.4	Additional details on the importance of bed life span added.
Section 8.3	Paragraph about sustainability outcomes added.
Section 9	References errors corrected, where DOI did not link appropriately.

Contents

Abbreviations

Term	Definition
AMU	Acute medical unit
CC	Complications and comorbidities
CDI	Clostridioides difficile infection
CI	Confidence interval
CPR	Cardiopulmonary resuscitation
DSA	Deterministic sensitivity analysis
EU	European Union
GEE	Generalized estimating equation
HAI	Healthcare-associated infection
HMRC	His Majesty's Revenue and Customs
HSE	Health and Safety Executive
ICER	Incremental cost-effectiveness ratio
ICU	Intensive care unit
IQR	Interquartile range
IT	Internet Technology
IV	Intravenous
JBI	Joanna Briggs Institute
LSA	Late-stage assessment
MHRA	Medicines and Healthcare products Regulatory Agency
MSSA	Methicillin-resistant Staphylococcus aureus
MTAC	Medical technologies advisory committee
NR	Not reported
NRLS	National Reporting and Learning System
OR	Odds ratio
PSA	Probabilistic sensitivity analysis
PSSRU	Personal Social Services Research Unit
QALY	Quality-adjusted life year
RCP	Royal College of Physicians
RCT	Randomised controlled trial
RFI	Request for information
RSA	Multiresistant but methicillin-susceptible strains of S. aureus
SD	Standard deviation
VAT	Value added tax

Term	Definition
YHEC	York Health Economics Consortium

Executive summary

Background

The aim of this late-stage assessment (LSA) was to review evidence and develop an economic model for acute-care adult bed frames with innovative features, additional to basic NHS technology requirements. A protocol for this work was developed on the basis of the NICE scope.

Quality and relevance of the clinical and technological evidence

We conducted systematic searches to identify evidence on the clinical and cost-effectiveness of innovative bed frame features for beds used in acute hospital settings. Due to few relevant published studies, the review eligibility criteria were broadened to also include studies conducted in ICUs (intensive care units), or other settings with acute care beds, as well as pre-clinical studies reporting 'technical outcomes'. Conference abstracts retrieved from the existing searches were also screened for inclusion.

We identified 17 relevant studies (in 18 publications) from database searches (13 studies) and company evidence submissions (1 relevant published study and 3 relevant unpublished papers). Evidence was submitted by 5 manufacturers (Arjo, Baxter, LINET, Medstrom and Stryker)..

The clinical and technological evidence review identified little evidence on the impact of innovative features on clinical outcomes. Evidence was available for 8 of the features listed in NICE scope: beds with a low height position (cluster RCT, lowered to at least 28.5 cm from the ground), designs to prevent patient migration (laboratory studies), brake location and steering assistance (laboratory studies), power-drive (laboratory studies), inbuilt weighing scales (cohort studies), in-built exit alarms (comparative cross-sectional study) and turn assist (laboratory studies).

For the 2 features with studies reporting clinical evidence (beds with a low height position and inbuilt exit alarms), neither provided robust evidence of their benefit. For low beds, a cluster RCT did not show significant benefits. However, because of the potential for bias and poor generalisability, we considered the evidence for beds with a low height position to be unclear. We also considered evidence for inbuilt bed exit alarms to be currently unclear despite a large reported reduction in falls, due to the studies high risk of bias.

Identified technical evidence demonstrated proof-of-principle for a number of innovative features (extendable and sliding pivot headboards, turn assist, alternative brake location and power-drive). However, inbuilt bed weighing scales may not currently be accurate enough to replace fluid balance. The advantage of the addition of a fifth wheel was unclear and double bogie castor configuration and auto-contour features may require more evidence.

Quality and relevance of the economic evidence

No economic evaluations, economic models, or cost or resource studies meeting review eligibility criteria were identified in the review.

We conducted a de-novo cost-utility model designed to explore the potential benefit that a range of innovative bed frame features may have on incidents which can be linked to economic outcomes. The analysis took a time-horizon of 1 year and captured the impact of innovative features on falls, entrapments, infections, pressure ulcers, and caregiver injuries. Model parameters were sourced through a mixture of company-provided evidence, published literature, and clinical advice. Due to the paucity of available evidence, it was not possible to evaluate the impact of each specific feature on potential economic outcomes. However, we conducted exploratory analysis to determine the value of reducing different outcomes, which can help prioritize features which may be of more value. Evidence was only available to determine the potential impact of bed exit alarms on falls, which was captured within the analysis.

Base case results suggest that the total monetary value of having a bed frame with innovative features which could reduce all 5 incidents by 10% is estimated at £1,681 per year. When comparing the total monetary value for each feature, base case results suggest that features which are designed to reduce caregiver injuries, falls, or infections may be the greatest value for money (estimated monetary value of £625,

£439, and £280, respectively if reduced by 10%). Features aimed to reduce pressure ulcers and entrapments (estimated monetary value of £43 and £0, respectively) may be of less value to the NHS. Scenario analysis indicated reduced falls may be even higher, producing a net monetary benefit of £1,180 if reduced by 10%.

We also conducted a fully incremental analysis and deterministic sensitivity analysis (DSA). The results of the fully incremental analysis indicated that the [redacted].

The key limitation of the economic analysis was the lack of efficacy evidence surrounding innovative features. Simplifying assumptions were used to populate the model where robust data was not available. Aligning with the findings from the clinical review, more real-world evidence on the impact of innovative features is required. Despite the acknowledged limitations, the direction of results in the exploratory analysis can still be used to support decision making processes when tied with clinical expert advice.

Recommendations for future evidence generation

Future evidence generation would address the scarcity of efficacy evidence, particularly in acute settings. In addition to a lack of evidence, we identified uncertainties around the function of innovative features in different beds and their cumulative effects. Quasi-experimental or observational designs, particularly before-after studies, may provide practical means of evaluation. These should involve clear reporting of beds and associated features used and other environmental changes that may affect outcomes. Where possible, there should be matching of patient characteristics, or transparent reporting of these characteristics, and measurement of intermediate outcomes where these directly impact incidents which have economic impacts..

However, first-hand experience from users is also important. A survey (or multiple surveys), of staff involved in the day-to-day use of acute bed frames, including nurses and healthcare assistants, across a substantial number of NHS trusts could be designed to identify the difficulties and benefits of different features. The most and least important features could be categorised. Any considered least important would not be prioritised for evidence generation. The user preference assessment conducted by NICE will also support evidence on usability and what is most important to users of acute bed frames.

1 Decision problem

The decision problem is described in the scope and our comments are included in the protocol. We made no further changes or comments on the decision problem during the assessment.

In terms of the review eligibility criteria, there was some broadening of the scope, as described in section 4.2.

2 Technologies

The technologies included in this evaluation are acute bed frames used in Acute Medical Units (AMUs), general and surgical wards. Acute bed frames in healthcare refer to specialised beds used in hospitals and other acute care settings to provide patient support and facilitate recovery. Acute bed frames are designed to meet the needs of patients with varying conditions, with a range of essential features to support movement of the bed frame, adjustability, treatment of the patient, and essential maintenance and cleaning.

There were a reported 105,634 general and acute beds being used in the NHS between April and June 2024, with an occupancy of 91.2% (NHS England, 2024a). As of November 2024, 117 different acute bed frames and accessories are currently available for purchase on the NHS supply chain. Technologies under consideration in this assessment should have features designed to ensure basic functionality and should demonstrate compliance with safety standards and legislation (NHS Supply Chain, 2021). All bed frames were available on NHS supply chain and were deemed to meet the minimum safety standards and legislation. Some bed frames used in acute hospital settings have been excluded from the assessment. These are as follows:

- Ultra-low beds.
- Bariatric beds.
- Junior beds for adult patients with atypical anatomy.
- Highly specialised intensive care beds.
- Beds with integrated mattresses.

Further details of the technologies evaluated in this assessment are provided in the NICE Scope. Six bed frames were excluded from this evaluation that were included in the final NICE scope. The bed frames excluded were:

- Citadel (Arjo). It was discovered that this bed frame was an integrated bed frame and mattress, so was excluded based on criteria defined in the NICE scope.
- Deprimo (Benmor medical). This is a floor bed, so was excluded based on criteria defined in the NICE scope.
- Enterprise E5000 (Arjo), Enterprise E8000 (Arjo), and Enterprise E9000 (Arjo). These bed frames were discontinued in 2013 and are no longer available for purchase, so were excluded from the evaluation.

As part of the assessment, we sought to characterise the innovative features identified in the NICE scope, in line with innovative features raised by clinical experts or company submissions. Table 2.1 to Table 2.7 display the technologies and their innovative features. These features were separated into 11 categories based on the key considerations for acute bed frames. Details presented are based on information provided by manufacturers, or where information was not available from companies, from our evidence review and from publicly available sources. We acknowledge that some features may benefit more than 1 consideration. Features have been listed in the consideration where the largest expected benefit will be, or which consideration best matches the feature.

We identified the following difficulties in characterising the features of acute bed frames:

- Published evidence identified by the EAG contained limited information about the features of the bed frames making it challenging to make reliable judgments about the presence or absence of specific features.
- Characterising a bed frame feature is more complex than just determining whether the bed frame has a given feature. For example, most acute bed frames have an expanded and variable range of heights, however, the range of

heights varies for each technology. Where possible, the variability of the heights that beds can be positioned was reported.

Table 2.1: Patient safety bed frame features*

Bed frame	Patient Safety					
	Bed exit alarm system	Under-frame lighting	Innovative side rails	Floor mount to secure the bed in place	Corner bumpers	Anti-entrapment system
Apex OOK SNOW ward bed	✓	✓	✓			
Apex OOK SNOW Falls bed	✓		✓			
Apex OOK SNOW mental health bed	✓			✓		
Arjo Enterprise 5000 X		✓	✓		✓	
Arjo Enterprise 8000 X		✓	✓		✓	
Arjo Enterprise 9000 X	✓	✓	✓		✓	✓
Baxter Centuris Pro		✓	✓		✓	
Baxter Hillrom 900 X2			✓		✓	
Baxter Hillrom 900 X3	✓	✓	✓		✓	
Baxter Accella Hillrom 900	✓	✓	✓		✓	
Direct Healthcare Delta 4	✓	✓				
Direct Healthcare Lago Hospital		✓	✓			
Drive DeVilbiss Innov8			✓			
Innova Care Interlude V3		✓	✓		✓	
Linet Eleganza 1			✓		✓	
Linet Eleganza 2			✓		✓	
Linet Essenza 300	✓	✓	✓		✓	
Linet Essenza 300TL	✓	✓	✓		✓	

Bed frame	Patient Safety					
	Bed exit alarm system	Under-frame lighting	Innovative side rails	Floor mount to secure the bed in place	Corner bumpers	Anti-entrapment system
Linet Image 3	✓	✓	✓		✓	
Medstrom Solo			✓		✓	✓
Medstrom Solo+		✓	✓		✓	✓
Medstrom Solo Luxe		✓	✓		✓	✓
Medstrom SoloMH				✓		✓
OSKA OSKA Florence			✓			
Stryker SV2 Electric Hospital Bed		✓	✓		✓	
Stryker ProCuity™ L model	✓	✓	✓			
Stryker ProCuity™ LE model	✓	✓	✓			
Stryker ProCuity™ Z model	✓	✓	✓			
Talley Group IMO Matrix E30			✓		✓	
Talley Group IMO Matrix U24			✓		✓	

* This table summarizes information collected from company submitted documents and online sources. Note that some of the features come as optional add-ons to the bed frames.

Table 2.2: Bed frame features for caregiver safety*

Bed frame	Safety of caregivers					
	Expanded range of heights[†]		Castor design	Fifth wheel option	In built weighing scales	Zoom motorized drive
Apex OOK SNOW ward bed	✓	Unspecified	✓	✓	✓	
Apex OOK SNOW Falls bed	✓	As low as 25.4cm		✓	✓	
Apex OOK SNOW mental health bed	✓	As low as 25.4cm		✓	✓	
Arjo Enterprise 5000 X	✓	Low height of 32cm, high height of 76cm	✓			
Arjo Enterprise 8000 X	✓	Low height of 32cm, high height of 76cm	✓	✓		
Arjo Enterprise 9000 X	✓	Low height of 32cm, high height of 76cm	✓	✓	✓	
Baxter Centuris Pro	✓	Low height of 39.7cm, high height of 76.8cm	✓			
Baxter Hillrom 900 X2	✓	Low height of 38.7cm, high height of 76.8cm	✓	✓		
Baxter Hillrom 900 X3	✓	Low height of 38.7cm, high height of 76.8cm	✓	✓		
Baxter Accella Hillrom 900	✓	Low height of 38.6cm, high height of 74.7cm	✓	✓	✓	
Direct Healthcare Delta 4						
Direct Healthcare Lago Hospital	✓	Low height of 25cmcm, high height of 80cm	✓			
Drive DeVilbiss Innov8	✓	Low height of 22.5cm, high height of 71cm	✓			
Innova Care Interlude V3	✓	Low height of 40cm, high height of 80cm	✓	✓		
Linet Eleganza 1	✓	Low height of 39.5cm, high height of 76cm	✓	✓		
Linet Eleganza 2	✓	Low height of 39.5cm, high height of 77.5cm)	✓	✓		
Linet Essenza 300	✓	Low height of 25.5cm, high height of 75.9cm	✓	✓		
Linet Essenza 300TL	✓	Low height of 39.5cm, high height of 89.8cm	✓	✓		

Bed frame	Safety of caregivers					
	Expanded range of heights†		Castor design	Fifth wheel option	In built weighing scales	Zoom motorized drive
Linet Image 3	✓	Low height of 28cm, high height of 80cm	✓	✓		
Medstrom Solo	✓	Low height of 21cm, high height of 83cm	✓			
Medstrom Solo+	✓	Low height of 21cm, high height of 83cm	✓			
Medstrom Solo Luxe	✓	Low height of 21cm, high height of 83cm	✓			
Medstrom SoloMH	✓	Low height of 19cm, high height of 81cm	✓			
OSKA OSKA Florence			✓	✓		
Stryker SV2 Electric Hospital Bed	✓	Low height of 37cm, high height of 75cm	✓	✓		
Stryker ProCuity™ L model	✓	Low height of 29.2cm, high height of 76.2cm	✓	✓	✓	
Stryker ProCuity™ LE model	✓	Low height of 29.2cm, high height of 76.2cm	✓	✓	✓	
Stryker ProCuity™ Z model	✓	Low height of 35.6cm, high height of 81.3cm	✓	✓	✓	✓
Talley Group IMO Matrix E30	✓	Low height of 39cm, high height of 76.5cm	✓	✓		
Talley Group IMO Matrix U24	✓	Low height of 24cm, high height of 78cm	✓			

* This table summarises information collected from company submitted documents and online sources. Note that some of the features come as optional add-ons to the bed frames.

† We have reported beds ranges which claim to have expanded height ranges. Notably, it was agreed at the user preference workshop that a low height of 21cm and high height of 83cm would be considered innovative.

Table 2.3: Bed frame features for adaptability*

Bed frame	Adaptability					
	Variable bed length	Variable bed width	Collapsible frame for easy transport and storage‡	Removeable headboards and footboards	Battery power backup	CPR levers
Apex OOK SNOW ward bed	✓		✓	✓		✓
Apex OOK SNOW Falls bed	✓					
Apex OOK SNOW mental health bed	✓		✓	✓		
Arjo Enterprise 5000 X	✓		✓	✓	✓	✓
Arjo Enterprise 8000 X	✓		✓	✓	✓	✓
Arjo Enterprise 9000 X	✓		✓	✓	✓	✓
Baxter Centuris Pro	✓	✓†	✓	✓	✓	✓
Baxter Hillrom 900 X2	✓		✓	✓	✓	✓
Baxter Hillrom 900 X3	✓	✓†	✓	✓	✓	✓
Baxter Accella Hillrom 900	✓	✓†	✓	✓	✓	✓
Direct Healthcare Delta 4			✓	✓		
Direct Healthcare Lago Hospital	✓		✓	✓	✓	✓
Drive DeVilbiss Innov8	✓		✓	✓	✓	✓
Innova Care Interlude V3	✓		✓	✓	✓	✓
Linet Eleganza 1	✓		✓	✓	✓	✓
Linet Eleganza 2	✓		✓		✓	✓
Linet Essenza 300			✓	✓	✓	✓
Linet Essenza 300TL			✓	✓	✓	✓

Bed frame	Adaptability					
	Variable bed length	Variable bed width	Collapsible frame for easy transport and storage‡	Removeable headboards and footboards	Battery power backup	CPR levers
Linet Image 3		✓	✓	✓	✓	✓
Medstrom Solo	✓		✓		✓	✓
Medstrom Solo+	✓		✓		✓	✓
Medstrom Solo Luxe	✓		✓		✓	✓
Medstrom SoloMH					✓	✓
OSKA OSKA Florence	✓		✓	✓		
Stryker SV2 Electric Hospital Bed	✓		✓	✓	✓	✓
Stryker ProCuity™ L model	✓		✓	✓	✓	✓
Stryker ProCuity™ LE model	✓		✓	✓	✓	✓
Stryker ProCuity™ Z model	✓		✓	✓	✓	✓
Talley Group IMO Matrix E30	✓		✓	✓	✓	✓
Talley Group IMO Matrix U24	✓		✓	✓	✓	✓

* This table summarises information collected from company submitted documents and online sources. Note that some of the features come as optional add-ons to the bed frames.

† Baxter bed frames do not have variable bed widths. However they do have adjustable mattress retainers to accommodate different widths of mattress.

‡ Bedframes were considered to have collapsible frames if parts of the bed frame, such as the mattress panels, could be removed, or if the company specified methods for ease of transport.

Table 2.4: Bed features for facilitation of recovery*

Bed frame	Facilitation of recovery						
	Bed controls		Ease of use accessories		Programmable custom height settings	Side rail grip	Connection point for IV pole/lifting pole
Apex OOK SNOW ward bed	✓	▪ Patient pendant ▪ Nurse control unit	✓	▪ Oxygen cylinder holder	✓	✓	
Apex OOK SNOW Falls bed							
Apex OOK SNOW mental health bed	✓	▪ Patient pendant ▪ Side-rail controls	✓	▪ Oxygen cylinder holder			
Arjo Enterprise 5000 X	✓	▪ Patient pendant ▪ Nurse controls	✓	▪ Oxygen cylinder holder ▪ X-ray compartment ▪ Catheter bag hooks ▪ Drainage bag holder ▪ Pull-out linen tray	✓	✓	✓
Arjo Enterprise 8000 X	✓	▪ Patient pendant ▪ Side-rail controls ▪ Nurse controls	✓	▪ Oxygen cylinder holder ▪ X-ray compartment ▪ Catheter bag hooks ▪ Drainage bag holder ▪ Pull-out linen tray	✓	✓	✓
Arjo Enterprise 9000 X	✓	▪ Patient pendant ▪ Side-rail controls ▪ Nurse controls	✓	▪ Oxygen cylinder holder ▪ X-ray compartment ▪ Catheter bag hooks ▪ Drainage bag holder ▪ Pull-out linen tray	✓	✓	✓
Baxter Centuris Pro	✓	▪ Patient pendant ▪ Side-rail controls	✓	▪ X-ray compartment	✓	✓	✓

Bed frame	Facilitation of recovery							
	Bed controls		Ease of use accessories		Programmable custom height settings	Side rail grip	Connection point for IV pole/lifting pole
		▪ Nurse controls		▪ Oxygen cylinder holder ▪ Drainage bag holder ▪ Pull-out linen tray			
Baxter Hillrom 900 X2	✓	▪ Patient pendant ▪ Side-rail controls ▪ Nurse controls	✓	▪ Oxygen cylinder holder	✓	✓	✓
Baxter Hillrom 900 X3	✓	▪ Patient pendant ▪ Nurse controls ▪ Side-rail controls	✓	▪ X-ray compartment ▪ oxygen cylinder holder ▪ Drainage bag holder ▪ Pull-out linen tray	✓	✓	✓
Baxter Accella Hillrom 900	✓	▪ Patient pendant ▪ Side-rail controls ▪ Nurse controls	✓	▪ X-ray compartment ▪ Oxygen cylinder holder ▪ Drainage bag holder ▪ Pull-out linen tray	✓	✓	✓
Direct Healthcare Delta 4	✓	▪ Unspecified	✓	▪ X-ray compartment ▪ Oxygen cylinder holder			✓
Direct Healthcare Lago Hospital	✓	▪ Side-rail control panel ▪ Patent pendant	✓	▪ Oxygen cylinder holder	✓	✓	✓
Drive DeVilbiss Innov8	✓	▪ Side-rail control panel ▪ Patent pendant ▪ Nurse control unit			✓	✓	✓

Bed frame	Facilitation of recovery						
	Bed controls		Ease of use accessories		Programmable custom height settings	Side rail grip	Connection point for IV pole/lifting pole
Innova Care Interlude V3	✓	▪ Side-rail control panel ▪ Patent pendant ▪ Nurse control unit.	✓	▪ X-ray compartment ▪ Pull-out linen tray	✓	✓	
Linet Eleganza 1	✓	▪ Side-rail control panel ▪ Patent pendant ▪ Satellite control panel	✓	▪ Pull-out linen tray	✓	✓	
Linet Eleganza 2	✓	▪ Side-rail control panel ▪ Nurse control unit	✓	▪ X-ray compartment ▪ Pull-out linen tray	✓	✓	✓
Linet Essenza 300	✓	▪ Side-rail control panel ▪ Patent pendant ▪ Nurse control unit	✓	▪ X-ray compartment	✓	✓	✓
Linet Essenza 300TL	✓	▪ Side-rail control panel ▪ Patent pendant ▪ Nurse control unit	✓	▪ X-ray compartment	✓	✓	✓
Linet Image 3	✓	▪ Patent pendant ▪ Nurse control unit	✓	▪ Pull-out linen tray	✓	✓	
Medstrom Solo	✓	▪ Patent pendant	✓	▪ Oxygen cylinder holder ▪ Pull-out linen tray	✓	✓	✓
Medstrom Solo+	✓	▪ Patent pendant ▪ Nurse control unit	✓	▪ Oxygen cylinder holder ▪ X-ray compartment ▪ Drainage bag holder ▪ Pull-out linen tray	✓	✓	✓

Bed frame	Facilitation of recovery							
	Bed controls		Ease of use accessories		Programmable custom height settings	Side rail grip	Connection point for IV pole/lifting pole
Medstrom Solo Luxe	✓	▪ Patent pendant ▪ Nurse control unit	✓	▪ Oxygen cylinder holder	✓	✓	✓
Medstrom SoloMH	✓	▪ Patent pendant			✓		
OSKA OSKA Florence						✓	
Stryker SV2 Electric Hospital Bed	✓	▪ Side-rail control panel ▪ Patent pendant ▪ Nurse control unit	✓	▪ Oxygen cylinder holder ▪ X-ray compartment ▪ Pull-out linen tray ▪ Foley bag hooks	✓	✓	
Stryker ProCuity™ L model	✓	▪ Side-rail control panel ▪ Nurse control unit	✓	▪ Foley bag hooks	✓	✓	
Stryker ProCuity™ LE model	✓	▪ Side-rail control panel ▪ Nurse control unit	✓	▪ Foley bag hooks	✓	✓	
Stryker ProCuity™ Z model	✓	▪ Side-rail control panel ▪ Nurse control unit	✓	▪ Foley bag hooks	✓	✓	
Talley Group IMO Matrix E30	✓	▪ Side-rail control panel ▪ Patient pendant ▪ Nurse control unit	✓	▪ X-ray compartment ▪ Oxygen cylinder holder ▪ Pull-out linin tray	✓	✓	✓
Talley Group IMO Matrix U24	✓	▪ Patient pendant ▪ Nurse control unit	✓	▪ X-ray compartment ▪ Crutches holder	✓	✓	

* This table summarises information collected from company submitted documents and online sources. Note that some of the features come as optional add-ons to the bed frames.

Table 2.5: Bed frame features for health-related considerations, infection prevention and comfort*

Bed frame	Health-related considerations		Infection prevention	Comfort
	Angle indication that ensures that the head of the bed is raised to the appropriate angle	Indication of safe position light	Frame structures that have unrestricted access to all parts for cleaning	Dual wheel castors which improve stability when the bed is moving
Apex OOK SNOW ward bed	✓		✓	✓
Apex OOK SNOW Falls bed	✓			
Apex OOK SNOW mental health bed	✓		✓	
Arjo Enterprise 5000 X	✓		✓	✓
Arjo Enterprise 8000 X	✓		✓	✓
Arjo Enterprise 9000 X	✓		✓	✓
Baxter Centuris Pro	✓	✓	✓	✓
Baxter Hillrom 900 X2	✓	✓	✓	✓
Baxter Hillrom 900 X3	✓	✓	✓	✓
Baxter Accella Hillrom 900	✓	✓	✓	✓
Direct Healthcare Delta 4	✓			
Direct Healthcare Lago Hospital	✓		✓	
Drive DeVilbiss Innov8	✓		✓	
Innova Care Interlude V3	✓		✓	
Linet Eleganza 1	✓		✓	
Linet Eleganza 2	✓	✓	✓	✓
Linet Essenza 300	✓		✓	
Linet Essenza 300TL	✓		✓	

Bed frame	Health-related considerations		Infection prevention	Comfort
	Angle indication that ensures that the head of the bed is raised to the appropriate angle	Indication of safe position light	Frame structures that have unrestricted access to all parts for cleaning	Dual wheel castors which improve stability when the bed is moving
Linet Image 3	✓		✓	
Medstrom Solo	✓		✓	✓
Medstrom Solo+	✓		✓	✓
Medstrom Solo Luxe	✓		✓	✓
Medstrom SoloMH	✓		✓	✓
OSKA OSKA Florence			✓	
Stryker SV2 Electric Hospital Bed	✓		✓	✓
Stryker ProCuity™ L model	✓		✓	✓
Stryker ProCuity™ LE model	✓		✓	✓
Stryker ProCuity™ Z model	✓		✓	✓
Talley Group IMO Matrix E30	✓		✓	
Talley Group IMO Matrix U24	✓		✓	

* This table summarises information collected from company submitted documents and online sources. Note that some of the features come as optional add-ons to the bed frames.

Table 2.6: Bed frame features for sustainability and maintenance and repair*

Bed frame	Sustainability	Maintenance and repair	
	Recycling options and recyclable materials	Access to all parts of the bed to facilitate easy repair	Durable frame constructed with integrated components to reduce hospital-acquired damage
Apex OOK SNOW ward bed		✓	
Apex OOK SNOW Falls bed		✓	
Apex OOK SNOW mental health bed			✓
Arjo Enterprise 5000 X	✓	✓	✓
Arjo Enterprise 8000 X	✓	✓	✓
Arjo Enterprise 9000 X	✓	✓	✓
Baxter Centuris Pro	✓	✓	
Baxter Hillrom 900 X2	✓	✓	
Baxter Hillrom 900 X3	✓	✓	✓
Baxter Accella Hillrom 900	✓	✓	✓
Direct Healthcare Delta 4		✓	
Direct Healthcare Lago Hospital			
Drive DeVilbiss Innov8	✓	✓	
Innova Care Interlude V3	✓	✓	
Linet Eleganza 1		✓	
Linet Eleganza 2		✓	
Linet Essenza 300		✓	
Linet Essenza 300TL		✓	

Bed frame	Sustainability	Maintenance and repair	
	Recycling options and recyclable materials	Access to all parts of the bed to facilitate easy repair	Durable frame constructed with integrated components to reduce hospital-acquired damage
Linet Image 3		✓	
Medstrom Solo	✓	✓	✓
Medstrom Solo+	✓	✓	✓
Medstrom Solo Luxe	✓	✓	✓
Medstrom SoloMH	✓	✓	✓
OSKA OSKA Florence			
Stryker SV2 Electric Hospital Bed		✓	
Stryker ProCuity™ L model		✓	
Stryker ProCuity™ LE model		✓	
Stryker ProCuity™ Z model		✓	
Talley Group IMO Matrix E30		✓	
Talley Group IMO Matrix U24		✓	

* This table summarises information collected from company submitted documents and online sources. Note that some of the features come as optional add-ons to the bed frames.

Table 2.7: Bed features for connectivity*

Bed frame	Connectivity		
	Features that enable connection between patients and caregivers when assistance is required	Features that enable patient data to be sent to electronic medical records	Features to track and locate beds
Apex OOK SNOW ward bed	✓		
Apex OOK SNOW Falls bed	✓		
Apex OOK SNOW mental health bed	✓		
Arjo Enterprise 5000 X			
Arjo Enterprise 8000 X			
Arjo Enterprise 9000 X	✓		
Baxter Centuris Pro			
Baxter Hillrom 900 X2			
Baxter Hillrom 900 X3	✓		
Baxter Accella Hillrom 900	✓	✓	✓
Direct Healthcare Delta 4			
Direct Healthcare Lago Hospital			
Drive DeVilbiss Innov8			
Innova Care Interlude V3			
Linet Eleganza 1	✓		
Linet Eleganza 2	✓		
Linet Essenza 300	✓		
Linet Essenza 300TL	✓		

Bed frame	Connectivity		
	Features that enable connection between patients and caregivers when assistance is required	**Features that enable patient data to be sent to electronic medical records**	**Features to track and locate beds**
Linet Image 3	✓		
Medstrom Solo			✓
Medstrom Solo+			✓
Medstrom Solo Luxe			✓
Medstrom SoloMH			✓
OSKA OSKA Florence			
Stryker SV2 Electric Hospital Bed			
Stryker ProCuity™ L model	✓		
Stryker ProCuity™ LE model	✓	✓	✓
Stryker ProCuity™ Z model	✓	✓	✓
Talley Group IMO Matrix E30			
Talley Group IMO Matrix U24			

* This table summarises information collected from company submitted documents and online sources. Note that some of the features come as optional add-ons to the bed frames.

Table 2.8: The anticipated benefits of innovative features of acute bed frames*

Innovative feature	How are they intended to provide benefit?	Groups of people who may benefit from the feature
Patient safety		
Under bed lighting	Makes it easier for patients to find their way at night in the dark, which may prevent falling.	Any patient needing an acute hospital bed, particularly those at heightened risk of falls. Not suitable for those with cognitive impairment, as the lights may cause confusion. Also beneficial to caregivers as bed lights can indicate the height of the bed.
Bed exit alert system	Supports fall prevention and contributes to potential reduction in fall incidence as well as reducing risk of entrapment.	Any patient needing an acute hospital bed, particularly those at heightened risk of falls.
Anti-entrapment systems	May reduce the risk of entrapment between bed frame and side rails.	Any patient at risk of entrapment, which may be due to mobility, frailty or another contributing factor.
Innovative side rails design	Innovative side rails that are flush to the side of the bed when lowered may reduce the risk of entrapment and improve patient independence, contributing to a better overall care experience.	Any patient needing an acute hospital bed.
Bluetooth connectivity to reduce the number of leads/cables required	Improve patient safety by minimising tripping hazards and improving accessibility. Streamlined design also simplifies cleaning and maintenance.	
Expanded range of heights	Provides the most ergonomic position for patients entering and exiting the bed, which may reduce the incidence of falls and other movement related injuries.	Any patient needing an acute hospital bed, particularly those at heightened risk of falls.
Corner bumpers	Improve patient safety by preventing impact injuries from knocking or striking the bed frame.	Any patient needing an acute hospital bed.
Floor mounts to secure the bed in place	Reduces risk of injury to the patient as it ensures the bed wheels will not move when the bed is stationary.	
Health-related considerations		

Innovative feature	How are they intended to provide benefit?	Groups of people who may benefit from the feature
Features designed to reduce patient migration in bed when head of bed is raised	May reduce development of hospital acquired pressure injury.	Any patient needing an acute hospital bed.
Features designed to ensure the head of the bed is raised to the appropriate angle, for example, head of bed pauses and angle indication	Ensures patient comfort and may reduce development of hospital acquired pressure injuries.	
Safety of caregivers		
Castor design	May improve manoeuvrability and repositioning of beds, enhancing accessibility for staff and patients.	Any patient needing an acute hospital bed. Also beneficial for caregivers as there is a reduced need to move patients or reposition beds manually which prevents risk of musculoskeletal injury.
Electric power-assisted steering	May enhance manoeuvrability, allowing staff to more easily adjust and reposition beds, leading to reduced physical strain on healthcare workers.	
Expanded range of heights	Allows staff to adjust beds to potentially more optimal working heights, which may reduce the risk of strain and injury during patient care. This feature promotes ergonomic practices, ensuring caregivers can provide effective treatment while minimising physical stress in busy hospital environments.	Any patient needing an acute hospital bed. Also beneficial for caregivers if leads to less physical strain when engaging with patients.
Features designed to reduce migration in bed	May reduce the frequency of manual patient repositioning by caregivers, reducing physical strain.	
Features that can help with the manual task of turning patients	Provides support for the caregiver when turning the patient which may reduce the risk of staff strain and injury during patient care.	
In-built bed weighing scales	Improves patient and caregiver safety as it reduces the need to move a patient which could, in turn, cause injury to the patient. Also reduce the amount of time it takes to weigh a patient, and the number of caregivers required. This	Any patient needing an acute hospital bed. Also beneficial for caregivers as there is a reduced need to move patients which prevents risk of musculoskeletal injury.

Innovative feature	How are they intended to provide benefit?	Groups of people who may benefit from the feature
	means that the frequency in which patients get weighed in hospital is improved,	
Fifth wheel option	Improves the safety and efficiency of transporting patients by providing the caregiver with more control over the bed when it is moving.	Any patient needing an acute hospital bed. Particularly those who are at heightened risk of falls as the fifth wheel improves manoeuvrability. Also beneficial for caregivers because the fifth wheel can reduce the risk of musculoskeletal injury from transporting the bed.
Adaptability		
Collapsible frame	May enhance mobility and makes transport and storage easier in healthcare settings. This may result in setup, reduced strain on staff and improve operational efficiency.	Healthcare providers and/or operational staff needing to transport and storage the bed frames.
Variable bed width and length	Allows for better accommodation of patients with varying body sizes and conditions, enhancing comfort and safety.	Any patient where adjustments in width and length size may be suitable, such as patients who are substantially shorter or taller than average height.
Removable headboards/footboards	Provides enhanced flexibility for patient care by allowing easier access for medical procedures and mobility. Also, may simplify cleaning and maintenance for staff.	Any patient needing an acute hospital bed. Also beneficial for healthcare providers.
Battery power backup	Allows healthcare providers to maintain critical functions, such as adjustments and monitoring in power outages.	
Compatible with a wider range of static, hybrid and dynamic mattresses than required	May enhance patient comfort and support by accommodating various medical needs and preferences. Allows procurement to consider a range of mattresses alongside the bed frame.	
Infection prevention		
Frame structures that have unrestricted access to all parts for cleaning	Facilitates thorough cleaning and maintenance, promoting infection control. Also, may streamline routine upkeep for healthcare staff.	Any patient needing an acute hospital bed. Also beneficial to healthcare providers and operational staff who would benefit from infection prevention measures.

Innovative feature	How are they intended to provide benefit?	Groups of people who may benefit from the feature
Ease of care		
Bed controls that are in an accessible location and have an intuitive design, such as a nurse control unit or a patient pendant.	Could enable quicker adjustments to the bed, streamlining care for the patient.	Any patient needing an acute hospital bed.
Ease of use of accessories, such as hoists	May allow for easier transfer and movement of the patient for caregivers if the bed frame easily integrates with other supports, such as hoists.	Any patient needing an acute hospital bed. May be most useful for people who are frail. Also beneficial for healthcare providers.
One-push buttons for cardiopulmonary resuscitation (CPR) positioning and 30° backrest angle positioning	Simplify emergency responses, allowing caregivers to more easily adjust beds for optimal patient support during critical situations.	Any patient needing an acute hospital bed, as well as the healthcare providers that are caring for patients.
A handle for adjusting the height of the bed	Could enable quicker adjustments to the bed, streamlining care for the patient. Also, if there is a power outage, useful to manually adjust the height of bed if required.	
QR code that links to videos on bed functionality	May streamline caregiver tasks by providing patients with immediate access to information, reducing the need for staff to repeatedly explain bed operations. May also save staff time with using other features related to the bed frame.	
Facilitation of recovery, independence and rehabilitation		
Programmable custom height settings	Facilitate the patient getting in or out of bed, including suitable height settings to allow a person to place their feet on the floor from a seated position. This may improve patient independence.	Any patient needing an acute hospital bed. This may not be suitable for people with cognitive impairments, unless the programmable settings are fully controlled by the caregivers.
Elements that are easy for patients to reach and use, such as handsets or controls	Encourages independence for the patient and could improve confidence to the patient due to the autonomy provided. May free up staff time, which could be spent on other aspects of care.	

Innovative feature	How are they intended to provide benefit?	Groups of people who may benefit from the feature
Side rail grips	Provides secure support for patients as they reposition themselves in bed. This feature empowers patients to engage more actively in their care, which could promote mobility and confidence.	Any patient needing an acute hospital bed. This would be most useful for people who are frail.
Comfort		
Castor configuration with low vibrations when the bed is moved	Minimizes vibrations during movement which could improve patient comfort by providing a smoother and quieter experience when beds are repositioned, reducing disturbances.	Any patient needing an acute hospital bed. Also beneficial for healthcare providers as these features make moving patient easier.
Dual wheel castors	Provides increased stability when the bed is moving, which minimizes vibrations resulting in improved patient comfort during transport.	
Sustainability†		
Local sourcing of materials and bed frame production	Reducing waste and encouraging responsible disposal practices. This choice also aligns with NHS net zero goals to minimize ecological footprint while maintaining high standards of patient care.	Beneficial for operational and procurement staff.
Recycling options and recyclable materials		
Maintenance and repair		
Durable frame construction and integrated or semi-integrated components, including any features designed to improve the life span of the bed frame.	May enhance maintenance and repair efficiency, reducing downtime and ensuring beds remain operational for longer periods, reducing costs.	Beneficial for operational and procurement staff.
Access to all parts of the bed to facilitate easy repair	May ensuring beds remain functional when needed most. This accessibility could streamline maintenance processes.	
Connectivity		

Innovative feature	How are they intended to provide benefit?	Groups of people who may benefit from the feature
Features that enable connection between patients and caregivers when assistance is required	May lead to more timely patient response, reducing health risks and improving patient satisfaction.	Any patient needing an acute hospital bed. Not suitable for those with cognitive impairment, who may not make appropriate use of the feature (either forgetting to use it or over-using the feature).
Features that enable patient data to be sent to electronic medical records, subject to national cyber security measures	integration allows healthcare providers to access real-time patient information, which may improve overall care coordination and reduce staff time.	Healthcare providers would benefit from efficient access to patient data.
Features to track and locate beds	Support staff to monitor usage and location in real time. May improve resource management within healthcare facilities.	Healthcare providers would benefit from being able to track and locate hospital beds.

* This table summarises the list of features identified during scoping. Additional innovative features identified during the user preference workshop have not been included.

† In order to fully assess sustainability, a full life cycle analysis would be required, although, features listed here may be key drivers of that analysis.

3 Clinical context

Important clinical background is presented in the NICE Scope. As part of this assessment report, we have summarised key considerations for the clinical context, as well as important considerations to understand the effectiveness of different bed frames.

Acute hospitals provide care for patients with urgent or severe health issues. Acute hospitals are made up of different types of wards, each of which are designed to meet specific patient needs and conditions.

- AMUs provide rapid assessment, investigation and treatment for medical emergencies. Patients typically spend no more than 48 hours in an AMU.
- General medical wards provide ongoing care for patients with a wide range of medical conditions. Patients may spend several days to weeks on a general medical ward.
- Surgical wards provide pre- and post-operative care for surgical patients. The length of stay for these patients can vary depending on the type of surgery they have received and the recovery process.

In acute hospital settings, the choice and quality of bed frames are important in delivering effective patient care. Risk assessments should be carried out to determine a person's requirements and ensure they are placed in a bed that is safe for them and meets their care needs.

Acute bed frames facilitate comfort, important medical interventions, patient positioning, mobility, and safety both for the patient and the caregivers. There is evidence of increasing demand for acute care services, meaning greater investment is likely required in acute bed frames. A previous study has estimated that in order to deliver 2018/19 (pre-COVID) rates of care, 21,000-37,000 additional general and acute beds would be needed over the next decade (Rocks & Rachet-Jacquet, 2024). [redacted]

[redacted] (NHS Supply Chain, 2021). Therefore, it is important that future purchasing decisions for acute bed frames are made based on the value for money to the healthcare system. As of November 2024, acute bed frame costs within the scope of this evaluation ranged from [redacted] (NHS Supply Chain, 2021). This highlights the wide range of costs associated with acute bed frames for adults.

All acute bed frames for adults will have features that are designed to ensure basic functionality. Acute bed frames should demonstrate that they are compliant with safety standards and legislation, as defined in the NICE Scope. However, acute bed frames available to the NHS may have additional innovative features which may improve clinical, patient or caregiver outcomes. It is important to determine if:

- The additional innovative features impact clinical or safety outcomes in adults receiving care in acute settings, or there is user preference for particular features.
- The additional features impact subpopulations differently. This includes people who are frail, have a learning disability or cognitive impairment.
- Differences between bed frames (and their associated innovative features) bring additional benefits and if these are worth the cost.

The following considerations were identified as important contextual information, raised by clinical experts and identified in relevant literature, to determine the effectiveness of different types of acute bed frames for the NHS:

- **Wider IT and infrastructure within hospitals will also determine the usefulness of innovative features**. In the NHS, IT and other hospital wide systems play a crucial role in supporting care. However, benefits of certain features such as connectivity may not be realised if the infrastructure is not in place to support these features. It was raised in the user preference workshop that NHS trusts, particularly trusts in more rural settings, struggle with connectivity across the ward. If the overarching IT infrastructure is not seamlessly integrated with the Bluetooth-enabled devices, issues such as data interoperability, signal interference, and connectivity reliability may arise. These challenges can limit the real-time communication and data exchange needed for effective patient monitoring and care coordination from features on the acute bed frame. Therefore, innovative features for connectivity may not be realised in trusts who require expensive upgrades to IT infrastructure.

- **Not all features are relevant or practical for all acute populations**. The scope of this evaluation is to consider the impact of innovative features for acute bed frames and the value for money of these features. However, clinical experts highlighted that a substantial proportion of these features would be of most benefit to a more specific subpopulation. For example, underframe lighting of beds may be useful in some cases but if used in people with cognitive impairments, may cause confusion and may actually cause harm rather than benefit. Therefore, it is likely that there is not a one-sized fits all approach to the procurement of bed frames within the NHS, and a representative mix of different acute beds may be more appropriate, based on estimated patient populations (Morris et al., 2022).
- **User-friendliness and integration of different features will be an important consideration**. Experts highlighted in previous user preference and correspondence that if the additional innovative feature is complex to use, or requires substantial training to use, it is less likely to be used. If more additional features are added to the bed that are interconnected, this may increase the complexity of use and diminish the effectiveness of isolated features. Therefore, integration of features and simplicity of use should be considered, even if quantitative evidence is not available.
- **The impact of the mattress may not be able to be isolated from the acute bed frame.** For certain outcomes, the impact of the mattress and its relevant features may be more important than the acute bed frame. For example, although autoregression may impact the risk of pressure ulcers, different features of mattresses may have a greater impact (Ahtiala et al., 2020; Gray et al., 2001). The evidence for these 2 components may not be able to isolate the impacts of the bed frame, depending on the study design. This is if new acute bed frames also led to a change in the mattress. Different acute bed frames

may also lead to changes in the performance of the mattress (for example, due to the bed's articulation). All acute bed frames will all have some degree of compatibility with different mattresses (NHS Supply Chain, 2021). However, this will vary between acute bed frames, and may impact the overall costs, so should be considered during any decision-making process.

- **The durability, robustness and maintenance requirements of different acute bed frames will be a key driver of the value for money, despite differences in features.** Many bed frames are only provided with a 1-year warranty to service users. Therefore, damage and associated repair requirements in future years will come at additional costs to the NHS, including staff time to deal with maintenance. During the user preference workshop, experts raised that the ability to maintain bed frames in house can reduce costs, rather than relying on third party vendors. Any evidence of difference between bed frames on the robustness of the acute bed frames should be considered during any procurement decisions. It is also important to consider if additional features are likely to contribute to additional repair and maintenance costs.
- **Different bed frames may claim the same innovative feature, but this does not mean they are necessarily as effective.** There is heterogeneity in the design of acute bed frames, and innovative features can be implemented differently. Evidence presented in this report is stratified by features, due to the way evidence is presented in the literature. Decision makers should be clear of the limitations of interpreting evidence on a feature-based approach and the generalisability of this across different bed frames.

3.1 Equality issues

Equality issues and considerations for this LSA are described in the equality impact assessment published alongside the scope. No additional equality issues have been identified during the assessment.

4 Clinical and technological evidence selection

4.1 Evidence search strategies

Database searches were conducted to identify studies reporting on features of bed frame design in acute hospital settings. A single set of searches was conducted to identify both clinical and economic evidence. The search approach reflected that outlined in the published protocol. The database searches were conducted on 23 September 2024. Full details of the search methods used are provided in Appendix A.

4.2 Study selection

On assessment of scoping search results, prior to the main searches being conducted, it was established that the quantity of evidence directly fitting the decision problem was limited. Several measures to broaden the review eligibility criteria and enlarge the pool of included studies were therefore implemented, as stated in the final protocol. These were the inclusion of:

- For all outcomes, studies conducted in ICUs that evaluated non-specialised acute care beds; or conducted in other settings where acute care beds had been used (for example, accident and emergency).
- For 'technical outcomes' derived from proof-of-concept studies, studies conducted in any setting and population.
- Conference abstracts retrieved from the existing searches.

The searches identified 4557 records. Following deduplication, 3250 records were assessed for relevance using the methods and study eligibility criteria described in the published protocol.

4.3 Included and excluded studies.

Of the 3250 unique records found by the searches, 904 obviously irrelevant records (such as those of community interventions) were excluded at first pass. Of the remaining 2346 records, 2272 were excluded and a total of 74 full papers were retrieved. Of these, 60 were excluded, leaving 13 included studies reported in 14 publications. 48 manufacturer submitted studies were assessed for relevance. Three additional unpublished studies and 1 published study were also included from these submissions (see section 4.4 below). Finally, 17 studies (in 18 publications) were included in the review.

Details of the included studies are shown in Table 4.1. Details of the number of records identified, and the inclusion and exclusion of studies during record selection, are given in Appendix A. A list of studies excluded at full text review is given in Appendix B.

4.4 Manufacturer submitted evidence

Five manufacturers (Arjo, Baxter, LINET, Medstrom and Stryker) submitted evidence comprising published studies and unpublished evidence (white papers). The submitted evidence is shown in Appendix C, along with a description of the content and whether it met eligibility criteria for the review (with the broadened eligibility criteria). Nine published studies met the review criteria and were included (all but 1 had been identified in the searches). Three unpublished studies that had not been identified in the searches also met the review criteria and were included.

Table 4.1: **Included studies**

Study name and location	Design and intervention(s) – including bed feature	Participants	Outcomes	EAG comments
Beds with a low height position				
Haines 2010 (Haines et al., 2010) **Location:** Australia **Setting:** Public hospital wards	**Design:** Cluster RCT. **Intervention:** One low-low bed (Healthcare "Sorrento" model) was provided to each of the intervention wards for every 12 existing beds on the ward, with written guidance for identifying patients at greatest risk of falls. The bed featuring a lowered bed height of 28.5 cm from the ground and a highest bed height of 64 cm, electronically controlled. **Comparator:** Regular beds. **Sample size:** 18 wards, 10,937 admissions.	Publicly funded hospital wards (n=18) within Queensland, Australia, who had not previously had access to or possession of low-low beds. Wards were matched based on rate of falls. **Intervention group (n=9) comprised:** Five standalone regional hospitals Two acute medicine wards One rehabilitation ward One orthopaedic ward **Control group (n=9) comprised:** Seven standalone regional hospitals One rehabilitation ward One general surgery ward	• Number of falls. • Rate of falls per 1,000 occupied bed days per ward per month. • Rate of falls with documented injury. • Rate of falls resulting in head injury. • Rate of falls in the bedroom per 1,000 occupied bed days per ward per month. • Number of falls with fracture.	The study was judged to have some concerns, mainly due to a lack of reported baseline characteristics for intervention and control patients, possible addition of other fall-prevention strategies to the low-low bed intervention, and a lack of blinding of outcome assessors. Generalisability: Used in different wards, not only in an acute setting. No detail given on patient characteristics or comparator bed (unclear whether this is a 'regular' or 'low' bed).
Design for preventing migration				

Study name and location	Design and intervention(s) – including bed feature	Participants	Outcomes	EAG comments
Davis 2014 (Davis et al., 2014) **Location:** USA **Setting:** Laboratory study in a university setting	**Design:** Prospective, experimental laboratory design (abstract). **Intervention:** Bed A: as the head-of-bed was raised the head section pivot slid backward while the head section simultaneously extended in length. Bed B: the head section did not lengthen, and the pivot did not slide. Bed C: the head section did not lengthen and pivoted at 2 hinge points that did not slide. **Comparator:** study compared 3 different types of bed. **Sample size:** 12 The head section was articulated from flat to 45 degrees to flat with 5 repetitions (12 subjects X 3 beds X 5 reps = 180 trials).	Six males and 6 females. No other details given.	• Trochanter migration distance. • Torso compression.	The study was judged to have an unclear risk of bias due to migration being likely to have been measured over a short time period and it being unclear if the subject could have influenced outcome measurements. Generalisability: Took place in a laboratory setting using ICU beds. Small sample size.
Davis 2015 (Davis & Kotowski, 2015) **Location:** USA	**Design:** Prospective, experimental laboratory design. **Intervention:** Bed A: (Hill-Rom Progressa with StayInPlace technology and integrated therapy mattress) designed with a head	Twelve healthy volunteers (6 male, 6 female) recruited based on different weight/height requirements. **Females**	• Net displacement. • Cumulative movement. • Torso compression. • Perceived sliding. • Perceived discomfort.	This study was judged to have an unclear risk of bias due to the short assessment period. It was also unclear if the subject could have influenced outcome measurements and some outcomes

Study name and location	Design and intervention(s) – including bed feature	Participants	Outcomes	EAG comments
Setting: Laboratory study in a university setting	pivot that slides backward simultaneously with a head section that extends when the head of bed is raised. Bed B: (Hill-Rom Progressa without the StayInPlace feature with an integrated therapy mattress) designed to have the head pivot sliding with no lengthening of the head section when raising the head of bed. Bed C: (Linet Multicare with Virtuoso mattress, EU version) designed with a simple stationary head pivot where the head-of-bed section pivots around when the head of bed is raised. Bed D: (Stryker InTouch with XPRT mattress) designed with 2 hinge points for the head pivot where the head-of-bed pivot changes from 1 pivot point to a second pivot at 20 degrees. **Comparator:** Study compared 4 different types of bed. **Sample size:** 12 Each articulation condition was repeated 5 times in a random order.	Mean (SD) age, years: 35 (11.5) Mean (SD) height, cm: 164.9 (5.9) Mean (SD) weight. kg: 63.1 (14.1) **Males** Mean (SD) age, years: 23.8 (9.7) Mean (SD) height, cm: 175.8 (9.5) Mean (SD) weight. kg: 77.3 (11.2)	• Subject preference ranking.	measured were subjective. Generalisability: Took place in a laboratory setting using ICU beds. Small sample size.
Davis 2017 (Davis et al., 2017)	**Design:** Prospective, experimental laboratory design.	Patients with limited ability to independently reposition themselves, as determined by	• Active and passive migration. • Torso compression.	Study was judged to have an unclear risk of bias due to short assessment

Study name and location	Design and intervention(s) – including bed feature	Participants	Outcomes	EAG comments
Location: USA **Setting:** Laboratory study in a university setting	**Intervention:** Bed A: (Hill-Rom Progressa with StayInPlace) designed to have the head pivot slide backward simultaneously as the head section extends when the head-of-bed is raised. Bed B (Hill-Rom Progressa without StayInPlace) had the head pivot sliding with no lengthening of the head section during the raising of the head-of-bed. Bed C: (Linet Multicare) had a simple stationary head pivot in which the head-of-bed section pivots around when articulated upward. Bed D: (Stryker InTouch) had 2 hinge points for the head pivot where the head-of-bed pivots about 1 up until 20 degrees and then pivots about the other pivot joint beyond that elevation. **Comparator:** Study compared 4 different types of bed. **Sample size:** 20 Single measurements made per participant per bed.	a Modified Barthel Index. Each patient was positioned in all 4 beds. Patients were 16 females and 4 males with clinical diagnoses that reduced mobility level. **Female patients** **Mean (SD) age (years):** 55.2 (7.7) **Mean (SD) height (cm):** 163.2 (7.2) **Mean (SD) weight (kg):** 88.6 (24.4) **Modified Barthel Index subscore (transfer):** 7.8 (3.0) **Modified Barthel Index subscore (ambulation):** 5.9 (4.8) **Male patients** **Mean (SD) age (years):** 54.2 (17.0) **Mean (SD) height (cm):** 182.5 (4.1) **Mean (SD) weight (kg):** 113.6 (27.4)	• Perception of sliding. • Perception of discomfort.	period and only single measurements taken from each participant per bed. It was also unclear if the subject could have influenced outcome measurements and some outcomes measured were subjective. Generalisability: Took place in a laboratory setting using ICU beds. Female and male patients varied in weight and height. Small sample size.

Study name and location	Design and intervention(s) – including bed feature	Participants	Outcomes	EAG comments
		Modified Barthel Index subscore (transfer): 2.9 (3.8) **Modified Barthel Index subscore (ambulation):** 4.0 (4.6)		
Lustig 2020 (Lustig et al., 2020) Location: NR Setting: NR (laboratory study – ICU bed frame)	**Design:** Prospective, experimental laboratory design. **Intervention:** Progressa ICU bed system (HillRom) with migration reduction technology (StayInPlace bed mechanism). Extends the head section of the bedframe and bed surface, in unison, as the HOB elevates. **Comparator:** Conventional bed without migration reduction technology (not specified). **Sample size:** 10 healthy subjects Each test was repeated twice, which equalled 8 tests per participant (2 bed types, 2 HOB angles and 2 repetitions).	10 healthy subjects (5 males, 5 females). **Mean (SD)** **Height:** 1.72 (0.08), range 1.60 to 1.85 m **Bodyweight**: 91.8 (24.3), range 62 to 144 kg **BMI:** 30.8 (5.9), range 24.3 to 41.8 kg/m2	• Net migration in bed with head of bed elevated to 45° and 65°.	Study had an unclear risk of bias due to the unclear length of assessment period and potential for participant influence on outcomes. Measurements were only repeated twice. Generalisability: Took place in a laboratory setting using ICU bed. Small sample size.

Study name and location	Design and intervention(s) – including bed feature	Participants	Outcomes	EAG comments
Rush 2018 (Rush, 2018) **Location:** UK **Setting:** NR (laboratory study)	**Design:** Prospective, experimental laboratory design. **Intervention:** 8 hospital beds – 7 acute beds by various manufacturers and the MMO 5000 (short-term care bed) with different backrest designs and auto-contour activated. **Comparator:** 8 hospital beds – 7 acute beds by various manufacturers and the MMO 5000 (short-term care bed) with different backrest designs and auto-contour deactivated. **Sample size:** 1	1 healthy female, no other information given.	• Net migration. • Patient comfort.	Study had an unclear risk of bias due to uncertainty in the reliability of outcome measurements and only 1 measurement of each outcome per bed being taken. It was unclear if outcomes were measured for long enough and if the subjects could have influenced the outcomes. No statistical testing was reported. Generalisability: Took place in a laboratory setting on 8 beds (7 acute, 1 short-term care). Only 1 participant was evaluated.
Brake location and steering assistance				
Kim 2009 (Kim et al., 2009) **Location:** USA	**Design:** Prospective, experimental laboratory design. **Intervention:** Two hospital beds.	**Brake engagement task:** Nine participants from the local student population and the community (6 males and 3 females) with no prior experience with nursing tasks	Brake engagement task: • Trunk flexion angle. • Task completion time. • Perceived overall difficulty.	Study was judged to have an unclear risk of bias due to some outcomes being subjective, self-report measures. Some tasks did not have a comparator arm.

Study name and location	Design and intervention(s) – including bed feature	Participants	Outcomes	EAG comments
Setting: NR (laboratory study)	Bed A: brake located at the head-end (brakehead) and foot-end (brakefoot) – front wheel caster lock Bed B: Brake centrally located (brakeside), fifth wheel activated. **Comparator:** For bed B, fifth wheel deactivated (patient transportation task only). **Sample size:** 18 A set of 10 replications of brake engagement was conducted in each of 6 conditions. For patient transportation (in-room), participants completed 3 replications in each of 4 conditions (2 steering and 2 patient mass). However, for patient transportation (corridor) patients completed 6 conditions 1 time.	undertook brake engagement tasks. **Mean (SD) age, years:** 31.8 (4.4) **Mean (SD) weight, kg:** 67.4 (12.2) **Mean (SD) height, cm:** 172.3 (8.8) **Transportation task:** Nine participants from the local student population and the community (7 males and 2 females) with no prior experience with nursing tasks undertook transportation tasks. **Mean (SD) age, years:** 32 (4.2) **Mean (SD) weight, kg:** 67.4 (12.2) **Mean (SD) height, cm:** 171.8 (9)	• Whole body postural comfort. • Confidence in using the brake system. Patient transportation task (weights applied to simulate a patient): • Hand forces. • Overall physical demands. • Confidence in controlling the bed.	Generalisability: took place in a laboratory setting on 2 commercially available medical/surgical hospital beds. Tasks conducted by inexperienced general population. Small sample size.

Study name and location	Design and intervention(s) – including bed feature	Participants	Outcomes	EAG comments
Medstrom 2021 (Medstrom, 2021) **Location:** NR **Setting:** NR (laboratory study)	[redacted] [redacted] [redacted]	[redacted]	[redacted]	Study was judged to have an unclear risk of bias [redacted]
Power-drive/drive-assist				
Kotowski 2022 (Kotowski et al., 2022) **Location:** USA **Setting:** NR (laboratory study)	**Design:** Prospective, experimental laboratory design. **Intervention:** Standard medical-surgical bed (Advanta bed) with power-drive engaged Transport stretcher bed with power-drive engaged. **Comparator:** Standard medical-surgical bed (Advanta bed) without power-drive engaged. Transport stretcher bed without power-drive engaged.	Twelve participants (6 males and 6 females) undertook transportation tasks. They were recruited based on weight-height classifications. All were inexperienced using power-drive and manual transporting of beds and stretchers. **Males:** Mean age, years: 25.8 Mean weight, kg: 70.2 Mean height, cm: 179.6	During transportation tasks (movement of beds/stretchers weighed down with sand in varying conditions: down a hallway, around a corner in the hall, and up and down a ramp): • Spine loading. • Perceived exertion.	Study was judged to have a low risk of bias. Generalisability: took place in a laboratory setting on a standard medical-surgical bed and stretcher. Tasks conducted by inexperienced general population. Small sample size.

Study name and location	Design and intervention(s) – including bed feature	Participants	Outcomes	EAG comments
	Sample size: 12 Each condition was repeated twice.	**Females:** Mean age, years: 28.5 Mean weight, kg: 65.2 Mean height, cm: 146.0		
Matz 2018 (Matz & Morgan, 2018) **Location:** Sweden **Setting:** NR (laboratory study)	**Design:** Prospective, experimental laboratory design. **Intervention:** 4 Arjo beds with Power Assist Module (IndiGo drive): Citadel bed frame system Enterprise 5000x Enterprise 8000x Enterprise 9000x **Comparator:** 4 Arjo beds without Power Assist module: Citadel bed frame system Enterprise 5000x Enterprise 8000x Enterprise 9000x **Sample size:** NR (4 different test set-ups were analysed [3 times per test]).	No details on participants conducting the tests were reported.	• Work reduction while decelerating down 4-degree slopes (target >40% reduction). • Work reduction when accelerating up 4-degree slopes (target >40% reduction). • Work reduction when decelerating on a flat surface (target >15% reduction). • Work reduction when accelerating on a flat surface (target >15% reduction).	Study was judged to have an unclear risk of bias due to having no information on participants and unclear reliability of findings (no CIs or statistical significance reported). Measurements were only repeated 3 times. Generalisability: Took place in a laboratory setting. No details were reported about the participants testing the beds. Beds tested were high-dependency and standard hospital bed frames.

Study name and location	Design and intervention(s) – including bed feature	Participants	Outcomes	EAG comments
Inbuilt weighing scale				
Schneider 2012 (Schneider et al., 2012) (Associated publication (Schneider et al., 2012)) **Location:** Australia **Setting:** ICU	**Design:** Prospective cohort study. **Intervention:** Two electronic beds with inbuilt weighing scales (Hill-Rom Avant Guard 1600 and Total Care bed systems). **Comparator:** Fluid balance charting. **Sample size:** 151	Consecutive patients who were admitted to the ICU between November 2010 and May 2011 for more than 48 hours and occupying beds with weighing capabilities (data obtained for 151 patients during 160 ICU admissions). **Median (IQR) age, years:** 69 (23) **Male gender n (%):** 96 (63.6) **Duration of ICU stay, days (IQR):** 5 (5.9) **Intubated n (%):** 56 (35) **In ICU mortality n (%):** 12 (7.9)	• Correlation between body weight from fluid balance and bed weighing. • Changes in body weight from bed weighing and fluid balance.	Study was judged to have a low risk of bias. Generalisability: Weighing function tested in critically ill patients.
Schneider 2013 (Schneider et al., 2013) **Location:** Australia **Setting:** ICU	**Design:** Prospective cohort study. **Intervention:** Electronic beds with weighing capabilities (Hill-Rom Versacare bed systems). **Comparator:** Regular weighing scales and fluid balance charting.	Consecutive patients who were admitted to the ICU after cardiac surgery between December 2011 and August 2012 with an ICU stay of more than 48 hours (103 patients included in the analysis). **Median (IQR) age, years:** 68 (60.6 to 76)	• Correlation of body weight by electronic beds with conventional scales. • Correlation of body weight between fluid balance and bed weighing. • Cumulative fluid balance and overall	Study was judged to have a low risk of bias. Generalisability: Weighing function tested in critically ill patients.

Study name and location	Design and intervention(s) – including bed feature	Participants	Outcomes	EAG comments
	Sample size: 103	**Male gender n (%):** 73 (71.8) **Median (IQR) duration of ICU stay, days:** 2 (2 to 3) **Median (IQR) duration of mechanical ventilation, hours:** 8 (6 to 11) **ICU mortality n (%):** 1 (1) Weight, mean (SD) Weight on ICU admission (electronic bed scale, kg; n=52): 84.6 (19.3) Weight on ICU discharge (electronic bed scale, kg; n=85): 85.7 (19.1) Weight on ICU discharge (conventional bed scale, kg): 85.6 (18.6)	change in bed weight.	
Inbuilt bed exit alarm				
Seow 2022 (Seow et al., 2022a) **Location:** Singapore	**Design:** Comparative cross-sectional study. **Intervention:** Hill-Rom 1000 Medical-Surgical bed with in-built 3-mode bed exit alarm.	All participants hospitalised in 3 acute inpatient wards during the study period were reviewed. There were 7,474 patients in pre-implementation phase (no bed exit alarm) from October 2015 to June 2016 and 9, 924 in the post-implementation phase (bed	• Falls incidence.	Study was judged to have an unclear risk of bias due to it being unclear whether other fall prevention efforts were being implemented in the bed alarm period. Falls were measured retrospectively from hospital records.

Study name and location	Design and intervention(s) – including bed feature	Participants	Outcomes	EAG comments
Setting: Acute tertiary teaching hospital	**Comparator:** NR (study explored before and after bed exit alarms were introduced). **Sample size:** 17,398	exit alarm) from July 2016 to June 2017. **Mean (SD) age:** 63 (16) **Male gender n (%):** 9,066 (52) **Mean (SD) length of stay, days:** 6 (7.5)		Generalisability: Applicable to an acute setting. Large sample size.
Turn assist				
Budarick 2020a (Aleksandra R. Budarick et al., 2020) **Location:** Canada **Setting:** NR (laboratory study – ICU bed surfaces)	**Design:** Prospective, experimental laboratory design. **Intervention:** Stryker Isolibrium support surface and Hill-Rom Progressor Pulmonary surface with turn-assist activated. **Comparator:** Stryker Isolibrium support surface and Hill-Rom Progressor Pulmonary surface without turn-assist activated (patients were turned using a manual technique). **Sample size:** 25 healthy individuals Each patient was measured on each of the 2 surfaces. Each turn was repeated 3	Convenience sample of 25 healthy individuals. 13 males and 12 females. **Average age, mean (SD):** 25 years (6.6), range 18 to 51 years **Average height, mean (SD):** 1.74m (0.1) **Average weight, mean (SD):** 80.2kg (25.9), range 38.2 to 135.9 kg Two trained patient handlers performed each turn.	• Interface pressure (contact area, average and peak pressure). • Patient turn quality metrics (turn angle and repeatability).	Study was judged to have an unclear risk of bias due to the potential for patient manipulation of outcomes, Measurements were only repeated 3 times. Generalisability: ICU beds were used for the experiment. Took place in a laboratory setting.

Study name and location	Design and intervention(s) – including bed feature	Participants	Outcomes	EAG comments
	times (3 Stryker turn-assist, 3 Hill-Rom turn-assist and 6 manual turns).			
Budarick 2020b (A. R. Budarick et al., 2020) **Location:** Canada **Setting:** NR (laboratory study – ICU bed surfaces)	**Design:** Prospective, experimental laboratory design. **Intervention:** Stryker Isolibrium support surface and Hill-Rom Progressor Pulmonary surface with turn-assist activated. **Comparator:** Stryker Isolibrium support surface and Hill-Rom Progressor Pulmonary surface without turn-assist activated (patients were turned using a manual technique). **Sample size:** 25 caregivers**.** Manual turns were repeated 3 times on each surface (6 times in total) and turn-assist trials were repeated 2 times on each surface (4 times in total).	25 caregivers with at least 1 year patient handling experience were recruited in pairs from local nursing facilities. Two caregivers performed each turn. Healthy participant (for turning) was a 50th percentile male patient (body mass = 82 kg; height 1.85 m)	• Hand force. • Movement strategy (shoulder flexion/extension angle, spine flexion/extension angle). • Internal exposures (shoulder moments, spine compression, shear force at spine).	Study was judged to have an unclear risk of bias due to the potential for patient manipulation of outcomes. Measurements were only repeated 2 to 3 times per surface. Generalisability: ICU beds were used for the experiment. Took place in a laboratory setting.
Wiggermann 2016 (Wiggermann, 2016) **Location:** USA	**Design:** Prospective, experimental laboratory design. **Intervention:** Hill-Rom TotalCare ICU bed frame equipped with a Sp02rt+ mattress with turn assist activated.	Nine female nurses with no history of back or shoulder injury and 2 healthy male participants acting as dependent patients.	• Effects of turn assist for turning and lateral repositioning (hand force, spine compression, spine shear force,	Study was judged to have an unclear risk of bias due to the potential for subject to manipulate outcomes. Measurements were only taken twice.

Study name and location	Design and intervention(s) – including bed feature	Participants	Outcomes	EAG comments
Setting: NR (laboratory study – ICU bed frame)	**Comparator:** Hill-Rom TotalCare ICU bed frame equipped with a Sp02rt+ mattress with turn assist not activated. **Sample size:** 9 nurses 2 healthy participants Each experimental condition measured once at each side of the bed.	**Nurses** Mean height (SD): 165 cm (5.3 cm) Mean weight (SD): 69.5 kg (15.3 kg) **Healthy participant 1:** Height: 170 cm Weight: 63 kg **Healthy participant 2:** Height: 165 cm Weight: 123 kg	horizontal hand distance).	Generalisability: An ICU bed was used for the experiment. Took place in a laboratory setting.
Zhou 2021 (Zhou & Wiggermann, 2021) **Location:** USA **Setting:** NR (laboratory study – surgical hospital bed)	**Design:** Prospective, experimental laboratory design. **Intervention:** The Hill-Rom Centrella Max medical surgical bed with traditional cotton fitted draw sheet using turn assist feature, Trendelenberg and mattress maximum inflation assisted features. **Comparator:** Draw sheet without assisted feature. **Sample size:** 10 caregivers	Ten female caregivers with at least 2 years' experience in a position where they had to regularly reposition patients in bed (at least once per shift) and 2 female participants acting as a dependent patient. **Nurses** Mean (SD) height: 169.8 cm (7.6 cm) Mean (SD) weight: 80.4 kg (16.6 kg)	• Effects of assistive features: boosting, lateral positioning and turning on peak L5/S1 compressive load and hand force.	Study was judged to have an unclear risk of bias due to the potential for subject to manipulate outcomes. Measurements were only taken twice. Generalisability: A medical-surgical bed was used for the experiment. Took place in a laboratory setting.

Study name and location	Design and intervention(s) – including bed feature	Participants	Outcomes	EAG comments
	2 healthy participants Each experimental condition was repeated twice.	**Healthy participant 1 (8 experimental sessions):** Weight: 77.1 kg **Healthy participant 2 (2 experimental sessions):** Weight: 81.6 kg		

5 Clinical and technological evidence review

5.1 Overview of methodology of included studies

5.1.1 Overview of all studies

The 17 included studies were all comparative. The clinical studies comprised 1 cluster randomised controlled trial (cluster RCT) (Haines et al., 2010), 2 prospective cohort studies (Schneider et al., 2012; Schneider et al., 2013) and 1 comparative cross-sectional study (Seow et al., 2022a). The remaining 13 studies were prospective experimental studies in a laboratory setting (Davis et al., 2014; Davis & Kotowski, 2015; Davis et al., 2017; Kim et al., 2009; Kotowski et al., 2022; Wiggermann, 2016; Zhou & Wiggermann, 2021;A. R. Budarick et al., 2020; Aleksandra R. Budarick et al., 2020; Lustig et al., 2020; Matz & Morgan, 2018; Medstrom, 2021; Rush, 2018). One study was conducted in the UK (Rush, 2018). The clinical studies took place in Australia (Haines et al., 2010; Schneider et al., 2012; Schneider et al., 2013) and Singapore (Seow et al., 2022a) and were set in public hospital wards, an acute tertiary teaching hospital, or the ICU. The laboratory studies took place in the USA (Davis et al., 2014; Davis & Kotowski, 2015; Davis et al., 2017; Kim et al., 2009; Kotowski et al., 2022; Wiggermann, 2016; Zhou & Wiggermann, 2021), UK (Rush, 2018), Sweden (Matz & Morgan, 2018), Canada (A. R. Budarick et al., 2020; Aleksandra R. Budarick et al., 2020) or location was not reported (Lustig et al., 2020; Medstrom, 2021).

Eight bed frame features were evaluated in the studies:

- Beds with a low height position (studies of beds lowering to ≥19 cm were eligible) (Haines et al., 2010).
- Bed frame designs for preventing patient migration (Davis et al., 2014; Davis & Kotowski, 2015; Davis et al., 2017; Lustig et al., 2020; Rush, 2018).
- Alternative brake location (Kim et al., 2009).

- Steering assistance (fifth wheel and/or front wheel caster lock (Kim et al., 2009) or double bogie castor configuration (Medstrom, 2021)).
- Power-drive (Kotowski et al., 2022; Matz & Morgan, 2018).
- Inbuilt weighing scales (Schneider et al., 2012; Schneider et al., 2013).
- In-built bed exit alarms (Seow et al., 2022a).
- Turn assist (A. R. Budarick et al., 2020; Aleksandra R. Budarick et al., 2020; Wiggermann, 2016; Zhou & Wiggermann, 2021).

Some included studies did not meet the decision problem. As explained in Section 4.2, in order to provide sufficient evidence, the eligibility criteria for the review was broadened from the decision problem to include laboratory studies in any population or setting. These studies were therefore included, despite not meeting the decision problem, mainly due to the setting: 2 studies took place in the ICU (Schneider et al., 2012; Schneider et al., 2013) and 1 in several different types of ward (including a rehabilitations ward) (Haines et al., 2010). 13 studies took place in a laboratory setting (A. R. Budarick et al., 2020; Aleksandra R. Budarick et al., 2020; Davis et al., 2014; Davis & Kotowski, 2015; Davis et al., 2017; Kim et al., 2009; Kotowski et al., 2022; Lustig et al., 2020; Matz & Morgan, 2018; Medstrom, 2021; Rush, 2018; Wiggermann, 2016; Zhou & Wiggermann, 2021).

5.1.2 Description of studies assessing each feature

5.1.2.1 Beds with a low height position

One cluster RCT investigated the impact of low-low beds on fall rates in 18 publicly funded hospital wards (10,937 ward admissions) (Haines et al., 2010). The intervention assessed was 1 low-low bed (Healthcare “Sorrento” model) for every 12 existing beds on the ward. The height of the intervention bed could be adjusted electronically and ranged from 28.5 cm to 64 cm. Wards randomised to receive 1/12 low-low beds were compared with wards with regular beds only. The study included several types of wards, including acute medicine, rehabilitation and orthopaedics.

5.1.2.2 Inbuilt weighing scales

Two prospective cohort studies compared bed frames with inbuilt weighing scales with fluid balance charting to assess fluid status changes in the ICU (Schneider et al., 2012; Schneider et al., 2013), with 1 study also confirming the reliability of bed weighing by comparing with a high-precision medical scale (Schneider et al., 2013). The beds included across the 2 studies were the Hill-Rom Avant Guard 1600, Total Care and Hill-Rom Versacare bed-systems. Both studies recruited consecutive patients admitted to the ICU for more than 48 hours. The studies investigated correlations between body weight from fluid balance monitoring or conventional scales and bed weighing.

5.1.2.3 Inbuilt bed exit alarms

One comparative cross-sectional study investigated whether inbuilt bed exit alarms had an impact on falls incidence in an acute tertiary teaching hospital (Seow et al., 2022a). The study explored fall rates before and after the bed exit alarms were introduced. The intervention was the Hill-Rom 1000 Medical-Surgical bed. All patients that were hospitalised in 3 inpatient wards during the study period were reviewed (pre- and post-implementation of the intervention).

5.1.2.4 Designs for preventing migration

Five laboratory studies evaluated different bed frames with different designs for preventing patient migration (e.g. head pivots, head section lengthening and auto-contouring) (Davis et al., 2014; Davis & Kotowski, 2015; Davis et al., 2017; Lustig et al., 2020; Rush, 2018). Two studies included the same 4 bed frames: the Hill-Rom Progressa with StayInPlace, Hill-Rom Progressa without StayInPlace, Linet Multicare and Stryker InTouch bed systems (Davis & Kotowski, 2015; Davis et al., 2017). Three studies recruited healthy volunteers (Davis & Kotowski, 2015; Lustig et al., 2020; Rush, 2018), 1 recruited patients with limited ability to reposition themselves (Davis et al., 2017) and 1 did not give information on the study participants, other than their gender (Davis et al., 2014).

5.1.2.5 Turn assist

Four laboratory studies compared beds with a turn assist feature either activated or deactivated when completing tasks such as turning or lateral repositioning of patients. The studies assessed the impact on physical stresses for caregivers (A. R. Budarick et al., 2020; Wiggermann, 2016; Zhou & Wiggermann, 2021) or turn quality and interface pressure (contact area, average and peak pressure) on patients (Aleksandra R. Budarick et al., 2020). These studies evaluated the Hill-Rom TotalCare ICU bed (Wiggermann, 2016) the Hill-Rom Centrella Max medical-surgical bed (Zhou & Wiggermann, 2021), the Stryker Isolibrium support surface (A. R. Budarick et al., 2020; Aleksandra R. Budarick et al., 2020) and the Hill-Rom Progressor pulmonary surface (A. R. Budarick et al., 2020; Aleksandra R. Budarick et al., 2020). Participants recruited in each study were nurses or caregivers, alongside healthy participants to act as dependent patients.

5.1.2.6 Brake location and steering assistance

One laboratory study assessed 2 bed frames and the impact of brake location and steering assistance (fifth wheel and/or front wheel caster lock) on completing a brake engagement and transportation task (Kim et al., 2009). The study aimed to evaluate several outcomes related to physical stress and work efficiency, as well as perceptions of comfort and usability. Authors reported use of medical-surgical hospital beds, though the bed model and manufacturer were not specified. Healthy participants, recruited from the local student population and the community, undertook brake engagement and transportation tasks.

A second laboratory study assessed 2 general medical bed frames, 1 with a traditional single castor configuration [redacted] and 1 with a double bogie castor configuration [redacted]

5.1.2.7 Power-drive

1 laboratory study investigated a bed frame (Advanta bed) with or without power-drive engaged during transportation tasks (e.g. pushing the bed around a corner or up a ramp) (Kotowski et al., 2022). The study evaluated physical stress (spine loading) and perceived exertion. Healthy participants, inexperienced using power-drive and manual transportation of beds, conducted tasks.

A second laboratory study evaluated 4 beds that were either standard hospital or high-dependency beds (Arjo Citadel, Enterprise 5000x, Enterprise 8000x and Enterprise 9000x) (Matz & Morgan, 2018). The beds were assessed with and without the power assist module IndiGo. The study assessed proportion work reduction with power drive when accelerating or decelerating the beds on either a flat surface or 4-degree slope. No details were reported on the participants that conducted the tests.

5.2 Quality appraisal of studies

5.2.1 Risk of bias assessment

The following section reports the formal risk of bias assessment for the 14 included studies. Full risk of bias assessments can be found in Appendix D.

Three studies were judged to have a low risk of bias. These were 2 cohort studies (Schneider et al., 2012; Schneider et al., 2013) (Figure 5.1) and 1 laboratory study (Kotowski et al., 2022) (Figure 5.2).

One comparative cross-sectional study was judged to have high risk of bias (Seow et al., 2022a) (Figure 5.4). Thirteen studies were judged to have some concerns/unclear risk of bias: 1 cluster RCT (Haines et al., 2010) (Figure 5.3), and 12 laboratory studies (A. R. Budarick et al., 2020; Aleksandra R. Budarick et al., 2020; Davis et al., 2014; Davis & Kotowski, 2015; Davis et al., 2017; Kim et al., 2009; Lustig et al., 2020; Matz & Morgan, 2018; Medstrom, 2021; Rush, 2018; Wiggermann, 2016; Zhou & Wiggermann, 2021) (

Figure 5.2).

Figure 5.1: Risk of bias in cohort studies

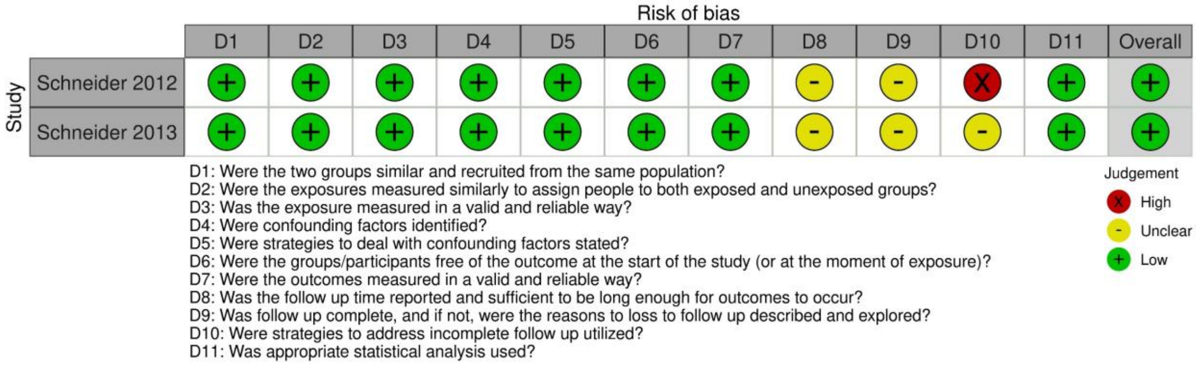


Figure 5.2: Risk of bias in quasi-experimental studies

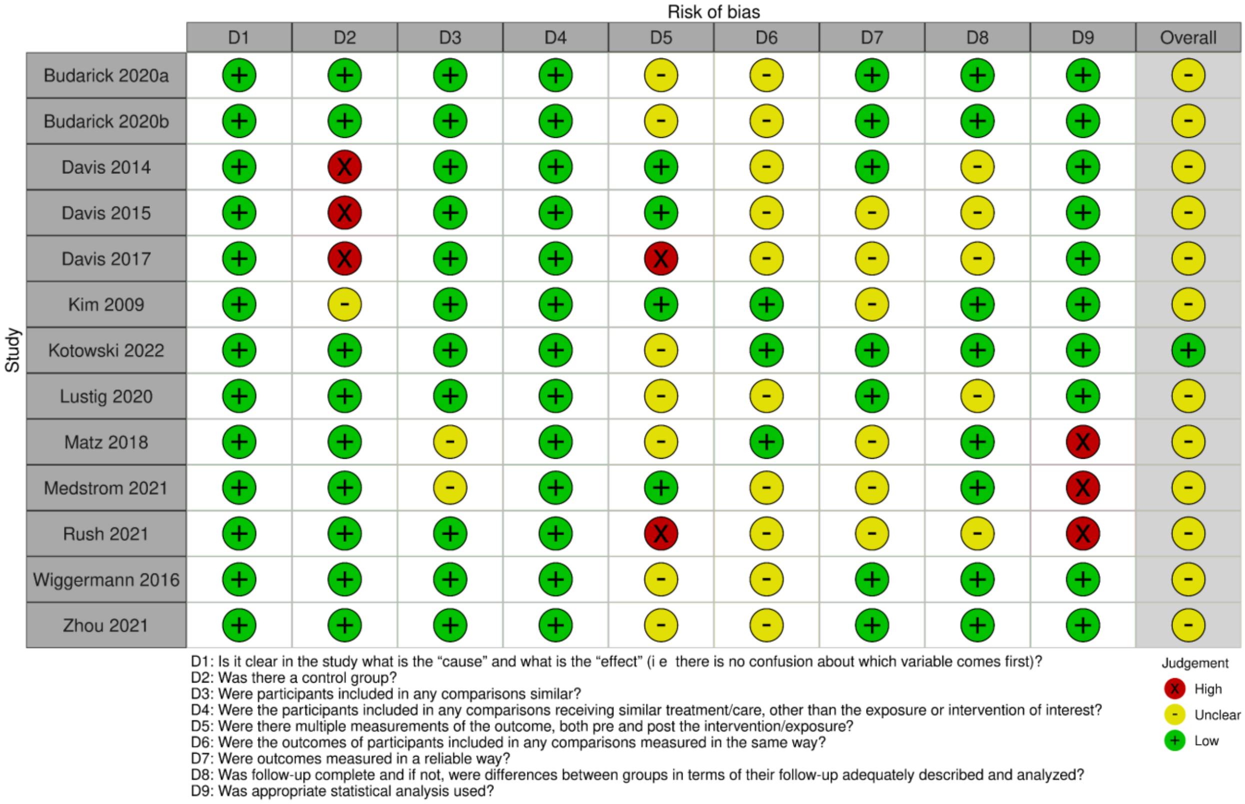


Figure 5.3: Risk of bias in the cluster RCT

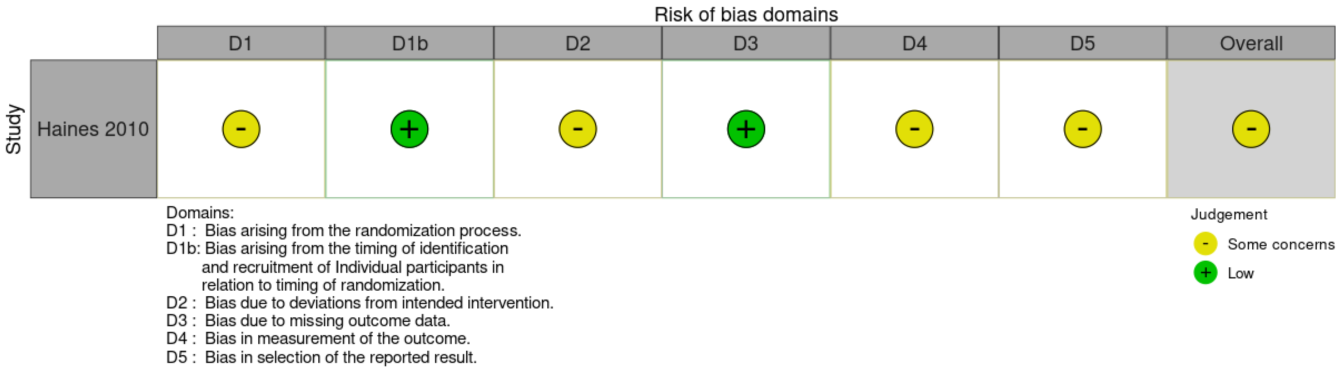
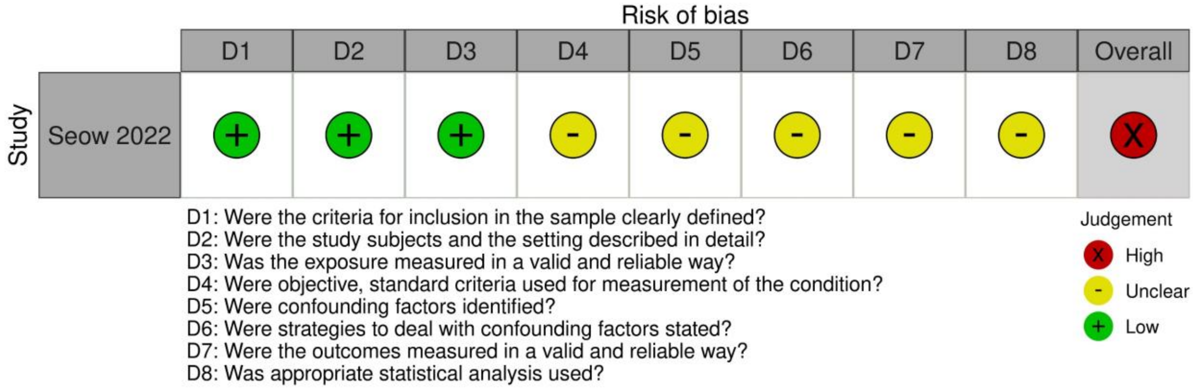


Figure 5.4: Risk of bias in the cross-sectional study



5.2.1.1 Beds with a low height position

One cluster RCT (Haines et al., 2010) was identified and assessed using the Cochrane Risk of Bias 2 tool for cluster RCTs (Eldridge, 2017). The study compared the use of beds with a low height position (1 per 12 existing beds) with no low beds in 18 public hospital wards, evaluating their impact on fall rates. The study was judged to have some concerns due to a lack of reported baseline characteristics for the intervention and control wards. Additionally, outcome assessors/caregivers were not blinded to the study allocation, potentially introducing bias into outcome assessment (although this was judged to be unlikely). It was also unclear whether other fall prevention strategies were used in intervention and/or control areas, potentially introducing bias due to deviations from the intended intervention.

5.2.1.2 Inbuilt weighing scales

Two prospective cohort studies (Schneider et al., 2012; Schneider et al., 2013) were included and risk of bias was assessed using the JBI cohort study checklist (Moola et al., 2024). The studies compared bed frames with inbuilt weighing scales with fluid balance charting to assess fluid status changes in the ICU. Although measurements were taken over relatively short periods of time (1-2 days), this would be applicable to an acute setting. There were missing data in both studies due to inability to obtain correct measurements. However, the authors acknowledged this as a limitation of bed weighing. The studies were judged to have a low risk of bias.

5.2.1.3 Inbuilt bed exit alarms

One comparative cross-sectional study (Seow et al., 2022a) was included and the risk of bias was assessed using the JBI analytical cross-sectional studies checklist (Moola et al., 2024). The study explored falls incidence before and after the introduction of beds with inbuilt bed exit alarms. It was unclear if other fall prevention efforts were being implemented in the fall alarm period and falls were measured retrospectively using hospital records. In addition, findings are likely to have been skewed by the exclusion of data. 187 patients whose hospital stay crossed over the pre- and post-intervention period were excluded. 7.5% (n=14) of these patients experienced falls compared with 0.1% to 0.2% of patients observed in the intervention period alone. If these patients had been included in the analysis, unadjusted rates of falls would have been similar for the pre- versus post intervention periods. On this basis, the study was judged to have a high risk of bias.

5.2.1.4 Designs for preventing migration

Five prospective laboratory studies comparing migration rates for different bed systems were included (Davis et al., 2014; Davis & Kotowski, 2015; Davis et al., 2017; Lustig et al., 2020; Rush, 2018). Risk of bias was assessed using the JBI quasi-experimental checklist (Barker et al., 2024). There were some concerns over the length of time that migration was measured (2 hours maximum) and whether this would be applicable to patients that were in bed for a longer period (Davis et al., 2014; Davis & Kotowski, 2015; Davis et al., 2017; Lustig et al., 2020; Rush, 2018). There was a concern that subjects could influence outcomes by the way that they lay in the beds. Most outcomes were measured objectively. However, 3 studies included outcomes that were measured subjectively (subjective assessments of sliding and/or comfort) (Davis & Kotowski, 2015; Davis et al., 2017; Rush, 2018). Three of the studies also only repeated each experimental condition once (Davis et al., 2017; Rush, 2018) or twice (Lustig et al., 2020) per patient per bed and 1 did not include any statistical analysis (Rush, 2018). The 5 studies were therefore judged to have an unclear risk of bias.

5.2.1.5 Turn assist

Four prospective laboratory studies were included that evaluated either the use of turn assist and its impact on physical stresses for caregivers or turn quality and interface pressure on patients (A. R. Budarick et al., 2020; Aleksandra R. Budarick et al., 2020; Wiggermann, 2016; Zhou & Wiggermann, 2021). Risk of bias in these studies was evaluated using the JBI quasi-experimental checklist (Barker et al., 2024). There was a concern that the subject could influence outcomes by the way they lie on each bed, which could have an effect on the ability of caregivers to turn the participant. Additionally, measurements were only taken 2 or 3 times per experimental condition. All 4 studies were therefore judged to have an unclear risk of bias.

5.2.1.6 Brake location and steering assistance

One prospective laboratory study evaluated the impact of brake location and steering assistance (a fifth wheel or front wheel caster lock) on risk factors for low back disorders, work efficiency, perception of postural comfort and usability (Kim et al., 2009). [redacted]

Both studies were judged to have an unclear risk of bias using the JBI quasi-experimental checklist (Barker et al., 2024). In the first study, this was due to a lack of control group for some tasks (features compared against each other without a no feature control) and the use of subjective, self-reported, measures for some outcomes (Kim et al., 2009). In the second study, [redacted]

5.2.1.7 Power-drive

One prospective laboratory study evaluated whether beds with power-drive led to a decrease in spine loading and perceived exertion (Kotowski et al., 2022). The study was judged to have a low risk of bias on the JBI quasi-experimental checklist (Barker et al., 2024). The number of test repetitions was small. However, in other respects, robust methods appear to have been used.

A second prospective laboratory study examined the proportion of work reduction while accelerating or decelerating 4 beds, with and without a power assist module, on either a flat or sloped surface (Matz & Morgan, 2018). This study was judged to have an unclear risk of bias on the JBI quasi-experimental checklist (Barker et al., 2024) as there was no information reported about the participants. The number of test repetitions was small. Additionally, the reliability of findings were unclear due to the lack of reported CIs or significance levels.

5.2.2 Generalisability

The following section discusses the generalisability of the studies in relation to the decision problem.

Only 1 study was conducted in the UK (Rush, 2018), therefore the generalisability of findings to the UK NHS setting needs to be considered.

2 studies were considered to be generally in line with the decision problem (Haines et al., 2010; Seow et al., 2022a). The remaining 15 studies were not in the correct setting, with some set in a laboratory (A. R. Budarick et al., 2020; Aleksandra R. Budarick et al., 2020; Davis et al., 2014; Davis & Kotowski, 2015; Davis et al., 2017; Kim et al., 2009; Kotowski et al., 2022; Lustig et al., 2020; Matz & Morgan, 2018; Medstrom, 2021; Rush, 2018; Wiggermann, 2016; Zhou & Wiggermann, 2021) or ICU (Schneider et al., 2012; Schneider et al., 2013).

The main identified issues of generalisability were:

- Patient population does not meet the decision problem. For some features:

    - Studies were conducted in healthy participants (Designs for preventing migration (Davis et al., 2014; Davis & Kotowski, 2015; Davis et al., 2017; Lustig et al., 2020; Rush, 2018)), turn-assist ((A. R. Budarick et al., 2020; Aleksandra R. Budarick et al., 2020; Wiggermann, 2016; Zhou & Wiggermann, 2021)).
    - Studies were conducted in patients in ICUs (inbuilt weight scales (Schneider et al., 2012; Schneider et al., 2013)).
    - There was a lack of information to identify the patient population (Low-low beds (Haines et al., 2010)).
- Setting does not meet the decision problem. For some features:
    - Studies were conducted in laboratory settings (Designs for preventing migration (Davis et al., 2014; Davis & Kotowski, 2015; Davis et al., 2017; Lustig et al., 2020; Rush, 2018), Turn assist (A. R. Budarick et al., 2020; Aleksandra R. Budarick et al., 2020; Wiggermann, 2016; Zhou & Wiggermann, 2021), Brake location and steering assistance (Kim et al., 2009; Medstrom, 2021), Power-drive (Kotowski et al., 2022; Matz & Morgan, 2018)).
    - Studies were conducted in ICUs (Inbuilt weighing scales (Schneider et al., 2012; Schneider et al., 2013)).
    - Settings included non-acute wards (rehabilitation ward) (Low-low beds (Haines et al., 2010)).
- Unclear whether bed frames fully align with specification for acute-care bed frames:
    - For designs to prevent migration (Davis et al., 2014; Davis & Kotowski, 2015; Davis et al., 2017; Lustig et al., 2020) and turn assist (A. R. Budarick et al., 2020; Aleksandra R. Budarick et al., 2020; Wiggermann, 2016; Zhou & Wiggermann, 2021), beds in ICU were used.
    - For brake location and steering assist (Medstrom, 2021) and power-drive (Matz & Morgan, 2018), some high-dependency beds were used.
- Feature intervention may not align with what would be given in practice:

- For the low bed feature (Haines et al., 2010), in the intervention setting, only 1/12 low beds were provided.
- For features aimed to prevent migration (Davis et al., 2014; Davis & Kotowski, 2015; Davis et al., 2017; Lustig et al., 2020; Rush, 2018), beds were only tested over a maximum of 2 hours.

5.2.2.1 Beds with a low height position

The cluster RCT comparing the use of beds with a low height position with no low beds on 18 public hospital wards (Haines et al., 2010) was considered to be relevant in terms of outcomes and study design. However, the study gave no baseline characteristics for the patients on the wards, and it is unclear if the patients included in the trial meet the population defined in the decision problem. In terms of setting, as per the decision scope, acute wards were included in the intervention group. However, a rehabilitation ward was also included in the analysis, potentially making finding less applicable to an acute setting. Finally, the study intervention involved the introduction of only 1/12 low beds and this may not be generalisable to settings where a higher proportion of beds with a low height position are available.

5.2.2.2 Inbuilt weighing scales

The 2 prospective cohort studies comparing bed frames with inbuilt weighing scales with fluid balance charting to assess fluid status changes were conducted in ICUs in critically ill patients (Schneider et al., 2012; Schneider et al., 2013). Although this setting and population do not match the decision problem, the results may be useful for considering proof of principle for inbuilt bed weighing scales.

5.2.2.3 Inbuilt bed exit alarms

One comparative cross-sectional study explored falls incidence before and after the introduction of beds with inbuilt bed exit alarms (Seow et al., 2022a). The study was set in an acute setting, and it was considered it to be in line with the decision problem.

5.2.2.4 Designs for preventing migration

Five prospective laboratory studies compared migration rates for bed systems with different head pivots and elongation features (Davis et al., 2014; Davis & Kotowski, 2015; Davis et al., 2017; Lustig et al., 2020; Rush, 2018). The 5 studies took place in a laboratory, taking measurements over a short time-period (maximum 2 hours). It is therefore unclear if the results would apply to an acute hospital setting. Four studies also evaluated migration in ICU beds, and so these results may not be generalisable to acute bed frames (Davis et al., 2014; Davis & Kotowski, 2015; Davis et al., 2017; Lustig et al., 2020).

5.2.2.5 Turn assist

The 4 studies evaluating the impact of turn assist on either physical stress for caregivers or turn quality and interface pressure were conducted in a laboratory setting (A. R. Budarick et al., 2020; Aleksandra R. Budarick et al., 2020; Wiggermann, 2016; Zhou & Wiggermann, 2021). It is therefore unclear whether results are generalisable to an acute hospital setting. Additionally, 3 studies assessed ICU beds (A. R. Budarick et al., 2020; Aleksandra R. Budarick et al., 2020; Wiggermann, 2016))and the other a medical-surgical bed (Zhou & Wiggermann, 2021) and it is unclear whether these results are generalisable to acute bed frames.

5.2.2.6 Brake location and steering assistance

Two prospective studies, 1 evaluating the impact of brake location and steering assistance (a fifth wheel or front wheel caster lock) (Kim et al., 2009), and the other [redacted] were conducted in laboratory settings. One study recruited users with no prior experience of nursing tasks (Kim et al., 2009) and [redacted] Studies evaluated commercially available medical/surgical hospital beds (Kim et al., 2009) or [redacted] It is unclear if the results of these studies would be applicable to an acute hospital setting with nursing staff and acute care beds.

5.2.2.7 Power-drive

Two prospective studies evaluating whether beds with power-drive decrease spine loading and perceived exertion (Kotowski et al., 2022), or work reduction (Matz & Morgan, 2018), were conducted in laboratory settings. One study evaluated medical-surgical beds (Kotowski et al., 2022) and the other both high-dependency and standard hospital beds (Matz & Morgan, 2018). It is unclear if the results would apply to an acute hospital setting with acute care beds.

5.3 Results and Interpretation

Full outcome data are presented in Table 5.1. The results are described in narrative in the sections below and interpretated considering the internal (risk of bias) and external (generalisability) validity of the evidence.

5.3.1 Beds with a low height position

One cluster RCT evaluated the effect of beds with a low height position on fall rates in public hospital wards (Haines et al., 2010). The study reported fewer falls postintervention (186) in the intervention group than in the comparator group (114). However, falls per 1,000 occupied bed days were higher in the intervention group (5.25 vs. 3.77 in the comparator group). The group-by-period interaction effect (GEE coefficient) was not statistically significant for any outcome measured (falls per 1,000 occupied bed days, p=0.28; falls in bedroom per 1,000 occupied bed days, p=0.27; falls with injury per 1,000 occupied bed days, p=0.39). The study concluded that the introduction of the low-low beds did not appear to reduce falls or falls with injury.

There were some concerns that this study was at risk of bias due to potential differences in patient characteristics between groups and possible implementation of additional falls-prevention strategies in intervention and/or control areas. In terms of generalisability, it was unclear whether the population was aligned with the decision problem and whether the intervention (1/12 low beds) would be similar to that used in practice.

Due to the lack of benefit observed in the study, the evidence suggests that caution should be taken when considering the use of low-low beds. However, due to the uncertainties, it does not provide robust evidence that beds with a low height position do not improve outcomes.

5.3.2 Inbuilt weighing scales

Two prospective cohort studies compared electronic beds with inbuilt weighing scales with fluid balance charting (Schneider et al., 2012; Schneider et al., 2013) to evaluate changes in fluid status in ICU patients. Both studies found that the correlation between body weight measured by electronic bed and fluid balance was significant but weak ($r = 0.34$; 95% CI: 0.26 to 0.42; $p<0.001$ in 1 study and $r = 0.28$; 95% CI, 0.17 to 0.39; $p<0.001$ in the second study). The second study also compared body weight by electronic beds on discharge with conventional scales on admission. Although there were similar mean weights observed, limits of agreement were wide on Bland-Altman analyses (-7.6 kg to 7.6 kg) (Schneider et al., 2013), suggesting poor agreement.

In the risk of bias assessment, these studies were judged to have low risk of bias, although study authors noted that, in a high proportion of cases, weight measurements could not be obtained. Although measurements were taken over relatively short periods of time (1-2 days), it was considered that this would be applicable to an acute setting. Studies were conducted in ICUs in critically ill patients which were not directly relevant to the decision problem; however, the results may be useful when considering proof of principle.

Since the evidence appears to be reasonably robust and applicable, the poor correlation with weight measurement by fluid balance suggests that the inbuilt weighing scales assessed in these studies do not give accurate measurements and may not be a useful innovative feature.

5.3.3 *Inbuilt bed exit alarms*

One comparative cross-sectional study compared falls incidence before and after the implementation of beds with an inbuilt 3-mode bed exit alarm (Seow et al., 2022a). There was a reduction in fall incidence from 0.23% to 0.11% between the bed exit alarm being introduced and 6 months post-implementation. The adjusted odds ratio for pre- vs. post-implementation falls was 0.50 (95% CI 0.27 to 0.94). The study concluded that the use of bed exit alarm systems is associated with a decrease in the incidence of falls.

The study was set in an acute setting and was considered applicable. However, there were some concerns over the validity of outcomes measures: falls were measured retrospectively using hospital records and it was unclear if other fall prevention efforts were being implemented in the fall alarm period. In addition, the exclusion of patients with hospital stay across both pre- and post-intervention periods may have skewed results in favour of the intervention period, due to the high rate of falls reported. It was therefore considered that the reliability of the large effect size, in favour of bed exit alarms, was compromised and that the benefits of inbuilt bed alarms is unclear.

5.3.4 *Designs for preventing migration*

Five prospective laboratory studies compared beds with different designs for preventing migration (e.g. head pivots, head section lengthening and auto-contouring) (Davis et al., 2014; Davis & Kotowski, 2015; Davis et al., 2017; Lustig et al., 2020; Rush, 2018).

In 1 study of 3 ICU beds, mean trochanter migration distance and torso compression were significantly lower during head-of-bed articulation (flat to 45 degrees) for a bed in which the head pivot slid backwards, and head section extended in length when the bed is raised than for 2 other beds without these features (both $p<0.05$) (Davis et al., 2014).

Similar results were reported by 3 of the remaining laboratory studies, where mean trochanter and ankle migration were significantly lower on a bed with a head pivot that slides backwards and a bed with this and an extending head section length compared with beds without these features (all $p<0.05$) (Davis & Kotowski, 2015; Davis et al., 2017; Lustig et al., 2020). Torso compression results varied. One study found that torso compression was significantly lower in the bed with sliding head pivot and elongation (Davis & Kotowski, 2015), whereas it was lowest for a bed with no sliding head pivot or elongation in the second study (Davis et al., 2017).

The studies concluded that different bed types can impact migration, with sliding pivot heads and elongation features leading to lower levels of migration.

In the fourth laboratory study of 8 different beds, use of an auto-contour function produced less heel migration (range 8.8 to 17.7 cm) than non-use (range 10 to 20.3 cm) in 7 acute care beds (Rush, 2018). In the short-term care bed (MMO 5000), there was zero heel migration when using the auto-contour function. However, only single measurements were made, and no values were reported for the statistical significance of differences.

Migration was measured over a relatively short time-period across all studies (2 hours maximum) and often with a small number of test sets. There were concerns that subjects could potentially influence outcomes, though most outcomes were measured objectively. Since the studies took place in a laboratory, it is unclear whether results would apply to beds used in an acute hospital setting. Therefore, these studies suggest that sliding and elongating pivot head sections, may reduce patient migration. However, the impact of these features on clinical outcomes, such as pressure ulcers, has not yet been demonstrated. The effect of auto-contour is unclear and would need larger studies with repeated measurements to demonstrate impact.

5.3.5 Turn assist

Four prospective laboratory studies evaluated the use turn assist and its impact on either physical stresses for caregivers when compared with manual turning (A. R.

Budarick et al., 2020; Wiggermann, 2016; Zhou & Wiggermann, 2021) or patient turn quality and interface pressure on patients (Aleksandra R. Budarick et al., 2020). Two studies found statistically significant differences in peak hand forces and spine loads during lateral repositioning, favouring the turn assist conditions (all $p<0.05$) (Wiggermann, 2016; Zhou & Wiggermann, 2021). When turning, 1 study found a significant difference between using turn assist and manual turning a 63 kg patient, with lower peak hand force and spinal loads ($p<0.001$) (Wiggermann, 2016). However, the difference in mean peak hand force when turning a 123 kg patient was not significant. The second study reported a significantly lower peak hand force for turn assist compared with manual turning ($p=0.006$), but no significant difference in peak spinal L5/S1 spinal compressive load ($p=0.511$) (Zhou & Wiggermann, 2021). In the third study, 2 caregivers completed each turn. The study found that, when pushing the participant away from their body, hand forces were reduced to 0 Newtons when using turn assist (from 204 Newtons during a manual turn). However, when pulling the patient towards their body, hand force was the same for both conditions (A. R. Budarick et al., 2020). Turn-assist also reduced shoulder moments when the caregiver turned the patient away from their body. Conversely, spine compression and anteroposterior shear spine force reduced when using turn assist for caregivers pulling the patient towards their body (A. R. Budarick et al., 2020). The studies concluded that, generally, the use of turn assist can reduce physical stresses for caregivers.

The fourth study focused on turn quality and interface pressure on patients being turned in bed (Aleksandra R. Budarick et al., 2020). The study found that manual turns were closer to the recommended 30° turn angle and that they were more repeatable than when using turn assist. For pressure outcomes, turn assist and manual turning were generally found to be similar. This suggests that, for the patient, there is no difference in whether caregivers use turn assist or manual turning in terms of pressure, but that manual turning may be more optimal for caregivers in terms of the angle and repetition.

In these studies, measurements were only taken 2 to 3 times per experimental condition and there were concerns that subjects could potentially influence outcomes. The studies were conducted in a laboratory setting on a range of bed frames and it may be unclear whether results are generalisable to an acute hospital setting. However, demonstrate a proof-of-principle that may be useful for considering these features.

This evidence suggests that a turn assist feature may reduce physical caregiver stresses but the benefit for patient-related outcomes appears limited the impact of turn assist features on clinical outcomes, e.g. related back pain, has yet to be demonstrated.

5.3.6 Brake location and steering assistance

One prospective laboratory study evaluated whether brake pedal location and steering assistance (with a fifth wheel) influenced risk factors for low back disorders, work efficiency, perception of postural comfort and usability (Kim et al., 2009).

In a brake engagement task, there were significant differences in the maximum trunk flexion angle depending on brake location ($p<0.0001$). A central brake located at the side of the bed exhibited the lowest mean angle (21 degrees) while a brake located at the head of the bed (head-of-bead) exhibited the highest mean angle (68 degrees). Head brake location also increased task completion times by 53% to 74% compared with side or foot brake locations ($p<0.0001$). Participant questionnaires reported significant differences in perceived confidence ($p=0.0049$), comfort ($p=0.011$) and overall difficulty in use ($p=0.0018$) depending on brake location, with a head-of-bed brake being reported as more difficult to use and less comfortable. Participants felt most confident using a brake at the side of the bed.

In a patient transportation task, no difference was found in peak hand forces between having a fifth wheel activated or deactivated when simulating pulling ($p=0.39$) or pushing ($p=0.50$) the bed into a patient room. There was also no significant difference when considering patient mass (pulling-out: $p=0.52$; pushing-in: $p=0.061$). There were significant effects for steering and patient mass condition in the questionnaire responses for initiating movement, turning, pushing and pulling the bed (all $p<0.05$), with users generally reporting lower physical demands when the fifth wheel was activated. Participants also had significantly higher levels of confidence in controlling bed movements with the fifth wheel activated ($p=0.044$).

Similar results were observed for the corridor transportation task with less perceived overall physical demands when a fifth wheel or front caster lock were activated than when the fifth wheel was deactivated (difference in steering condition: $p<0.0001$). However, there was no significant difference in confidence in controlling bed movements ($p=0.15$).

Overall, the study concluded that brake pedal location influenced the measured outcomes, and that use of steering assistance features further reduced perceived physical demands.

A number of outcomes were subjective, self-reported, measures, reported by users aware of the features they were testing and this introduced potential for risk of bias. The study was conducted in a laboratory setting, by participants with no experience of nursing tasks. It is therefore unclear if the results would be applicable to an acute hospital setting with nursing staff and acute care beds.

Brake pedal location may have some impact on force requirements. However, given that objective measures showed little benefit of the addition of a fifth wheel, and subjective measures were associated with some risk of bias, it is unclear whether the addition of a fifth wheel impact risk factors for low back disorders or work efficiency.

A second laboratory study [redacted]

[redacted]

[redacted] Further data from larger studies would be needed to demonstrate whether a double bogie castor design consistently impacts force requirements.

5.3.7 Power-drive

One prospective laboratory study evaluated the impact of power-drive on spine loading and perceived exertion during simulated patient transportation tasks (Kotowski et al., 2022). The study found that having power-drive engaged significantly reduced 3-dimensional spine loads by 8% to 21% when compared with manually pushing the bed ($p<0.05$). Perceived exertion was higher for beds with no power-drive engaged compared with power-drive engaged (11 versus 10.2), but no significance level was reported for this.

A second laboratory study evaluated 4 beds that were either standard hospital or high-dependency beds (Arjo Citadel, Enterprise 5000x, Enterprise 8000x and Enterprise 9000x) (Matz & Morgan, 2018). The study reported the proportion of mean work reduction with IndiGo power drive compared with without power drive on each bed. Mean work reduction was greater than the established target for all 4 beds in each condition: accelerating on a flat surface (>15% reduction); decelerating on a flat surface (>15% reduction); accelerating up a 4-degree slope (>40% reduction); decelerating down a 4-degree slope (40% reduction). The studies were conducted in a laboratory setting with medical-surgical, standard or high-dependency beds. It is unclear if the results would apply to an acute hospital setting with acute care beds. Robust methods appear to have been used in the design and execution of 1 study

(Kotowski et al., 2022). However, the second study d lacked reporting of participant characteristics (Matz & Morgan, 2018). Additionally, no CIs or significance levels were reported, so it was unclear how reliable the results are.

Therefore, as proof-of-principle, it appears that power-drive is likely to reduce spine loading during patient transportation or bed moving. Further data would be needed to demonstrate whether this reduction in loading results in reduced caregiver injury in the acute hospital setting.

Table 5.1: Results from the evidence base

Study name and location	Design and intervention(s) – including bed feature	Results	Author conclusions
Beds with a low height position			
Haines 2010 (Haines et al., 2010) **Location:** Australia **Setting:** Public hospital wards	**Design:** Cluster RCT. **Intervention:** Low-low bed (Healthcare "Sorrento" model) was provided to each of the intervention wards for every 12 existing beds on the ward. The bed featuring a lowered bed height of 28.5 cm from the ground and a highest bed height of 64 cm, electronically controlled. **Comparator:** Regular beds. **Sample size:** 18 wards, 10,937 admissions.	**Number of falls** Intervention group: Preintervention: 257; Postintervention: 186 Control group: Preintervention: 154; Postintervention: 114 **Falls per 1,000 occupied bed days, n** Intervention group: Preintervention: 7.1; Postintervention: 5.25 Control group: Preintervention: 5.14; Postintervention: 3.77 **Falls per 1,000 occupied bed days, median (IQR)** Intervention group: Preintervention: 5.9 (2.0 to 8.7); Postintervention: 4.6 (2.6 to 7.8) Control group: Preintervention: 3.6 (1.5 to 10.0); Postintervention: 2.5 (1.1 to 5.6) Group-by-period interaction effect, GEE coefficient (95% CI): 0.23 (-0.18 to 0.65) p=0.28 Per protocol comparison, group-by-period interaction effect, GEE coefficient (95% CI): 0.30 (-0.16 to 0.76) p=0.21	A policy for the introduction of low-low beds did not appear to reduce falls or falls with injury. Larger studies would be required to determine their effect on fall-related fractures.

Study name and location	Design and intervention(s) – including bed feature	Results	Author conclusions
		Falls in the bedroom, n Intervention group: Preintervention: 170; Postintervention: 109 Control group: Preintervention: 100; Postintervention: 67 **Falls in bedroom per 1,000 occupied bed days, median (IQR)** Intervention group: Preintervention: 3.7 (0 to 6.6); Postintervention: 2.2 (0 to 4.3) Control group: Preintervention: 2.1 (0 to 5.3); Postintervention: 1.7 (0 to 3.8) Group-by-period interaction effect, GEE coefficient (95% CI): 0.38 (-0.30 to 1.06) p=0.27 Per protocol comparison, group-by-period interaction effect, GEE coefficient (95% CI): 0.48 (-0.26 to 1.21) p=0.21 **Falls with injury, n** Intervention group: Preintervention: 84; Postintervention: 85 Control group: Preintervention: 63; Postintervention: 51 **Falls with injury per 1,000 occupied bed days, median (IQR)** Intervention group: Preintervention: 1.5 (0 to 3.5); Postintervention: 1.7 (0 to 3.7) Control group:	

Study name and location	Design and intervention(s) – including bed feature	Results	Author conclusions
		Preintervention: 1.7 (0 to 3.2); Postintervention: 1.2 (0 to 3.7) Group-by-period interaction effect, GEE coefficient (95% CI): 0.30 (-0.39 to 0.99) p=0.39 Per protocol comparison, group-by-period interaction effect, GEE coefficient (95% CI): 0.37 (-0.39 to 1.12) p=0.34 **Falls with head injury, n** Intervention group: Preintervention: 7; Postintervention: 6 Control group: Preintervention: 3; Postintervention: 2 **Falls with fracture, n** Intervention group: Preintervention: 0; Postintervention: 1 Control group: Preintervention: 3; Postintervention: 1	
Design for preventing migration			
Davis 2014 (Davis et al., 2014) **Location:** USA **Setting:** Laboratory study in a university setting	**Design:** Prospective, experimental laboratory design. **Intervention:** Bed A: as the head-of-bed was raised the head section pivot slid	**Mean trochanter migration distance during head-of-bed articulation (0 to 45 degrees), cm:** Bed A: 1.6 Bed B: 9.9 Bed C: 10.5 Bed A resulted in 85 % less patient migration compared with bed C: p<0.05	Critical care beds with fixed pivots and head sections that do not lengthen appear to result in more patient migration and torso compression. Reduced migration and compression on Bed A suggests that its

Study name and location	Design and intervention(s) – including bed feature	Results	Author conclusions
	backward while the head section simultaneously extended in length. Bed B: the head section did not lengthen, and the pivot did not slide. Bed C: the head section did not lengthen and pivoted at 2 hinge points that did not slide. **Comparator:** NR, study compared 3 different types of bed. **Sample size:** 12 The head section was articulated from flat to 45 degrees to flat with 5 repetitions (12 subjects X 3 beds X 5 reps = 180 trials).	**Mean torso compression during head-of-bed articulation (0 to 45 degrees), cm:** Bed A: 5.3 Bed B: 6.8 Bed C: 8.1 Torso compression was significantly lower for bed A than beds B and C: $p<0.05$	articulation accommodated the natural elongation of the patient as the patient bends at the hip. Optimal bed design should minimize patient migration and torso compression, which may lead to clinically significant reductions in health risks to patients and caregivers.
Davis 2015 (Davis & Kotowski, 2015) **Location:** USA	**Design:** Prospective, experimental laboratory design. **Intervention:**	**Net displacement (head-of-bed up)** Mean (SD) trochanter migration distance at the upright position, 0-30-0 degrees, cm: Bed A: 1.28 (2.18) Bed B: 2.08 (1.25)	Migration, cumulative movement, and torso compression were higher on beds with simple head section pivot designs that lack the ability to

Study name and location	Design and intervention(s) – including bed feature	Results	Author conclusions
Setting: Laboratory study in a university setting	Bed A: (Hill-Rom Progressa with StayInPlace technology and integrated therapy mattress) designed with a head pivot that slides backward simultaneously with a head section that extends when the head of bed is raised. Bed B: (Hill-Rom Progressa without the StayInPlace feature with an integrated therapy mattress) designed to have the head pivot sliding with no lengthening of the head section when raising the head of bed. Bed C: (Linet Multicare with Virtuoso mattress, EU version) designed with a simple stationary head pivot where the head-of-bed section pivots around when the head of bed is raised. Bed D: (Stryker InTouch with XPRT mattress)	Bed C: 6.46 (1.54) Bed D: 6.76 (1.60) Trochanter migrated significantly more on beds C and D: $p<0.0001$ Mean (SD) trochanter migration distance at the upright position, 0-45-0 degrees, cm: Bed A: 1.51 (1.12) Bed B: 3.34 (1.49) Bed C: 9.90 (3.14) Bed D: 10.57 (2.36) Trochanter migrated significantly more on beds C and D: $p<0.0001$ Mean (SD) ankle migration distance at the upright position, 0-30-0 degrees, cm: Bed A: 1.63 (2.21) Bed B: 2.05 (1.26) Bed C: 6.79 (1.80) Bed D: 7.10 (1.48) Ankle migrated significantly more on beds C and D: $p<0.0001$ Mean (SD) ankle migration distance at the upright position, 0-45-0 degrees, cm: Bed A: 1.61 (2.19) Bed B: 3.57 (1.59) Bed C: 9.91 (2.68) Bed D: 10.49 (2.03)	elongate and slide backward.

Study name and location	Design and intervention(s) – including bed feature	Results	Author conclusions
	designed with 2 hinge points for the head pivot where the head-of-bed pivot changes from 1 pivot point to a second pivot at 20 degrees. **Comparator:** Study compared 4 different types of bed. **Sample size:** 12 Each articulation condition was repeated 5 times in a random order.	Ankle migrated significantly more on beds C and D: p<0.0001 **Net displacement (returned to flat)** Mean (SD) trochanter migration distance at the end of articulation, 0-30-0 degrees, cm: Bed A: 0.85 (0.83) Bed B: 0.48 (0.56) Bed C: 1.45 (0.96) Bed D: 0.89 (0.78) Bed B had lower migration than beds C and D: p<0.01 Mean (SD) trochanter migration distance at the end of articulation, 0-45-0 degrees, cm: Bed A: 1.22 (1.16) Bed B: 1.14 (1.72) Bed C: 2.32 (1.61) Bed D: 1.08 (1.10) Bed B had lower migration than beds C and D: p<0.01 Mean (SD) ankle migration distance at the end of articulation, 0-30-0 degrees, cm: Bed A: 1.18 (1.70) Bed B: 0.74 (0.73) Bed C: 1.70 (1.31) Bed D: 0.93 (0.93) Bed B had lower migration than beds C and D: p<0.01	

Study name and location	Design and intervention(s) – including bed feature	Results	Author conclusions
		Mean (SD) ankle migration distance at the end of articulation, 0-45-0 degrees, cm: Bed A: 1.34 (1.27) Bed B: 1.17 (1.08) Bed C: 2.59 (1.86) Bed D: 1.31 (1.22) Bed B had lower migration than beds C and D: p<0.01 **Cumulative movement** Mean (SD) trochanter cumulative migration distance, 0-30-0 degrees, cm: Bed A: 4.74 (4.10) Bed B: 5.29 (1.41) Bed C: 11.94 (2.52) Bed D: 13.09 (2.75) Beds C and D had significantly higher cumulative migration than beds A and B: p<0.0001 Mean (SD) trochanter cumulative migration distance, 0-45-0 degrees, cm: Bed A: 7.45 (2.36) Bed B: 7.70 (2.33) Bed C: 18.25 (5.50) Bed D: 20.49 (4.15) Beds C and D had significantly higher cumulative migration than beds A and B: p<0.0001	

Study name and location	Design and intervention(s) – including bed feature	Results	Author conclusions
		Mean (SD) ankle cumulative migration distance, 0-30-0 degrees, cm: Bed A: 6.97 (3.13) Bed B: 8.20 (1.69) Bed C: 12.47 (2.77) Bed D: 13.57 (2.25) Beds C and D had significantly higher cumulative migration than beds A and B: $p<0.001$ Mean (SD) ankle cumulative migration distance, 0-45-0 degrees, cm: Bed A: 8.40 (3.39) Bed B: 10.67 (3.00) Bed C: 18.24 (3.79) Bed D: 20.19 (3.54) Beds C and D had significantly higher cumulative migration than beds A and B: $p<0.001$ **Torso compression** Mean (SD) torso compression, 0-30-0 degrees, cm: Bed A: 3.74 (1.08) Bed B: 4.70 (1.31) Bed C: 4.44 (1.97) Bed D: 5.67 (1.04) Bed A had significantly less torso compression than the other beds: $p<0.001$ Bed D had significantly more torso compression than bed A, B or C: $p<0.001$	

Study name and location	Design and intervention(s) – including bed feature	Results	Author conclusions
		Mean (SD) torso compression, 0-45-0 degrees, cm: Bed A: 5.24 (1.62) Bed B: 6.89 (2.28) Bed C: 6.72 (1.96) Bed D: 8.01 (1.48) Bed A had significantly less torso compression than the other beds: $p<0.001$ Bed D had significantly more torso compression than bed A, B or C: $p<0.001$ **Perceived sliding** Mean (SD) score for perception of sliding (scale: 0—no sliding to 10—a lot, moved many inches), 0-30-0 degrees: Bed A: 1.22 (0.67) Bed B: 1.28 (0.64) Bed C: 2.07 (0.82) Bed D: 2.12 (0.76) Beds A and B were perceived to have significantly less sliding than beds C and D: $p<0.0001$ Mean (SD) score for Perception of sliding (scale: 0—no sliding to 10—a lot, moved many inches), 0-45-0 degrees: Bed A: 1.43 (0.62) Bed B: 1.72 (0.56) Bed C: 2.63 (0.90)	

Study name and location	Design and intervention(s) – including bed feature	Results	Author conclusions
		Bed D: 2.82 (0.87) Beds A and B were perceived to have significantly less sliding than beds C and D: p<0.0001 **Perceived discomfort** Mean (SD) score for perception of discomfort (scale: 0—none to 10—extreme), 0-30-0 degrees: Bed A: 1.00 (0.26) Bed B: 0.93 (0.31) Bed C: 1.33 (0.60) Bed D: 1.38 (0.78) Beds A and B had the lowest discomfort ratings as compared with beds C and D (p<0.01) Mean (SD) score for perception of discomfort (scale: 0—none to 10—extreme), 0-45-0 degrees: Bed A: 1.17 (0.56) Bed B: 1.43 (0.77) Bed C: 1.57 (0.70) Bed D: 1.72 (0.98) Bed A was lowest followed by beds B and C and bed D being the highest for the 0-45-0 articulation (p<0.05). **Subject preference ranking** Most preferred bed: Bed A: 9/12	

Study name and location	Design and intervention(s) – including bed feature	Results	Author conclusions
		Bed B: 2/12 Bed C: 1/12 Bed D: 0/12 Least preferred bed: Bed A: 0/12 Bed B: 1/12 Bed C: 1/12 Bed D: 10/12	
Davis 2017 (Davis et al., 2017) **Location:** USA **Setting:** Laboratory study in a University setting	**Design:** Prospective, experimental laboratory design. **Intervention:** Bed A: (Hill-Rom Progressa with StayInPlace) designed to have the head pivot slide backward simultaneously as the head section extends when the head-of-bed is raised. Bed B (Hill-Rom Progressa without StayInPlace) had the head pivot sliding with no lengthening of the	**Mean (SD) active migration (trochanter) after head-of-bed elevation, cm** Bed A: 3.6 (0.6) Bed B: 5.8 (1.0) Bed C: 13.2 (1.3) Bed D: 13.8 (1.1) Beds A and B had significantly less migration than beds C and D: $p<0.05$ **Mean (SD) active migration (ankle) after head-of-bed elevation, cm** Bed A: 5.1 (0.9) Bed B: 5.7 (0.7) Bed C: 10.2 (1.0) Bed D: 12 (1.0) Beds A and B had significantly less migration than beds C and D: $p<0.05$ **Mean (SD) total passive migration (trochanter) at 2 hours, cm**	The distance moved during a single 45-degree head-of-bed elevation was significantly affected by bed type and ranged from 3.6 cm (bed A) to 13.8 cm (bed D). When observing patients over a 2-hour period, the total migration distances ranged from 5.0 cm (bed A) to 19.6 cm (bed C).

Study name and location	Design and intervention(s) – including bed feature	Results	Author conclusions
	head section during the raising of the head-of-bed. Bed C: (Linet Multicare) had a simple stationary head pivot in which the head-of-bed section pivots around when articulated upward. Bed D: (Stryker InTouch) had 2 hinge points for the head pivot where the head-of-bed pivots about 1 up until 20 degrees and then pivots about the other pivot joint beyond that elevation. **Comparator:** NR, study compared 4 different types of bed. **Sample size:** 20 Single measurements made per participant per bed.	Bed A: 5 (8) Bed B: 7.5 (1.4) Bed C: 19.6 (1.7) Bed D: 16 (1.4) Beds A and B had significantly less migration than beds C and D: $p<0.05$ **Mean (SD) total passive migration (ankle) at 2 hours, cm** Bed A: 8.8 (1.9) Bed B: 8.8 (1.3) Bed C: 17.1 (1.7) Bed D: 14.1 (1.2) Beds A and B had significantly less migration than beds C and D: $p<0.05$ **Mean passive migration following active migration (trochanter), cm:** Bed A: 1.4 Bed B: 1.7 Bed C: 6.4 Bed D: 2.2 Beds A, B and D had significantly lower migration than bed C: $p<0.05$ **Mean passive migration following active migration (ankle), cm:** Bed A: 3.7 Bed B: 3.1 Bed C: 6.9 Bed D: 2.1	

Study name and location	Design and intervention(s) – including bed feature	Results	Author conclusions
		Beds A, B and D had significantly lower migration than bed C: p<0.05 For all the beds, the majority of the trochanter and ankle migration occurred during the active phase (>58%). However, bed D had the greatest percentage of migration in the active phase relative to the passive phase (>85% for trochanter and ankle) **Torso compression** Greatest for bed B, lowest for bed D. Torso compression steady throughout 2-hour period, although there was a slight trend of increased torso compression in the second hour for beds A, B, and D. **Mean (SD) score for perception of sliding at 2-hours (0=none, 10=sliding many inches)** Bed A: 2.4 (0.4) Bed B: 2.0 (0.3) Bed C: 6.3 (0.6) Bed D: 3.7 (0.7) Bed C was significantly higher for perceived sliding than beds A and B: p<0.05 There was no significant difference in perceived sliding between beds A, B and D **Mean (SD) rating of discomfort at 2-hours (0=none, 10 = unbearable pain)** Bed A: 2.2 (0.4)	

Study name and location	Design and intervention(s) – including bed feature	Results	Author conclusions
		Bed B: 2.3 (0.4) Bed C: 5.8 (0.6) Bed D: 3.1 (0.5) Bed C was significantly higher for discomfort than beds A and B: p<0.05	
Lustig 2020 (Lustig et al., 2020) Location: NR Setting: NR (laboratory study)	**Design:** Prospective, experimental laboratory design. **Intervention:** Progressa ICU bed system (HillRom) with migration reduction technology (StayInPlace bed mechanism). Extends the head section of the bedframe and bed surface, in unison, as the HOB elevates. **Comparator:** Conventional bed without migration reduction technology (not specified). **Sample size:** 10 healthy subjects. Each test was repeated twice, which equalled 8	**Trochanter migration** **Head of bed elevation 45^{o}:** Conventional bed: mean 7 (SD 2.7) cm Migration reduction technology bed: mean 4.0 (SD 1.9) cm P<0.001 for the comparison **Head of bed elevation 65^{o}:** Conventional bed: mean 7.5 (SD 3.7) cm Migration reduction technology bed: mean 4.7 (SD 1.6) cm P<0.001 for the comparison	Our results, based on the novel integrated experimental-computational method, point to clear biomechanical benefits in minimising migration using migration reduction technology.

Study name and location	Design and intervention(s) – including bed feature	Results	Author conclusions
	tests per participant (2 bed types, 2 HOB angles and 2 repetitions).		
Rush 2018 (Rush, 2018) **Location:** UK **Setting:** NR (laboratory study)	**Design:** Prospective, experimental laboratory design. **Intervention:** 8 hospital beds – 7 acute beds by various manufacturers and the MMO 5000 (short-term care bed) with different backrest designs and auto-contour activated. **Comparator:** 8 hospital beds – 7 acute beds by various manufacturers and the MMO 5000 (short-term care bed) with different backrest designs and auto-contour deactivated. **Sample size:** 1 participant testing beds, 1 measurement	**Net migration** Without auto-contour function deactivated (head of bed up only): • beds 1-8: 10 to 20.3cm heel migration With auto-contour function activated: • beds 1-6 and 8: 8.8 to 17.7cm heel migration • bed 7 (MMO 500): 0 cm heel migration **Patient comfort** When auto-contour function was in use, patient needed to be repositioned on all beds except bed 7 (MMO 5000) and shear and friction was observed on all beds except bed 7 (MMO 5000)	The MMO 5000 with its elliptical backrest enables a 17.7cm HOB extension and is fit for purpose. The auto-contour function creates zero migration, promoting patient comfort, reducing torso compression and can be a cost-effective addition to pressure ulcer prevention for the institution whilst potentially improving a patient's quality of life. It will also help to reduce staff musculoskeletal injuries by reducing the frequency of the repositioning task of moving the patient up the bed.

Study name and location	Design and intervention(s) – including bed feature	Results	Author conclusions
	for each bed condition.		
Brake location and steering assistance			
Kim 2009 (Kim et al., 2009) **Location:** USA **Setting:** NR (laboratory study)	**Design:** Prospective, experimental laboratory design. **Intervention:** 2 hospital beds. Bed A: brake located at the head-end (BrakeHead) and foot-end (BrakeFoot) Bed B: Brake centrally located (BrakeSide), fifth wheel activated. **Comparator:** For bed B, fifth wheel deactivated (in-bed transportation task only). **Sample size:** 18 A set of 10 replications of brake engagement was conducted in each of 6 conditions. For patient transportation	**Brake engagement task** **Mean (SD) maximum trunk flexion angle (degrees):** BrakeHead: 68 (27) BrakeFoot: 39 (35) BrakeSide: 21 (8) Brake pedal location significantly affected maximum trunk flexion angle: p<0.0001 **Task completion time:** Brakehead: Increased completion times by 53% to 74% compared with either brakefoot or brakeside (brake pedal location had significant effects on task completion time: p<0.0001) Hands-occupied* condition increased completion times by 7% to 12% compared with the hands-free condition (hand condition had a significant effect on task completion time: p=0.0085) **Perceived overall difficulty (questionnaire responses):** Difference in brake pedal location had a significant impact on perceived difficulty: p=0.0018 Difference in hand condition had a significant impact on perceived difficulty: p=0.0008 **Whole body postural comfort (questionnaire responses):**	Brake pedal location was found to influence exposure to risk factors for low back disorders (i.e. trunk flexion magnitude and duration) and work efficiency (task completion time), as well as participants' perceptions related to postural comfort and usability. Use of steering-assistance features (the fifth wheel and front caster lock) further reduced perceived physical demands during the corridor transportation task. Thus, these findings suggest that considering ergonomics principles in the design of hospital beds can reduce physical demands and enhance usability.

Study name and location	Design and intervention(s) – including bed feature	Results	Author conclusions
	(in-room), participants completed 3 replications in each of 4 conditions (2 steering and 2 patient mass). However, for patient transportation (corridor) patients completed 6 conditions 1 time.	Difference in brake pedal location had a significant impact on perceived postural comfort: p=0.011 Difference in hand condition had a significant impact on perceived postural comfort: p=0.0084 **Confidence in using the brake system (questionnaire responses):** Difference in brake pedal location had a significant impact on perceived confidence: p=0.0049 Difference in hand condition had a significant impact on perceived confidence: p=0.0087 **Patient transportation task (in-room transportation)** **Pulling-out phase** No difference in peak hand force for fifth wheel activated vs. fifth wheel deactivated: p= 0.39 **Pushing-in phase** No difference in peak hand force for fifth wheel activated vs. fifth wheel deactivated: p=0.50 **Confidence in controlling bed movements (questionnaire responses):** Difference in confidence for fifth wheel activated vs. fifth wheel deactivated : p=0.044 **Patient transportation task (corridor transportation)** **Overall physical demands (questionnaire responses)**	

Study name and location	Design and intervention(s) – including bed feature	Results	Author conclusions
		. Difference in overall physical demands for caster lock activated vs. fifth wheel activated vs. fifth wheel deactivated: p<0.0001 **Confidence in controlling bed movements:** Difference confidence for fifth wheel activated and caster lock activated compared with fifth wheel deactivated: p=0.15	
Medstrom 2021 (Medstrom, 2021) **Location:** NR **Setting:** NR (laboratory study)	[redacted] [redacted] [redacted] [redacted]	[redacted] [redacted]	[redacted]

Study name and location	Design and intervention(s) – including bed feature	Results	Author conclusions
Power-drive/drive-assist			
Kotowski 2022 (Kotowski et al., 2022) **Location:** USA **Setting:** NR (laboratory study)	**Intervention:** Standard medical-surgical bed (Advanta bed) with power-drive engaged. Transport stretcher bed with power-drive engaged. **Comparator:** Standard medical-surgical bed (Advanta bed) without power-drive engaged. Transport stretcher bed without power-drive engaged. **Sample size:** 12 Each condition was repeated twice.	**During patient transportation tasks:** **Spine loading** Power-drive vs. no power-drive: Overall, the power-drive significantly reduced lateral shear and A-P shear (125 newtons) while compression had a significant interaction effect with power-drive and bed type ($p<0.05$). Decrease in lateral shear for power-drive compared with no power-drive, reduction in newtons (%): Bed: 200 (21) Stretcher: 45 (6) Decrease in A-P shear for power-drive compared with no power-drive, reduction in newtons (%): Bed: 120 (8) Stretcher: 125 (7) Compression reduction for power-drive compared with no power-drive, in newtons (%): Bed: 700 (17) Stretcher: 270 (7) Patient weight had no direct impact on spinal loads. **Rating of perceived exertion (rated from 6 to 20):**	Power-drive was found to significantly ($p<0.05$) reduce the 3-dimension loads as compared with manual pushing of the beds (8 to 21%) and stretchers (6% to 7%).

Study name and location	Design and intervention(s) – including bed feature	Results	Author conclusions
		Bed power-drive: 10.2 No power-drive for the bed: 11 Stretcher power-drive: 8.9 No power-drive for the stretcher: 10 Transport tasks, highest rating of perceived exertion: Up the ramp without power-drive: 11.7 Corner without power-drive: 10.6 Down the ramp without power-drive: 10.6 Transport tasks, lowest rating of perceived exertion: Straight with power-drive: 9.2 Down the ramp with power-drive: 9.3	
Matz 2018 (Matz & Morgan, 2018) **Location:** Sweden **Setting:** NR (laboratory study)	**Design:** Prospective, experimental laboratory design. **Intervention:** 4 Arjo beds with Power Assist Module (IndiGo drive): 1. Citadel bed frame system 2. Enterprise 5000x	Mean work reduction with IndiGo drive compared with without IndiGo drive when accelerating on a flat surface (target >15% reduction) Citadel*: 30.1% Enterprise 9000x: 20.5% Enterprise 8000x: 16.6% Enterprise 5000x: 29.5% Mean work reduction with IndiGo drive compared with without IndiGo drive when decelerating on a flat surface (target >15% reduction) Citadel*: 55.8% Enterprise 9000x: 53.6% Enterprise 8000x: 54.6%	The introduction of IndiGo drive assist adds to existing technology - a 'grab anywhere' interface that allows caregivers to move the bed and push in any direction, delivering significant work/ force reduction when accelerating, decelerating and moving up and down slopes. Unlike bed power drive systems used in

Study name and location	Design and intervention(s) – including bed feature	Results	Author conclusions
	3. Enterprise 8000x 4. Enterprise 9000x **Comparator:** 4 Arjo beds without Power Assist module: Citadel bed frame system: 1. Enterprise 5000x 2. Enterprise 8000x 3. Enterprise 9000x **Sample size:** NR (4 different test set-ups were analysed, 3 measurements per set-up).	Enterprise 5000x: 50.2% Mean work reduction with IndiGo drive compared with without IndiGo drive when accelerating up 4-degree slopes (target >40% reduction) Citadel*: 60.1% Enterprise 9000x: 50.7% Enterprise 8000x: 43.1% Enterprise 5000x: 49.5% Mean work reduction with IndiGo drive compared with without IndiGo drive while decelerating down 4-degree slopes (target >40% reduction) Citadel*: 72.7% Enterprise 9000x: 64.4% Enterprise 8000x: 59.4% Enterprise 5000x: 66.9% *Citadel is the heaviest bed frame CIs and statistical significance of reductions NR	specialist critical care and bariatric beds the introduction of new technologies such as IndiGo drive assist brings work reduction benefits to many other departments in the hospital that account for the majority of a hospital's bed transport activities.
Inbuilt weighing scales			
Schneider 2012 (Schneider et al., 2012)	**Design:** Prospective cohort study. **Intervention:** 2 electronic beds with	**Successful body weight measurements n (%):** 160/504 (31.7) **Correlation between body weight from fluid balance and bed weighing:** Weak correlation (r = 0.34; 95% CI: 0.26 to 0.42; p<0.001)	The correlation between changes in body weights and fluid balance was weak. Further studies are required to establish if accurate and

Study name and location	Design and intervention(s) – including bed feature	Results	Author conclusions
Location: Australia **Setting:** ICU	inbuilt weighing scales (Hill-Rom Avant Guard 1600 and Total Care bed systems). **Comparator:** Fluid balance charting. **Sample size:** 151	Remained unchanged after exclusion of extreme values (delta >5 L or 5 kg per day) (r = 0.37; 95% CI: 0.28 to 0.46) and correction for insensible fluid losses (r = 0.34; CI:, 0.25 to 0.42; p<0.001) Bland-Altman: Mean bias: 0.07 kg (95% interval of agreement (-5.9 to 6.0 kg) **Difference in measurements, n (%)** Difference by more than 3L (kg): 102 data pairs (24.2) Difference by more than 7L (kg): 20 data pairs (4.7) **Disagreement between data pairs, n (%)** Less than 10%: 27 data pairs (6.9% of nonnull differences) 10% to 25%: 19 pairs (4.8) 25% to 50%: 36 pairs (9.1) 50% to 100%: 135 pairs (34.4) >100%: 176 pairs (44.8) **Changes in body weight from bed weighing and fluid balance:** Same direction: 243 (57.4%) of 423 observations	reproducible daily weighing of ICU patients is feasible.
Schneider 2013 (Schneider et al., 2013) **Location:** Australia **Setting:** ICU	**Design:** Prospective cohort study. **Intervention:** Electronic beds with weighing capabilities (Hill-Rom	**Correlation of body weight by electronic beds with conventional scales**: r = 0.98; P <0.001 Bland-Altman limits of agreement: −7.6 to 7.6 kg **Correlation of body weight between fluid balance and bed weighing:**	There was an excellent correlation between weights obtained with weight-enabled beds (on ICU discharge) and those obtained with a regular scale (on ward

Study name and location	Design and intervention(s) – including bed feature	Results	Author conclusions
	Versacare bed systems). **Comparator:** Regular weighing scales and fluid balance charting. **Sample size:** 103	Correlation between 12-hourly changes: r = 0.28; 95% CI, 0.17 to 0.39; p<0.001 After correction for insensible fluid losses: r = 0.27; 95% CI, 0.15 to 0.38; p<0.001 Values obtained in intubated patients: r = 0.34; 95% CI, 0.16 to 0.49; p<0.001 Bland-Altman: Mean bias: 0.12 kg (95% agreement interval: −3.3 to 3.5 kg **Cumulative fluid balance and overall change in bed weight, mean (SD):** Correlation between cumulative fluid balance and overall changes in bed weight: r = 0.36; p<0.001 For patients with admission weights available (n=52): r = 0.5; p<0.0001	admission). Nevertheless, weights obtained with clinical beds and regular scale had poor agreement. Even with satisfactory compliance with the weighing process and study protocol, the correlation of body weight as measured with electronic beds with fluid balance is weak.
Inbuilt bed exit alarm			
Seow 2022 (Seow et al., 2022a) **Location:** Singapore **Setting:** Acute tertiary teaching hospital	**Design:** Comparative cross-sectional study. **Intervention:** Hill-Rom 1000 Medical-Surgical bed with in-built 3-mode bed exit alarm. **Comparator:** NR (study explored before and	**Falls incidence:** July 2016 (when bed exit alarm was first introduced): 0.23% (95% CI: 0.10% to 0.51%) December 2016 (6-months post-implementation): 0.11% (95% CI: 0.05% to 0.25%) Adjusted OR for observing a fall (July 2016 vs. December 2016): 0.50 (95% CI 0.27 to 0.94)	The use of bed exit alarm systems is associated with reduced fall incidence. The implementation team will need to consider the effects of “alarm fatigue”, the ability of nurses to respond in time to alarms, and having nurses equipped with knowledge and skills in selection of right alarm

Study name and location	Design and intervention(s) – including bed feature	Results	Author conclusions
	after bed exit alarms were introduced). **Sample size:** 17,398		mode/limits based on patient profiles.
Turn assist			

Budarick 2020 (Aleksandra R. Budarick et al., 2020) **Location:** Canada **Setting:** NR (laboratory study – ICU bedframes/surfaces)	**Design:** Prospective, experimental laboratory design. **Intervention:** Stryker Isolibrium support surface and Hill-Rom Progressor Pulmonary surface with turn-assist activated. **Comparator:** Stryker Isolibrium support surface and Hill-Rom Progressor Pulmonary surface without turn-assist activated (patients were turned using a manual technique). **Sample size:** 25 healthy individuals Each patient was measured on each of the 2 surfaces. Each turn was repeated 3 times (3 Stryker turn-assist, 3 Hill-Rom turn-assist and 6 manual turns).	**Turn angle** Upper body region: Difference between surfaces (Stryker vs. Hill-Rom surface): $p<0.001$, Lower body region: Difference between surfaces (Stryker vs. Hill-Rom surface): $p<0.001$, Turn-assist (maximum inflation): Average turn angle, Stryker: 6.98 degrees over the recommended 30 degrees Average turn angle, Hill-Rom: 14.68 degrees below the recommended angle Manual turn (final position): Average turn angle, Stryker: 2.5 degrees below the recommended 30 degrees Average turn angle, Hill-Rom: 5.41 degrees below the recommended angle Manual turning produced more optimal (closer to 30 degrees) turn angles than both turn-assist surfaces and higher repeatability. **Pressure distribution: Contact area (initial time point)** Pairwise comparison – right pelvis region: Higher contact for Stryker (turn-assist) than Hill-Rom (turn-assist) (+8.357, 95% CI: 3.657 to 13.057) and Hill-Rom (manual turn) (+9.280, 95% CI: 4.429 to 14.131) Pairwise comparison – right pelvis region: Higher contact for Stryker (manual turn) than Hill-Rom (turn-assist) (+5.752, 95% CI: 2.308 to 9.195) and Hill-Rom (manual turn) (+6.675, 95% CI: 3.913 to 9.437)	Manual turns produced the most repeatable turn angles and closest to the recommended 30-degree angle. Turn-assist surfaces produced similar interface pressure outcomes compared to manual turning. Pressure outcome differences between turn-assist surfaces were most prominent at the pelvis across all 3 time points, where Stryker (turn-assist) produced lower interface pressure, in general, when compared to Hill-Rom (turn-assist).

Study name and location	Design and intervention(s) – including bed feature	Results	Author conclusions
		Pairwise comparison – left pelvis region: Higher contact for Stryker (turn-assist) than Hill-Rom (turn-assist) (+10.910, 95% CI: 4.865 to 16.955) and Hill-Rom (manual turn) (+9.777, 95% CI: 4.739 to 14.815) Pairwise comparison – left pelvis region: Higher contact for Stryker (manual turn) than Hill-Rom (turn-assist) (+10.317, 95% CI: 5.577 to 15.056) and Hill-Rom (manual turn) (+9.183, 95% CI: 5.681 to 12.686) **Pressure distribution: Contact area (final time point)** Pairwise comparison – right back region: Stryker (turn-assist) had lowest contact area compared with Hill-Rom (turn-assist) (–15.217, 95% CI: –26.103 to –4.331), Stryker (manual turn) (–17.81, 95% CI: –29.649 to –5.951) and Hill-Rom (manual turn) (–29.50, 95% CI: –42.108 to –16.892) Pairwise comparison – right back region: Hill-Rom (turn assist) had lower contact area than Hill-Rom (manual turn) (–14.283, 95% CI: –26.315 to –2.252) Pairwise comparison – left back region: Hill-Rom (turn-assist) had lower contact area than Stryker (turn-assist) (-13.573, 95% CI: -23.535 to -3.611) and Stryker (manual turn) (–26.515, 95% CI: –39.241 to –13.789) and Stryker (turn-assist) had lower contact area than Stryker (manual turn) (–12.942, 95% CI: –23.365 to –2.518) Pairwise comparison – left pelvis region: Hill-Rom (turn assist) had lower contact area than Stryker (turn assist) (–13.213, 95% CI: –23.912 to –2.515) and Stryker (manual turn) (–13.532, 95% CI: –24.342 to –2.722) and Hill-Rom (manual turn) had lower contact area than Stryker (turn-assist) (–14.420, 95% CI: –22.861 to –5.979] and Stryker (manual turn) (–14.738, 95% CI: –21.996 to –7.481). **Average pressure (initial time point)**	

Study name and location	Design and intervention(s) – including bed feature	Results	Author conclusions
		Pairwise comparison – right back region: Stryker (manual turn) had higher average pressure than Stryker (turn-assist) (+1.253, 95% CI: 0.235 to 2.271) and Hill-Rom (manual turn) (+1.276, 95% CI: 0.026 to 2.525) Pairwise comparison – right pelvis region: Hill-Rom (turn assist) had higher average pressure than Stryker (turn assist) (+1.612, 95% CI: 0.288 to 2.936) Pairwise comparison – left pelvis region: Hill-Rom (turn assist) had higher average pressure than Stryker (turn assist) (+2.262, 95% CI: 0.526 to 3.997) and Stryker (manual turn) (+1.553, 95% CI: 0.099 to 3.006). Hill-Rom (manual turn) resulted in higher average pressure than Stryker (manual turn) (+1.684, 95% CI: 0.353 to 3.015) and Stryker (turn assist) (+2.393, 95% CI: 0.514 to 4.271) **Average pressure (maximum inflation) – initial time point** Pairwise comparison – right back region: Hill-Rom (turn assist) had higher average pressure than Stryker (turn assist) (+2.622, 95% CI: 1.579 to 3.665) Pairwise comparison – left back region: Hill-Rom (turn assist) had higher average pressure than Stryker (turn assist) (+1.040, 95% CI: 0.110 to 1.971) **Average pressure (final time point)** Pairwise comparison – right back region: Hill-Rom (manual turn) had higher average pressure than Stryker (turn assist) (+1.002, 95% CI: 0.278 to 1.725)	

Study name and location	Design and intervention(s) – including bed feature	Results	Author conclusions
		Pairwise comparison – left back region: No significant differences between any 2 pairs Pairwise comparison – left pelvis region: Hill-Rom (turn-assist) had greater average pressure than Stryker (turn-assist) (+3.515, 95% CI: 2.484 to 4.546) and Stryker (manual turn) (+3.008, 95% CI: 1.825 to 4.191). Hill-Rom (manual turn) had greater average pressure than Stryker (turn-assist) (+2.478, 95% CI: 1.127 to 3.828) and Stryker (manual turn) (+1.971, 95% CI: 0.740 to 3.201). **Peak pressure (initial position)** Pairwise comparison – right back region: Stryker (manual turn) had higher peak pressure than Hill-Rom (turn-assist) (+2.086), 95% CI: 0.077 to 4.095) and Hill-Rom (manual turn) (+3.646, 95% CI: 1.074 to 6.218). Pairwise comparison – right pelvis region: Stryker (manual turn) had higher peak pressure than Hill-Rom (manual turn) (+2.969, 95% CI 0.515 to 5.423) **Peak pressure (maximum inflation)** Pairwise comparison – right pelvis region: Stryker (turn-assist) had higher peak pressure than Hill-Rom (turn-assist) (+4.075, 95% CI: 1.797 to 6.352) Pairwise comparison – left pelvis region: Stryker (turn-assist) had higher peak pressure than Hill-Rom (turn-assist) (+4.775, 95% CI: 3.720 to 5.830) **Peak pressure (final time)** Pairwise comparisons did not reveal significant differences between any 2 pairs.	

Budarick 2020b (A. R. Budarick et al., 2020) **Location:** Canada **Setting:** NR (laboratory study – ICU bed surfaces)	**Design:** Prospective, experimental laboratory design. **Intervention:** Stryker Isolibrium support surface and Hill-Rom Progressor Pulmonary surface with turn-assist activated. **Comparator:** Stryker Isolibrium support surface and Hill-Rom Progressor Pulmonary surface without turn-assist activated (patients were turned using a manual technique). **Sample size:** 25 caregivers**.** Manual turns were repeated 3 times on each surface (6 times in total) and turn-assist trials were repeated 2 times on each surface (4 times in total).	**Hand force - turn-away (pushing patient away from body)** Manual turning – 204 newtons (102 applied by each hand) 97% of the 105-newton maximum acceptable Turn-assist – 0 newtons **Hand force - turn-toward (pulling patient toward their body)** Manual and turn-assist: 62 newtons (31 applied by each hand) 18% of the 176 newton maximum acceptable hand force **<u>Shoulder flexion/extension angle</u>** Turn away: manual turn required less shoulder flexion than turn-assist turns Turn towards: manual turn required more shoulder flexion than turn-assist turns **Shoulder movements** Turn away: turn-assist reduced shoulder moments about the left and right shoulders compared to a manual turn. **<u>Compression for at L4/L5 spine</u>** Turn away: Turn assist resulted in more compression force compared to a manual turn. Turn toward: Conversely, turn-assist decreased compression force compared to a manual turn. **Anteroposterior shear force at L4/L5 spine** Turn away: No difference between turn-assist and manual turn. Turn towards: turn-assist decreased anteroposterior shear force compared to manual turn.	Use of a turn-assist surface eliminated hand forces required to initiate the patient turn for the turn-away caregiver, where their role was reduced to inserting appropriate wedging behind the patient once the facilitated turn was complete. Use of a turn-assist surface reduced peak hand force and shoulder-related exposures for turning away and reduced spine-related exposures for turning toward.

Study name and location	Design and intervention(s) – including bed feature	Results	Author conclusions
Wiggermann 2016 (Wiggermann, 2016) **Location:** USA **Setting:** NR (laboratory study – ICU bed frame)	**Design:** Prospective, experimental laboratory design. **Intervention:** Hill-Rom TotalCare ICU bed frame equipped with a Sp02rt+ mattress with turn assist activated. **Comparator:** Hill-Rom TotalCare ICU bed frame equipped with a Sp02rt+ mattress with turn assist not activated. **Sample size:** 9 nurses 2 healthy participants Each experimental condition measured once at each side of the bed.	**Effects of turn assist for turning and lateral repositioning** **Mean (SD) peak hand force (newtons), 63 kg patient:** Turning: Manual: 109 (13.8) Turn assist: 70 (20.1) Comparison: p<0.001 Lateral repositioning: Manual: 340 (40) Turn assist: 253 (25) Comparison: p<0.001 **Mean (SD) peak spine compression force (newtons), 63 kg patient:** Turning: Manual: 459 (63) Turn assist: 391 (67) Comparison: p<0.001 Lateral repositioning: Manual: 382 (180) Turn assist: 278 (93) Comparison: p<0.05 **Mean (SD) peak spine shear force (newtons), 63 kg patient:**	Turn Assist reduced hand forces and spine loads when both turning and laterally repositioning patients.

Study name and location	Design and intervention(s) – including bed feature	Results	Author conclusions
		Turning: Manual: 235 (8.5) Turn assist: 193 (9.1) Comparison: p<0.001 Lateral repositioning: Manual: 431 (17.0) Turn assist: 352 (12.9) Comparison: p<0.001 **Patient weight** **Mean (SD) peak spine compression force (newtons), 123 kg patient:** Turning: Manual: 2474 (247) Turn assist: 1956 (239) Comparison: p<0.001 **Mean (SD) horizontal distance of the hands from L4/L5 when the maximum hand force was generated (mm), 63 kg patient:** Manual: 605 (89) Turn assist: 488 (145) Comparison: p<0.001 **Mean (SD) horizontal distance of the hands from L4/L5 when the maximum hand force was generated (mm), 123 kg patient:**	

Study name and location	Design and intervention(s) – including bed feature	Results	Author conclusions
		Manual: 547 (133) Turn assist: 409 (118) p<0.001 **Mean (SD) peak hand force (newtons), 123 kg patient:** Turning: Manual: 556 (56) Turn assist: 440 (54) Not significant	
Zhou 2021 (Zhou & Wiggermann, 2021) **Location:** USA **Setting:** NR (laboratory study – surgical hospital bed)	**Design:** Prospective, experimental laboratory design. **Intervention:** The Hillrom Centrella Max medical surgical bed with traditional cotton fitted draw sheet using turn assist feature, Trendelenberg and mattress maximum inflation assisted features. **Comparator:** Draw sheet without assisted feature.	**Effects of assistive features (ANOVA vs. no assistive features)** **Boosting** Trendelenberg: Peak spinal L5/S1 compressive load: p=0.001 Peak hand force: p<0.001 Both favour Trendelenberg **Lateral repositioning** Turn assist: Peak spinal L5/S1 compressive load: p=0.03 Peak hand force: p<0.001 Both favour turn assist **Turning** Turn assist: Peak spinal L5/S1 compressive load: p=0.511	Results demonstrated that except for the peak L5/S1 compressive load in the turning task, the use of assistive features significantly reduced the physical stresses for all repositioning activities. However, recommended thresholds for injury were still exceeded in many conditions. Mechanical lift equipment remains the safest and most robust way to reposition a patient.

Study name and location	Design and intervention(s) – including bed feature	Results	Author conclusions
	Sample size: 10 caregivers 2 healthy participants Each experimental condition was repeated twice.	Peak hand force: p=0.006 (favours turn assist)	

5.4 Summary of clinical and technological evidence

The clinical review identified evidence on features that may be considered innovative additions to acute-care bed frames. Only 2 features were evidenced by studies reporting clinical outcomes (beds with a low height position and inbuilt bed exit alarms). For beds with a low height position, a cluster RCT did not show significant benefits on rates of falls. However, because of the potential for bias and a lack of generalisability, the evidence for this feature was considered to be unclear. For inbuilt bed exit alarms, although a before-after study showed a large reduction in falls, it was considered to have a high risk of bias. The value of inbuilt bed alarms is therefore also currently unclear.

For the other innovative features, evidence was from non-clinical 'technical' settings, testing proof-of concept of the evaluated feature, but not its impact on patient or caregiver outcomes. For some of these innovative features (extendable and sliding pivot headboards, alternative brake pedal location, turn assist and power-drive) there was proof-of concept, where studies showed improved technical outcome compared with beds without the innovative feature. For example, there was a reduction in migration or pushing force requirement.

For inbuilt bed weighing scales, studies did not show good correlation with weighing via fluid balance, suggesting that the features evaluated may not currently be accurate enough to replace fluid balance. For the addition of a fifth wheel, studies did not show a clear advantage in objective outcome measures, and it was unclear whether it reduced forces associated with low back disorders or improved work efficiency. For auto-contour and double bogie configuration features, further evidence from larger studies would be required to demonstrate their impact on migration and force requirements respectively.

5.5 Assessment of clinical equivalence

For the evidence review, no evidence was found on the clinical equivalence of the same innovative features in different bed designs and no evidence was submitted by manufacturers to demonstrate equivalence. In our review, we have therefore assumed equivalence of the efficacy of features between bed designs. However, it is possible that features demonstrate different levels of efficacy in different beds. This may be due to:

- The specific design of the feature in different bed frame models i.e. bed frames differ in respect to the components and functioning of a particular innovative feature.
- Differences in the bed frames that impact feature functionality e.g. bed weight or size.
- The interaction of innovative features within different bed frames, e.g. a bed alarm and innovative bed rails may both impact the rate of falls.

Therefore, in many cases, it is difficult to predict the efficacy of a specific feature and whether that efficacy will vary across beds.

6 Economic evidence searches and selection

6.1 Evidence search strategy and study selection

A single set of searches was conducted to identify both clinical and economic evidence (see section 4.1). Full details of the search methods used are provided in Appendix A.

6.2 Included and excluded studies

No economic evaluations or cost or resource studies meeting review eligibility criteria were identified in the review. Companies did not submit any economic models as part of their evidence submission.

7 Economic evaluation

7.1 Quality appraisal of selected studies

No studies were included in the economic evidence review – see section 6.

Full details of the search methods used are provided in Appendix A. A list of excluded studies is provided in Appendix B. A list of manufacturer submitted evidence is provided in Appendix C.

7.2 Economic model

No previous NICE guidelines or economic models were identified which could inform the development of the economic model. Therefore, we developed a de-novo model based on innovative features and their potential benefits, focusing on quantifiable economic outcomes. Our conceptual model was based upon

- Information and user preferences supplied by clinical experts to NICE, including key points raised during the user preference workshop.
- Information supplied by companies on features included within their bed frames, and clinical evidence identified through the clinical review.
- How the bed frame innovative features were linked listed on the NICE scope and their intended benefit to patients (See Table 2.1).

The model was designed to evaluate changes in the following incidents:

- Falls
- Pressure ulcers
- Entrapment
- Infections
- Caregiver musculoskeletal injuries.

Based on the evidence currently available for the assessment, we were not able to evaluate the impact of every feature on potential incidents. This is because only 1 of the innovative features had any evidence to support their effect. In our base case analysis, we took 2 approaches. The first approach taken was to use exploratory analysis to evaluate the value of different bed frame features and to assess their potential economic impact on incidents. The second approach in the base case was a fully incremental analysis of bed frames available on the NHS. The fully incremental analysis only incorporated the impact from innovative features with evidence. We developed a flexible model focusing on the high-level outcomes, rather than specific features, given the limited evidence. However, this exploration will still provide useful context for decision makers, since an absence of evidence, in this case, does not necessarily mean an absence of clinical effect. Decision makers should consider the plausibility of the required benefits for different bed frames, combined with the considerations described in section 3 to guide purchasing decisions.

Regardless of any purchasing decisions, we would encourage all bed frame providers to develop robust evidence to justify differentials in price. Further details about future research needs are discussed in section 8.

7.2.1 Population

We considered users of acute adult bed frames for the modelled population, which includes adults admitted to acute care settings and caregivers providing care for these patients. This is consistent with the NICE Scope. However, based on the limited evidence available, it was not possible to model evidence-based impacts on the subgroups outlined in the scope. Only 1 feature (bed exit alarms) had any evidence to support a potential economic benefit. The model was primarily used for exploratory analysis to determine the potential impact of different groups of features. The generalisability of evidence across different sub-populations should be considered by decision-makers when interpreting the results.

7.2.2 Model structure

We developed a cost-utility model with a 1-year time horizon, structured as a decision tree comparing differences between bed frames and their innovative features. The time horizon covers 1 year for the people using the bedframe (and their associated outcomes), as well as 1 year for the bedframe itself, annuitizing the cost of the bedframe over its life cycle. The 1-year time horizon was used given the uncertainty of longer-term impacts that can be directly linked to differences in innovative features across bed frames. For example, it is unclear if an innovative feature which may impact falls, may impact future outcomes 5 or 6 years into the future for that person for preventing a fall. This may result in underestimating potential benefits, if an innovative feature does have long-term impacts on the person. However, there is limited evidence that any features impact incidents, therefore, limiting the time horizon reduces the uncertainty of the estimated figures, if features can lead to reductions in events.

Using the stated time horizon, we considered the impact the bed would have every year in its operation. Using a decision tree, meaning a linear approach to the analysis, we estimated the impact of the bedframe over 1 year, but this can be scaled to longer time periods for the bed frame. For example, if a feature led to a £2,000 savings associated with falls in 1 year of using the bed frame, we can estimate over 10 years the value of this would be £20,000, not accounting for discounting. Keeping the time horizon as 1 year for the bed frame and the person or user maintains consistency for interpreting the results.

The model was used to estimate resource use associated with innovative features, and the key outcomes they may impact. We then applied costs to the different resource uses. QALYs were also captured within the 1-year time horizon for the people using the bed, with decrements assigned to each incident that was experienced, either by patients or caregivers.

We therefore considered that, in the context of the existing evidence, a 1-year time horizon was appropriate. If more evidence is collected on bed frame features, a longer time horizon may be more appropriate. We have provided a detailed discussion of future evidence recommendations, including future modelling approaches in section 8. These recommendations are made regardless of the outcome of the LSA process. We would highly recommend that companies engage in further evidence generation considering the current paucity in existing data.

The impact was captured in the model and presented as an incremental cost-effectiveness ratio (ICER) for pairwise comparisons and fully incremental analysis of different bed frames. Cost-effectiveness is determined by using a threshold of £20,000 per QALY. We did not consider it sensible to use the upper £30,000 per QALY threshold because of the high uncertainty and limited nature of the evidence, as per the NICE methods guide (NICE, 2022). The impact of innovative features towards modelled incidents were also presented separately, not related to each specific bed frame. There was limited evidence to identify any effect of innovative features, therefore, exploratory analysis was conducted to determine the value of groups of features. The exploratory analysis was based on assumed impacts which reduce either falls, pressure ulcers, infections, entrapment and caregiver injuries to determine which features may represent the highest value at different effectiveness rates.

The model structure was limited by the level of evidence available, and assumptions were required to populate it. The model should therefore be seen as an exploration of the economic impact of acute bed frames with innovative features.

The modelling approach captured different resource use that can be attributed to care associated with different acute bed frames with different sets of innovative features. Within the model, each bed frame was assigned innovative features, as described in section 2, to outcomes these features were likely to impact. The incidents captured in the model were:

- Falls
- Pressure ulcers
- Infections
- Entrapments
- Caregiver injuries.

The model was limited to these 5 incidents, as these were incidents that could be linked directly to health economic impacts. There may be other preferences, which may be important to users of the bed frame (patients, caregivers, technicians), but cannot be clearly linked to health economic impacts. User preferences should also be considered within the decision-making process.

Only 1 specific feature was modelled based on available evidence. This was bed exit alarms and their association with a change in falls. All other features were assigned to an outcome where they were expected to have benefit. However, since there was no identified evidence for any other features, these were grouped and explored by looking at assumed impacts to determine the possible value of the features. If a bed frame had more than 1 feature which contributed to an outcome (e.g. falls), this did not have an additive effect on the assumed impact. It will be important for the committee to consider if additional innovative features will lead to additive effects of reducing the 5 outcomes modelled, or if the features have a cancelling effect (i.e. if adding a second feature has no additional impact).

Cost of the bed frames included acquisition costs and maintenance costs, which were calculated as annual costs, based on the expected life cycle of the bed frame. There was no evidence to indicate any difference in training costs between bed frames, so this was excluded from the analysis. If the training time differs between operation of bed frames, then this will underestimate the cost of selecting bed frames which require more training. For instance, those with more innovative features may require more time to train staff to use them, so excluding these costs would underestimate the true cost of implementing them in clinical practice. Additionally, any differences in user experience and operability of bed frames due to varying training requirements may influence the effectiveness of innovative features. If the features are not used optimally due to inadequate training, this could reduce their potential to impact incidents such as falls or pressure ulcers.

The approach to modelling uses a simple calculation by estimating the cost of the outcomes with and without the innovative feature(s), by changing the base number of incidents occurring. Therefore, for each bedframe, we are calculating the total number of incidents that occur within each year for the specified incident. If a bedframe has an innovative feature, we are capturing the difference in the number of incidents that occur, either through evidenced benefit, or exploratory analysis of the potential benefit.

Figure 7.1 and Figure 7.2 outlines the modelling approach.

Figure 7.1: Cost-utility model structure

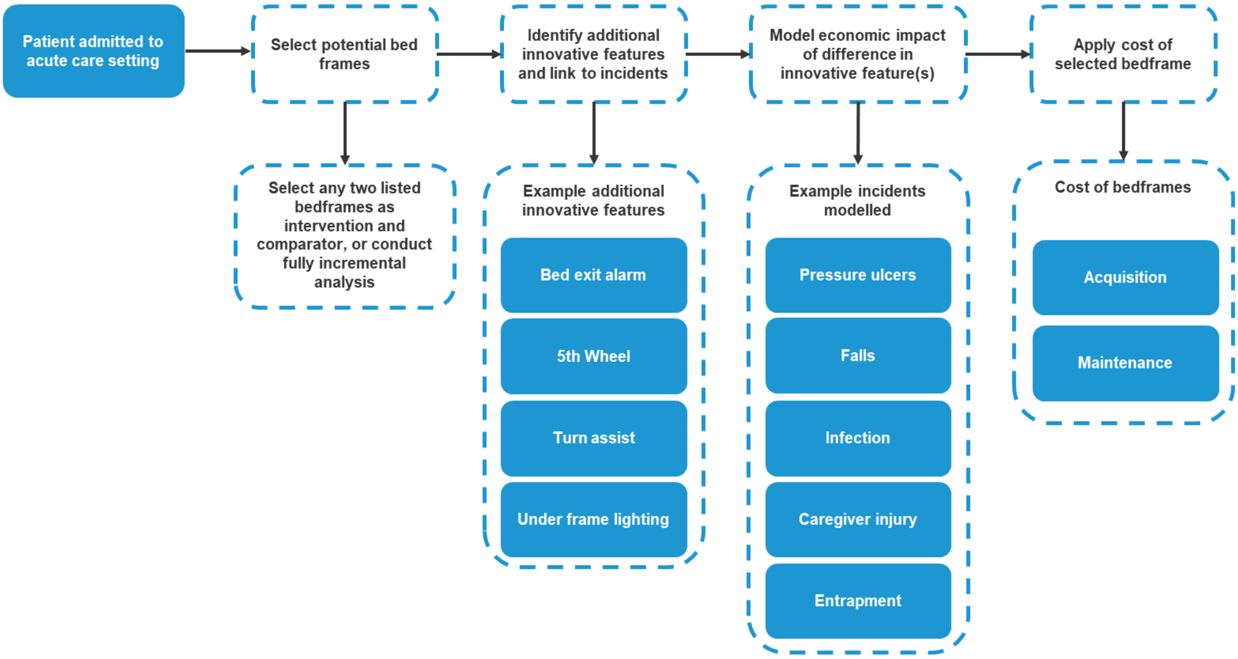
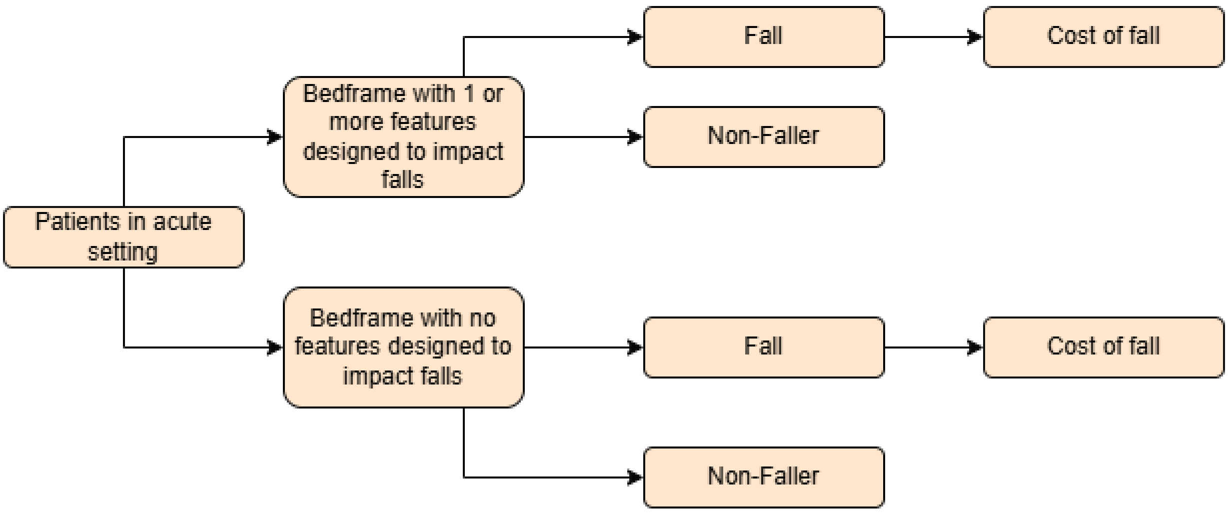


Figure 7.2: Example of approach to modelling economic outcomes of feature



Future modelling as more evidence is collected should be considered, regardless of any recommendation made within this LSA.

7.2.3 Model assumptions

A number of assumptions were required to produce the cost-utility model using the available data. These assumptions are required to provide a useful exploratory analysis for the committee but should be considered when making any recommendation. These assumptions are discussed in Table 7.1.

Table 7.1: Assumptions and limitations of the model

Assumption	Discussion
Costs of the bed frames can be scaled down to a per-patient stay cost based on estimated occupancy rates and average length of patient stay.	The cost of purchasing and using a bed frame is captured as a per-patient stay cost. These costs vary between companies as listed on NHS supply chain, and these costs do not include commercial discounts or alternative payment structures offered by companies to the NHS (upfront cost payment structure only). Costs are annuitized based on the estimated lifespan of the technology, rather than an upfront cost, for which there was limited information to inform this.
All bed users have the same probability of having a modelled incident.	Limited evidence was available to estimate the impact to different subpopulations. Some subpopulations in acute settings may have higher baseline rates of incidents or may have a greater capacity to benefit from innovative features. By taking a generalised approach, the benefit may be overestimated for some groups of patients but underestimated for others. Baseline rate of incidents and the level of effectiveness is explored as part of sensitivity analysis and may be useful to articulate the potential benefit in different populations.
Generic features are expected to reduce the number of incidents by 10%. This is used in the exploratory base case on the value of features, but not included in the fully incremental analysis.	There are a range of innovative features for acute bed frames, of which there is no evidence of any effect. An absence of evidence, does not necessarily mean an absence of effect. However, without published evidence the true effect is unknown. Therefore, in the base case we assume a 10% reduction where there is no evidence, which is explored further in sensitivity analysis to indicate the potential impact the feature could have. If more than 1 feature may impact the outcome, there is not an additive effect of that feature, as it is unclear how the features will interact, and creating an additive effect will likely overestimate the impact of innovative features together.
Long-term outcomes of bed frames are not captured for people experiencing events. The model uses a time horizon of 1 year due to the range of long-term outcomes from the use of bed frames.	Patient and carer populations who experience fewer incidents may realise additional benefits, such as improved quality or quantity of life or reduction in healthcare resource use over time (for example, from fewer falls after the initial fall) over time. The long-term follow-up evidence is currently for very specific use cases of specific bed frames, and evidence is not available to generalize these outcomes. Furthermore, even for specific bed frames, there is likely substantial heterogeneity in patient and carer populations using these, meaning that estimates of long-term impacts are likely to be very diverse and uncertain. A short-term perspective is taken for this analysis, with results presented and contextualized with the potentially additional long-term

Assumption	Discussion
	outcomes. The EAG notes this should be discussed among the committee, and the available evidence should be considered to determine which bed frames are more likely to be cost-effective.
The cost of the bed frames are annuitized, to keep consistency with the time horizon of the people using them.	The life cycle of the bed is estimated to be 10 years. The structure of the model, given the limited evidence, is linear for estimating potential impacts. Therefore, we have scaled down the bed costs, and the expected impacts, to per year, to keep consistency with the impact on the users. Results from the analysis can be scaled to the full life cycle, simply by multiplying the results by the expected life cycle.
Cleaning costs for bed frames were not captured within the model.	From our experience of costing cleaning within the NHS, the processes (and therefore costs) differ significantly at each local hospital. There is likely to be large variation within costing for cleaning of instruments, and no evidence was identified to suggest cleaning differs between bed frames.
Only entrapments which cause severe harm are included in the base case.	Entrapments are sparsely reported in the available literature. Where entrapments are reported, they only consider major events or deaths. We believe that it is likely that more entrapments occur within practice, which are not reported, and do not lead to major or severe consequences. However, in light of available evidence, we have limited the analysis to only major entrapments. Clinical experts indicated that entrapments are very rare in clinical practice within acute settings. Experts indicated when entrapments have occurred in their experience, they have led to no consequences and are resolved very quickly. Therefore, in the base case we have only considered entrapments which are more severe. Sensitivity analysis explores the impact of including more minor entrapments, as well as the baseline level of events. Committee members should consider if features related to entrapments will reduce entrapments, or whether other organizational interventions will reduce entrapments. Examples of other interventions which may have more effect include staff training, or updated processes for moving patients. There is currently no evidence to suggest innovative features will impact the number of entrapments.

Assumption	Discussion
Training costs were not captured in the model.	There was no evidence to indicate that training costs were different across any acute bed frame. Those with more innovative features, may require more training to use the innovative features. However, it is not clear if this linear relationship exists in practice, while some features are unlikely to require any training (such as a fifth bed wheel). Companies who submitted evidence all indicated that additional training would be provided free of charge, however, the scope of this training was not necessarily detailed. Therefore, additional costs from training may arise from more complex bed frames due to staff time required to undergo training. It is not clear which features may actually require longer training, and which can easily be imbedded into current training programmes.
The average cost to the NHS of caregiver injury is £58 per hour of lost work.	This assumes that the additional incurred cost to the NHS of caregiver injury is equivalent to the average hourly rate of funding band 6 nurse. This value (£58/hr) is sourced from PSSRU and covers a range of costs including salary, staff training, and hospital overheads. It may not be appropriate to assume that all of these costs are incurred again when a member of staff is injured (for example, overheads are unlikely to change) and so this assumption potential double counts the cost incurred to the NHS. However, where staff are absent, the NHS may be forced to utilize the services of a staffing agency. The average hourly rates are expected to be substantially higher than permanent staff.
Potential connectivity benefits related to innovative features, such as reduced staff time, is not included in the model.	There was no evidence to indicate the economic benefits of improved connectivity from innovative features associated with bed frames. We believe if there is any benefit, the likely benefit would be reducing staff time. However, feedback from the user preference workshop indicated that a substantial number of trusts do not have the IT infrastructure to make use of potential connectivity benefits. Therefore, even if the bed had innovative features related to connectivity, it would have no impact on day-to-day practice, if it cannot be integrated with current IT systems, or there is poor WIFI coverage. Based on this feedback, we have not included this in the model and anticipate that connectivity is a less important metric to consider in purchasing decisions, at the time of writing.
Annual bed frame maintenance costs .	Annual maintenance costs were only available for a small number of bed frames. For this reason, it is assumed that for companies who have not provided maintenance costs, the value is equal to the highest submitted value [redacted] This is varied within sensitivity analysis, given in the first year, bed frames are still under warranty.

Assumption	Discussion
All bed frames have a life cycle of 10 years, and the cost of bed frames are annuitized based on this life cycle.	Providers indicated a the most common lifespan is approximately 10 years. One RFI indicated that this value would be [redacted], although no evidence was provided to substantiate the longer average lifespan. Therefore, a lifespan of 10 years across all bed frames is assumed. Information provided by external clinical experts suggested that some bed frames have shorter lifespans than 10 years due to collisions and bending of the frame that is unrepairable. However, this evidence was anecdotal, and was not specific to any bed frame.
All costs are exclusive of VAT and the NHS will not pay VAT on bed frames.	The NHS would typically pay a reduced VAT rate of 0% (zero rate) for bed frames and other medical equipment that are classed as essential medical devices as per HMRC Notice 701/31 so this has not been incorporated.

Key: EAG – External assessment group, HMRC – His Majesty's Revenue and Custom, NHS – National Health Service, RFI – Request for information, VAT – Value added tax.

7.2.4 Set-up parameters

The model compares 2 selected bed frames with each other over a 1-year time horizon, given the annual costs and benefits are scalable. Therefore, the relative cost benefit ratio will remain the same year on year, until the bed frames life cycle ends. For example, a bedframe with a 1-year increase in QALYs by 0.2, and a cost of £800, will lead to 2 QALYs and £8000 over 10 years. This is because the model structure is linear, meaning the costs and benefits are scalable.

The cohort value (the total number of patients per bed days) was calculated using the average annual occupancy rate. The total number of patients was calculated by dividing the number of occupied bed days by the average length of stay. The discount rate (for cost annuitisation) and the cost-effectiveness threshold (for QALY threshold analysis) were set as 3.5% and £20,000 per QALY respectively. Set up parameters are outlined in Table 7.2.

7.2.5 Clinical and efficacy parameters

Proportions, split by severity level, were reported for 3 of the incidents: Falls, pressure ulcers, and entrapment. These are outlined in Table 7.3. For entrapment, no evidence was identified for minor injuries. It is suspected that minor injuries due to entrapment are likely to go unreported, and this was confirmed with clinical experts. Experts also confirmed that these are extremely rare, and likely do not lead to additional resource use. Therefore, in the base case, only major injuries have been captured.

Where possible, the number of events per 1,000 bed days were sourced from the literature for each incident. The number of caregiver injuries and infections per 1,000 bed days were calculated from the annual number of caregiver injuries/infections, and the number of bed days in the relevant population.

7.2.6 Resource use parameters

Length of stay (LoS) values were sourced from the literature for the key model outcomes. These are outlined in Table 7.4. For generic outcomes, the percentage reduction due to features was assumed to be 10% due to paucity of available evidence, and then explored to test the potential impact in scenario and sensitivity analysis. The 10% reduction was only applied as part of the first approach, which considered the value of reducing different features. The generic 10% impact was not applied in the fully incremental analysis. Specific resource use values for the reduction in falls due to bed exit alarms and innovative side rails were sourced from Seow et al (2022) and the NHS Patient Safety Agency (2007) respectively.

7.2.7 Cost parameters

Costs of the key incidents are outlined in Table 7.5. Falls and pressure ulcer costs, split by severity level, were sourced from the NICE clinical guidelines (2013), and Guest et al (2018) respectively. Costs for entrapment and caregiver injury were derived from the Personal Social Services Research Unit (PSSRU) and the National Cost Collection. It was assumed that minor entrapments would result in an increase in staff time of 15 mins, and the cost is based on a Band 5 hospital-based nurse. This is based on clinical feedback suggesting they are unlikely to lead to any substantial impact on resource. Major entrapment injuries are based on a weighted average of fracture cost codes across limbs and neck. The cost of caregiver injury per working day was calculated using the average number of hours worked by a band 6 hospital-based nurse (derived from the PSSRU Costs of Health and Social Care) multiplied by the cost per hour of work lost. The cost of additional patient bed days was also included and was derived from the NHS Archived reference costs (2017/18). Costs not derived from 2023 literature were inflated to the 2023 costing year using the PSSRU.

Technology costs are outlined in Table 7.6. Bed frame unit costs were derived from the NHS supply chain. Where possible bed frame maintenance costs were sourced from the RFIs. In the absence of evidence the maintenance costs for other bed frames were assumed to be the highest annual maintenance cost from submitted evidence. Bed frame lifespan was also sourced from the RFIs. The most common lifespan indicated by companies was approximately 10 years. [redacted]

Therefore, a 10-year lifespan was assumed for all bed frames. Annuitized bed frame costs were calculated by using the NHS supply chain cost of the bed frame and estimating the annual cost based on the life cycle of the bed frame, and a 3.5% discount rate. The total cost of the bed frame applied in the model therefore was the annuitized unit acquisition cost summed to the annual maintenance cost.

7.2.8 Utilities parameters

Utility decrements for falls and infections were derived from NICE clinical guidelines 139, and decrements for pressure ulcer by grade of severity were sourced from Posnett et al (2022). Table 7.7 displays the utility decrements for each incident. Total disutility per caregiver injury was calculated by multiplying the disutility per day absent from work due to injury by the average number of work days lost (6.60). Minor harm due to entrapment was assumed to cause no change in utility. Severe harm due to entrapment was assumed to have a disutility of half of the population utility value (0.43). This assumption was that the disutility was approximately double a severe fall. The assumption was explored in deterministic sensitivity analysis (DSA) to evaluate the likely impact it would have on the results. UK population EQ-5D-3L background utility values were also included in the model and were derived from the NICE Decision Support Unit (2022).

Table 7.2: Set-up parameters

Variable	Value	Source	EAG commentary on availability, quality, reliability and relevance of the source/s
Average annual occupancy rate	93.6%	NHS Performance report 2022/23 (NHS England, 2024c)	
Average bed occupancy length of time (days)	4.70	NHS England Digital. 2023/24 (NHS England, 2024b)	This value will also include non-acute ward bed stays. No data was identified specifically for acute wards.
Average number of acute beds	116,947	(NHS England, 2023)	Average I number of general and acute ward beds available within the NHS (in England only) between Q2 2023/2024 and Q1 2024/2025.
Annual number of occupied bed days per year	39,981,139	Calculated	Number of acute beds (116,947) multiplied by bed occupancy rate (93.6%) multiplied by the days in the year (365).
Discount rate	3.5%	National Institute for Health and Care Excellence. NICE health technology evaluations: the manual. 2022 (NICE, 2022)	N/A
Cost-effectiveness threshold	£20,000 per QALY		

Table 7.3: Proportions for each incident

Variable	Value	Source	EAG commentary on availability, quality, reliability and relevance of the source/s
Falls			
Proportion of falls: no harm	66.5%	(Healey et al., 2008)	National Reporting and Learning System (NRLS) data for slips trips and falls in England and Wales. Incidents for 12 months (Sept 2005 – Aug 2006) was searched. Input references are from acute hospital data only (≈152,000 falls). Data used is from 18 years ago so may not be generalizable due to updated in clinical practice or risk mitigation efforts.
Proportion of falls: low harm	29.5%		
Proportion of falls: moderate harm	3.3%		
Proportion of falls: severe harm	0.7%		
Pressure ulcers			
Proportion of pressure ulcers: grade 1	32.3%	(Clark et al., 2017)	Survey assessing 8,365 patients were assessed across 66 hospitals in Wales across a 5-day period in 2015. Short study period so may not accurately reflect long-term changes in the number of pressure ulcers. Varying scales used to assess the severity of pressure ulcers.
Proportion of pressure ulcers: grade 2	50.1%		
Proportion of pressure ulcers: grade 3	12.6%		
Proportion of pressure ulcers: grade 4	5.0%		
Entrapment			
Entrapment: proportion which are minor harm	0.0%	Assumption	No evidence identified for minor injuries. We expect this will not be reported, so have only captured major injuries in the base case. Clinical experts have also confirmed that entrapments are very rare, and minor incidents are resolved very quickly with little impact on resource or the patient.
Entrapment: proportion which are serious harm	100.0%	Assumption	
Caregiver Injury			
Proportion of caregiver injuries due lifting or turning patients, or moving beds	60.0%	Arjo company-provided evidence	<u>Referenced in the Arjo company evidence submission, based on a patient handling survey among caregivers at a military healthcare facility. Only the abstract is publicly</u>

Variable	Value	Source	EAG commentary on availability, quality, reliability and relevance of the source/s
			available, so independent validation was not possible. Study location is unclear, though the EAG assumes it is from the U.S, based on the author's publication history.

Table 7.4: Resource use parameters

Variable	Value	Source	EAG commentary on availability, quality, reliability and relevance of the source/s
Falls			
Increase in length of stay with fall (days). Applied to people who have a fall with low harm.	10.60	NICE guideline. (NICE, 2013b)	Unpublished trial data from a UK study as referenced by NICE in CG161. n=1,695 (no fall), n=34 (fall which lead to injury). Small sample size for those who fall. No fall= 11.6 days, fall= 21 days. Difference of 10.6 days. No fall= 11.6 days, fall with injury= 24.4 days. Difference of 12.8 days. Confidence intervals reported and used in sensitivity analysis.
Increase in length of stay with injury (days). Applied to people who have a fall with moderate or severe harm.	12.80		
Falls per 1,000 bed days	6.63	National Audit of Inpatient falls audit report (2015). (HQIP, 2015)	National audit conducted by The Royal College of Physicians (RCP) involving NHS trusts and health boards in England and Wales during May 2015. Reported as a “per 1,000 occupied bed days”.
Odds ratio of falls with bed exit alarm	0.50	(Seow et al., 2022b)	Retrospective study conducted in Singapore in a 1,700-bed acute hospital on the use of the Hill-Rom 1000 medical-surgical bed. OR at 6-month post-implementation = 0.5. Committee should consider the generalisability to the UK population. Used in absence of any other evidence.
Pressure ulcers			
Increase in length of stay with pressure ulcers (days)	6.50	(Wood et al., 2019)	Sourced from NICE costing statement CG179, Pressure ulcers: prevention and management “pressure ulcers increasing length of stay by an average of 5–8 days per pressure ulcer”. Midpoint assumed representative of the average increase in LoS. Not grade specific.
Pressure ulcers per 1,000 bed days	0.27	Pressure Ulcer Prevalence Improvement Plan	Population prevalence study on pressure ulcers in NHS Tyneside hospitals in 2009. May not be generalizable to whole of UK.

Variable	Value	Source	EAG commentary on availability, quality, reliability and relevance of the source/s
		2013.(NHS Tayside, 2013)	
Entrapment			
Entrapments per 1,000 bed days - injury	0.0003	Medicines and Healthcare products Regulatory Agency and NHS England. (Gov.UK, 2020; NHS England, 2023)	MHRA reported number of entrapments that lead to serious injury or death (54 and 18 respectively) between 2018-2022. Occupied bed days estimated using NHS Bed Availability and Occupancy (KH03) data were used to calculate the number of entrapments per 1,000 bed day. These values are very low and only capture reported incidents so may underestimate the number of entrapments. Due to the small number of events, these calculated values are associated with a high level of uncertainty.
Entrapments per 1,000 bed days - deaths	0.0001		
Caregiver Injury			
Annual number of lost days due to musculoskeletal injury (England total)	416,000	(Health and Safety Executive, 2022a)	HSE England 2022/2023 data on workplace illness and injury (submitted from the self-reported Labour Force Survey) was processed to only represent musculoskeletal injury among caregivers. This captured all caregivers, not just in an acute setting and is limited to musculoskeletal injury. This is primarily captured by the number of work days lost so will not capture those who are injured but continue to work.
Number of lost days of work per caregiver injury	6.60	(Health and Safety Executive, 2022b)	Not specific to acute settings.
Number of caregiver injuries (per 1,000 patient bed days)	6.24	Calculated	Calculated from the above references. The total number of lost days due to musculoskeletal injury (416,000) multiplied by the number of lost days of work per caregiver (6.6). Divided by the annual number of occupied bed days per year (39,981,139).
Infections			

Variable	Value	Source	EAG commentary on availability, quality, reliability and relevance of the source/s
Total number of hospital-acquired infections	83,299	Gov.UK Official Statistics. (Gov.UK, 2016)	Total number of HAIs (RSA, MSSA, Gram-negative bacteraemia and CDI) in 2022/23 in England only. Excluded data that failed to link correctly to NHS Spine.
Proportion of infections leading to death	17.6%		Case fatality rate for all hospital acquired infections (RSA, MSSA, Gram-negative bacteraemia and CDI) in 2022/23 in England only.
Increase in length of stay from infections (days)	7.80	(Stewart et al., 2021)	One-year prospective incidence study of HAIs in 2 hospitals in NHS on 107,000 admissions to all settings (i.e., not only acute setting)
Number of infections (per 1,000 patient bed days)	2.08	Calculated	The number of hospital acquired infections (83,299) divided by the annual number of occupied bed days per year (39,981,139).

Table 7.5: Key incident cost parameters

Variable	Value	Source	EAG commentary on availability, quality, reliability and relevance of the source/s
Falls			
No harm inpatient falls cost	£61	(NICE, 2013a) Prices inflated to 2023. (PSSRU, 2024b)	Sourced from NICE CG161. No harm cost (2010-11) = £47; inflated to 2022-23 using PSSRU inflation indices to £61 Low harm cost (2010-11) = £77; inflated to 2022-23 using PSSRU inflation indices to £98 Moderate harm cost (2010-11) = £371; inflated to 2022-23 using PSSRU inflation indices to £476 Severe harm (2010-11) = £2,291; inflated to 2022-23 using PSSRU inflation indices to £2,940.
Low harm inpatient falls cost	£98		
Moderate harm inpatient falls cost	£476		
Severe harm inpatient falls cost	£2,940		

Variable	Value	Source	EAG commentary on availability, quality, reliability and relevance of the source/s
Pressure ulcers			
Pressure ulcer cost: grade 1	£1,382	(Guest et al., 2018) Prices inflated to 2023. (PSSRU, 2024b)	Retrospective cohort analysis of the records of 209 patients with diagnosed PUs. Location non-specific and many of the patients who were assessed had PU onset not in a care setting. Costs estimated over 12 months and in the costing year 2014/2015. Costs inflated to 2022/23 using PSSRU inflation indices.
Pressure ulcer cost: grade 2	£10,455		
Pressure ulcer cost: grade 3	£11,723		
Pressure ulcer cost: grade 4	£12,147		
Entrapment			
Entrapment costs: minor harm	£12	(PSSRU, 2024a)	Assumption that entrapment would result in an increase in staff time (15 minutes of a Band 5 hospital-based nurse) in order to resolve. This assumption is varied in sensitivity analysis.
Entrapment costs: major harm or death	£2,731	(NHS England, 2022)	Weighted average of all NHS cost collection fracture costs, regardless of CC score. This assumes that the cost of an entrapment is the same as treating an average fracture that a patient may present to the NHS with.
Caregiver injury			
Nurse lost work cost (per hour)	£58	(PSSRU, 2024a)	Assumption that the average NHS cost per hour of lost work for a caregiver who is injured is similar to that of a band 6 nurse.
Caregiver cost per lost working day	£444	(PSSRU, 2024a)	Working days per year = 203; Working hours per year = 1553. 1553/203 = 7.65 hours worked per working day.
Additional patient bed day cost	£503	(NHS Improvement, 2020) Price inflated to 2023. (PSSRU, 2024b)	Archived 2017/2018 reference costs and guidance. Elective inpatient excess bed days cost = £431. Inflated to 2023 costing values using PSSRU inflation indices = £503.

Table 7.6: Key technology costs

Technology	Unit cost	Source	Annual maintenance cost	Source	EAG commentary on availability, quality, reliability and relevance of the source/s
Apex OOK SNOW ward bed	[redacted]	NHS supply chain	[redacted]	Assumption	Any companies who have not provided maintenance costs are assumed to have the highest annual maintenance costs from submitted evidence.
Apex OOK SNOW falls bed	[redacted]		[redacted]		
Apex OOK SNOW mental health bed	[redacted]		[redacted]		
Arjo Enterprise 5000X	[redacted]		[redacted]		
Arjo Enterprise 8000X	[redacted]		[redacted]		
Arjo Enterprise 9000X	[redacted]		[redacted]		
Baxter Centuris Pro	[redacted]		[redacted]	Baxter company-submitted evidence	
Baxter Hillrom 900 X2 (B2)	[redacted]		[redacted]		
Baxter Hillrom 900 X3 (C2)	[redacted]		[redacted]		
Baxter Hillrom 900 Accella	[redacted]		[redacted]		
Direct Healthcare Delta 4	[redacted]		[redacted]	Assumption	
Direct Healthcare Lago Hospital	[redacted]		[redacted]		
Drive DeVilbiss Innov8	[redacted]		[redacted]		
Innova Care Interlude V3	[redacted]		[redacted]		
Linet Eleganza 1	[redacted]		[redacted]		
Linet Eleganza 2	[redacted]		[redacted]		
Linet Essenza 300	[redacted]		[redacted]		
Linet Essenza 300 LT	[redacted]		[redacted]		
Linet Image 3	[redacted]		[redacted]		

Technology	Unit cost	Source	Annual maintenance cost	Source	EAG commentary on availability, quality, reliability and relevance of the source/s
Medstrom Solo	[redacted]		[redacted]	Medstrom company-submitted evidence on. Lifetime bed cost	
Medstrom Solo+	[redacted]		[redacted]		
Medstrom Solo Luxe	[redacted]		[redacted]		
Medstrom SoloMH	[redacted]		[redacted]		
OSKA Florence	[redacted]		[redacted]	Assumption	
Stryker SV2 Electric Hospital Bed	[redacted]		[redacted]		
Stryker ProCuity™ L model	[redacted]		[redacted]		
Stryker ProCuity™ LE model	[redacted]		[redacted]		
Stryker ProCuity™ Z model	[redacted]		[redacted]		
Talley Group IMO Matrix E30	[redacted]		[redacted]		
Talley Group IMO Matrix U24	[redacted]		[redacted]		

Table 7.7: Utility parameters

Variable	Value	Source	EAG commentary on availability, quality, reliability and relevance of the source/s
Fall utility decrements			
Falls disutility no harm (hospital)	0.05	(NICE, 2013a)	Unpublished trial data from a UK study as referenced by NICE in CG161. n=1,695 (no fall), n=34 (fall which lead to injury). Small sample size for those who fall. Data used were the relative decrements for fallers compared with non-fallers. No differential utility based on the number of previous falls was reported so this is assumed applicable regardless of whether there have had previous falls. A fall utility decrement was applied once they were discharged from hospital (applied for the remainder of the year). Once a patient was discharged, they reverted to the utility decrement associated with the same severity of fall in the home or care state, an assumption which aligns with the NICE CG161 economic evaluation.
Falls disutility low harm (hospital)	0.21		
Falls disutility moderate harm (hospital)	0.23		
Falls disutility severe harm (hospital)	0.26		
Falls disutility no harm (home)	0.00		
Falls disutility low harm (home)	0.02		
Falls disutility moderate harm (home)	0.04		
Falls disutility severe harm (home)	0.26		
Pressure ulcer utility decrements (annual)			
Pressure ulcer disutility grade 1	0.01	(Posnett et al., 2023)	Originally sourced from a 2015, QoL outcomes captured using EQ-5D survey of patients (n=307) who were using pressure relieving mattresses in inpatient and community settings.
Pressure ulcer disutility grade 2	0.05		
Pressure ulcer disutility grade 3	0.09		
Pressure ulcer disutility grade 4	0.11		
Entrapment utility decrements (annual)			
Entrapment disutility leading to minor harm	0.00	Assumption	Assumption that entrapment that leads to no harm has a negligible utility impact. This is varied in sensitivity analysis to determine the relative impact of this assumption.

Variable	Value	Source	EAG commentary on availability, quality, reliability and relevance of the source/s
Entrapment disutility leading to severe harm	0.43		In the absence of evidence on what serious injuries from entrapment are, assumed the disutility is half of the population utility value (0.855). This is varied in sensitivity analysis.
Infection utility decrements (annual)			
Infection disutility	0.01	NICE guidelines. (NICE)	The utility decrement experience by a patient with a HAI was assumed equal to those who have a bacterium infection as reported in NICE CG139: Healthcare-associated infections: prevention and control in primary and community care.
Caregiver injury utility decrements			
Background utility	0.74	(Obradovic et al., 2013)	Study on individuals living with chronic pain. Assumption that the utility experienced by these individuals is the same as those experience by a caregiver whilst they are injured. This is varied in sensitivity analysis.
Utility whilst injured (per day)	0.55		

7.2.9 Sensitivity analysis

Deterministic sensitivity analysis (DSA) was conducted and the results are represented graphically using a tornado diagram. The main purpose of the tornado diagram was to highlight the key drivers of potential monetary value related to innovative features. Therefore, the focus was not on pairwise comparisons of different bed frames, rather understanding what drives economic value from innovative features. Other one-way and two-way deterministic analysis was also included in graphical form. The one-way exploratory analysis varied the effectiveness of innovative features in reducing key incidents (falls, pressure ulcers, caregiver injuries, entrapment and infections) and the value of reducing these events. Two-way exploratory analysis varied both the relative effectiveness of reducing events, as well as the baseline number of incidents, given baseline number is likely to be heterogenous across different hospitals, wards and patient populations.

Probabilistic sensitivity analysis (PSA) was not conducted within this LSA. This is because of the limited evidence available to populate an economic model. As a result, it was not possible to identify standard errors for over 90% of parameters, meaning it was not possible to understand the uncertainty of the parameter estimates within a PSA. Assuming a range and a distribution and applying them for these parameters would introduce greater uncertainty, rather than producing a reliable estimate for the uncertainty already in the results. If we used assumptions to populate these uncertainty estimates, we believe the PSA would be limited, and not support the committee to make an appropriate recommendation. Any future modelling should look to determine appropriate confidence intervals for all parameters of interest, as future evidence should be collected, as detailed in section 8.

7.2.10 Scenario analysis

One scenario analysis is included in this report, using data from the NHS Improvement (2017) report on the incidence and costs of inpatient falls in hospitals (NHS Improvement, 2017). This report provides a breakdown of falls by severity, along with the associated costs for each severity level. The data used for this scenario analysis are presented in Table 7.8. This is included only as a scenario analysis as the assumptions to derive the costs are substantially different to other falls sources, including much higher length of stay. Furthermore, the report is no longer available on the NHS website, which may indicate the paper has been removed in case of a factual inaccuracy. We believe it is still worthwhile to explore the alternative cost in a scenario, for determining the value of reducing falls.

Table 7.8: Scenario analysis falls alternative data

Variable	Value	Source	EAG commentary on availability, quality, reliability and relevance of the source/s
Fall proportions			
Proportion of falls: no harm	72.0%	NHS Improvement (2017)	The NHS Improvement report provided data on hospital falls across all settings in England for 2015/2016. Including data from all settings (rather than focusing solely on acute care) may introduce uncertainty, as these figures might not be fully generalisable to the acute settings.
Proportion of falls: low harm	25.5%		
Proportion of falls: moderate harm	2.0%		
Proportion of falls: severe harm	0.5%		
Fall costs			
No harm inpatient falls cost	£2,807	NHS Improvement (2017)	The NHS Improvement report provided data on hospital falls across all settings in England for 2015/2016. Including data from all settings (rather than focusing solely on acute care) may introduce uncertainty, as these figures might not be fully generalisable to the acute settings. Inflated to 2023 costing values using PSSRU inflation indices. The length of stay is assumed much higher in this source than alternative sources, and the report is no longer available on the NHS website. These costs were initially reported separately for individuals under 65 and those aged 65 and over. Since the report indicates that 77% of falls in hospital settings occur in individuals aged 65 and over, the cost values
Low harm inpatient falls cost	£3,113		
Moderate harm inpatient falls cost	£8,976		
Severe harm inpatient falls cost	£11,846		

Variable	Value	Source	EAG commentary on availability, quality, reliability and relevance of the source/s
			have been calculated as a weighted average of the age-stratified figures.

7.3 Results from the economic modelling

7.3.1 Base case results

The base case results for the impacts of innovative features, including healthcare costs and QALYs over a 1-year time horizon are shown in Table 7.9. The results presented are based on a theoretical 10% improvement from associated innovative features to explore which outcomes may have the highest impact on value for money. Total monetary value is also reported in the table, this adds the monetary value of any QALY gains (valued at £20,000 per QALY) to any monetary cost savings. Innovative features are categorised into the 5 key health outcomes they may impact; falls, pressure ulcers, entrapments, infections and caregiver injury, based on the potential reductions in events. The total monetary value of having a bed frame with innovative features which could reduce all incidents by 10% is estimated at £1,681 in 1 year, this excludes the cost of the bed frame itself.

The results also show that innovative features that can be demonstrated to reduce caregiver injuries results in the greatest cost saving (£625) and QALY impact (0.001), resulting in a total monetary value of £640. Whilst innovative features that can be demonstrated to reduce entrapments had the least cost and QALY impact, with approximately £0.20 savings represented in monetary value. The efficacy of innovative features and health outcomes chosen are detailed further in section 7.2. The results give an indication of which innovative features may be the most value for money when selecting a bed frame. They also demonstrate at what cost features would be considered value for money, if the annual cost of the feature is less than the net monetary benefit. However, it should be considered that purchasing decisions are for an entire bed frame and individual features cannot be purchased.

Table 7.9: Generic innovative features total monetary value (per bed, per year)

Innovative feature	Cost impact (per bed per year)	QALY impact (per bed per year)	Net monetary benefit*
Reduction in falls due to feature(s)	£439	0.002	£487
Reduction in pressure ulcer due to feature(s)	£43	0.0004	£51
Reduction in entrapment due to feature(s)	£0	0.00001	£0.20
Reduction in infections due to feature(s)	£280	0.01	£503
Reduction in caregiver injuries due to feature(s)	£625	0.001	£640

*QALYs converted to monetary value using £20,000 per QALY threshold

Evidence was available to determine the potential impact of 1 specific feature, bed exit alarms. The economic impact of this feature is presented in Table 7.10. The results suggest that bed exit alarms could potentially lead to cost savings of £2,196 per bed frame per year, based on the available evidence. This feature could also lead to 0.01 QALYs generated per bed frame per year. The limitations of this analysis, including the correlation and interactions between features, and how the bed exit alarm is implemented is discussed further in section 7.3.3 and 8.2.

Table 7.10: Specific innovative features total monetary value (per bed, per year)

Innovative feature	Cost impact (per bed per year)	QALY impact (per bed per year)	Net monetary benefit*
Reduction in falls due to bed exit alarms	£2,196	0.01	£2,433

*QALYs converted to monetary value using £20,000 per QALY threshold

The deterministic base case results include a fully incremental analysis of bed frames available on the NHS. The incremental results presented in Appendix E consider the annual cost of branded bed frames available on the NHS and the cost and QALY impact of outcomes which are estimated to occur in people using that bed frame over the year, for example the number of falls. The baseline number of outcomes (falls, pressure ulcers, infections, entrapment and caregiver injuries) therefore are not all necessarily related to the bed. The potential cost and QALY impacts associated with any innovative features they have were then applied. In the fully incremental analysis, where a bed exit alarm was indicated for a bed frame, the efficacy data of this feature was applied. No other bed feature had published evidence on its impact on key incidents (caregiver injury, infections, pressure ulcers, entrapments and falls) ,therefore, only the bed exit alarm efficacy was applied in the base case fully incremental analysis.

The fully incremental analysis was conducted to explore potential differences between bed frames. However, these results should be interpreted with caution due to the limited uncertain evidence available to populate the model. Additionally, the assumptions made regarding exit alarms and their unclear benefits further limit the reliability of the findings. The fully incremental analysis selects the cheapest bedframe, or the cheapest bedframe with a bed exit alarm, given the limited evidence.

The fully incremental analysis ranked [redacted], as the bed frame that would generate the smallest cost over the 1-year time horizon, [redacted] per person using the bedframe. This is because there is a baseline number of events that will occur in that bed, which the bedframe may impact, and the outcomes are averaged per person. To interpret this, the breakdown of the cost is approximately:

- [redacted] bed frame
- [redacted] due to falls
- [redacted] pressure ulcers
- [redacted] entrapment
- [redacted] infections
- [redacted] caregiver injuries.

The fully incremental analysis results were driven by [redacted] being the cheapest bed frame to have a bed exit alarm, the only feature with demonstrable benefit.

All other bed frames were dominated or extendedly dominated by the referent [redacted]. The results do not change if generic feature impacts are included (assuming a 10% reduction in events due to an associated feature), due to the other innovative features the bed frame has. If bed exit alarms were not included in the analysis, but assumed generic impacts were, the fully incremental analysis would lead to [redacted] being cost-effective, because it is the cheapest bed frame to purchase. Compared with the next cheapest bed frame, the [redacted] is £200 cheaper over the life span of the bed frame. Therefore, over 10 years, the required benefits to key economic outcomes to mitigate the additional cost may be minimal. This highlights the uncertainty of the fully incremental analysis.

The results demonstrate that the cost effectiveness of the bed frames is largely driven by costs, including the bed frame acquisition costs. The results can be used as an indication to healthcare decision makers on the evidence gaps and highlight the need for further evidence collection to conduct a more comprehensive analysis.

7.3.2 Sensitivity analysis results

One-way sensitivity analysis was conducted on all model parameters. Where possible, DSA was conducted by varying key input parameters by low and high values found in published literature or guided by clinical assumptions. When evidence was not available, an arbitrary range of ±25% around the mean was used to determine the potential impact the parameter has on the overall results.

The DSA considers a features-based sensitivity analysis, with innovative features value (per bed frame, per year) being used in the analysis, rather than considering specific bed frames.

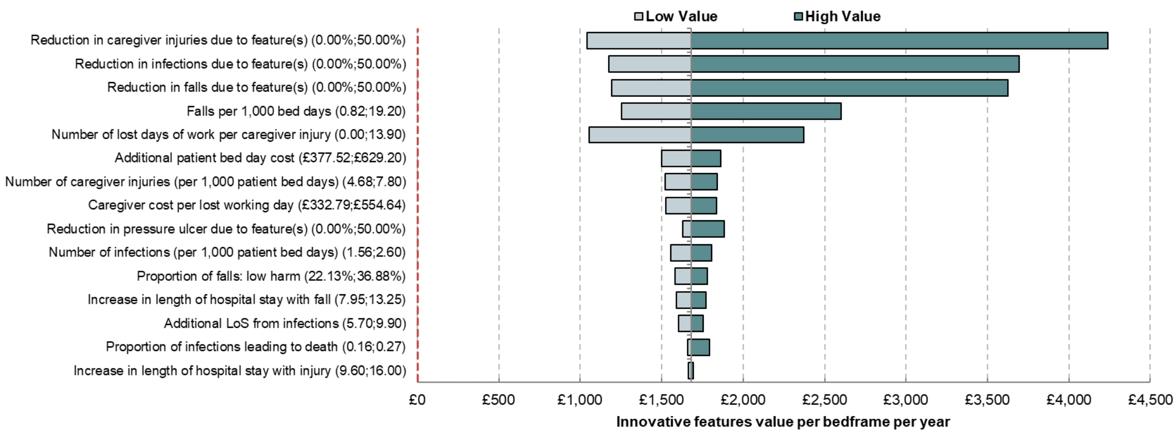
The analysis suggests the key drivers of the model results are:

- Reduction in caregiver injuries due to feature(s).
- Reduction in infections due to feature(s).
- Reduction in falls due to feature(s).

- Baseline number of falls per 1,000 bed days.
- Number of lost days of work due to caregiver injury.

As shown in the tornado plot (**Error! Reference source not found.**), reduction in caregiver injuries is the primary driver of the innovative features value when all other parameters remain constant at base case settings. Reduction in health outcomes (caregiver injury, infections, pressure ulcers, entrapments and falls) were independently varied (i.e., they were all changed 1 at a time, whilst the others remained at the base case value of 10%) from the low value of 0% to the high value of 50%, reflecting the uncertainty of the values used in the base case and lack of robust published evidence. When the reduction in caregiver injuries is increased from the baseline 10% to 50% the impact caregiver injury has on the total monetary value changes from £640 to £3.198. The total innovative features value increases from £1,681 in the base case to £4,239, when caregiver injury is reduced to 50%. When caregiver injury is reduced to 0% (£0 impact to caregiver injuries) the total innovative feature value is reduced from £1,681 to £1,041. Health outcome reductions are demonstrated to be the key drivers of the analysis. Variations to the costs of health outcomes, such as falls, and their associated disutility were also included in the DSA but made relatively little difference to the innovative features value. The cost of bed frames was not included in this DSA.

Figure 7.3: Tornado plot of innovative features value (per bed frame, per year)



When DSA was conducted on pairwise comparisons of different bed frames, the key drivers of the results were:

- If the bed frame had a specific feature (bed exit alarm).
- The relative impact of the specific feature in reducing falls.
- The relative cost of the bed frame, which includes the lifespan of the bed (if bed exit alarm not captured).

Figure 7.4: Tornado plot of net monetary benefit of pairwise bed frame comparison

[redacted]

Due to limited published evidence on the effectiveness of innovative features on reducing adverse health outcomes in acute care, the results of this analysis are intended to be exploratory. One-way analysis was conducted to demonstrate the impact of reducing the number of falls, entrapments, pressure ulcers, infections, or caregiver injuries on the monetary value of associated features. Two-way sensitivity analysis was also conducted on reducing the same incidents compared with their baseline prevalence in UK acute care. Additional one-way and two-way analysis are presented in Appendix E.

The results reflect those of the baseline analysis shown in Table 7.9. Caregiver injury reduction has the potential to be the most impactful driver of cost-effectiveness, followed by infections, falls, pressure ulcers and lastly entrapments.

7.3.3 Scenario analysis results

The results of the scenario analysis, which utilised the cost and severity distribution of falls from the NHS Improvement (2017) study(NHS Improvement, 2017), are shown in Table 7.10. This analysis estimates that the total monetary value of a bed frame with innovative features capable of reducing all incidents by 10% is £2,374 over 1 year, excluding the cost of the bed frame itself. In the base case, the monetary value of a feature leading to a 10% reduction in falls is £487 (see Table 7.8), whereas this scenario suggests a value of £1,180. In this scenario, reducing all incidents by 10% would result in falls having the greatest net monetary benefit.

Table 7.11: Scenario analysis generic innovative features total monetary value (per bed, per year)

Innovative feature	Cost impact (per bed per year)	QALY impact (per bed per year)	Net monetary benefit*
Reduction in falls due to feature(s)	£1,132	0.002	£1,180
Reduction in pressure ulcer due to feature(s)	£43	0.0004	£51
Reduction in entrapment due to feature(s)	£0	0.00001	£0
Reduction in infections due to feature(s)	£280	0.01	£503
Reduction in caregiver injuries due to feature(s)	£625	0.001	£640

*QALYs converted to monetary value using £20,000 per QALY threshold

7.3.4 Summary and interpretation of the economic evidence

Results from the economic analysis suggest that features which are designed to reduce falls, caregiver injuries or infections may be the greatest value for money. Conversely, features designed to reduce entrapments or pressure ulcers may be of comparatively less value from the NHS perspective. For NHS providers determining which bed frames to purchase for acute settings the balancing of innovative features with the cost of the bed frame will be the most important factors to consider. At the time of writing, evidence for these innovative features was limited. However, exploratory analysis suggests that features designed to reduce entrapments or pressure ulcers may be of less value to the NHS, when determining the appropriate bed frame to purchase.

Clinical experts were able to add context to the findings on value for money in entrapments and pressure ulcers. Firstly, experts suggested that cases of entrapments are rare and are primarily due to staff not following correct procedures. Therefore, they suggested that features to prevent entrapments, in their experience, may not necessarily lead to a measurable reduction in entrapments. Secondly, experts suggested that the key consideration for reducing pressure ulcers is a pressure relieving mattress, rather than the bed frame or its potential features. However, this is not to conclude that these innovative bed features are not potentially useful, especially for more specific populations (such as frailer populations, or those defined at high risk of entrapment). Nonetheless, we found that innovative features designed to reduce entrapments or pressure ulcers may comparatively be less value for money to the NHS, when compared with other features, across all acute populations.

Fully incremental analysis was conducted as part of the exploratory analysis. The [redacted] acute bed frame was estimated to be cost-effective. However, this result only considers bed exit alarms, the only feature to have quantifiable evidence. In this scenario, all alternative bed frames were either dominated or extendedly dominated. This fully incremental result was driven by the [redacted] bed frame being the cheapest bed frame to have the bed exit alarm, with the benefit of the bed alarm outweighing cheaper acute bed frames. However, the fully incremental analysis should be interpreted with caution due to:

- A lack of evidence for all innovative features, except bed exit alarms. An absence of evidence does not necessarily indicate that there is no effect from these other innovative features, and the likely impact should be considered by the committee when making a recommendation.
- The uncertainty of the impact of bed exit alarms. For instance, the wide confidence intervals associated with the impact would change the result, if bed exit alarms were less effective than the central estimate. Furthermore,

underlying biases within the study, such as other policy changes and a lack of UK context, may also influence the estimated impact on falls. Bed exit alarms may also differ between different bed frames, so may not be similar levels of effectiveness across all bed frames. This study was determined as part of the clinical evidence review to have a high risk of bias.

- Bed exit alarms may only be effective in a specific subpopulation (such as frailer populations at higher risk of falling), so it may not be sensible to consider this in purchasing decisions across all acute bed frames. The evidence on specific subpopulations who may benefit the most is not currently available and therefore not built into the model.

To contextualise the estimated costs per patient from the analysis, the cost of inpatient falls to the NHS was estimated to be £630 million each year (Audit report, 2017). The cost to the NHS of manual handling caregiver related sickness is estimate to be in excess of £400 million each year (Handling of people, 2011). Although these outcomes will not all be related to the bedframe, the cost savings that could be accrued could be substantial, even if innovative features reduce these by 1%.

When bed exit alarms were not considered in the analysis, the cost-effective bed in the fully incremental analysis was the [redacted], driven by it being the cheapest acute bed frame to purchase on NHS supply chain. However, the cost of the bed frame is also driven by the expected life of the bed frame. There was no evidence to differentiate between the life of different bed frames. Given cost is a key driver in the analysis, by definition, the life cycle of the bed frame is also a key driver. Bed frames which are more susceptible to breaking and require sooner replacement are going to be relatively more expensive, on a per person basis. Furthermore, short life cycles or beds susceptible to breaking may lead to other costs and consequences, particularly if time to replace them leads to reduced bed capacity. The consequences of this may be patients diverted to other types of wards, less suitable for care needs, or patients discharged faster to accommodate higher risk patients, with early discharge leading to a higher risk of adverse consequences.

The DSA and scenario analysis highlighted the most important drivers of the value of innovative features were:

- Relative impact of innovative features on caregiver injuries, infections, falls.
- Baseline number of falls and caregiver injuries.
- Relative severity of caregiver injuries (measured in days off work).
- Relative cost of falls

When considering the differences between bed frames, the relative difference in features and the cost of the bed frame was also a key driver in pairwise results.

A key limitation of the cost-effectiveness analysis is the quality of evidence available. There is a lack comparative evidence between bed frames, or even single arm evidence to inform the model. The analysis conducted should be seen as exploratory, to help determine the potential impact of additional features, given the lack of evidence. It is important regardless of the direction of results in this LSA, that providers of acute bed frames in the NHS collect further evidence to determine the value of their bed frames and associated innovative features. Due to the lack of evidence, simplifications were made in the model listed in Table 7.1. The most important to consider when interpreting the results are:

- The model does not account for additive effects of more than 1 feature which may impact an associated outcome. Hence, there is no difference in effect of a bed frame which has 1 feature which may impact falls, compared with a bed frame which has 5 features. This assumption was driven by the justification that just because there are additional features, this does not necessarily mean the impact will be greater. Despite a bed frame having 5 features which impact an outcome, it may still only be 1 feature which drives the difference, and the interaction between features may improve the overall effect or may actually reduce the impact on the specified outcome. It is important to consider the likely interaction between features when making any purchasing decisions.
- The baseline prevalence of falls, pressure ulcers, entrapments, infections and caregiver injuries was taken from the best available evidence. However, due to

the assumptions required about their applicability to our population of interest it is likely these figures may be an over or under estimation of the real-world occurrences in acute care. The impact of varying these figures is detailed in the DSA tornado plot (see **Error! Reference source not found.**) and Appendix E.

- All bed frames were given the same lifespan. Information provided by external clinical experts suggested that some bed frames have shorter lifespans than reported in the RFIs due to collisions and bending of the frame that is unrepairable. A comparison of the lifespan of different bed frames is not currently available. If bed frames have a shorter lifespan than estimated, this would increase the relative cost of the bedframe, compared with key economic outcomes. This would also require greater benefit to be incurred from innovative features over the lifespan of the bed frame to be cost-effective.
- Training costs are not captured in the model. This was not captured because there was no evidence to indicate any difference in training times or costs between acute bed frames. However, it may be that bed frames with more innovative features require greater training time for staff to operate these features effectively, which may impact the overall cost-effectiveness.
- Benefits of connectivity features are not captured in the model. Connectivity features are likely to improve efficiency, by digitising aspects of care, and therefore saving staff time. However, clinical experts suggested IT systems and WIFI at hospitals were not a high enough standard to best make use of these features. Therefore, we have not quantified this within our analysis. It is also not clear how much staff time would likely be saved, given the lack of evidence surrounding connectivity features.
- Litigation costs were not captured in the economic model as they are relatively rare and an assumption would need to be made on the relationship between an overall reduction in the number of pressure ulcers/falls and the number of litigations. We acknowledge however that the NHS legal costs are likely to reduce around litigations if the number of these incidents could be reduced by a bed frame.

8 Discussion

8.1 Summary of clinical evidence

The clinical and technological evidence review identified little evidence on the impact of innovative features on incidents. For the 2 features with studies reporting clinical evidence (beds with a low height position and inbuilt exit alarms), neither provided robust evidence of their benefit. For beds with a low height position, a cluster RCT did not show statistically significant benefits. However, because of the potential for bias and a lack of generalisability, we consider the evidence for low-low beds to be unclear. For inbuilt bed exit alarms, although a before-after study showed a large reduction in falls, we considered it at high risk of bias, and also consider the value of inbuilt bed alarms to be currently unclear.

Identified technical evidence suggested that, for a number of innovative features (extendable and sliding pivot headboards, alternative brake pedal location, turn assist and power-drive) there was proof-of principle, where features achieved the desired technical objective, e.g. a reduction in migration or pushing force requirement. However, for inbuilt bed weighing scales, evidence suggested that the features evaluated may not currently be accurate enough to replace fluid balance. For the addition of a fifth wheel, it was unclear whether it impacted force requirements. For double bogie configuration and auto-contour features, larger studies may be required to confirm proof-of-principle.

8.2 Summary of economic evidence

The economic evidence review identified no economic studies evaluating the cost-effectiveness of different acute bed frames.

Results from the economic analysis suggest that innovative features which can be proven to reduce falls, caregiver injuries or infections may be the greatest value for money. Conversely, exploratory analysis suggests that features designed to reduce entrapments or pressure ulcers may be of comparatively less value to the NHS. At the time of writing, efficacy evidence for these innovative features was limited and therefore the results should be interpreted with caution when determining the appropriate bed frame to purchase. The results of the fully incremental analysis indicated that the cheapest bed frames were cost-effective, depending on if bed exit alarms were included in the analysis. In both analyses, the cost of the bed frame itself was a key driver in the analysis. [redacted]

The key limitation of the economic analysis was the lack of efficacy evidence surrounding innovative features. Simplifying assumptions were used to populate the model where robust data was not available. Aligning with the findings from the clinical review, more real-world evidence on the impact of innovative features is required. Despite the acknowledged limitations, the direction of results in the exploratory analysis can still be used to aid decisions when tied with clinical expert advice.

User preferences should also be considered when determining purchasing decisions, especially given the lack of evidence. Although it may not be possible to rank every feature based on its relative importance, we believe it is likely that key innovative features, that are imperative to users, caregivers and engineers can be identified. Integrating user preferences with the available economic and clinical evidence will help to determine purchasing decisions in the NHS.

8.3 Evidence generation

The evidence review did not identify robust evidence of the impact of innovative features on incidents. However, this was predominately because of a lack of evidence, rather than evidence of no effect. These features are used in NHS settings and may improve incidents. However, the current evidence base does not provide proof of this.

An added complication in the evaluation of these innovative features is that their operation and ‘effectiveness’ is likely to differ between bed frame types. For example, there may be differences in the specific design of the feature in different bed frames or differences in bed frames that impact feature functionality e.g. bed weight or size.

Furthermore, the impact of an innovative feature may be distorted by the presence of other bed frame features. For instance, an inbuilt bed alarm and innovative bed rails may both impact the rate of falls, but when implemented together, the impact of each feature alone may be reduced. Several innovative features may not have cumulative effects equivalent to the effect of each feature separately. Therefore, a single quantitative estimate of the value of different features may not be appropriate.

Given the lack of evidence and difficulty in ascribing specific estimates of impact to different features, further information should be generated to make recommendations about the true value of different features. Research studies may be relevant, but it is also likely that other sources of information will be needed.

RCTs are not likely to be appropriate due to the cost. They may also be limited by the inability to fully control environmental factors when conducting trials in real hospital settings. It is likely that, on randomisation to a control group, areas or wards participating in the trial may implement concurrent interventions such as increased staff training and vigilance to account for the lack of bed feature intervention. In addition, the strict control to the evaluation of single features may make findings inapplicable to real-world hospital settings, where combinations of features may be used.

Quasi-experimental or observational designs, particularly before-after studies, are most likely to provide practical means of evaluating the likely benefit of innovative bed frame features on clinical and intermediate outcomes. However, outcomes for specific features from these studies must be considered in light of other changes made to the ward environment and bed frames. When changes are implemented, it is likely that a number of bed features may be introduced, and other interventions applied. For example, staff training and improved protocols for managing risk. Outcomes from these types of studies should therefore be interpreted accordingly. The following may be useful considerations during the design of a research study:

- **Clear reporting of the beds and associated features for the intervention and control period**. If a study is evaluating the use of a particular feature by comparing outcomes before and after the introduction of new beds/features, the full specification of the beds used before and after the change should be documented. This allows evaluators to examine when a specific feature, or combination of features are being evaluated.

- **Clear reporting of other environmental changes**. Where new beds frame features are introduced, it is important to also document any other changes that may have taken place, such as staff training.
- **Matching of patient characteristics** where possible, or transparent reporting of these characteristics. Changes in the features of available beds may be associated with changes in the types of patients using them. Clear documentation of patient characteristics allows investigators to examine whether groups are comparable in terms of patient characteristics.
- **Appropriate choice of outcomes.** If possible, outcomes should be clinical or important economic outcomes (such as incidents captured in the economic model) and reflect changes in patient or carer health due to the innovative feature. Intermediate outcomes may also be helpful where there is good evidence that these impact clinical or economic outcomes. Intermediate outcomes are much more likely to be linked to key economic metrics (e.g. falls, pressure ulcers, caregiver injuries) than experimental or technical outcomes considered in existing evidence. Linking to key demonstrable economic metrics can be used to consider the value for money of different acute bed frames.

However, gathering information on the usability of bed frames with different innovative features is also important, given the difficulties in linking specific bed frame features with estimates of 'effectiveness'. First-hand experience from users of bed frames, including nurses, health-care assistants and porters, is particularly important for providing information on features which:

- Are most important to users and not having this feature would substantially impact their experience of using the acute bed frame.
- Are least important to users and are either not utilised or are considered low value by the user.

In the absence of information on the effect of a particular feature on incidents which link to economic outcomes, understanding which features are not considered important by users could potentially allow managers to rule them out or deprioritise them. Equally, features identified as having good acceptance and functionality could be identified as targets for observational research to evaluate their effects on incidents which can be linked to economic outcomes.

Approaches to gather information on usability could include surveys of caregiver users, including nurses, healthcare assistants and other staff involved in the day-to-day use of acute bed frames. A survey (or multiple surveys) across a substantial number of NHS trusts could be designed to identify the difficulties and benefits of different features. A more pragmatic approach may be adopted for the surveys, so that not every feature is ranked, but that the most and least important features are categorised. Any considered least important would not be prioritised for evidence generation. The user preference assessment conducted by NICE will also support evidence on usability and what is most important to users of acute bed frames.

For some features, these surveys may be the main source of evidence, particularly where features have become widely used and it is not possible to compare with a pre-feature period. In these cases, systematic collection of information on the relative usefulness of different features compared with others, may be particularly important and aid decision-making.

Finally, for evidence claims on sustainability, it is likely that a full life cycle assessment will be required. This is a process of evaluating the effects that a product has on the environment over the entire period of its life. A more detailed evaluation will be required to appropriately consider sustainability outcomes, beyond just local suppliers and options for recycling of parts.

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Appendices

Appendix A: Clinical, technological and economic search strategies

Search methods

A MEDLINE (OvidSP) search strategy was designed to identify studies reporting on features of bed frame design in acute hospital settings. The search strategy was not restricted by outcome or study design and was therefore appropriate for identifying evidence on clinical, safety and economic outcomes.

The strategy comprised 4 concepts:

- Bed purchasing / leasing (search lines 2 to 4).
- Bed design / specific bed features (search line 1 and lines 5 to 51).
- Inpatient / hospital setting (search lines 52 to 64).
- Product names (search lines 67 to 80).

The concepts were combined as follows: bed purchasing / leasing OR (bed design / specific bed features AND inpatient / hospital setting) OR product names.

Generic terms for bed design were additionally searched in the title and not combined further with terms for any other concept (search line 1). This mitigated the possibility of missing potentially eligible records that were highly relevant.

The strategy was devised using a combination of subject indexing terms and free text search terms in the Title, Abstract and Keyword Heading Word fields. The search terms were identified through discussion within the research team, scanning background literature and browsing database thesauri.

Database records may refer to specific features of bed frames. The search terms for bed design / features included terms for generic and specific bed features. These were adapted from the NHS Supply Chain framework for beds. These terms were, in some cases, intentionally restricted in order to achieve manageable screening numbers that suited the project timelines and available resources.

The terms for inpatients and hospital settings were not a comprehensive selection of terms but aimed to balance sensitivity and specificity in order to retrieve manageable record numbers that suited the project timelines and resources. The risk of missing eligible studies was mitigated by checking company submissions and the reference lists of any relevant retrieved systematic reviews (see below for details of resources searched).

The product names used in the strategy reflected those listed in the scope. Product names that were words in common usage were combined with terms for beds.

The strategy excluded animal studies from MEDLINE using a standard algorithm (search line 82). The strategy also excluded some ineligible publication types which were unlikely to yield relevant study reports (editorials, news items and case reports) and records with the phrase 'case report' in the title (search line 83).

Reflecting the eligibility criteria, the strategy was restricted to studies published in English (search line 86). The final Ovid MEDLINE strategy was peer-reviewed before execution by a second Information Specialist. Peer review considered the appropriateness of the strategy for the review scope and eligibility criteria, inclusion of key search terms, errors in spelling, syntax and line combinations, and application of exclusions.

Resources searched

We conducted the literature search in the databases shown in the table below.

Table A.1: Databases and information sources used

Resource	**Interface / URL**
Databases	
MEDLINE(R) ALL	OvidSP
Embase	OvidSP
Cochrane Database of Systematic Reviews (CDSR)	Cochrane Library/Wiley
Cochrane Central Register of Controlled Trials (CENTRAL)	Cochrane Library/Wiley
Reference list checking	n/a

Company Submission Evidence	n/a

Reflecting the eligibility criteria, records indexed in Embase as preprints were excluded from the Embase search results. Records indexed as conference abstracts in Embase were downloaded at the time of the search. These records were screened due to the lack of relevant evidence from other sources.

We also checked included studies lists of any retrieved relevant systematic reviews published in the last 5 years for any eligible studies that may have been missed by the database searches.

For details of how we used company submission evidence to identify eligible evidence, see section 4.4.

Running the search strategies and downloading results

We conducted searches using each database or resource listed in the protocol, translating the agreed Ovid MEDLINE strategy appropriately. Translation included consideration of differences in database interfaces and functionality, in addition to variation in indexing languages and thesauri. The final translated database strategies were peer-reviewed by a second Information Specialist. Peer review considered the appropriateness of the translation for the database being searched, errors in syntax and line combinations, and application of exclusions.

The full search strategies (including search dates) for all databases searched are shown below (A1 to A4).

Where possible, the results of searches were downloaded in a tagged format and loaded into bibliographic management software (EndNote) (Clarivate, 2021). The results were deduplicated using several algorithms and the deduplicated references were held in a duplicates EndNote database for checking if required. Results from resources that did not allow export in a format compatible with EndNote were saved in Word or Excel documents as appropriate and manually deduplicated.

Literature search results

The database searches were conducted on 23 September 2024 and identified 4557 records (Table A.2). Following deduplication, 3250 records were assessed for relevance.

Table A.2: Literature search results

Resource	Number of records identified
Databases	
MEDLINE	1629
Embase	1712
Embase (indexed as conference abstracts)	900
Cochrane Database of Systematic Reviews (CDSR)	11
Cochrane Central Register of Controlled Trials (CENTRAL)	305
Total additional records identified from database sources	4557
Other sources	
Reference list checking	0
Company submissions	48
Total additional records identified through other sources	48
Total number of records retrieved	**4605**
Total number of records after deduplication	**3298**

Search strategies

A.1: Source: MEDLINE ALL
Interface / URL: OvidSP
Database coverage dates: 1946 to 19 September 2024
Search date: 23 September 2024
Retrieved records: 1629
Search strategy:

1 ((bed or beds) adj6 (design or designs or feature or features or innovat*)).ti. 187
2 beds/ and (exp purchasing, hospital/ or leasing, property/ or hospitals/) 242
3 ((bed or beds) adj3 (tender* or procur* or purchas* or contract* or lease* or leasing or hire* or hiring or rent*)).ti,ab,kf. 172

4 or/2-3 406
5 beds/ and (equipment design/ or equipment safety/) 570
6 beds/ and patient positioning/ 111
7 beds/ and (frame or frames).ti,ab,kf. 45
8 ((bed or beds) adj3 (frame or frames)).ti,ab,kf. 67
9 bedframe*.ti,ab,kf. 7
10 ((bed or beds) adj1 (design or designs or feature or features or innovat*)).ab,kf. 75
11 ((bed or beds) adj3 (access* or egress* or exit or awareness monitor*)).ti,ab,kf. 327
12 ((bed or beds) adj3 safe*).ti,ab,kf. 199
13 ((bed or beds) adj3 (profile or profiles or profiling)).ti,ab,kf. 121
14 ((bed or beds) adj3 (ultralow or low or high or height or heights or width* or length or lengths)).ti,ab,kf. 2616
15 ((bed or beds) adj1 (novel* or new*)).ti,ab,kf. 152
16 ((bed or beds) adj3 (castor or castors or caster or casters or wheel or wheels or brake or brakes)).ti,ab,kf. 35
17 ((bed or beds) adj3 (rail or rails or siderail* or grabrail* or bedrail*)).ti,ab,kf. 198
18 ((bed or beds) adj3 (CPR or chest compression* or resus*)).ti,ab,kf. 74
19 ((bed or beds) adj3 flatten*).ti,ab,kf. 13
20 ((bed or beds) adj3 (adjust* or adapt* or variable)).ti,ab,kf. 457
21 ((bed or beds) adj3 (back rest* or backrest* or back support*)).ti,ab,kf. 20
22 ((bed or beds) adj3 (plug* or socket* or cable*)).ti,ab,kf. 29
23 ((bed or beds) adj3 (power* or battery or batteries)).ti,ab,kf. 114
24 ((bed or beds) adj3 (weight* limit* or patient* weight* or load or loads or loadbearing)).ti,ab,kf. 124
25 ((bed or beds) adj3 (clean* or disinfect* or hygien*)).ti,ab,kf. 290
26 ((bed or beds) adj3 (decontaminat* or hydrogen or peroxide or wash* or UV or ultraviolet or ultra-violet or steam*)).ti,ab,kf. 193
27 ((bed or beds) adj3 (water proof* or waterproof* or water resist* or water repel* or splash* or IPX 4 or IPX4)).ti,ab,kf. 4
28 ((bed or beds) adj3 (maintenance or maintain* or repair*)).ti,ab,kf. 362
29 ((bed or beds) adj3 (compatible or compatibility)).ti,ab,kf. 20
30 ((bed or beds) adj3 (assembly or assemble* or construct* or build*)).ti,ab,kf. 259
31 ((bed or beds) adj3 (decommission* or dispos* or waste or WEEE or recycl* or re cycl* or sustainable or sustainability)).ti,ab,kf. 180
32 ((bed or beds) adj3 (electric* or electronic* or auto or automat*)).ti,ab,kf. 269
33 ((bed or beds) and (cardiac chair* or chair position*)).ti,ab,kf. 14
34 ((bed or beds) adj3 (trendelenburg or incline* or inclining or recline or reclining or tilt* or angle* or self-level* or selflevel* or elevat*)).ti,ab,kf. 999
35 ((bed or beds) adj3 (position* or reposition* or turn or rotate or rotation or CLRT)).ti,ab,kf. 980
36 ((bed or beds) adj3 (migrat* or move or moving or movement or mobility)).ti,ab,kf. 1813
37 ((bed or beds) adj3 (extend* or extension*)).ti,ab,kf. 248
38 ((bed or beds) adj3 (steer* or lock* or motor* or drive)).ti,ab,kf. 84

39 ((bed or beds) adj3 (head board* or headboard* or foot board* or footboard* or feet board* or feetboard*)).ti,ab,kf. 11
40 ((bed or beds) adj3 (control panel* or controls or dashboard*)).ti,ab,kf. 136
41 ((bed or beds) adj3 (hand held or handheld or handset* or hand set*)).ti,ab,kf. 7
42 ((bed or beds) adj3 (light* or scales or indicator*)).ti,ab,kf. 231
43 ((bed or beds) adj3 (connectivity or wifi or wi-fi or wlan or wireless)).ti,ab,kf. 24
44 ((bed or beds) adj3 (buffer or buffers)).ti,ab,kf. 12
45 ((bed or beds) adj3 (attach* or accessor* or pole or poles or drip or drips or rack or racks or catheter or catheters or hoist? or pump?)).ti,ab,kf. 194
46 ((bed or beds) adj3 contour*).ti,ab,kf. 37
47 ((bed or beds) adj3 (storage* or slide away or slideaway)).ti,ab,kf. 26
48 ((bed or beds) adj3 (xray* or x-ray*)).ti,ab,kf. 39
49 ((bed or beds) adj3 (cutout* or cut out* or sensor* or alarm or alarms or alert or alerts or shutdown* or shut down*)).ti,ab,kf. 306
50 ((bed or beds) adj3 (trap* or entrap*)).ti,ab,kf. 116
51 or/5-50 11104
52 inpatients/ 31617
53 hospitals/ 105861
54 hospital units/ 10519
55 inpatient*.ti,ab,kf. 151605
56 (hospital* adj3 bed*).ti,ab,kf. 13240
57 (acute adj3 (bed or beds or hospital or hospitals or ward or wards or unit or units or facility or facilities)).ti,ab,kf. 34987
58 (surg* adj3 (bed or beds or ward or wards)).ti,ab,kf. 7797
59 (general* adj3 (ward or wards)).ti,ab,kf. 5792
60 (acute adj5 setting*).ti,ab,kf. 20680
61 ((short stay or short stays or fast track* or fasttrack*) adj3 (ward or wards or unit or units)).ti,ab,kf. 627
62 (medical adj3 (admission* or plan* or assessment*) adj3 unit*).ti,ab,kf. 592
63 (acute care or acute medical or acute surgical or acute admission*).ti,ab,kf. 37193
64 or/52-63 346486
65 51 and 64 1363
66 1 or 4 or 65 1891
67 OOK SNOW*.ti,ab,kf,ot. 0
68 (enterprise E5000* or enterprise E8000* or enterprise E9000*).ti,ab,kf,ot. 0
69 (citadel* adj10 (bed or beds)).ti,ab,kf,ot. 0
70 ((centuris* or hillrom* or hill rom* or hillenbrand* or welch allyn* or avantguard* or total care sport* or versacare* or centrella* or advanta or advantar or advantatm or progressa*) adj10 (bed or beds)).ti,ab,kf,ot. 14
71 deprimo*.ti,ab,kf,ot. 5
72 ((delta 4* or lago or lagor or lagotm) adj10 (bed or beds)).ti,ab,kf,ot. 1
73 innov8*.ti,ab,kf,ot. 2
74 interlude v3*.ti,ab,kf,ot. 0

75 ((eleganza* or essenza* or image 3* or multicare*) adj10 (bed or beds)).ti,ab,kf,ot. 1
76 ((solo* or solo luxe*) adj10 (bed or beds)).ti,ab,kf,ot.9
77 OSKA florence*.ti,ab,kf,ot. 0
78 (SV2 electric hospital bed* or ProCuity*).ti,ab,kf,ot. 0
79 (IMO matrix E30* or IMO matrix U24*).ti,ab,kf,ot. 0
80 or/67-79 32
81 66 or 80 1920
82 exp animals/ not humans/ 5260351
83 (news or editorial or case reports).pt. or case report.ti. 3415352
84 or/82-83 8609475
85 81 not 84 1803
86 limit 85 to english language 1629

A.2: Source: Embase

Interface / URL: OvidSP
Database coverage dates: 1974 to 20 September 2024
Search date: 23 September 2024
Retrieved records: 1712 (and additional 900 indexed as conference abstracts)
Search strategy:

1 ((bed or beds) adj6 (design or designs or feature or features or innovat*)).ti. 226
2 hospital bed/ and (hospital purchasing/ or leasing/) 26
3 ((bed or beds) adj3 (tender* or procur* or purchas* or contract* or lease* or leasing or hire* or hiring or rent*)).ti,ab,kf,dq. 222
4 or/2-3 247
5 hospital bed/ and (equipment design/ or product design/ or design/ or device safety/) 40
6 hospital bed/ and patient positioning/ 103
7 hospital bed/ and (frame or frames).ti,ab,kf,dq. 46
8 ((bed or beds) adj3 (frame or frames)).ti,ab,kf,dq. 106
9 bedframe*.ti,ab,kf,dq. 9
10 ((bed or beds) adj1 (design or designs or feature or features or innovat*)).ab,kf,dq. 149
11 ((bed or beds) adj3 (access* or egress* or exit or awareness monitor*)).ti,ab,kf,dq. 515
12 ((bed or beds) adj3 safe*).ti,ab,kf,dq. 361
13 ((bed or beds) adj3 (profile or profiles or profiling)).ti,ab,kf,dq. 203
14 ((bed or beds) adj3 (ultralow or low or high or height or heights or width* or length or lengths)).ti,ab,kf,dq. 4183
15 ((bed or beds) adj1 (novel* or new*)).ti,ab,kf,dq. 197
16 ((bed or beds) adj3 (castor or castors or caster or casters or wheel or wheels or brake or brakes)).ti,ab,kf,dq. 49

17 ((bed or beds) adj3 (rail or rails or siderail* or grabrail* or bedrail*)).ti,ab,kf,dq. 303
18 ((bed or beds) adj3 (CPR or chest compression* or resus*)).ti,ab,kf,dq. 112
19 ((bed or beds) adj3 flatten*).ti,ab,kf,dq. 22
20 ((bed or beds) adj3 (adjust* or adapt* or variable)).ti,ab,kf,dq. 653
21 ((bed or beds) adj3 (back rest* or backrest* or back support*)).ti,ab,kf,dq. 25
22 ((bed or beds) adj3 (plug* or socket* or cable*)).ti,ab,kf,dq. 45
23 ((bed or beds) adj3 (power* or battery or batteries)).ti,ab,kf,dq. 121
24 ((bed or beds) adj3 (weight* limit* or patient* weight* or load or loads or loadbearing)).ti,ab,kf,dq. 195
25 ((bed or beds) adj3 (clean* or disinfect* or hygien*)).ti,ab,kf,dq. 448
26 ((bed or beds) adj3 (decontaminat* or hydrogen or peroxide or wash* or UV or ultraviolet or ultra-violet or steam*)).ti,ab,kf,dq. 273
27 ((bed or beds) adj3 (water proof* or waterproof* or water resist* or water repel* or splash* or IPX 4 or IPX4)).ti,ab,kf,dq. 5
28 ((bed or beds) adj3 (maintenance or maintain* or repair*)).ti,ab,kf,dq. 553
29 ((bed or beds) adj3 (compatible or compatibility)).ti,ab,kf,dq. 38
30 ((bed or beds) adj3 (assembly or assemble* or construct* or build*)).ti,ab,kf,dq. 383
31 ((bed or beds) adj3 (decommission* or disposal or dispose* or waste or WEEE or recycl* or re cycl* or sustainable or sustainability)).ti,ab,kf,dq. 235
32 ((bed or beds) adj3 (electric* or electronic* or auto or automat*)).ti,ab,kf,dq. 429
33 ((bed or beds) and (cardiac chair* or chair position*)).ti,ab,kf,dq. 31
34 ((bed or beds) adj3 (trendelenburg or incline* or inclining or recline or reclining or tilt* or angle* or self-level* or selflevel* or elevat*)).ti,ab,kf,dq. 1459
35 ((bed or beds) adj3 (position* or reposition* or turn or rotate or rotation or CLRT)).ti,ab,kf,dq. 2302
36 ((bed or beds) adj3 (migrat* or move or moving or movement or mobility)).ti,ab,kf,dq. 2614
37 ((bed or beds) adj3 (extend* or extension*)).ti,ab,kf,dq. 388
38 ((bed or beds) adj3 (steer* or lock* or motor* or drive)).ti,ab,kf,dq. 132
39 ((bed or beds) adj3 (head board* or headboard* or foot board* or footboard* or feet board* or feetboard*)).ti,ab,kf,dq. 26
40 ((bed or beds) adj3 (control panel* or controls or dashboard*)).ti,ab,kf,dq. 186
41 ((bed or beds) adj3 (hand held or handheld or handset* or hand set*)).ti,ab,kf,dq. 8
42 ((bed or beds) adj3 (light* or scales or indicator*)).ti,ab,kf,dq. 351
43 ((bed or beds) adj3 (connectivity or wifi or wi-fi or wlan or wireless)).ti,ab,kf,dq. 26
44 ((bed or beds) adj3 (buffer or buffers)).ti,ab,kf,dq. 13
45 ((bed or beds) adj3 (attach* or accessor* or pole or poles or drip or drips or rack or racks or catheter or catheters or hoist? or pump?)).ti,ab,kf,dq. 297
46 ((bed or beds) adj3 contour*).ti,ab,kf,dq. 96
47 ((bed or beds) adj3 (storage* or slide away or slideaway)).ti,ab,kf,dq. 36
48 ((bed or beds) adj3 (xray* or x-ray*)).ti,ab,kf,dq. 73
49 ((bed or beds) adj3 (cutout* or cut out* or sensor* or alarm or alarms or alert or alerts or shutdown* or shut down*)).ti,ab,kf,dq. 460

50 ((bed or beds) adj3 (trap* or entrap*)).ti,ab,kf,dq. 137
51 or/5-50 16950
52 hospital patient/ 242560
53 hospital bed/ 6697
54 inpatient*.ti,ab,kf,dq. 262081
55 (hospital* adj3 bed*).ti,ab,kf,dq. 21591
56 (acute adj3 (bed or beds or hospital or hospitals or ward or wards or unit or units or facility or facilities)).ti,ab,kf,dq. 56868
57 (surg* adj3 (bed or beds or ward or wards)).ti,ab,kf,dq. 12645
58 (general* adj3 (ward or wards)).ti,ab,kf,dq. 9110
59 (acute adj5 setting*).ti,ab,kf,dq. 33350
60 ((short stay or short stays or fast track* or fasttrack*) adj3 (ward or wards or unit or units)).ti,ab,kf,dq. 1034
61 (medical adj3 (admission* or plan* or assessment*) adj3 unit*).ti,ab,kf,dq. 1192
62 (acute care or acute medical or acute surgical or acute admission*).ti,ab,kf,dq. 54251
63 or/52-62 489809
64 51 and 63 2528
65 1 or 4 or 64 2978
66 OOK SNOW*.ti,ab,kf,dq,dv,my,ot. 0
67 (enterprise E5000* or enterprise E8000* or enterprise E9000*).ti,ab,kf,dq,dv,my,ot. 0
68 (citadel* adj10 (bed or beds)).ti,ab,kf,dq,dv,my,ot. 0
69 ((centuris* or hillrom* or hill rom* or hillenbrand* or welch allyn* or avantguard* or total care sport* or versacare* or centrella* or advanta or advantar or advantatm or progressa*) adj10 (bed or beds)).ti,ab,kf,dq,dv,my,ot. 22
70 deprimo*.ti,ab,kf,dq,dv,my,ot. 6
71 ((delta 4* or lago or lagor or lagotm) adj10 (bed or beds)).ti,ab,kf,dq,dv,my,ot. 1
72 innov8*.ti,ab,kf,dq,dv,my,ot. 3
73 interlude v3*.ti,ab,kf,dq,dv,my,ot. 0
74 ((eleganza* or essenza* or image 3* or multicare*) adj10 (bed or beds)).ti,ab,kf,dq,dv,my,ot. 6
75 ((solo* or solo luxe*) adj10 (bed or beds)).ti,ab,kf,dq,dv,my,ot. 10
76 OSKA florence*.ti,ab,kf,dq,dv,my,ot. 0
77 (SV2 electric hospital bed* or ProCuity*).ti,ab,kf,dq,dv,my,ot. 0
78 (IMO matrix E30* or IMO matrix U24*).ti,ab,kf,dq,dv,my,ot. 0
79 or/66-78 48
80 65 or 79 3024
81 (animal/ or animal experiment/ or animal model/ or animal tissue/ or nonhuman/) not exp human/ 7089249
82 editorial.pt. or case report.ti. 1239679
83 conference abstract.pt. 5239707
84 preprint.pt. 138614
85 or/81-84 13288179

86 80 not 85 1912
87 limit 86 to english language 1712
88 or/81-82,84 8399250
89 (80 and 83) not 88 900
90 limit 89 to english language 900

A.3: Source: Cochrane Database of Systematic Reviews (CDSR)

Interface / URL: Cochrane Library / Wiley
Database coverage dates: Information not found. Issue searched: Issue 9 of 12, September 2024
Search date: 23 September 2024
Retrieved records: 11
Search strategy:

#1 ((bed or beds) near/6 (design or designs or feature or features or innovat*)):ti 3
#2 [mh ^beds] and ([mh "purchasing, hospital"] or [mh ^"leasing, property"] or [mh ^hospitals]) 8
#3 ((bed or beds) near/3 (tender* or procur* or purchas* or contract* or lease* or leasing or hire* or hiring or rent*)):ti,ab,kw 16
#4 #2 or #3 24
#5 [mh ^beds] and ([mh ^"equipment design"] or [mh ^"equipment safety"]) 63
#6 [mh ^beds] and [mh ^"patient positioning"] 18
#7 [mh ^beds] and (frame or frames):ti,ab,kw 4
#8 ((bed or beds) near/3 (frame or frames)):ti,ab,kw 9
#9 bedframe*:ti,ab,kw 2
#10 ((bed or beds) near/1 (design or designs or feature or features or innovat*)):ab,kw 14
#11 ((bed or beds) near/3 (access* or egress* or exit or awareness next monitor*)):ti,ab,kw 32
#12 ((bed or beds) near/3 safe*):ti,ab,kw 43
#13 ((bed or beds) near/3 (profile or profiles or profiling)):ti,ab,kw 9
#14 ((bed or beds) near/3 (ultralow or low or high or height or heights or width* or length or lengths)):ti,ab,kw 263
#15 ((bed or beds) near/1 (novel* or new*)):ti,ab,kw 13
#16 ((bed or beds) near/3 (castor or castors or caster or casters or wheel or wheels or brake or brakes)):ti,ab,kw 4
#17 ((bed or beds) near/3 (rail or rails or siderail* or grabrail* or bedrail*)):ti,ab,kw 30
#18 ((bed or beds) near/3 (CPR or chest next compression* or resus*)):ti,ab,kw 24
#19 ((bed or beds) near/3 flatten*):ti,ab,kw 1
#20 ((bed or beds) near/3 (adjust* or adapt* or variable)):ti,ab,kw 63
#21 ((bed or beds) near/3 (back next rest* or backrest* or back next support*)):ti,ab,kw 12
#22 ((bed or beds) near/3 (plug* or socket* or cable*)):ti,ab,kw 3
#23 ((bed or beds) near/3 (power* or battery or batteries)):ti,ab,kw 14

#24 ((bed or beds) near/3 (weight* next limit* or patient* next weight* or load or loads or loadbearing)):ti,ab,kw 9
#25 ((bed or beds) near/3 (clean* or disinfect* or hygien*)):ti,ab,kw 55
#26 ((bed or beds) near/3 (decontaminat* or hydrogen or peroxide or wash* or UV or ultraviolet or "ultra violet" or steam*)):ti,ab,kw 32
#27 ((bed or beds) near/3 (water next proof* or waterproof* or water next resist* or water next repel* or splash* or "IPX 4" or IPX4)):ti,ab,kw 0
#28 ((bed or beds) near/3 (maintenance or maintain* or repair*)):ti,ab,kw 71
#29 ((bed or beds) near/3 (compatible or compatibility)):ti,ab,kw2
#30 ((bed or beds) near/3 (assembly or assemble* or construct* or build*)):ti,ab,kw 3
#31 ((bed or beds) near/3 (decommission* or disposal or dispose* or waste or WEEE or recycl* or re next cycl* or sustainable or sustainability)):ti,ab,kw 2
#32 ((bed or beds) near/3 (electric* or electronic* or auto or automat*)):ti,ab,kw 42
#33 ((bed or beds) and (cardiac next chair* or chair next position*)):ti,ab,kw 8
#34 ((bed or beds) near/3 (trendelenburg or incline* or inclining or recline or reclining or tilt* or angle* or self next level* or selflevel* or elevat*)):ti,ab,kw337
#35 ((bed or beds) near/3 (position* or reposition* or turn or rotate or rotation or CLRT)):ti,ab,kw 302
#36 ((bed or beds) near/3 (migrat* or move or moving or movement or mobility)):ti,ab,kw 173
#37 ((bed or beds) near/3 (extend* or extension*)):ti,ab,kw 43
#38 ((bed or beds) near/3 (steer* or lock* or motor* or drive)):ti,ab,kw 14
#39 ((bed or beds) near/3 (head next board* or headboard* or foot next board* or footboard* or feet next board* or feetboard*)):ti,ab,kw 6
#40 ((bed or beds) near/3 (control next panel* or controls or dashboard*)):ti,ab,kw 16
#41 ((bed or beds) near/3 ("hand held" or handheld or handset* or hand next set*)):ti,ab,kw 1
#42 ((bed or beds) near/3 (light* or scales or indicator*)):ti,ab,kw 44
#43 ((bed or beds) near/3 (connectivity or wifi or "wi fi" or wlan or wireless)):ti,ab,kw 0
#44 ((bed or beds) near/3 (buffer or buffers)):ti,ab,kw 0
#45 ((bed or beds) near/3 (attach* or accessor* or pole or poles or drip or drips or rack or racks or catheter or catheters or hoist* or pump*)):ti,ab,kw 46
#46 ((bed or beds) near/3 contour*):ti,ab,kw 2
#47 ((bed or beds) near/3 (storage* or "slide away" or slideaway)):ti,ab,kw 0
#48 ((bed or beds) near/3 (xray* or x next ray*)):ti,ab,kw6
#49 ((bed or beds) near/3 (cutout* or cut next out* or sensor* or alarm or alarms or alert or alerts or shutdown* or shut next down*)):ti,ab,kw 50
#50 ((bed or beds) near/3 (trap* or entrap*)):ti,ab,kw 1
#51 #5 OR #6 OR #7 OR #8 OR #9 OR #10 OR #11 OR #12 OR #13 OR #14 OR #15 OR #16 OR #17 OR #18 OR #19 OR #20 OR #21 OR #22 OR #23 OR #24 OR #25 OR #26 OR #27 OR #28 OR #29 OR #30 OR #31 OR #32 OR #33 OR #34 OR #35 OR #36 OR #37 OR #38 OR #39 OR #40 OR #41 OR #42 OR #43 OR #44 OR #45 OR #46 OR #47 OR #48 OR #49 OR #50 1665

#52 [mh ^inpatients] 1676
#53 [mh ^hospitals] 1357
#54 [mh ^"hospital units"] 236
#55 inpatient*:ti,ab,kw 24247
#56 (hospital* near/3 bed*):ti,ab,kw 1367
#57 (acute near/3 (bed or beds or hospital or hospitals or ward or wards or unit or units or facility or facilities)):ti,ab,kw 3849
#58 (surg* near/3 (bed or beds or ward or wards)):ti,ab,kw 1641
#59 (general* near/3 (ward or wards)):ti,ab,kw 912
#60 (acute near/5 setting*):ti,ab,kw 2203
#61 (("short stay" or "short stays" or fast next track* or fasttrack*) near/3 (ward or wards or unit or units)):ti,ab,kw 93
#62 (medical near/3 (admission* or plan* or assessment*) near/3 unit*):ti,ab,kw 63
#63 ("acute care" or "acute medical" or "acute surgical" or acute next admission*):ti,ab,kw 3041
#64 #52 OR #53 OR #54 OR #55 OR #56 OR #57 OR #58 OR #59 OR #60 OR #61 OR #62 OR #63 34590
#65 #51 and #64 254
#66 #1 or #4 or #65 277
#67 OOK next SNOW*:ti,ab,kw 0
#68 (enterprise next E5000* or enterprise next E8000* or enterprise next E9000*):ti,ab,kw 0
#69 (citadel* near/10 (bed or beds)):ti,ab,kw 0
#70 ((centuris* or hillrom* or hill next rom* or hillenbrand* or welch next allyn* or avantguard* or total next care next sport* or versacare* or centrella* or advanta or advantar or advantatm or progressa*) near/10 (bed or beds)):ti,ab,kw 1
#71 deprimo*:ti,ab,kw 0
#72 (("delta 4" or "delta 4r" or "delta 4tm" or lago or lagor or lagotm) near/10 (bed or beds)):ti,ab,kw 0
#73 innov8*:ti,ab,kw 0
#74 ("interlude v3" or "interlude v3r" or "interlude v3tm"):ti,ab,kw 0
#75 ((eleganza* or essenza* or "image 3" or "image 3r" or "image 3tm" or multicare*) near/10 (bed or beds)):ti,ab,kw 1
#76 ((solo* or solo next luxe*) near/10 (bed or beds)):ti,ab,kw 1
#77 OSKA next florence*:ti,ab,kw 0
#78 (SV2 next electric next hospital next bed* or ProCuity*):ti,ab,kw 0
#79 (IMO next matrix next E30* or IMO next matrix next U24*):ti,ab,kw 0
#80 #67 OR #68 OR #69 OR #70 OR #71 OR #72 OR #73 OR #74 OR #75 OR #76 OR #77 OR #78 OR #79 3
#81 #66 or #80 in Cochrane Reviews, Cochrane Protocols 11

A.4: Source: Cochrane Central Register of Controlled Trials (CENTRAL)

Interface / URL: Cochrane Library / Wiley

Database coverage dates: Information not found. Issue searched: Issue 8 of 12, August 2024
Search date: 23 September 2024
Retrieved records: 305
Search strategy:

A pragmatic decision was taken in relation to translation of search lines #1 and #10. The field codes for these lines were retained to increase specificity.

#1	((bed or beds) near/6 (design or designs or feature or features or innovat*)):ti	3
#2	[mh ^beds] and ([mh "purchasing, hospital"] or [mh ^"leasing, property"] or [mh ^hospitals])	8
#3	((bed or beds) near/3 (tender* or procur* or purchas* or contract* or lease* or leasing or hire* or hiring or rent*))	19
#4	#2 or #3	27
#5	[mh ^beds] and ([mh ^"equipment design"] or [mh ^"equipment safety"])	63
#6	[mh ^beds] and [mh ^"patient positioning"]	18
#7	[mh ^beds] and (frame or frames)	13
#8	((bed or beds) near/3 (frame or frames))	17
#9	bedframe*	2
#10	((bed or beds) near/1 (design or designs or feature or features or innovat*)):ab,kw	14
#11	((bed or beds) near/3 (access* or egress* or exit or awareness next monitor*))	48
#12	((bed or beds) near/3 safe*)	52
#13	((bed or beds) near/3 (profile or profiles or profiling))	11
#14	((bed or beds) near/3 (ultralow or low or high or height or heights or width* or length or lengths))	304
#15	((bed or beds) near/1 (novel* or new*))	21
#16	((bed or beds) near/3 (castor or castors or caster or casters or wheel or wheels or brake or brakes))	5
#17	((bed or beds) near/3 (rail or rails or siderail* or grabrail* or bedrail*))	35
#18	((bed or beds) near/3 (CPR or chest next compression* or resus*))	33
#19	((bed or beds) near/3 flatten*)	1
#20	((bed or beds) near/3 (adjust* or adapt* or variable*))	94
#21	((bed or beds) near/3 (back next rest* or backrest* or back next support*))	13
#22	((bed or beds) near/3 (plug* or socket* or cable*))	3
#23	((bed or beds) near/3 (power* or battery or batteries))	20
#24	((bed or beds) near/3 (weight* next limit* or patient* next weight* or load or loads or loadbearing))	11
#25	((bed or beds) near/3 (clean* or disinfect* or hygien*))	61
#26	((bed or beds) near/3 (decontaminat* or hydrogen or peroxide or wash* or UV or ultraviolet or "ultra violet" or steam*))	39
#27	((bed or beds) near/3 (water next proof* or waterproof* or water next resist* or water next repel* or splash* or "IPX 4" or IPX4))	0

#28 ((bed or beds) near/3 (maintenance or maintain* or repair*)) 73
#29 ((bed or beds) near/3 (compatible or compatibility)) 2
#30 ((bed or beds) near/3 (assembly or assemble* or construct* or build*)) 4
#31 ((bed or beds) near/3 (decommission* or dispos* or waste or WEEE or recycl* or re next cycl* or sustainable or sustainability)) 13
#32 ((bed or beds) near/3 (electric* or electronic* or auto or automat*)) 55
#33 ((bed or beds) and (cardiac next chair* or chair next position*)) 9
#34 ((bed or beds) near/3 (trendelenburg or incline* or inclining or recline or reclining or tilt* or angle* or self next level* or selflevel* or elevat*)) 364
#35 ((bed or beds) near/3 (position* or reposition* or turn or rotate or rotation or CLRT)) 328
#36 ((bed or beds) near/3 (migrat* or move or moving or movement or mobility)) 199
#37 ((bed or beds) near/3 (extend* or extension*)) 51
#38 ((bed or beds) near/3 (steer* or lock* or motor* or drive)) 17
#39 ((bed or beds) near/3 (head next board* or headboard* or foot next board* or footboard* or feet next board* or feetboard*)) 6
#40 ((bed or beds) near/3 (control next panel* or controls or dashboard*)) 18
#41 ((bed or beds) near/3 ("hand held" or handheld or handset* or hand next set*)) 2
#42 ((bed or beds) near/3 (light* or scales or indicator*)) 50
#43 ((bed or beds) near/3 (connectivity or wifi or "wi fi" or wlan or wireless)) 1
#44 ((bed or beds) near/3 (buffer or buffers)) 0
#45 ((bed or beds) near/3 (attach* or accessor* or pole or poles or drip or drips or rack or racks or catheter or catheters or hoist* or pump*)) 51
#46 ((bed or beds) near/3 contour*) 3
#47 ((bed or beds) near/3 (storage* or "slide away" or slideaway)) 1
#48 ((bed or beds) near/3 (xray* or x next ray*)) 6
#49 ((bed or beds) near/3 (cutout* or cut next out* or sensor* or alarm or alarms or alert or alerts or shutdown* or shut next down*)) 64
#50 ((bed or beds) near/3 (trap* or entrap*)) 1
#51 #5 OR #6 OR #7 OR #8 OR #9 OR #10 OR #11 OR #12 OR #13 OR #14 OR #15 OR #16 OR #17 OR #18 OR #19 OR #20 OR #21 OR #22 OR #23 OR #24 OR #25 OR #26 OR #27 OR #28 OR #29 OR #30 OR #31 OR #32 OR #33 OR #34 OR #35 OR #36 OR #37 OR #38 OR #39 OR #40 OR #41 OR #42 OR #43 OR #44 OR #45 OR #46 OR #47 OR #48 OR #49 OR #50 1865
#52 [mh ^inpatients] 1676
#53 [mh ^hospitals] 1357
#54 [mh ^"hospital units"] 236
#55 inpatient* 26460
#56 (hospital* near/3 bed*) 1562
#57 (acute near/3 (bed or beds or hospital or hospitals or ward or wards or unit or units or facility or facilities)) 4413
#58 (surg* near/3 (bed or beds or ward or wards)) 1785
#59 (general* near/3 (ward or wards)) 1025

#60 (acute near/5 setting*) 2732

#61 (("short stay" or "short stays" or fast next track* or fasttrack*) near/3 (ward or wards or unit or units)) 106

#62 (medical near/3 (admission* or plan* or assessment*) near/3 unit*) 89

#63 ("acute care" or "acute medical" or "acute surgical" or acute next admission*) 3739

#64 #52 OR #53 OR #54 OR #55 OR #56 OR #57 OR #58 OR #59 OR #60 OR #61 OR #62 OR #63 37899

#65 #51 and #64 360

#66 #1 or #4 or #65 384

#67 OOK next SNOW* 0

#68 (enterprise next E5000* or enterprise next E8000* or enterprise next E9000*) 0

#69 (citadel* near/10 (bed or beds)) 0

#70 ((centuris* or hillrom* or hill next rom* or hillenbrand* or welch next allyn* or avantguard* or total next care next sport* or versacare* or centrella* or advanta or advantar or advantatm or progressa*) near/10 (bed or beds)) 4

#71 deprimo* 13

#72 (("delta 4" or "delta 4r" or "delta 4tm" or lago or lagor or lagotm) near/10 (bed or beds)) 0

#73 innov8* 0

#74 ("interlude v3" or "interlude v3r" or "interlude v3tm") 0

#75 ((eleganza* or essenza* or "image 3" or "image 3r" or "image 3tm" or multicare*) near/10 (bed or beds)) 1

#76 ((solo* or solo next luxe*) near/10 (bed or beds)) 2

#77 OSKA next florence* 0

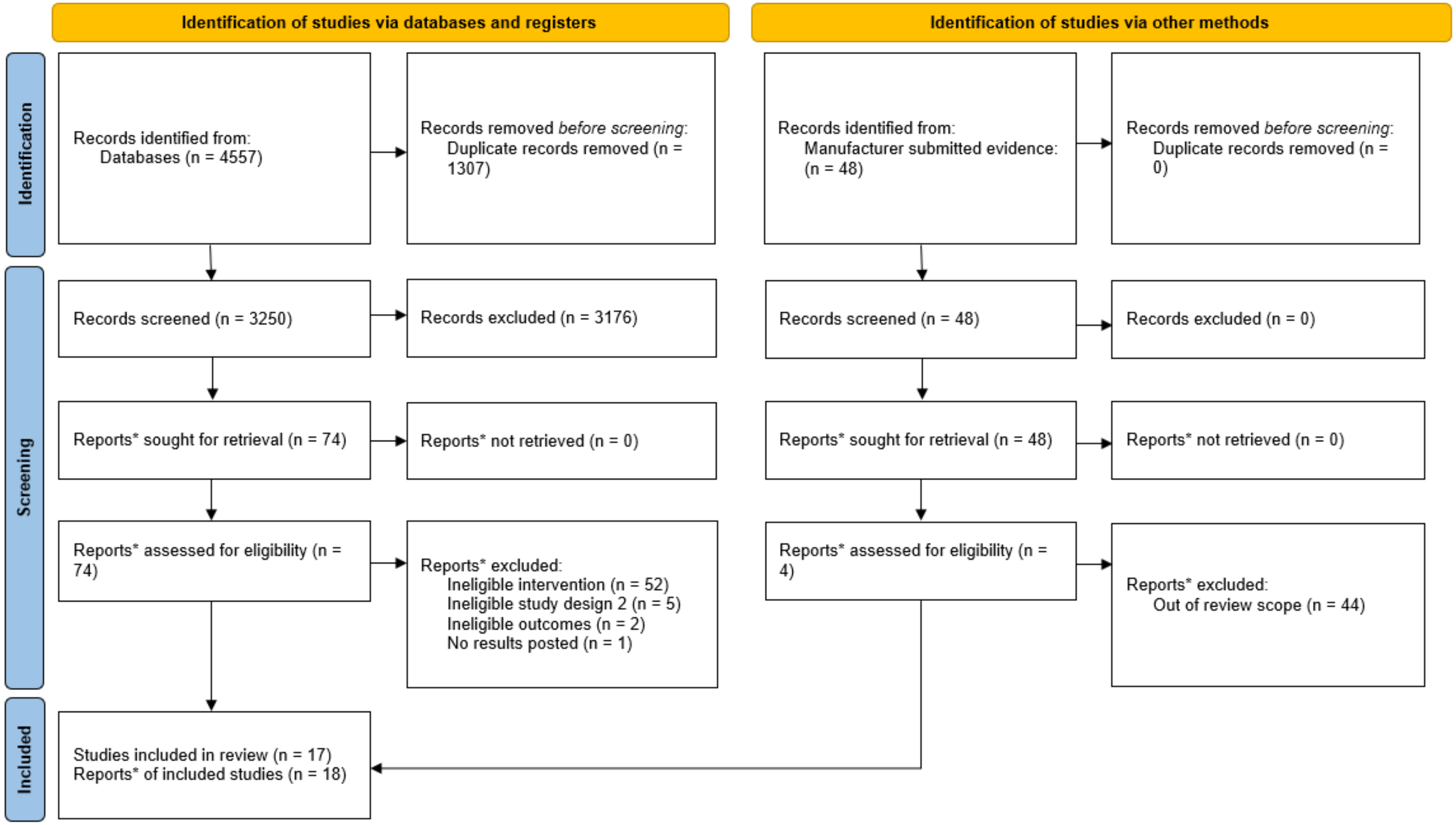
#78 (SV2 next electric next hospital next bed* or ProCuity*) 0

#79 (IMO next matrix next E30* or IMO next matrix next U24*) 0

#80 #67 OR #68 OR #69 OR #70 OR #71 OR #72 OR #73 OR #74 OR #75 OR #76 OR #77 OR #78 OR #79 20

#81 #66 or #80 in Trials 305

Figure A.1: PRISMA study selection diagram



*"Note that a "report" could be a journal article, preprint, conference abstract, study register entry, clinical study report, dissertation, unpublished manuscript, government report or any other document providing relevant information": https://www.bmj.com/content/372/bmj.n71.

Adapted from: Page MJ, McKenzie JE, Bossuyt PM, Boutron I, Hoffmann TC, Mulrow CD, et al. The PRISMA 2020 statement: an updated guideline for reporting systematic reviews. BMJ 2021;372:n71. doi: 10.1136/bmj.n71. For more information, visit: http://www.prisma-statement.org/

Appendix B: Excluded studies

Table B.9.1 Excluded studies (n=60)

Reference	Exclusion reason
Barker A, Morello R, Wolfe R, Brand C. The 6-PACK program to decrease fall injuries in acute hospitals: a cluster randomised controlled trial. Int J Qual Health Care. 2016: 6-7. Available from: https://www.cochranelibrary.com/central/doi/10.1002/central/CN-01753255/full	Ineligible intervention
Barker AL, Morello RT, Wolfe R, Brand CA, Haines TP, Hill KD, et al. 6-PACK programme to decrease fall injuries in acute hospitals: cluster randomised controlled trial. BMJ. 2016;352:h6781.	Ineligible intervention
Allen V, Ryan DW, Murray A. Air-fluidized beds and their ability to distribute interface pressures generated between the subject and the bed surface. Physiol Meas. 1993;14(3):359-64.	Ineligible intervention
Allman RM, Walker JM, Hart MK, Laprade CA, Noel LB, Smith CR. Air-fluidized beds or conventional therapy for pressure sores. A randomized trial. Ann Intern Med. 1987;107(5):641-8.	Ineligible intervention
Ropper R. The benefits of using a first generation SEM scanner versus an equipment selection pathway in preventing HAPUs. Br J Nurs. 2021;30(15):S12-S23.	Ineligible intervention
Xing X, Li H, Chen Q, Jiang C, Dong WF. Blood pressure monitoring with piezoelectric bed sensor systems. Biomedical Signal Processing and Control. 2024;87((Xing) School of Biomedical Engineering (Suzhou), Division of Life Sciences and Medicine, University of Science and Technology of China, Jiangsu, Suzhou, China):105479.	Ineligible intervention
Kang S-Y, DiStefano MJ, Yehia F, Koszalka MV, Padula WV. Critical Care Beds With Continuous Lateral Rotation Therapy to Prevent Ventilator-Associated Pneumonia and Hospital-Acquired Pressure Injury: A Cost-effectiveness Analysis. J Patient Saf. 2021;17(2):149-55.	Ineligible intervention
Guo Z, Xiao X, Yu H. Design and Evaluation of a Motorized Robotic Bed Mover with Omnidirectional Mobility for Patient Transportation. IEEE J Biomed Health Inform. 2018;22(6):1775-85.	Ineligible intervention
Nageswaran S, Vijayakumar R, Sivarasu S. Design evaluation of an automated bed for early detection and prevention of decubitus ulcers in nonambulatory patients. Journal of Medical Devices, Transactions of the ASME. 2014;8(2):020925.	Ineligible intervention
Crisp AH, Stonehill E, Eversden ID. The design of a motility bed including its calibration for the subject's weight. Med Biol Eng. 1970;8(5):455-63.	Ineligible outcomes
Hilbe J, Schulc E, Linder B, Them C. Development and alarm threshold evaluation of a side rail integrated sensor technology for the prevention of falls. Int J Med Inf. 2010;79(3):173-80.	Ineligible intervention
Walls C. Do electric patient beds reduce the risk of lower back disorders in nurses? Occup Med (Oxf). 2001;51(6):380-4.	Ineligible intervention
Ho C, Ocampo W, Southern DA, Sola D, Baylis B, Conly JM, et al. Effect of a Continuous Bedside Pressure Mapping System for Reducing Interface Pressures: A Randomized Clinical Trial. JAMA netw. 2023;6(6):e2316480.	Ineligible intervention
Campo M, Shiyko MP, Margulis H, Darragh AR. Effect of a safe patient handling program on rehabilitation outcomes. Arch Phys Med Rehabil. 2013;94(1):17-22.	Ineligible intervention

Reference	Exclusion reason
Zhou X-L, Sheng L-P, Wang J, Li S-Q, Wang H-L, Ni S-Z, et al. Effect of bed width on the quality of compressions in simulated resuscitation: a randomized crossover manikin study. Am J Emerg Med. 2016;34(12):2272-76.	Ineligible intervention
de Looze MP, Zinzen E, Caboor D, Heyblom P, van Bree E, van Roy P, et al. Effect of individually chosen bed-height adjustments on the low-back stress of nurses. Scand J Work Environ Health. 1994;20(6):427-34.	Ineligible intervention
Subermaniam K, Welfred R, Subramanian P, Chinna K, Ibrahim F, Mohktar MS, Tan MP. The Effectiveness of a Wireless Modular Bed Absence Sensor Device for Fall Prevention among Older Inpatients. Front Public Health. 2016;4:292.	Ineligible intervention
Northeast Center for Rehabilitation and Brain Injury. Effectiveness of Freedom Bed Compared to Manual Turning in Prevention of Pressure Injuries in Persons With Limited Mobility Due to Traumatic Brain Injury and/or Spinal Cord Injury. Identifier: NCT03048357. In: ClinicalTrials.gov [internet]. Bethesda: US National Library of Medicine: 2017. Available from https://clinicaltrials.gov/show/NCT03048357.	Trial no results
Daniell N, Merrett S, Paul G. Effectiveness of powered hospital bed movers for reducing physiological strain and back muscle activation. Appl Ergon. 2014;45(4):849-56.	Ineligible intervention
Shorr RI, Chandler AM, Mion LC, Waters TM, Liu M, Daniels MJ, et al. Effects of an intervention to increase bed alarm use to prevent falls in hospitalized patients: a cluster randomized trial. Ann Intern Med. 2012;157(10):692-9.	Ineligible intervention
Yi C-H, Kim H-S, Yoo W-G, Kim M-H, Kwon O-Y. The effects of different types of automated inclining bed and tilt angle on body-pressure redistribution. Adv Skin Wound Care. 2009;22(6):259-64.	Ineligible intervention
Capodaglio EM. Electric versus hydraulic hospital beds: differences in use during basic nursing tasks. Int J Occup Saf Ergon. 2013;19(4):597-606.	Ineligible intervention
Zhou J, Wiggermann N. Ergonomic evaluation of brake pedal and push handle locations on hospital beds. Appl Ergon. 2017;60:305-12.	Ineligible intervention
Mehta RK, Horton LM, Agnew MJ, Nussbaum MA. Ergonomic evaluation of hospital bed design features during patient handling tasks. Int J Ind Ergonom. 2011;41(6):647-52.	Ineligible intervention
Kelley RE, Vibulsresth S, Bell L, Duncan RC. Evaluation of kinetic therapy in the prevention of complications of prolonged bed rest secondary to stroke. Stroke. 1987;18(3):638-42.	Ineligible intervention
Potter P, Allen K, Costantinou E, Klinkenberg WD, Malen J, Norris T, et al. Evaluation of Sensor Technology to Detect Fall Risk and Prevent Falls in Acute Care. Joint Commission Journal on Quality & Patient Safety. 2017;43(8):414-21.	Ineligible intervention
Guo Z, Yee RB, Mun K-R, Yu H. Experimental evaluation of a novel robotic hospital bed mover with omni-directional mobility. Appl Ergon. 2017;65:389-97.	Ineligible intervention
Tideiksaar R, Feiner CF, Maby J. Falls prevention: the efficacy of a bed alarm system in an acute-care setting. Mt Sinai J Med. 1993;60(6):522-7.	Ineligible intervention
Wong Shee A, Phillips B, Hill K, Dodd K. Feasibility, acceptability, and effectiveness of an electronic sensor bed/chair alarm in reducing falls in patients with cognitive impairment in a subacute ward. J Nurs Care Qual. 2014;29(3):253-62.	Ineligible intervention
Call E, Call KJ, Oberg C, Capunay C, Clark DN. Healthcare-Associated Infections and the Hospital Bed. Adv Skin Wound Care. 2023;36(10):1-7.	Ineligible intervention

Reference	Exclusion reason
Todd JF. Hospital bed side rails. Preventing entrapment. Nursing. 1997;27(5):67.	Ineligible intervention
Engkasan JP. How effective is alternating pressure (active) air surfaces for preventing pressure ulcers? A Cochrane Review summary with commentary. NeuroRehabilitation. 2023;52(1):149-51.	Ineligible intervention
Caboor DE, Verlinden MO, Zinzen E, Van Roy P, Van Riel MP, Clarys JP. Implications of an adjustable bed height during standard nursing tasks on spinal motion, perceived exertion and muscular activity. Ergonomics. 2000;43(10):1771-80.	Ineligible intervention
Skolka MP, Neth BJ, Brown A, Steel SJ, Hacker K, Arnold C, et al. Improving Neurology Inpatient Fall Rate: Effect of a Collaborative Interdisciplinary Quality Improvement Initiative. Mayo Clin Proc Innov Qual Outcomes. 2023;7(4):267-75.	Ineligible intervention
Ould S, Guertler M, Hanna P, Bennett NS. Internet-of-Things-Enabled Smart Bed Rail for Application in Hospital Beds. Sensors (Basel). 2022;22(15):25.	Ineligible intervention
Morris ME, Webster K, Jones C, Hill A-M, Haines T, McPhail S, et al. Interventions to reduce falls in hospitals: a systematic review and meta-analysis. Age Ageing. 2022;51(5):01.	Ineligible study design
Vilas-Boas M, Silva P, Cunha SR, Correia MV. Monitoring of bedridden patients: development of a fall detection tool. Annu Int Conf IEEE Eng Med Biol Soc. 2013;2013:4742-5.	Ineligible intervention
Yonezawa Y, Miyamoto Y, Maki H, Ogawa H, Ninomiya I, Sada K, et al. A new intelligent bed care system for hospital and home patients. Biomed Instrum Technol. 2005;39(4):313-19.	Ineligible intervention
Tay JL, Xie HT. Novel interventions significantly reduce falls with fractures: A meta-analysis and systematic review. Geriatr Nurs. 2023;52:181-90.	Ineligible study design
Lo CC, Tsai SH, Lin BS. Novel non-contact control system of electric bed for medical healthcare. Med Biol Eng Comput. 2017;55(3):517-26.	Ineligible intervention
Nguyen HH, Nguyen TN, Clout R, Nguyen HT. A novel target following solution for the electric powered hospital bed. Annu Int Conf IEEE Eng Med Biol Soc. 2015;2015:3569-72.	Ineligible intervention
Bills E. Preventing bed entrapments: a report from the hospital bed safety workgroup. Biomed Instrum Technol. 2007;41(3):227-9.	Ineligible study design
Keogh A, Dealey C. Profiling beds versus standard hospital beds: effects on pressure ulcer incidence outcomes. J Wound Care. 2001;10(2):15-9.	Ineligible intervention
Simonis G, Steiding K, Schaefer K, Rauwolf T, Strasser RH. A prospective, randomized trial of Continuous lateral rotation ("Kinetic therapy") in patients with cardiogenic shock. Clin Res Cardiol. 2012;101(12):955-62.	Ineligible intervention
Dealey C, Keogh A. A randomised controlled trial comparing the effect of using an electric profiling bed with standard hospital bed for patients at high risk of pressure sore development. 10th conference of the european wound management association; 2000 18-20 may; stockholm, sweden. 2000: 30. Available from: https://www.cochranelibrary.com/central/doi/10.1002/central/CN-00388265/full	Ineligible intervention
Cuttler SJ, Barr-Walker J, Cuttler L. Reducing medical-surgical inpatient falls and injuries with videos, icons and alarms. BMJ open qual. 2017;6(2):e000119.	Ineligible intervention
Barker A, Kamar J, Tyndall T, Hill K. Reducing serious fall-related injuries in acute hospitals: are low-low beds a critical success factor? J Adv Nurs. 2013;69(1):112-21.	Ineligible intervention

Reference	Exclusion reason
Sahota O, Drummond A, Kendrick D, Grainge MJ, Vass C, Sach T, et al. REFINE (REducing Falls in In-patieNt Elderly) using bed and bedside chair pressure sensors linked to radio-pagers in acute hospital care: a randomised controlled trial. Age Ageing. 2014;43(2):247-53.	Ineligible intervention
Vass CD, Sahota O, Drummond A, Kendrick D, Grainge M, Gladman J, et al. Refine-reducing falls in in-patient elderly using bed and chair pressure sensors in acute hospital care: a randomised controlled trial. Age Ageing. 2013: ii20. Available from: https://www.cochranelibrary.com/central/doi/10.1002/central/CN-01053007/full	Ineligible intervention
Stone P, Collins B. Rochester, New York hospitals: leasing acute-care beds. NAHAM Manage J. 1994;21(2):23-4.	Ineligible intervention
Wagner JJ, Ingram TN. A safe electric medical bed for an acute inpatient behavioral health care setting. J Psychosoc Nurs Ment Health Serv. 2013;51(1):31-4.	Ineligible study design
Palumbo MV. Swing beds: providing extended care in rural acute-care hospitals. NLN Publ. 1991(21-2408):229-46.	Ineligible intervention
Swope C. The team approach: using hospital owned low air loss beds. Ostomy Wound Manage. 1994;40(6):40-2, 44, 46-7.	Ineligible study design
Diduszyn J, Hofmann MT, Naglak M, Smith DG. Use of a wireless nurse alert fall monitor to prevent inpatient falls. J Clin Outcomes Manag. 2008;15(6):293-96.	Ineligible intervention
Hignett S, Sands G, Fray M, Xanthopoulou P, Healey F, Griffiths P. Which bed designs and patient characteristics increase bed rail use? Age Ageing. 2013;42(4):531-5.	Ineligible intervention
Arnold M, Yanez C, Yanez B. Wound Healing in the Long-Term Acute Care Setting Using an Air Fluidized Therapy/Continuous Low-Pressure Therapeutic Bed: A Multiple Case Series. J Wound Ostomy Continence Nurs. 2020;47(3):284-90.	Ineligible intervention
Barker A, Morello R, Wolfe R, Brand C. The 6-PACK program to decrease fall injuries in acute hospitals: A cluster randomised controlled trial. International Journal for Quality in Health Care. 2016;28(Supplement 1):6-7.	Ineligible intervention
Fitch Z, Duquaine D, Ohkuma R, Schneider E, Whitman G. The impact of hospital bed type on practices related to maintaining proper head of bed angle. Critical Care Medicine. 2012;40(12 SUPPL. 1):191.	Ineligible outcomes
Mion LC, Shorr RI, Minnick AF, Dietrich M, Hunt G, Donaghey B. Prevalence of very low bed use to prevent bed-related fall-injury in hospitals: Preliminary findings. Journal of the American Geriatrics Society. 2012;60(SUPPL. 4):S223.	Ineligible intervention
Thomson F, Brighton K, Howley S, Watson L. A falls reduction project on an acute medical elderly ward. Age and Ageing. 2017;46(Supplement 1):i1.	Ineligible intervention

Appendix C: Manufacturer submitted evidence

Table C.1: Manufacturer submitted evidence

Company	Document	Related feature	Evidence type	Review eligibility
Arjo	Matz, M., Morgan, J. (2018) - Lab testing. The case for powered bed transport. White paper	Powered bed transportation	Unpublished literature review and laboratory study	Included
Arjo	Newton et al, via Varying the Immersion Level of a Support Surface in Use	Different bed surfaces	Unpublished laboratory study	Excluded. Bed out of scope for this review.
Arjo	Arjo Citadel Patient Care A new era in performance Whitepaper reports lab findings of both Reactive and Active therapies in the Citadel patient care system	Interface pressure testing (reactive mode, active mode)	Unpublished laboratory study	Excluded. Integrated system out of scope for this review.
Arjo	Arjo.Citadel Patient Care System Patient Turn and Continuous Patient Turn.1.0.int Arjo	Patient turn (assists manual turning of patients) and continuous patient turn	Unpublished literature review	Excluded. No innovative bed feature evaluated.
Arjo	Arjo. Adverse events	NA	Report of AE data	Excluded. [redacted]
Arjo	Arjo. Cost of technologies	NA	Report of cost of technologies	Excluded. [redacted]
Arjo	Call, E., & Baker, L. (2008). How does bed frame design influence tissue interface pressure? A comparison of 4 different technologies designed for long-term or home care. Journal of Tissue Viability,	Feature to prevent migration	Published laboratory study	Excluded. Beds/features out of scope for this review.

Company	Document	Related feature	Evidence type	Review eligibility
	17(1), 22-29. https://doi.org/10.1016/j.jtv.2007.09.007			
LINET	Trial of LINET beds August 2018	Weighing scale, lateral tilt	Unclear	Requested from company
Medstrom Ltd	Barker et al 2013. Barker A., Kamar J., Tyndall T. & Hill K. (2013) Reducing serious fall related injuries in acute hospitals: are low-low beds a critical success factor? Journal of Advanced Nursing 69(1), 112–121. doi: 10.1111/j.1365-2648.2012.05997.x	Ultra-low beds	Published study	Excluded. Bed out of scope for this review (can be lowered to the floor)
Medstrom Ltd	Blackpool Teaching Hospitals NHS Foundation Trust Annual Report and Accounts 2019/20	Ultra-low platform height (21 cm)/ custom egress height/ unique split side rail design	Annual report	Excluded. Insufficient information on intervention.
Medstrom Ltd	Martindale D (2022) Using gravitational potential energy to assess the risk of falls from bed. Nursing Times [online]; 118: 2, 36-39.	Ultra-low platform height (21 cm)	Published review	Excluded. No innovative bed feature evaluated.
Medstrom Ltd	de Looze MP, Zinzen E, Caboor D, Heyblom P, van Bree E, van Roy P, Toussaint HM, Clarijs JP. Effect of individually chosen bed-height adjustments on the low-back stress of nurses. Scand J Work Environ Health. 1994 Dec;20(6):427-34. doi: 10.5271/sjweh.1378. PMID: 7701288.	High height (83 cm)/A frame open base structure/in-built X-ray cassette holder deigned into backrest as standard	Published laboratory study	Excluded. No innovative bed feature evaluated.
Medstrom Ltd	Rush 2018. Can the design and articulation of the bed frame positively influence patient migration, heel travel and consequently help to reduce heel pressure ulcers?	Elliptical backrest movement (auto-contour function)	Unpublished Laboratory study	Included
Medstrom Ltd	Fletcher 2015. Articulated bed frames and heel ulcer prevalence. Wound Essentials 2015, Vol 10 No 1.	Elliptical backrest movement	Published review	Excluded. No innovative bed feature evaluated.

Company	Document	Related feature	Evidence type	Review eligibility
Medstrom Ltd	Iannella G, Cammaroto G, Meccariello G, Cannavicci A, Gobbi R, Lechien JR, Calvo-Henríquez C, Bahgat A, Di Prinzio G, Cerritelli L et al. Head-Of-Bed Elevation (HOBE) for Improving Positional Obstructive Sleep Apnea (POSA): An Experimental Study. J. Clin. Med. 2022, 11, 5620. https://doi.org/10.3390/jcm11195620	Supine and elevated head of bed positions on respiratory function	Published study	Excluded. No innovative bed feature evaluated
Medstrom Ltd	Data on file (2021). A comparison of pull force requirements on 2 hospital beds	Unique bogie castor configuration	Unpublished study	Included
Medstrom Ltd	Hignett S, McAtamney L. Rapid entire body assessment (REBA). Appl Ergon. 2000 Apr;31(2):201-5. doi: 10.1016/s0003-6870(99)00039-3. PMID: 10711982.	Unique brake and steer/MOGO system (transporter)	Published study	Excluded. No innovative bed feature evaluated.
Medstrom Ltd	Ibrahim MI, Zubair IU, Yaacob NM, Ahmad MI, Shafei MN. Low Back Pain and Its Associated Factors among Nurses in Public Hospitals of Penang, Malaysia. Int J Environ Res Public Health. 2019 Nov 1;16(21):4254. doi: 10.3390/ijerph16214254. PMID: 31683911; PMCID: PMC6861894.	Unique brake and steer	Published study	Excluded. No innovative bed feature evaluated
Medstrom Ltd	Olson EV, Johnson BJ, Thompson LF. The hazards of immobility. 1967. Am J Nurs. 1990;90(3):43-48.	One button cardiac chair	Published study	Excluded. No innovative bed feature evaluated.
Medstrom Ltd	Dean E (1999) The effect of positioning and mobilisation on oxygen transport. In: Pryor JA & Webber BA (eds) Physiotherapy for respiratory and cardiac problems (2nd edition), Churchill Livingstone, London pp121-136.	One button cardiac chair	Book chapter	Excluded. No innovative bed feature evaluated.
Medstrom Ltd	Appeadu MK, Bordoni B. Falls and Fall Prevention in Older Adults. [Updated 2023 Jun 4]. In: StatPearls	Underbed light	Book chapter	Excluded. No innovative bed feature evaluated.

Company	Document	Related feature	Evidence type	Review eligibility
	[Internet]. Treasure Island (FL): StatPearls Publishing; 2024 Jan-. Available from: https://www.ncbi.nlm.nih.gov/books/NBK560761/			
Medstrom Ltd	[redacted]	[redacted]	[redacted]	Excluded. [redacted]
Medstrom Ltd	[redacted]	[redacted]	[redacted]	Excluded. [redacted]
Stryker	Tzeng, H.M., et al., Nursing staff's awareness of keeping beds in the lowest position to prevent falls and fall injuries in an adult acute surgical inpatient care setting. Medsurg Nurs, 2012. 21(5): p. 271-4.	Bed height	Published qualitative study	Excluded. No innovative bed feature evaluated.
Stryker	Tzeng, H.M. and C.Y. Yin, Heights of occupied patient beds: a possible risk factor for inpatient falls. J Clin Nurs, 2008. 17(11): p. 1503-9.	Bed height	Published narrative review	Excluded. No innovative bed feature evaluated.
Stryker	Crane, B.A., M. Wininger, and M. Kunsman, Proxy study on minimizing risk of sacral pressure ulcers while complying with ventilator-associated pneumonia risk reduction guidelines. Advances in Skin & Wound Care, 2015. 28(12): p. 541-550.	Bed positioning	Published laboratory study	Excluded. No innovative bed feature evaluated.
Stryker	Zhuo, X., L. Pan, and X. Zeng, The effects of the 45° semi-recumbent position on the clinical outcomes of mechanically ventilated patients: a systematic review and meta-analysis study. Ann Palliat Med, 2021. 10(10): p. 10643-10651.	Bed positioning	Published systematic review and meta-analysis	Excluded. No innovative bed feature evaluated.

Company	Document	Related feature	Evidence type	Review eligibility
Baxter Healthcare	Lustig M, Wiggermann N, Gefen A. How patient migration in bed affects the sacral soft tissue loading and thereby the risk for a hospital-acquired pressure injury. International Wound Journal. 2020 Jun;17(3):631-40.	Migration-reduction technology	Published laboratory study	Included
Baxter Healthcare	Davis KG, Kotowski SE, Coombs MT. Stopping the slide: how hospital bed design can minimize active and passive patient migration. Journal of Nursing Care Quality. 2017 Jan 1;32(1):E11-9.	Head pivot	Published laboratory study	Included
Baxter Healthcare	Davis KG, Kotowski SE. Role of bed design and head-of-bed articulation on patient migration. Journal of nursing care quality. 2015 Jul 1;30(3):E1-9.	Head of bed elevation	Published laboratory study	Included
Baxter Healthcare	Seow JP, Chua TL, Aloweni F, Lim SH, Ang SY. Effectiveness of an integrated 3-mode bed exit alarm system in reducing inpatient falls within an acute care setting. Japan Journal of Nursing Science. 2022 Jan;19(1):e12446.	Bed exit alarm	Published study	Included
Baxter Healthcare	Cuttler SJ, Barr-Walker J, Cuttler L. Reducing medical-surgical inpatient falls and injuries with videos, icons and alarms. BMJ open quality. 2017 Oct 1;6(2):e000119.	Bed exit alarm	Published study	Excluded. Mixed intervention including staff education - not eligible for inclusion.
Baxter Healthcare	Albuquerque LH, Jacob B, Mahon EH. Hill-Rom's bed exit system with audible alarm, used in con-junction with falls protocol: Reduces falls on a medical-surgical inpatient unit: A Process Improvement Project. J Comp Nurs Res Care. 2020;5(1):159.	Bed exit alarm	Published study	Excluded. Mixed intervention including staff education - not eligible for inclusion.
Baxter Healthcare	[redacted]	[redacted]	[redacted]	Excluded. [redacted]

Company	Document	Related feature	Evidence type	Review eligibility
				[redacted]
Baxter Healthcare	Merryweather AS, Morse JM, Doig AK, Godfrey NW, Gervais P, Bloswick DS. Effects of bed height on the biomechanics of hospital bed entry and egress. Work. 2015 Jan 1;52(3):707-13.	Bed height	Published study	Excluded. No innovative bed feature evaluated
Baxter Healthcare	Usmani AR, Kotowski SE, Davis KG. Effects of Bed Height on Balance during Ingress and Egress from a Hospital Bed. International Journal of Nursing and Health Care Research. 2024;7.	Bed height	Published laboratory study	Excluded. No innovative bed feature evaluated
Baxter Healthcare	Ghersi I, Mariño M, Miralles MT. Smart medical beds in patient-care environments of the twenty-first century: a state-of-art survey. BMC medical informatics and decision making. 2018 Dec;18:1-2.	Electric beds	Published study	Excluded. No innovative bed feature evaluated.
Baxter Healthcare	Wiggermann N. Biomechanical evaluation of a bed feature to assist in turning and laterally repositioning patients. Human factors. 2016 Aug;58(5):748-57.	Turn assist	Published laboratory study	Included
Baxter Healthcare	Wiggermann N, Zhou J, McGann N. Effect of repositioning aids and patient weight on biomechanical stresses when repositioning patients in bed. Human factors. 2021 Jun;63(4):565-77.	Repositioning aids	Published laboratory study	Excluded. No innovative bed feature evaluated.
Baxter Healthcare	Zhou J, Wiggermann N. The effects of hospital bed features on physical stresses on caregivers when repositioning patients in bed. Appl Ergon. 2021;90:103259.	Patient repositioning test	Published laboratory study	Included
Baxter Healthcare	Budarick AR, Lad U, Fischer SL. Can the use of turn-assist surfaces reduce the physical burden on caregivers when performing patient turning?. Human factors. 2020 Feb;62(1):77-92.	Turn assist	Published laboratory study	Included.

Company	Document	Related feature	Evidence type	Review eligibility
Baxter Healthcare	Brito ALA, Ferreira ACA, Costa LSP, da SJEFF, Campos SL. Efficacy of Continuous Lateral Rotation Therapy in Mechanically Ventilated Critically Ill Adults on Clinical Outcomes. Respir Care. 2024.	Continuous lateral rotation therapy	Published systematic review	Excluded. Feature out of review scope.
Baxter Healthcare	Schieren M, Piekarski F, Dusse F, Marcus H, Poels M, Wappler F, et al. Continuous lateral rotational therapy in trauma—A systematic review and meta-analysis. Journal of Trauma and Acute Care Surgery. 2017;83(5)	Continuous lateral rotation therapy	Published systematic review	Excluded. Feature out of review scope.
Baxter Healthcare	Kirschenbaum L, Azzi E, Sfeir T, Tietjen P, Astiz M. Effect of continuous lateral rotational therapy on the prevalence of ventilator-associated pneumonia in patients requiring long-term ventilatory care. Crit Care Med. 2002;30(9):1983-6	Continuous lateral rotation therapy	Published study	Excluded. Feature out of review scope.
Baxter Healthcare	Morse JM, Gervais P, Pooler C, Merryweather A, Doig AK, Bloswick D. The Safety of Hospital Beds: Ingress, Egress, and In-Bed Mobility. Glob Qual Nurs Res. 2015;2:2333393615575321	Side rails, bed height	Published study	Excluded. No innovative bed feature evaluated.
Baxter Healthcare	Christman M, Morse JM, Wilson C, Godfrey NW, Doig AK, Bloswick D, et al. Analysis of the Influence of Hospital Bed Height on Kinematic Parameters Associated with Patient Falls During Egress. Procedia Manufacturing. 2015;3:280-7.	Bed height	Published study	Excluded. No innovative bed feature evaluated.
Baxter Healthcare	Guner CK, Kutluturkan S. Role of head-of-bed elevation in preventing ventilator-associated pneumonia bed elevation and pneumonia. Nurs Crit Care. 2022;27(5):635-45.	Head of bed elevation	Published study	Excluded. No innovative bed feature evaluated.

Appendix D: Risk of bias assessment

Table D 1: Cochrane risk of bias II for cluster RCTs

Study	Risk of bias arising from the randomization process				
Study	1a.1 Was the allocation sequence random?	1a.2 Was the allocation sequence concealed until clusters were enrolled and assigned to interventions?	1a.3 Did baseline differences between intervention groups suggest a problem with the randomization process?	Risk-of-bias judgement	Optional: What is the predicted direction of bias arising from the randomization process?
Haines 2010 (Haines et al., 2010)	Yes	Yes	No information	Some concerns	Unpredictable
	The 18 wards were then matched into pairs based on local fall rate data in the previous 6 months and ordered alphabetically within pairs. A research assistant in a separate location and blinded to this ordering flipped a coin to determine whether the first or second listed ward in the pair was to be allocated to the intervention group.		No baseline information on the patients in the wards was reported. Wards were matched on local fall rate data for the previous 6 months. There was some information on ward characteristics given but not enough to assess whether the patients were similar.		
Study	Risk of bias arising from the timing of identification or recruitment of participants in a cluster-randomized trial				
Study	1b.1 Were all the individual participants identified and recruited (if appropriate) before randomization of clusters?	1b.2 If N/PN/NI to 1b.1: Is it likely that selection of individual participants was affected by knowledge of the intervention assigned to the cluster?	1b.3 Were there baseline imbalances that suggest differential identification or recruitment of individual participants between intervention groups?	Risk-of-bias judgement	Optional: What is the predicted direction of bias arising from the timing of identification and recruitment of participants?
	Probably no	No	No information	Low	NA

Haines 2010 (Haines et al., 2010)	There is no information on if patients on the wards were recruited prior to randomisation. However, as the trial took place over 6 months it is likely that patients changed over the time period and that different patients were included.	Selection was based on patients who happened to be treated in the wards.	No baseline information on the patients in the wards was reported. Wards were matched on local fall rate data for the previous 6 months.		

Study	**Risk of bias due to deviations from the intended interventions (effect of assignment to intervention)**									
	2.1a Were participants aware that they were in a trial?	**2.1b If Y/PY/NI to 2.1a: Were participants aware of their assigned intervention during the trial?**	**2.2. Were carers and people delivering the interventions aware of participants' assigned intervention during the trial?**	**2.3. If Y/PY/NI to 2.1 or 2.2: Were there deviations from the intended intervention that arose because of the trial context?**	**2.4 If Y/PY to 2.3: Were these deviations likely to have affected the outcome?**	**2.5. If Y/PY/NI to 2.4: Were these deviations from intended intervention balanced between groups?**	**2.6 Was an appropriate analysis used to estimate the effect of assignment to intervention?**	**2.7 If N/PN/NI to 2.6: Was there potential for a substantial impact (on the result) of the failure to analyse participants in the group to which they were randomized?**	**Risk-of-bias judgement**	**Optional: What is the predicted direction of bias due to deviations from intended interventions?**
	No information	No information	Yes	No information	NA	NA	Yes	NA	Some concerns	Favours experimental

Haines 2010 (Haines et al., 2010)	There is no information given as to whether patients were aware of the intervention.	There is no information given as to whether patients were aware of the intervention. Ward staff were not blinded to allocation of intervention. May have been risk of bias where additional falls prevention efforts were made.	There is no information given as to whether there were deviations from the intended intervention.	NA.	NA.	All clusters were analysed according to the groups which they were assigned.	NA.		

Study	Risk of bias due to missing outcome data						
	3.1a Were data for this outcome available for all clusters that recruited participants?	**3.1b Were data for this outcome available for all, or nearly all, participants within clusters?**	**3.2 <u>If N/PN/NI to 3.1a or 3.1b</u>: Is there evidence that the result was not biased by missing data?**	**3.3 <u>If N/PN to 3.2</u> Could missingness in the outcome depend on its true value?**	**3.4 <u>If Y/PY/NI to 3.3</u>: Is it likely that missingness in the outcome depended on its true value?**	**Risk-of-bias judgement**	**Optional: What is the predicted direction of bias due to missing outcome data?**
	Yes	No information	Probably yes	NA	NA	Low	NA

Haines 2010 (Haines et al., 2010)	All clusters were analysed and an ITT analysis was conducted	No information is given on the participants within the clusters or how many patients were analysed from each ward.	The trial used an ITT analysis. However, it is unclear whether there was missing data or how missing data was imputed. However, outcome data recorded prospectively and might expect reasonably good follow-up.	NA	NA		

Study	**Risk of bias in measurement of the outcome**							
	4.1 Was the method of measuring the outcome inappropriate?	**4.2 Could measurement or ascertainment of the outcome have differed between intervention groups?**	**4.3a If N/PN/NI to 4.1 and 4.2: Were outcome assessors aware that a trial was taking place?**	**4.3b If Y/PY/NI to 4.3a: Were outcome assessors aware of the intervention received by study participants?**	**4.4 If Y/PY/NI to 4.3b: Could assessment of the outcome have been influenced by knowledge of intervention received?**	**4.5 If Y/PY/NI to 4.4: Is it likely that assessment of the outcome was influenced by knowledge of intervention received?**	**Risk-of-bias judgement**	**Optional: What is the predicted direction of bias in measurement of the outcome?**
	Probably no	Probably yes	NA	NA	NA	NA		Unpredictable

Haines 2010 (Haines et al., 2010)	Hospital staff (predominantly nursing staff) recorded falls using a computer-based incident reporting system. Self-report system but appropriate for the outcome being assessed and was reviewed by the nurse unit manager or departmental director.	Nurse-reported measures and so could have been differences between the groups, especially when reporting injuries. Because there was no outcome assessor blinding, there potentially could have been bias in outcomes reported in intervention and control settings.	NA	NA	NA	NA	Some concerns	

Study	Risk of bias in selection of the reported result				
	5.1 Were the data that produced this result analysed in accordance with a pre-specified analysis plan that was finalized before unblinded outcome data were available for analysis?	**5.2 Is the numerical result being assessed likely to have been selected, on the basis of the results, from multiple eligible outcome measurements (e.g. scales, definitions, time points) within the outcome domain?**	**5.3 Is the numerical result being assessed likely to have been selected, on the basis of the results, from multiple eligible analyses of the data?**	**Risk-of-bias judgement**	**Optional: What is the predicted direction of bias due to selection of the reported result?**
Haines 2010 (Haines et al., 2010)	No information	Probably no	Probably no	Some concerns	NA
	No protocol or clinical trial number located.	Outcome data aligns with proposed methods.	Outcome data aligns with proposed methods		

Study	Overall risk of bias	
Haines 2010 (Haines et al., 2010)	**Risk of bias judgement**	**Optional: What is the overall predicted direction of bias for this outcome?**
	Some concerns	Unpredictable

Table D 2: JBI cohort study checklist

Study	1. Were the 2 groups similar and recruited from the same population?	2. Were the exposures measured similarly to assign people to both exposed and unexposed groups?	3. Was the exposure measured in a valid and reliable way?	4. Were confounding factors identified?	5. Were strategies to deal with confounding factors stated?	6. Were the groups/participants free of the outcome at the start of the study (or at the moment of exposure)?	7. Were the outcomes measured in a valid and reliable way?	8. Was the follow up time reported and sufficient to be long enough for outcomes to occur?	9. Was follow up complete, and if not, were the reasons to loss to follow up described and explored?	10. Were strategies to address incomplete follow up utilized?	11. Was appropriate statistical analysis used?	Overall appraisal
Schneider 2012 (Schneider et al., 2012)	Yes	Not applicable	Not applicable	Not applicable	Not applicable	Not applicable	Yes	Unclear	Unclear	No	Yes	Low
	The same patients were assessed using the 2 methods of weighing.	The same patients were assessed using the 2 methods of weighing.	Patients were on the same bed with weighing capabilities, weighed by a medical	The same patients were assessed using the 2 methods of weighing.	The same patients were assessed using the 2 methods of weighing.	Outcomes were correlation between weighing methods.	Weighing procedures described in detail and ensured consistency between patients. Fluid balance	Measurements made over 2 days. Correlation may have been better if it was being used in a long-term context.	Study included all complete datasets, but compliance decreased during	Missing data was not considered.	Pearson's R used for correlations.	Although measurements were only taken over 2 days, this is applicable to the acute setting. Non-

Study	1. Were the 2 groups similar and recruited from the same population?	2. Were the exposures measured similarly to assign people to both exposed and unexposed groups?	3. Was the exposure measured in a valid and reliable way?	4. Were confounding factors identified?	5. Were strategies to deal with confounding factors stated?	6. Were the groups/participants free of the outcome at the start of the study (or at the moment of exposure)?	7. Were the outcomes measured in a valid and reliable way?	8. Was the follow up time reported and sufficient to be long enough for outcomes to occur?	9. Was follow up complete, and if not, were the reasons to loss to follow up described and explored?	10. Were strategies to address incomplete follow up utilized?	11. Was appropriate statistical analysis used?	Overall appraisal
			high-precision scale and fluid balance recorded on a chart as per usual clinical practice.				was measured using software. Noncompliant measurements (e.g. failure to calibrate the bed) were excluded from the analysis. No information given on if results	But reasonably applicable to the acute setting.	the study period (344 admissions had incomplete data and were not included in the analysis). The reasons were			compliance and failure to take measurements resulted in missing data, but this is flagged by study authors and considered as another potential limitation

Study	1. Were the 2 groups similar and recruited from the same population?	2. Were the exposures measured similarly to assign people to both exposed and unexposed groups?	3. Was the exposure measured in a valid and reliable way?	4. Were confounding factors identified?	5. Were strategies to deal with confounding factors stated?	6. Were the groups/participants free of the outcome at the start of the study (or at the moment of exposure)?	7. Were the outcomes measured in a valid and reliable way?	8. Was the follow up time reported and sufficient to be long enough for outcomes to occur?	9. Was follow up complete, and if not, were the reasons to loss to follow up described and explored?	10. Were strategies to address incomplete follow up utilized?	11. Was appropriate statistical analysis used?	Overall appraisal
							were checked		described.			of bed weighing.
Schneider 2013 (Schneider et al., 2013)	Yes	Not applicable	Not applicable	Not applicable	Not applicable	Not applicable	Yes	Unclear	Unclear	Unclear	Yes	Low
	The same patients were assessed using the different methods of weighing.	The same patients were assessed using the different methods of weighing.	Patients were on the same bed with weighing capabilities, weighed by a medical	The same patients were assessed using the different methods of weighing.	The same patients were assessed using the different methods of weighing.	Outcomes were correlation between weighing methods.	Weighing procedures described in detail and ensured consistency between patients. Fluid balance	Measurements made over 2 consecutive 12-hour periods. Correlation may have been better if it was being used in a	414/548 possible weights were obtained and 8 were excluded. Reasons for	Correlation reported for those with ICU admission weight available, no	Pearson's R used for correlations.	Although measurements were only taken over 2 consecutive 12-hour periods, this is applicable to the acute

Study	1. Were the 2 groups similar and recruited from the same population?	2. Were the exposures measured similarly to assign people to both exposed and unexposed groups?	3. Was the exposure measured in a valid and reliable way?	4. Were confounding factors identified?	5. Were strategies to deal with confounding factors stated?	6. Were the groups/participants free of the outcome at the start of the study (or at the moment of exposure)?	7. Were the outcomes measured in a valid and reliable way?	8. Was the follow up time reported and sufficient to be long enough for outcomes to occur?	9. Was follow up complete, and if not, were the reasons to loss to follow up described and explored?	10. Were strategies to address incomplete follow up utilized?	11. Was appropriate statistical analysis used?	Overall appraisal
			high-precision scale and fluid balance recorded on a chart as per usual clinical practice.				was recorded as per usual clinical practice and manually calculated. Weighing technique, adequate recording and calculations were checked on	long-term context. But reasonably applicable to the acute setting.	exclusion of the 8 were described (change in body weight greater than 15 kg).	other analyses conducted.		setting. Non-compliance and failure to take measurements resulted in missing data, but this is flagged by study authors and considered as a another

Study	1. Were the 2 groups similar and recruited from the same population?	2. Were the exposures measured similarly to assign people to both exposed and unexposed groups?	3. Was the exposure measured in a valid and reliable way?	4. Were confounding factors identified?	5. Were strategies to deal with confounding factors stated?	6. Were the groups/participants free of the outcome at the start of the study (or at the moment of exposure)?	7. Were the outcomes measured in a valid and reliable way?	8. Was the follow up time reported and sufficient to be long enough for outcomes to occur?	9. Was follow up complete, and if not, were the reasons to loss to follow up described and explored?	10. Were strategies to address incomplete follow up utilized?	11. Was appropriate statistical analysis used?	Overall appraisal
							random occasions.					potential limitation of bed weighing.

Table D 3: JBI analytical cross-sectional studies checklist

Study	1. Were the criteria for inclusion in the sample clearly defined?	2. Were the study subjects and the setting described in detail?	3. Was the exposure measured in a valid and reliable way?	4. Were objective, standard criteria used for measurement of the condition?	5. Were confounding factors identified?	6. Were strategies to deal with confounding factors stated?	7. Were the outcomes measured in a valid and reliable way?	8. Was appropriate statistical analysis used?	Overall appraisal
Seow 2022 (Seow et al., 2022a)	Yes	Yes	Yes	Unclear	Unclear	Unclear	Unclear	Unclear	High
	Inclusion criteria clear (all patients in 3 acute wards).	Study subjects and settings are well described.	Patients were measured pre- or post-implementation of a bed with or without an in-built exit alarm.	Wards were chosen with similar conditions (physical settings, discipline and nursing care practices), but no other details given. It is unclear how similar the participants were.	There is no consideration for the effects of changes in falls prevention policies over time i.e. in the alarm period there may also have been other falls prevention efforts (since they had gone to the effort of getting alarms).	Analyses were adjusted to account for a limited number of important confounders, but unclear whether all important confounding factors were considered.	Fall incidents were identified from the hospital's Risk Management System (RMS), a non-punitive self-reporting mechanism for healthcare professionals to document details of adverse events including falls. Information provided in the RMS is verified by unit managers and	Multivariable logistic generalized linear mixed-effects model. However, exclusion of patients whose hospitalisation crossed over the pre and post periods - in this group, there were 14/175 falls and these could have been counted in the post-	Unclear whether other falls prevention efforts were being implemented in the bed alarm period. Ascertainment of falls incidence measured retrospectively from hospital records. Exclusion of patients whose hospitalisation crossed over the pre and

Study	1. Were the criteria for inclusion in the sample clearly defined?	2. Were the study subjects and the setting described in detail?	3. Was the exposure measured in a valid and reliable way?	4. Were objective, standard criteria used for measurement of the condition?	5. Were confounding factors identified?	6. Were strategies to deal with confounding factors stated?	7. Were the outcomes measured in a valid and reliable way?	8. Was appropriate statistical analysis used?	Overall appraisal
							hospital quality control officers. Measurements could be inaccurate due to self-reporting measures.	intervention group.	post periods - in this group, there were 14/175 falls and these could have been counted in the post-intervention group.

Table D 4: JBI quasi-experimental studies checklist

Study	1. Is it clear in the study what is the “cause” and what is the “effect” (i.e. there is no confusion about which variable comes first)?	2. Was there a control group?	3. Were participants included in any comparisons similar?	4. Were the participants included in any comparisons receiving similar treatment/care, other than the exposure or intervention of interest?	5. Were there multiple measurements of the outcome, both pre and post the intervention/exposure?	6. Were the outcomes of participants included in any comparisons measured in the same way?	7. Were outcomes measured in a reliable way?	8. Was follow-up complete and if not, were differences between groups in terms of their follow-up adequately described and analysed?	9. Was appropriate statistical analysis used?	Overall appraisal
Wiggermann 2016	Yes	Yes	Yes	Yes	Unclear	Unclear	Yes	Yes	Yes	Unclear
	Bed features were manipulated before measurem	Study compared the use of assistive bed features	The same participants were evaluated for both groups	Experimental conditions were the same aside from the	Each experimental condition was performed once at each side of the bed.	The way that the subjects lie in bed could have an effect	Outcomes were measured by motion capture, force	Outcomes were measured instantly.	ANOVA, Tukey pairwise comparisons.	Unclear if subject could have influenced outcomes. Measurem

Study	1. Is it clear in the study what is the "cause" and what is the "effect" (i.e. there is no confusion about which variable comes first)?	2. Was there a control group?	3. Were participants included in any comparisons similar?	4. Were the participants included in any comparisons receiving similar treatment/care, other than the exposure or intervention of interest?	5. Were there multiple measurements of the outcome, both pre and post the intervention/exposure?	6. Were the outcomes of participants included in any comparisons measured in the same way?	7. Were outcomes measured in a reliable way?	8. Was follow-up complete and if not, were differences between groups in terms of their follow-up adequately described and analysed?	9. Was appropriate statistical analysis used?	Overall appraisal
	ent of outcomes.	vs. no assistive features.	(assistive features. vs. no features).	beds been tested.		on the caregivers ability to turn the participant and may be reasonably open to manipulation	measurement and biomechanical modelling.			ents were only taken twice on a small sample size.
	Yes	Yes	Yes	Yes	Unclear	Unclear	Yes	Yes	Yes	Unclear

Study	1. Is it clear in the study what is the “cause” and what is the “effect” (i.e. there is no confusion about which variable comes first)?	2. Was there a control group?	3. Were participants included in any comparisons similar?	4. Were the participants included in any comparisons receiving similar treatment/care, other than the exposure or intervention of interest?	5. Were there multiple measurements of the outcome, both pre and post the intervention/exposure?	6. Were the outcomes of participants included in any comparisons measured in the same way?	7. Were outcomes measured in a reliable way?	8. Was follow-up complete and if not, were differences between groups in terms of their follow-up adequately described and analysed?	9. Was appropriate statistical analysis used?	Overall appraisal
Zhou 2021	Bed features were manipulated before measurement of outcomes.	Study compared the use of assistive bed features vs. no assistive features.	The same participants were evaluated for both groups (assistive features vs. no features).	Experimental conditions were the same aside from the beds been tested.	Each experimental condition was repeated twice.	The way that the subjects lie in bed could have an effect on the caregivers ability to turn the participant and may be	Motion capture was used to capture body movements. Ground reaction force during the patient handling activities was	Outcomes were measured instantly.	ANOVA.	re Unclear if subject could have influenced outcomes. Measurements were only taken twice on a small sample size.

Study	1. Is it clear in the study what is the “cause” and what is the “effect” (i.e. there is no confusion about which variable comes first)?	2. Was there a control group?	3. Were participants included in any comparisons similar?	4. Were the participants included in any comparisons receiving similar treatment/care, other than the exposure or intervention of interest?	5. Were there multiple measurements of the outcome, both pre and post the intervention/exposure?	6. Were the outcomes of participants included in any comparisons measured in the same way?	7. Were outcomes measured in a reliable way?	8. Was follow-up complete and if not, were differences between groups in terms of their follow-up adequately described and analysed?	9. Was appropriate statistical analysis used?	Overall appraisal
						reasonably open to manipulation	recorded by a force platform. Two force gauges and 4 reflective markers were attached to the draw sheets to measure the magnitude			

Study	1. Is it clear in the study what is the “cause” and what is the “effect” (i.e. there is no confusion about which variable comes first)?	2. Was there a control group?	3. Were participants included in any comparisons similar?	4. Were the participants included in any comparisons receiving similar treatment/care, other than the exposure or intervention of interest?	5. Were there multiple measurements of the outcome, both pre and post the intervention/exposure?	6. Were the outcomes of participants included in any comparisons measured in the same way?	7. Were outcomes measured in a reliable way?	8. Was follow-up complete and if not, were differences between groups in terms of their follow-up adequately described and analysed?	9. Was appropriate statistical analysis used?	Overall appraisal
							and 3-dimensional direction of hand force. The coordinates of 38 reflective markers, ground reaction force, and hand force were inputs to a			

Study	1. Is it clear in the study what is the "cause" and what is the "effect" (i.e. there is no confusion about which variable comes first)?	2. Was there a control group?	3. Were participants included in any comparisons similar?	4. Were the participants included in any comparisons receiving similar treatment/care, other than the exposure or intervention of interest?	5. Were there multiple measurements of the outcome, both pre and post the intervention/exposure?	6. Were the outcomes of participants included in any comparisons measured in the same way?	7. Were outcomes measured in a reliable way?	8. Was follow-up complete and if not, were differences between groups in terms of their follow-up adequately described and analysed?	9. Was appropriate statistical analysis used?	Overall appraisal
							validated biomechanical model.			
Davis 2014 (Davis et al., 2014)	Yes	No	Yes	Yes	Yes	Unclear	Yes	Unclear	Yes	Unclear
	Subjects were tested on each bed and then outcomes were measured.	Three beds with different features were evaluated, no standard bed was	The same participants were evaluated for all beds.	Experimental conditions were the same aside from the beds been tested.	The head section was articulated from flat to 45 degrees to flat with 5 repetitions (12 subjects X 3 beds X 5 reps = 180 trials).	. The way that the subjects lie in bed could have an effect on migration	Motion capture was used to analyse movement.	Unclear if trial was long enough to assess migration (outcomes appear to be	Repeated ANOVA.	Migration likely to be measured over a too short time period. Unclear if subject could have

Study	1. Is it clear in the study what is the “cause” and what is the “effect” (i.e. there is no confusion about which variable comes first)?	2. Was there a control group?	3. Were participants included in any comparisons similar?	4. Were the participants included in any comparisons receiving similar treatment/care, other than the exposure or intervention of interest?	5. Were there multiple measurements of the outcome, both pre and post the intervention/exposure?	6. Were the outcomes of participants included in any comparisons measured in the same way?	7. Were outcomes measured in a reliable way?	8. Was follow-up complete and if not, were differences between groups in terms of their follow-up adequately described and analysed?	9. Was appropriate statistical analysis used?	Overall appraisal
		tested as a comparator.				and it may be reasonably open to manipulation.		measured instantly), unlikely to represent a real-life setting		influenced outcomes.
Davis 2015 (Davis & Kotowski, 2015)	Yes	No	Yes	Yes	Yes	Unclear	Unclear	Unclear	Yes	Unclear
	Subjects were tested on each bed	Four beds with different features	The same participants were evaluated	Experimental conditions were the same aside	Each articulation condition was repeated 5 times in a random order. In	The way that the subjects lie in bed	Motion capture was used to analyse	Unclear if trial was long enough	ANOVA.	Unclear if outcomes were measured

Study	1. Is it clear in the study what is the "cause" and what is the "effect" (i.e. there is no confusion about which variable comes first)?	2. Was there a control group?	3. Were participants included in any comparisons similar?	4. Were the participants included in any comparisons receiving similar treatment/care, other than the exposure or intervention of interest?	5. Were there multiple measurements of the outcome, both pre and post the intervention/exposure?	6. Were the outcomes of participants included in any comparisons measured in the same way?	7. Were outcomes measured in a reliable way?	8. Was follow-up complete and if not, were differences between groups in terms of their follow-up adequately described and analysed?	9. Was appropriate statistical analysis used?	Overall appraisal
	and then outcomes were measured.	were evaluated, no standard bed was tested as a comparator.	for all beds.	from the beds been tested.	total, 40 trials were completed by each participant (4 bed types × 2 articulation types × 5 repeats).	could have an effect on migration and it may be reasonably open to manipulation	movement. Subjective assessments of sliding and comfort were undertaken.	to assess migration (outcomes appear to be measured instantly), unlikely to represent a real-life setting.		for a long enough period. Unclear if subject could have influenced outcomes. Some outcomes were measured subjectively.

Study	1. Is it clear in the study what is the "cause" and what is the "effect" (i.e. there is no confusion about which variable comes first)?	2. Was there a control group?	3. Were participants included in any comparisons similar?	4. Were the participants included in any comparisons receiving similar treatment/care, other than the exposure or intervention of interest?	5. Were there multiple measurements of the outcome, both pre and post the intervention/exposure?	6. Were the outcomes of participants included in any comparisons measured in the same way?	7. Were outcomes measured in a reliable way?	8. Was follow-up complete and if not, were differences between groups in terms of their follow-up adequately described and analysed?	9. Was appropriate statistical analysis used?	Overall appraisal
Davis 2017 (Davis et al., 2017)	Yes	No	Yes	Yes	No	Unclear	Unclear	Unclear	Yes	Unclear
	Subjects were tested on each bed and then outcomes were measured.	Four beds with different features were evaluated, no standard bed was tested as a comparator.	The same participants were evaluated for all beds.	Experimental conditions were the same aside from the beds been tested.	Only single measurements made per participant, per bed over the 2-hour period.	The way that the subjects lie in bed could have an effect on migration and it may be reasonably open to	Motion capture was used to analyse movement. Subjective assessments of sliding and comfort were	Follow-up was 2 hours, unclear whether this is long enough to assess migration.	Repeated-measures analysis and Kruskal-Wallis test.	Unclear if follow-up was long enough and only single measurements per participant were collected for each bed.

Study	1. Is it clear in the study what is the “cause” and what is the “effect” (i.e. there is no confusion about which variable comes first)?	2. Was there a control group?	3. Were participants included in any comparisons similar?	4. Were the participants included in any comparisons receiving similar treatment/care, other than the exposure or intervention of interest?	5. Were there multiple measurements of the outcome, both pre and post the intervention/exposure?	6. Were the outcomes of participants included in any comparisons measured in the same way?	7. Were outcomes measured in a reliable way?	8. Was follow-up complete and if not, were differences between groups in terms of their follow-up adequately described and analysed?	9. Was appropriate statistical analysis used?	Overall appraisal
						manipulation	undertaken.			Unclear if subject could have influenced outcomes. Some outcomes were measured subjectively.
	Yes	Unclear	Yes	Yes	Yes	Yes	Unclear	Yes	Yes	Unclear

Study	1. Is it clear in the study what is the "cause" and what is the "effect" (i.e. there is no confusion about which variable comes first)?	2. Was there a control group?	3. Were participants included in any comparisons similar?	4. Were the participants included in any comparisons receiving similar treatment/care, other than the exposure or intervention of interest?	5. Were there multiple measurements of the outcome, both pre and post the intervention/exposure?	6. Were the outcomes of participants included in any comparisons measured in the same way?	7. Were outcomes measured in a reliable way?	8. Was follow-up complete and if not, were differences between groups in terms of their follow-up adequately described and analysed?	9. Was appropriate statistical analysis used?	Overall appraisal
Kim 2009 (Kim et al., 2009)	Bed features were manipulated before measurement of outcomes.	Not for all tasks, for the brake engagement task, 2 different bed systems were assessed with brakes in different locations. For the	The same participants were evaluated for the brake engagement task, and the same for the patient transportation task.	Experimental conditions were the same aside from the beds been tested.	A set of 10 replications of brake engagement was conducted in each of 6 conditions. For patient transportation (in-room), participants completed 3 replications in each of 4 conditions (2 steering and 2 patient mass).	Outcomes were measured in the same way for each bed.	Objective measures used for certain outcomes. However, others were assessed using questionnaire responses.	Outcomes were measured instantly.	ANOVA.	Some outcomes were subjective, self-report measures. Some tasks did not have a comparator arm.

Study	1. Is it clear in the study what is the "cause" and what is the "effect" (i.e. there is no confusion about which variable comes first)?	2. Was there a control group?	3. Were participants included in any comparisons similar?	4. Were the participants included in any comparisons receiving similar treatment/care, other than the exposure or intervention of interest?	5. Were there multiple measurements of the outcome, both pre and post the intervention/exposure?	6. Were the outcomes of participants included in any comparisons measured in the same way?	7. Were outcomes measured in a reliable way?	8. Was follow-up complete and if not, were differences between groups in terms of their follow-up adequately described and analysed?	9. Was appropriate statistical analysis used?	Overall appraisal
		patient transportation task, study compared the use of a caster lock activated in 1 bed system vs. fifth wheel activated vs. fifth wheel			However, for patient transportation (corridor) participants completed 6 conditions 1 time. However, the order of the steering conditions were counterbalanced.					

Study	1. Is it clear in the study what is the “cause” and what is the “effect” (i.e. there is no confusion about which variable comes first)?	2. Was there a control group?	3. Were participants included in any comparisons similar?	4. Were the participants included in any comparisons receiving similar treatment/care, other than the exposure or intervention of interest?	5. Were there multiple measurements of the outcome, both pre and post the intervention/exposure?	6. Were the outcomes of participants included in any comparisons measured in the same way?	7. Were outcomes measured in a reliable way?	8. Was follow-up complete and if not, were differences between groups in terms of their follow-up adequately described and analysed?	9. Was appropriate statistical analysis used?	Overall appraisal
		deactivated in a second bed system for corridor transportation, and fifth-wheel activated vs. deactivated for in-room								

Study	1. Is it clear in the study what is the “cause” and what is the “effect” (i.e. there is no confusion about which variable comes first)?	2. Was there a control group?	3. Were participants included in any comparisons similar?	4. Were the participants included in any comparisons receiving similar treatment/care, other than the exposure or intervention of interest?	5. Were there multiple measurements of the outcome, both pre and post the intervention/exposure?	6. Were the outcomes of participants included in any comparisons measured in the same way?	7. Were outcomes measured in a reliable way?	8. Was follow-up complete and if not, were differences between groups in terms of their follow-up adequately described and analysed?	9. Was appropriate statistical analysis used?	Overall appraisal
		transportation.								
Kotowski 2022 (Kotowski et al., 2022)	Yes	Yes	Yes	Yes	Unclear	Yes	Yes	Yes	Yes	Low
	Bed features were manipulated before measurement of outcomes.	Beds were compared with and without power-drive.	The same participants were evaluated for all beds.	Experimental conditions were the same aside from the beds been tested.	Each condition was repeated twice.	Outcomes were measured in the same way for each bed.	The 3-dimensional spine loading (lateral shear, anterior-posterior shear and compressi	Outcomes were measured instantly.	ANOVA.	Robust methods appear to have been used, although only 2 repetitions

Study	1. Is it clear in the study what is the “cause” and what is the “effect” (i.e. there is no confusion about which variable comes first)?	2. Was there a control group?	3. Were participants included in any comparisons similar?	4. Were the participants included in any comparisons receiving similar treatment/care, other than the exposure or intervention of interest?	5. Were there multiple measurements of the outcome, both pre and post the intervention/exposure?	6. Were the outcomes of participants included in any comparisons measured in the same way?	7. Were outcomes measured in a reliable way?	8. Was follow-up complete and if not, were differences between groups in terms of their follow-up adequately described and analysed?	9. Was appropriate statistical analysis used?	Overall appraisal
							on) were predicted for each of the trials by the EMG-assisted model and the rating of perceived exertion was based on the Borg scale,			

Study	1. Is it clear in the study what is the "cause" and what is the "effect" (i.e. there is no confusion about which variable comes first)?	2. Was there a control group?	3. Were participants included in any comparisons similar?	4. Were the participants included in any comparisons receiving similar treatment/care, other than the exposure or intervention of interest?	5. Were there multiple measurements of the outcome, both pre and post the intervention/exposure?	6. Were the outcomes of participants included in any comparisons measured in the same way?	7. Were outcomes measured in a reliable way?	8. Was follow-up complete and if not, were differences between groups in terms of their follow-up adequately described and analysed?	9. Was appropriate statistical analysis used?	Overall appraisal
							which has been widely used and validated.			
Matz 2018 (Matz & Morgan, 2018)	Yes	Yes	Unclear	Yes	Unclear	Yes	Unclear	Yes	No	Unclear
	Bed features were manipulated before measurem	Beds were compared with and without power-assist.	There was no information given on the participant	Experimental conditions were the same aside from the	Each condition was tested 3x.	Outcomes were measured in the same way	Bed frames were configured with calibrated	Outcomes were measured instantly.	No CIs reported - only a mean. So can't see variability,	No information on participants, unclear reliability of

Study	1. Is it clear in the study what is the “cause” and what is the “effect” (i.e. there is no confusion about which variable comes first)?	2. Was there a control group?	3. Were participants included in any comparisons similar?	4. Were the participants included in any comparisons receiving similar treatment/care, other than the exposure or intervention of interest?	5. Were there multiple measurements of the outcome, both pre and post the intervention/exposure?	6. Were the outcomes of participants included in any comparisons measured in the same way?	7. Were outcomes measured in a reliable way?	8. Was follow-up complete and if not, were differences between groups in terms of their follow-up adequately described and analysed?	9. Was appropriate statistical analysis used?	Overall appraisal
	ent of outcomes.		s conducting the tests.	beds been tested.		for each bed.	load cells to record user input force into the system. Doesn't measure force on participant but on bed.		which might be an indication of the reliability of the test. Unclear if difference is significant as not reported.	findings as no CIs or significance reported. Only 3 test repetitions.
	Yes	Yes	Unclear	Yes	Yes	Unclear	Unclear	Yes	No	Unclear

Study	1. Is it clear in the study what is the "cause" and what is the "effect" (i.e. there is no confusion about which variable comes first)?	2. Was there a control group?	3. Were participants included in any comparisons similar?	4. Were the participants included in any comparisons receiving similar treatment/care, other than the exposure or intervention of interest?	5. Were there multiple measurements of the outcome, both pre and post the intervention/exposure?	6. Were the outcomes of participants included in any comparisons measured in the same way?	7. Were outcomes measured in a reliable way?	8. Was follow-up complete and if not, were differences between groups in terms of their follow-up adequately described and analysed?	9. Was appropriate statistical analysis used?	Overall appraisal
Medstrom 2021 (Medstrom, 2021)	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]

Study	1. Is it clear in the study what is the "cause" and what is the "effect" (i.e. there is no confusion about which variable comes first)?	2. Was there a control group?	3. Were participants included in any comparisons similar?	4. Were the participants included in any comparisons receiving similar treatment/care, other than the exposure or intervention of interest?	5. Were there multiple measurements of the outcome, both pre and post the intervention/exposure?	6. Were the outcomes of participants included in any comparisons measured in the same way?	7. Were outcomes measured in a reliable way?	8. Was follow-up complete and if not, were differences between groups in terms of their follow-up adequately described and analysed?	9. Was appropriate statistical analysis used?	Overall appraisal
							[redacted]			
Rush 2018 (Rush, 2018)	Yes	Yes	Yes	Yes	No	Unclear	Unclear	Unclear	No	Unclear
	Subject was tested on each	Study compared beds with	The same participant was	Experimental conditions were the	Seems to be 1 measurement of	The way that the subjects	A pre-determined evaluation	Unclear how long migration	Ranges and results for	Unclear if outcome measurem

Study	1. Is it clear in the study what is the "cause" and what is the "effect" (i.e. there is no confusion about which variable comes first)?	2. Was there a control group?	3. Were participants included in any comparisons similar?	4. Were the participants included in any comparisons receiving similar treatment/care, other than the exposure or intervention of interest?	5. Were there multiple measurements of the outcome, both pre and post the intervention/exposure?	6. Were the outcomes of participants included in any comparisons measured in the same way?	7. Were outcomes measured in a reliable way?	8. Was follow-up complete and if not, were differences between groups in terms of their follow-up adequately described and analysed?	9. Was appropriate statistical analysis used?	Overall appraisal
	bed and then outcomes were measured.	autocontour function activated and deactivated.	evaluated for all beds.	same aside from the beds been tested.	each outcome per bed.	lie in bed could have an effect on migration and it may be reasonably open to manipulation.	form was used to record migration distance. May not be accurate as large, unexplained variability between beds. Data for patient comfort was	was measured for (appears to be instantly) but unlikely to represent real-life settings.	each individual bed were given, but no statistical testing.	ent reliable and only 1 measurement of each outcome per bed taken. Unclear if outcome measured for long enough. Unclear if subjects could

Study	1. Is it clear in the study what is the "cause" and what is the "effect" (i.e. there is no confusion about which variable comes first)?	2. Was there a control group?	3. Were participants included in any comparisons similar?	4. Were the participants included in any comparisons receiving similar treatment/care, other than the exposure or intervention of interest?	5. Were there multiple measurements of the outcome, both pre and post the intervention/exposure?	6. Were the outcomes of participants included in any comparisons measured in the same way?	7. Were outcomes measured in a reliable way?	8. Was follow-up complete and if not, were differences between groups in terms of their follow-up adequately described and analysed?	9. Was appropriate statistical analysis used?	Overall appraisal
							analysed qualitatively.			influence outcomes. No significance testing.
Lustig 2020 (Lustig et al., 2020)	Yes	Yes	Yes	Yes	Unclear	Unclear	Yes	Unclear	Yes	Unclear
	Subject was tested on each bed and then outcomes	Two beds were compared, 1 with anti migration feature and 1 without	The same participants used both types of beds	Experimental conditions were the same aside from the beds been tested	Two repetitions of each test	The way that the subjects lie in bed could have an effect on	Motion capture was used to analyse movement.	Unclear how long migration was measured for (appears	Two-way analysis of variance for the factors of (a) bed	Unclear if subjects could influence outcomes and if test duration

Study	1. Is it clear in the study what is the "cause" and what is the "effect" (i.e. there is no confusion about which variable comes first)?	2. Was there a control group?	3. Were participants included in any comparisons similar?	4. Were the participants included in any comparisons receiving similar treatment/care, other than the exposure or intervention of interest?	5. Were there multiple measurements of the outcome, both pre and post the intervention/exposure?	6. Were the outcomes of participants included in any comparisons measured in the same way?	7. Were outcomes measured in a reliable way?	8. Was follow-up complete and if not, were differences between groups in terms of their follow-up adequately described and analysed?	9. Was appropriate statistical analysis used?	Overall appraisal
	were measured					migration and it may be reasonably open to manipulation		to be instantly) but unlikely to represent real-life settings	type and (b) HOB elevation in order to identify potential significant differences in the extent of migration in bed between the experimen	sufficient to reflect real life use. Only 2 test repetitions

Study	1. Is it clear in the study what is the “cause” and what is the “effect” (i.e. there is no confusion about which variable comes first)?	2. Was there a control group?	3. Were participants included in any comparisons similar?	4. Were the participants included in any comparisons receiving similar treatment/care, other than the exposure or intervention of interest?	5. Were there multiple measurements of the outcome, both pre and post the intervention/exposure?	6. Were the outcomes of participants included in any comparisons measured in the same way?	7. Were outcomes measured in a reliable way?	8. Was follow-up complete and if not, were differences between groups in terms of their follow-up adequately described and analysed?	9. Was appropriate statistical analysis used?	Overall appraisal
									tal conditions. Tukey pairwise comparisons were followed, to identify the specific combination of conditions affecting the	

Study	1. Is it clear in the study what is the “cause” and what is the “effect” (i.e. there is no confusion about which variable comes first)?	2. Was there a control group?	3. Were participants included in any comparisons similar?	4. Were the participants included in any comparisons receiving similar treatment/care, other than the exposure or intervention of interest?	5. Were there multiple measurements of the outcome, both pre and post the intervention/exposure?	6. Were the outcomes of participants included in any comparisons measured in the same way?	7. Were outcomes measured in a reliable way?	8. Was follow-up complete and if not, were differences between groups in terms of their follow-up adequately described and analysed?	9. Was appropriate statistical analysis used?	Overall appraisal
									migration in bed. A P < .05 was considered statistically significant	
Budarick 2020a (Aleksandra R. Budarick	Yes	Yes	Yes	Yes	Unclear	Unclear	Yes	Yes	Yes	Unclear
	Subject was tested on each	Two bed surfaces were	The same participants were	Experimental conditions were the	Each turn was repeated 3 times per participant.	The way that the subjects	Outcomes were measured	Outcomes were measure	Group means and	Unclear if subjects could

Study	1. Is it clear in the study what is the "cause" and what is the "effect" (i.e. there is no confusion about which variable comes first)?	2. Was there a control group?	3. Were participants included in any comparisons similar?	4. Were the participants included in any comparisons receiving similar treatment/care, other than the exposure or intervention of interest?	5. Were there multiple measurements of the outcome, both pre and post the intervention/exposure?	6. Were the outcomes of participants included in any comparisons measured in the same way?	7. Were outcomes measured in a reliable way?	8. Was follow-up complete and if not, were differences between groups in terms of their follow-up adequately described and analysed?	9. Was appropriate statistical analysis used?	Overall appraisal
et al., 2020)	bed and then outcomes were measured.	compared, both with turn-assist either activated or de-activated.	tested on each bed surface.	same aside from the beds been tested.		lie in bed could have an effect on the caregivers ability to turn the participant and may be reasonably open to manipulation.	using motion units (sensors) and a pressure imaging system.	d instantly.	standard error were calculated for all dependent variables. A one-way repeated measures ANOVA was applied to detect	influence outcomes. Only 3 test repetitions.

Study	1. Is it clear in the study what is the “cause” and what is the “effect” (i.e. there is no confusion about which variable comes first)?	2. Was there a control group?	3. Were participants included in any comparisons similar?	4. Were the participants included in any comparisons receiving similar treatment/care, other than the exposure or intervention of interest?	5. Were there multiple measurements of the outcome, both pre and post the intervention/exposure?	6. Were the outcomes of participants included in any comparisons measured in the same way?	7. Were outcomes measured in a reliable way?	8. Was follow-up complete and if not, were differences between groups in terms of their follow-up adequately described and analysed?	9. Was appropriate statistical analysis used?	Overall appraisal
									differences in outcome measures. Post-hoc Tukey’s pairwise comparisons were examined to determine significant differences between	

Study	1. Is it clear in the study what is the "cause" and what is the "effect" (i.e. there is no confusion about which variable comes first)?	2. Was there a control group?	3. Were participants included in any comparisons similar?	4. Were the participants included in any comparisons receiving similar treatment/care, other than the exposure or intervention of interest?	5. Were there multiple measurements of the outcome, both pre and post the intervention/exposure?	6. Were the outcomes of participants included in any comparisons measured in the same way?	7. Were outcomes measured in a reliable way?	8. Was follow-up complete and if not, were differences between groups in terms of their follow-up adequately described and analysed?	9. Was appropriate statistical analysis used?	Overall appraisal
									individual conditions when a main effect of turn type was detected.	
Budarick 2020b (A. R. Budarick et al., 2020)	Yes	Yes	Yes	Yes	Unclear	Unclear	Yes	Yes	Yes	Unclear
	Bed features were manipulat	Two bed surfaces were compared,	The same participants were evaluated	Experimental conditions were the same aside	Manual turns were repeated 3 times on each surface (6 times in total) and	The way that the subject lie in bed	Hand force was measured using a	Outcomes were measure	Two-way repeated measures analysis	Unclear if subjects could influence

Study	1. Is it clear in the study what is the “cause” and what is the “effect” (i.e. there is no confusion about which variable comes first)?	2. Was there a control group?	3. Were participants included in any comparisons similar?	4. Were the participants included in any comparisons receiving similar treatment/care, other than the exposure or intervention of interest?	5. Were there multiple measurements of the outcome, both pre and post the intervention/exposure?	6. Were the outcomes of participants included in any comparisons measured in the same way?	7. Were outcomes measured in a reliable way?	8. Was follow-up complete and if not, were differences between groups in terms of their follow-up adequately described and analysed?	9. Was appropriate statistical analysis used?	Overall appraisal
	ed before measurement of outcomes.	both with turn-assist either activated or de-activated.	for all beds.	from the beds been tested.	turn-assist trials were repeated 2 times on each surface (4 times in total).	could have an effect on the caregivers ability to turn the participant and may be reasonably open to manipulation.	force gauge. The data was collected using an instrumented bed sheet which consisted of a metal rod (the same length as the	d instantly.	of variance and Tukey's post-hoc pairwise comparisons were performed.	outcomes. Only 2 or 3 test repetitions.

Study	1. Is it clear in the study what is the “cause” and what is the “effect” (i.e. there is no confusion about which variable comes first)?	2. Was there a control group?	3. Were participants included in any comparisons similar?	4. Were the participants included in any comparisons receiving similar treatment/care, other than the exposure or intervention of interest?	5. Were there multiple measurements of the outcome, both pre and post the intervention/exposure?	6. Were the outcomes of participants included in any comparisons measured in the same way?	7. Were outcomes measured in a reliable way?	8. Was follow-up complete and if not, were differences between groups in terms of their follow-up adequately described and analysed?	9. Was appropriate statistical analysis used?	Overall appraisal
							patient’s torso) inserted into the seam of the bed sheet, and the force gauge was attached to the rod. Movement strategy was measured			

Study	1. Is it clear in the study what is the “cause” and what is the “effect” (i.e. there is no confusion about which variable comes first)?	2. Was there a control group?	3. Were participants included in any comparisons similar?	4. Were the participants included in any comparisons receiving similar treatment/care, other than the exposure or intervention of interest?	5. Were there multiple measurements of the outcome, both pre and post the intervention/exposure?	6. Were the outcomes of participants included in any comparisons measured in the same way?	7. Were outcomes measured in a reliable way?	8. Was follow-up complete and if not, were differences between groups in terms of their follow-up adequately described and analysed?	9. Was appropriate statistical analysis used?	Overall appraisal
							using motion capture and inertial measurement units were measured using sensors.			

Appendix E: Additional sensitivity analysis

Table E1: Fully incremental analysis results of bed frames (accounting only for bed exit alarms, per person)

Bed Frame	QALYs	Cost	Dominance results	Efficacy frontier
Apex OOK SNOW ward bed	[redacted]	[redacted]	[redacted]	[redacted]
Apex OOK SNOW falls bed	[redacted]	[redacted]	[redacted]	[redacted]
Apex OOK SNOW mental health bed	[redacted]	[redacted]	[redacted]	[redacted]
Arjo Enterprise 5000X	[redacted]	[redacted]	[redacted]	[redacted]
Arjo Enterprise 8000X	[redacted]	[redacted]	[redacted]	[redacted]
Arjo Enterprise 9000X	[redacted]	[redacted]	[redacted]	[redacted]
Baxter Centuris Pro	[redacted]	[redacted]	[redacted]	[redacted]
Baxter Hillrom 900 X2 (B2)	[redacted]	[redacted]	[redacted]	[redacted]
Baxter Hillrom 900 X3 (C2)	[redacted]	[redacted]	[redacted]	[redacted]
Baxter Hillrom 900 Accella	[redacted]	[redacted]	[redacted]	[redacted]
Direct Healthcare Delta 4	[redacted]	[redacted]	[redacted]	[redacted]
Direct Healthcare Lago Hospital	[redacted]	[redacted]	[redacted]	[redacted]
Drive DeVilbiss Innov8	[redacted]	[redacted]	[redacted]	[redacted]
Innova Care Interlude V3	[redacted]	[redacted]	[redacted]	[redacted]
Linet Eleganza 1	[redacted]	[redacted]	[redacted]	[redacted]
Linet Eleganza 2	[redacted]	[redacted]	[redacted]	[redacted]
Linet Essenza 300	[redacted]	[redacted]	[redacted]	[redacted]
Linet Essenza 300 LT	[redacted]	[redacted]	[redacted]	[redacted]
Linet Image 3	[redacted]	[redacted]	[redacted]	[redacted]
Medstrom Solo	[redacted]	[redacted]	[redacted]	[redacted]
Medstrom Solo+	[redacted]	[redacted]	[redacted]	[redacted]
Medstrom Solo Luxe	[redacted]	[redacted]	[redacted]	[redacted]

Medstrom SoloMH	[redacted]	[redacted]	[redacted]	[redacted]
OSKA OSKA Florence	[redacted]	[redacted]	[redacted]	[redacted]
Stryker SV2 Electric Hospital Bed	[redacted]	[redacted]	[redacted]	[redacted]
Stryker ProCuity™ L model	[redacted]	[redacted]	[redacted]	[redacted]
Stryker ProCuity™ LE model	[redacted]	[redacted]	[redacted]	[redacted]
Stryker ProCuity™ Z model	[redacted]	[redacted]	[redacted]	[redacted]
Talley Group IMO Matrix E30	[redacted]	[redacted]	[redacted]	[redacted]
Talley Group IMO Matrix U24	[redacted]	[redacted]	[redacted]	[redacted]

Table E2: Fully incremental costs breakdown (annual cost, per bed frame)

Bed Frame	Cost of bed frame	Cost of falls	Cost of pressure ulcers	Cost of entrapments	Cost of infections	Cost of caregiver injury
Apex OOK SNOW ward bed	[redacted]	£2,196	£430	£0	£2,797	£6,250
Apex OOK SNOW falls bed	[redacted]	£2,196	£430	£0	£2,797	£6,250
Apex OOK SNOW mental health bed	[redacted]	£2,196	£430	£0	£2,797	£6,250
Arjo Enterprise 5000X	[redacted]	£4,392	£430	£0	£2,797	£6,250
Arjo Enterprise 8000X	[redacted]	£4,392	£430	£0	£2,797	£6,250
Arjo Enterprise 9000X	[redacted]	£2,196	£430	£0	£2,797	£6,250

Baxter Centuris Pro	[redacted]	£4,392	£430	£0	£2,797	£6,250
Baxter Hillrom 900 X2 (B2)	[redacted]	£4,392	£430	£0	£2,797	£6,250
Baxter Hillrom 900 X3 (C2)	[redacted]	£2,196	£430	£0	£2,797	£6,250
Baxter Hillrom 900 Accella	[redacted]	£2,196	£430	£0	£2,797	£6,250
Direct Healthcare Delta 4	[redacted]	£2,196	£430	£0	£2,797	£6,250
Direct Healthcare Lago Hospital	[redacted]	£4,392	£430	£0	£2,797	£6,250
Drive DeVilbiss Innov8	[redacted]	£4,392	£430	£0	£2,797	£6,250
Innova Care Interlude V3	[redacted]	£4,392	£430	£0	£2,797	£6,250
Linet Eleganza 1	[redacted]	£4,392	£430	£0	£2,797	£6,250
Linet Eleganza 2	[redacted]	£4,392	£430	£0	£2,797	£6,250
Linet Essenza 300	[redacted]	£2,196	£430	£0	£2,797	£6,250
Linet Essenza 300 LT	[redacted]	£2,196	£430	£0	£2,797	£6,250
Linet Image 3	[redacted]	£2,196	£430	£0	£2,797	£6,250
Medstrom Solo	[redacted]	£4,392	£430	£0	£2,797	£6,250
Medstrom Solo+	[redacted]	£4,392	£430	£0	£2,797	£6,250
Medstrom Solo Luxe	[redacted]	£4,392	£430	£0	£2,797	£6,250
Medstrom SoloMH	[redacted]	£4,392	£430	£0	£2,797	£6,250

OSKA OSKA Florence	[redacted]	£4,392	£430	£0	£2,797	£6,250
Stryker SV2 Electric Hospital Bed	[redacted]	£4,392	£430	£0	£2,797	£6,250
Stryker ProCuity™ L model	[redacted]	£2,196	£430	£0	£2,797	£6,250
Stryker ProCuity™ LE model	[redacted]	£2,196	£430	£0	£2,797	£6,250
Stryker ProCuity™ Z model	[redacted]	£2,196	£430	£0	£2,797	£6,250
Talley Group IMO Matrix E30	[redacted]	£4,392	£430	£0	£2,797	£6,250
Talley Group IMO Matrix U24	[redacted]	£4,392	£430	£0	£2,797	£6,250

Figure E1. Caregiver injury one-way sensitivity analysis

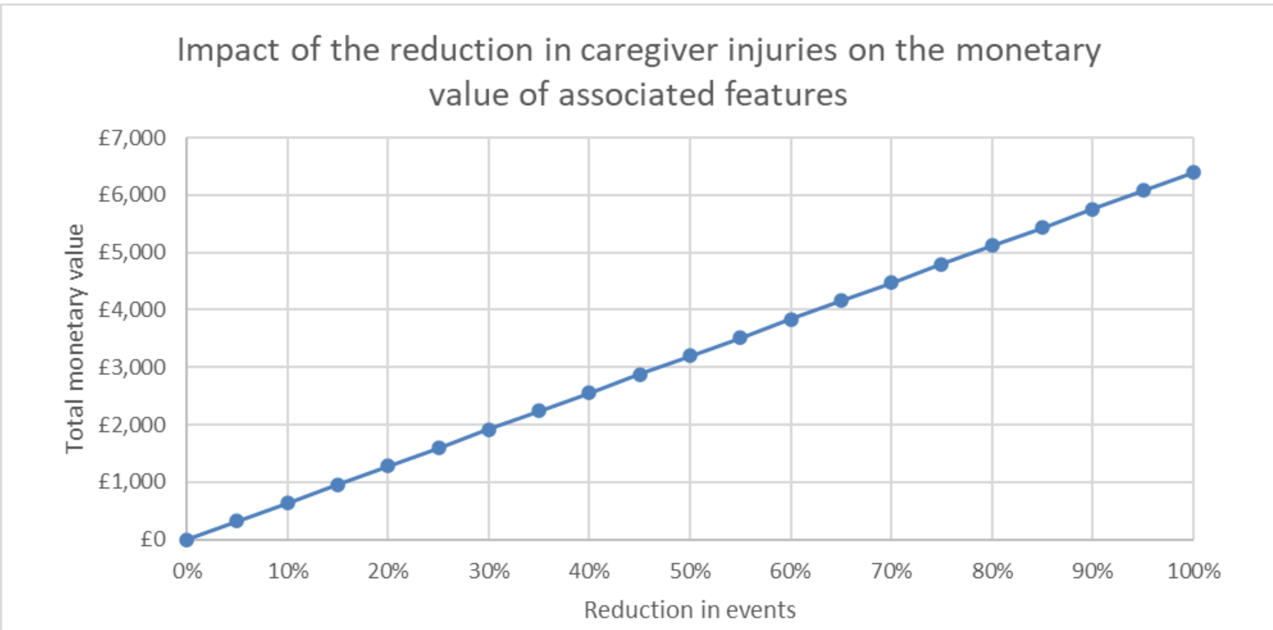


Figure E2. Infections one-way sensitivity analysis

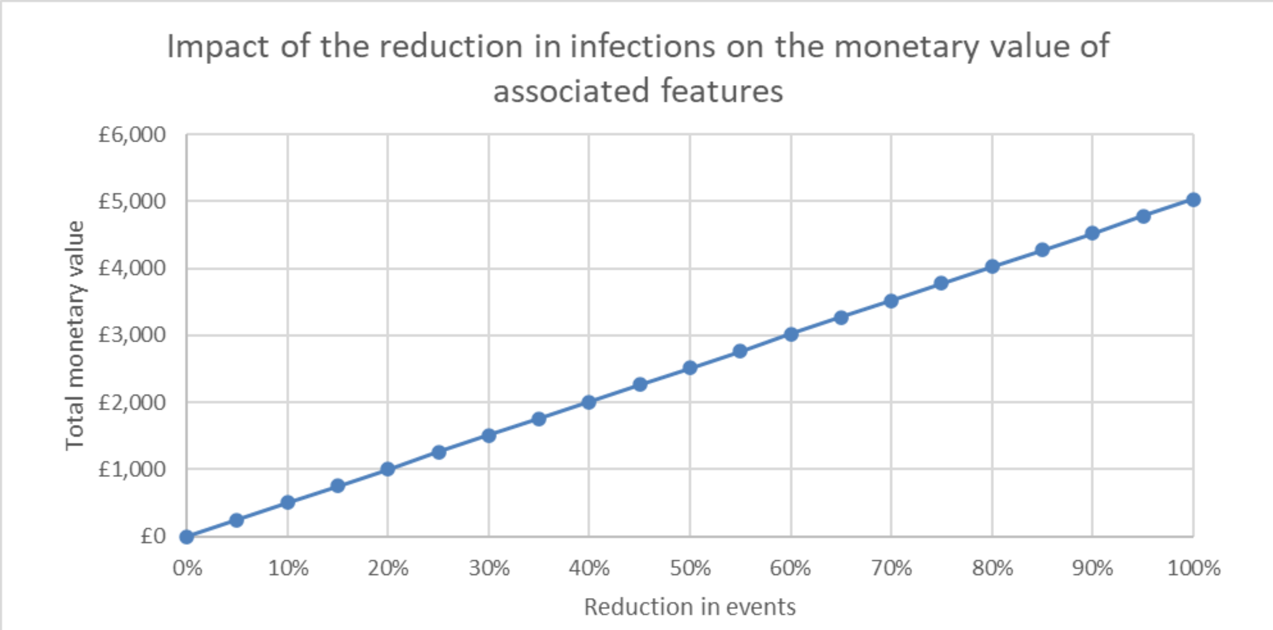


Figure E3. Pressure ulcers one-way sensitivity analysis

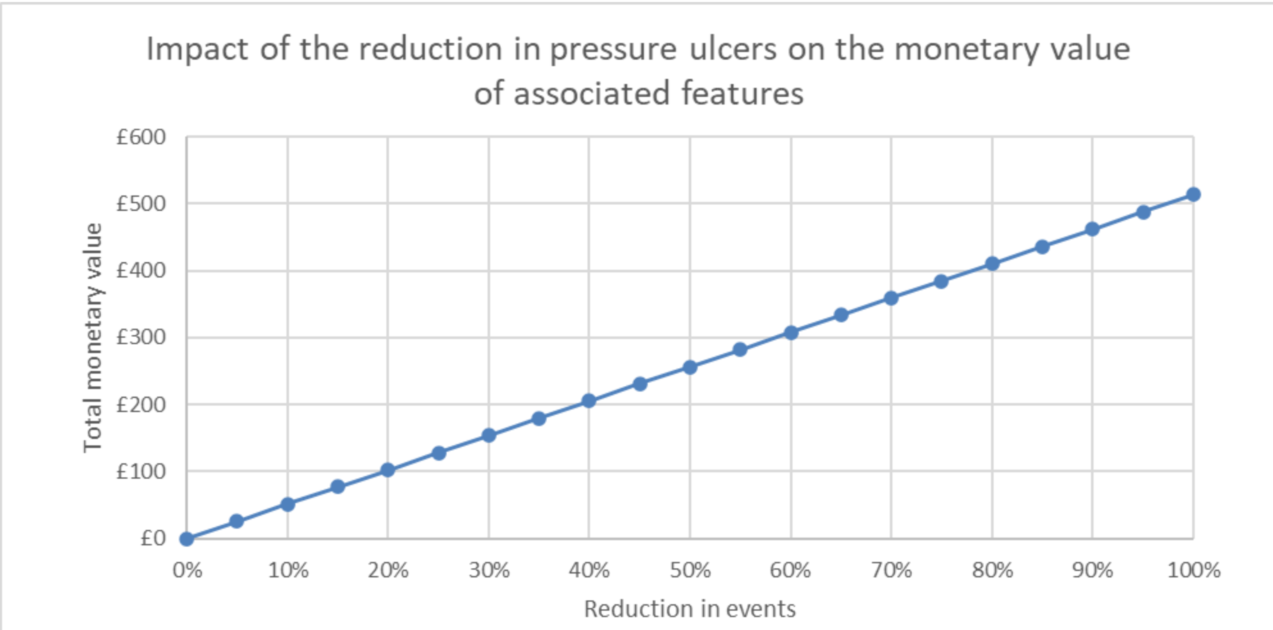


Figure E4. Falls one-way sensitivity analysis

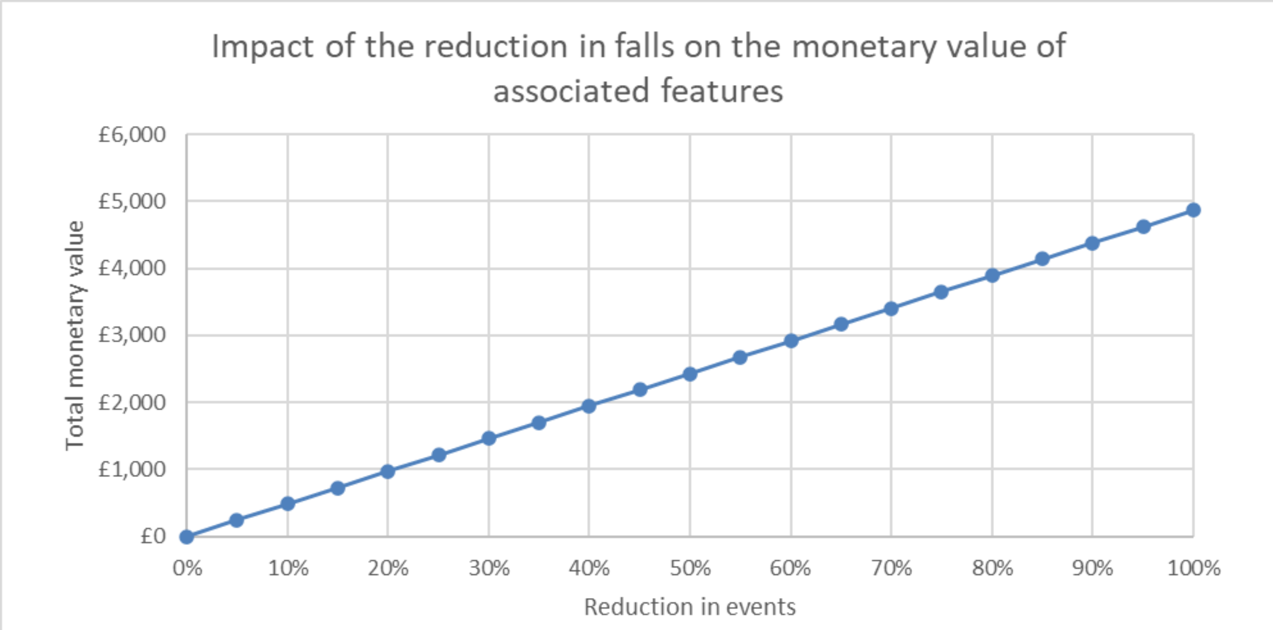


Figure E5. Entrapments one-way sensitivity analysis

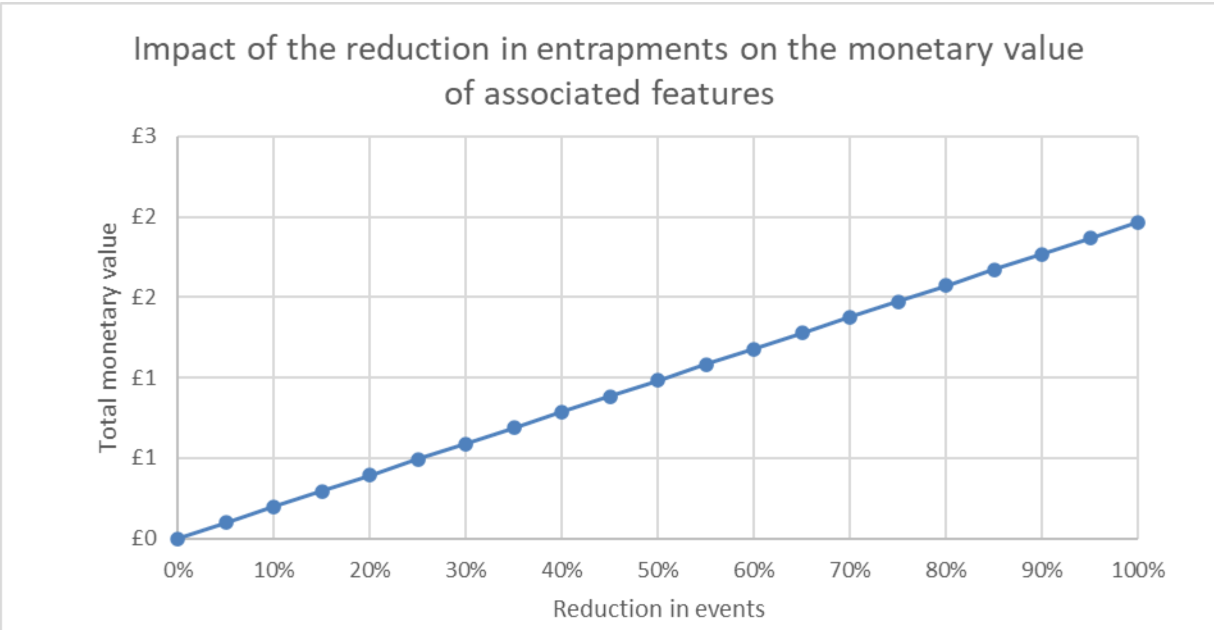


Figure E6. Caregiver injury reduction and baseline (per 1,000 bed days) two-way sensitivity analysis

Reduction in number of caregiver injuries	Baseline number of caregiver injuries (per 1,000 bed days)										
	0.00	2.00	4.00	6.00	8.00	10.00	12.00	14.00	16.00	18.00	20.00
0.0%	£0.00	£0.00	£0.00	£0.00	£0.00	£0.00	£0.00	£0.00	£0.00	£0.00	£0.00
5.0%	£0.00	£102.47	£204.93	£307.40	£409.86	£512.33	£614.79	£717.26	£819.73	£922.19	£1,024.66
10.0%	£0.00	£204.93	£409.86	£614.79	£819.73	£1,024.66	£1,229.59	£1,434.52	£1,639.45	£1,844.38	£2,049.32
15.0%	£0.00	£307.40	£614.79	£922.19	£1,229.59	£1,536.99	£1,844.38	£2,151.78	£2,459.18	£2,766.58	£3,073.97
20.0%	£0.00	£409.86	£819.73	£1,229.59	£1,639.45	£2,049.32	£2,459.18	£2,869.04	£3,278.90	£3,688.77	£4,098.63
25.0%	£0.00	£512.33	£1,024.66	£1,536.99	£2,049.32	£2,561.64	£3,073.97	£3,586.30	£4,098.63	£4,610.96	£5,123.29
30.0%	£0.00	£614.79	£1,229.59	£1,844.38	£2,459.18	£3,073.97	£3,688.77	£4,303.56	£4,918.36	£5,533.15	£6,147.95
35.0%	£0.00	£717.26	£1,434.52	£2,151.78	£2,869.04	£3,586.30	£4,303.56	£5,020.82	£5,738.08	£6,455.34	£7,172.60
40.0%	£0.00	£819.73	£1,639.45	£2,459.18	£3,278.90	£4,098.63	£4,918.36	£5,738.08	£6,557.81	£7,377.54	£8,197.26
45.0%	£0.00	£922.19	£1,844.38	£2,766.58	£3,688.77	£4,610.96	£5,533.15	£6,455.34	£7,377.54	£8,299.73	£9,221.92
50.0%	£0.00	£1,024.66	£2,049.32	£3,073.97	£4,098.63	£5,123.29	£6,147.95	£7,172.60	£8,197.26	£9,221.92	£10,246.58
55.0%	£0.00	£1,127.12	£2,254.25	£3,381.37	£4,508.49	£5,635.62	£6,762.74	£7,889.86	£9,016.99	£10,144.11	£11,271.24
60.0%	£0.00	£1,229.59	£2,459.18	£3,688.77	£4,918.36	£6,147.95	£7,377.54	£8,607.13	£9,836.71	£11,066.30	£12,295.89
65.0%	£0.00	£1,332.06	£2,664.11	£3,996.17	£5,328.22	£6,660.28	£7,992.33	£9,324.39	£10,656.44	£11,988.50	£13,320.55
70.0%	£0.00	£1,434.52	£2,869.04	£4,303.56	£5,738.08	£7,172.60	£8,607.13	£10,041.65	£11,476.17	£12,910.69	£14,345.21
75.0%	£0.00	£1,536.99	£3,073.97	£4,610.96	£6,147.95	£7,684.93	£9,221.92	£10,758.91	£12,295.89	£13,832.88	£15,369.87
80.0%	£0.00	£1,639.45	£3,278.90	£4,918.36	£6,557.81	£8,197.26	£9,836.71	£11,476.17	£13,115.62	£14,755.07	£16,394.52
85.0%	£0.00	£1,741.92	£3,483.84	£5,225.75	£6,967.67	£8,709.59	£10,451.51	£12,193.43	£13,935.35	£15,677.26	£17,419.18
90.0%	£0.00	£1,844.38	£3,688.77	£5,533.15	£7,377.54	£9,221.92	£11,066.30	£12,910.69	£14,755.07	£16,599.46	£18,443.84
95.0%	£0.00	£1,946.85	£3,893.70	£5,840.55	£7,787.40	£9,734.25	£11,681.10	£13,627.95	£15,574.80	£17,521.65	£19,468.50
100.0%	£0.00	£2,049.32	£4,098.63	£6,147.95	£8,197.26	£10,246.58	£12,295.89	£14,345.21	£16,394.52	£18,443.84	£20,493.16

Figure E7. Infections reduction and baseline (per 1,000 bed days) two-way sensitivity analysis

Reduction in number of infections	Baseline number of infections (per 1,000 bed days)										
	0.00	1.00	2.00	3.00	4.00	5.00	6.00	7.00	8.00	9.00	10.00
0.0%	£0.00	£0.00	£0.00	£0.00	£0.00	£0.00	£0.00	£0.00	£0.00	£0.00	£0.00
5.0%	£0.00	£120.70	£241.40	£362.10	£482.80	£603.50	£724.20	£844.89	£965.59	£1,086.29	£1,206.99
10.0%	£0.00	£241.40	£482.80	£724.20	£965.59	£1,206.99	£1,448.39	£1,689.79	£1,931.19	£2,172.59	£2,413.99
15.0%	£0.00	£362.10	£724.20	£1,086.29	£1,448.39	£1,810.49	£2,172.59	£2,534.68	£2,896.78	£3,258.88	£3,620.98
20.0%	£0.00	£482.80	£965.59	£1,448.39	£1,931.19	£2,413.99	£2,896.78	£3,379.58	£3,862.38	£4,345.17	£4,827.97
25.0%	£0.00	£603.50	£1,206.99	£1,810.49	£2,413.99	£3,017.48	£3,620.98	£4,224.47	£4,827.97	£5,431.47	£6,034.96
30.0%	£0.00	£724.20	£1,448.39	£2,172.59	£2,896.78	£3,620.98	£4,345.17	£5,069.37	£5,793.57	£6,517.76	£7,241.96
35.0%	£0.00	£844.89	£1,689.79	£2,534.68	£3,379.58	£4,224.47	£5,069.37	£5,914.26	£6,759.16	£7,604.05	£8,448.95
40.0%	£0.00	£965.59	£1,931.19	£2,896.78	£3,862.38	£4,827.97	£5,793.57	£6,759.16	£7,724.75	£8,690.35	£9,655.94
45.0%	£0.00	£1,086.29	£2,172.59	£3,258.88	£4,345.17	£5,431.47	£6,517.76	£7,604.05	£8,690.35	£9,776.64	£10,862.93
50.0%	£0.00	£1,206.99	£2,413.99	£3,620.98	£4,827.97	£6,034.96	£7,241.96	£8,448.95	£9,655.94	£10,862.93	£12,069.93
55.0%	£0.00	£1,327.69	£2,655.38	£3,983.08	£5,310.77	£6,638.46	£7,966.15	£9,293.84	£10,621.54	£11,949.23	£13,276.92
60.0%	£0.00	£1,448.39	£2,896.78	£4,345.17	£5,793.57	£7,241.96	£8,690.35	£10,138.74	£11,587.13	£13,035.52	£14,483.91
65.0%	£0.00	£1,569.09	£3,138.18	£4,707.27	£6,276.36	£7,845.45	£9,414.54	£10,983.63	£12,552.72	£14,121.82	£15,690.91
70.0%	£0.00	£1,689.79	£3,379.58	£5,069.37	£6,759.16	£8,448.95	£10,138.74	£11,828.53	£13,518.32	£15,208.11	£16,897.90
75.0%	£0.00	£1,810.49	£3,620.98	£5,431.47	£7,241.96	£9,052.45	£10,862.93	£12,673.42	£14,483.91	£16,294.40	£18,104.89
80.0%	£0.00	£1,931.19	£3,862.38	£5,793.57	£7,724.75	£9,655.94	£11,587.13	£13,518.32	£15,449.51	£17,380.70	£19,311.88
85.0%	£0.00	£2,051.89	£4,103.78	£6,155.66	£8,207.55	£10,259.44	£12,311.33	£14,363.21	£16,415.10	£18,466.99	£20,518.88
90.0%	£0.00	£2,172.59	£4,345.17	£6,517.76	£8,690.35	£10,862.93	£13,035.52	£15,208.11	£17,380.70	£19,553.28	£21,725.87
95.0%	£0.00	£2,293.29	£4,586.57	£6,879.86	£9,173.14	£11,466.43	£13,759.72	£16,053.00	£18,346.29	£20,639.58	£22,932.86
100.0%	£0.00	£2,413.99	£4,827.97	£7,241.96	£9,655.94	£12,069.93	£14,483.91	£16,897.90	£19,311.88	£21,725.87	£24,139.85

Figure E8. Pressure ulcers reduction and baseline (per 1,000 bed days) two-way sensitivity analysis

Reduction in number of pressure ulcers	Baseline number of pressure ulcers (per 1,000 bed days)										
	0.00	0.10	0.20	0.30	0.40	0.50	0.60	0.70	0.80	0.90	1.00
0.0%	£0.00	£0.00	£0.00	£0.00	£0.00	£0.00	£0.00	£0.00	£0.00	£0.00	£0.00
5.0%	£0.00	£9.50	£19.00	£28.50	£38.01	£47.51	£57.01	£66.51	£76.01	£85.51	£95.01
10.0%	£0.00	£19.00	£38.01	£57.01	£76.01	£95.01	£114.02	£133.02	£152.02	£171.03	£190.03
15.0%	£0.00	£28.50	£57.01	£85.51	£114.02	£142.52	£171.03	£199.53	£228.03	£256.54	£285.04
20.0%	£0.00	£38.01	£76.01	£114.02	£152.02	£190.03	£228.03	£266.04	£304.05	£342.05	£380.06
25.0%	£0.00	£47.51	£95.01	£142.52	£190.03	£237.54	£285.04	£332.55	£380.06	£427.56	£475.07
30.0%	£0.00	£57.01	£114.02	£171.03	£228.03	£285.04	£342.05	£399.06	£456.07	£513.08	£570.09
35.0%	£0.00	£66.51	£133.02	£199.53	£266.04	£332.55	£399.06	£465.57	£532.08	£598.59	£665.10
40.0%	£0.00	£76.01	£152.02	£228.03	£304.05	£380.06	£456.07	£532.08	£608.09	£684.10	£760.11
45.0%	£0.00	£85.51	£171.03	£256.54	£342.05	£427.56	£513.08	£598.59	£684.10	£769.62	£855.13
50.0%	£0.00	£95.01	£190.03	£285.04	£380.06	£475.07	£570.09	£665.10	£760.11	£855.13	£950.14
55.0%	£0.00	£104.52	£209.03	£313.55	£418.06	£522.58	£627.09	£731.61	£836.13	£940.64	£1,045.16
60.0%	£0.00	£114.02	£228.03	£342.05	£456.07	£570.09	£684.10	£798.12	£912.14	£1,026.15	£1,140.17
65.0%	£0.00	£123.52	£247.04	£370.56	£494.07	£617.59	£741.11	£864.63	£988.15	£1,111.67	£1,235.19
70.0%	£0.00	£133.02	£266.04	£399.06	£532.08	£665.10	£798.12	£931.14	£1,064.16	£1,197.18	£1,330.20
75.0%	£0.00	£142.52	£285.04	£427.56	£570.09	£712.61	£855.13	£997.65	£1,140.17	£1,282.69	£1,425.21
80.0%	£0.00	£152.02	£304.05	£456.07	£608.09	£760.11	£912.14	£1,064.16	£1,216.18	£1,368.21	£1,520.23
85.0%	£0.00	£161.52	£323.05	£484.57	£646.10	£807.62	£969.15	£1,130.67	£1,292.19	£1,453.72	£1,615.24
90.0%	£0.00	£171.03	£342.05	£513.08	£684.10	£855.13	£1,026.15	£1,197.18	£1,368.21	£1,539.23	£1,710.26
95.0%	£0.00	£180.53	£361.05	£541.58	£722.11	£902.64	£1,083.16	£1,263.69	£1,444.22	£1,624.74	£1,805.27
100.0%	£0.00	£190.03	£380.06	£570.09	£760.11	£950.14	£1,140.17	£1,330.20	£1,520.23	£1,710.26	£1,900.29

Figure E9. Falls reduction and baseline (per 1,000 bed days) two-way sensitivity analysis

Reduction in number of falls	Baseline number of falls (per 1,000 bed days)										
	0.00	2.00	4.00	6.00	8.00	10.00	12.00	14.00	16.00	18.00	20.00
0.0%	£0.00	£0.00	£0.00	£0.00	£0.00	£0.00	£0.00	£0.00	£0.00	£0.00	£0.00
5.0%	£0.00	£73.39	£146.77	£220.16	£293.55	£366.94	£440.32	£513.71	£587.10	£660.49	£733.87
10.0%	£0.00	£146.77	£293.55	£440.32	£587.10	£733.87	£880.65	£1,027.42	£1,174.20	£1,320.97	£1,467.75
15.0%	£0.00	£220.16	£440.32	£660.49	£880.65	£1,100.81	£1,320.97	£1,541.14	£1,761.30	£1,981.46	£2,201.62
20.0%	£0.00	£293.55	£587.10	£880.65	£1,174.20	£1,467.75	£1,761.30	£2,054.85	£2,348.40	£2,641.95	£2,935.50
25.0%	£0.00	£366.94	£733.87	£1,100.81	£1,467.75	£1,834.69	£2,201.62	£2,568.56	£2,935.50	£3,302.43	£3,669.37
30.0%	£0.00	£440.32	£880.65	£1,320.97	£1,761.30	£2,201.62	£2,641.95	£3,082.27	£3,522.60	£3,962.92	£4,403.25
35.0%	£0.00	£513.71	£1,027.42	£1,541.14	£2,054.85	£2,568.56	£3,082.27	£3,595.98	£4,109.70	£4,623.41	£5,137.12
40.0%	£0.00	£587.10	£1,174.20	£1,761.30	£2,348.40	£2,935.50	£3,522.60	£4,109.70	£4,696.79	£5,283.89	£5,870.99
45.0%	£0.00	£660.49	£1,320.97	£1,981.46	£2,641.95	£3,302.43	£3,962.92	£4,623.41	£5,283.89	£5,944.38	£6,604.87
50.0%	£0.00	£733.87	£1,467.75	£2,201.62	£2,935.50	£3,669.37	£4,403.25	£5,137.12	£5,870.99	£6,604.87	£7,338.74
55.0%	£0.00	£807.26	£1,614.52	£2,421.78	£3,229.05	£4,036.31	£4,843.57	£5,650.83	£6,458.09	£7,265.35	£8,072.62
60.0%	£0.00	£880.65	£1,761.30	£2,641.95	£3,522.60	£4,403.25	£5,283.89	£6,164.54	£7,045.19	£7,925.84	£8,806.49
65.0%	£0.00	£954.04	£1,908.07	£2,862.11	£3,816.15	£4,770.18	£5,724.22	£6,678.25	£7,632.29	£8,586.33	£9,540.36
70.0%	£0.00	£1,027.42	£2,054.85	£3,082.27	£4,109.70	£5,137.12	£6,164.54	£7,191.97	£8,219.39	£9,246.81	£10,274.24
75.0%	£0.00	£1,100.81	£2,201.62	£3,302.43	£4,403.25	£5,504.06	£6,604.87	£7,705.68	£8,806.49	£9,907.30	£11,008.11
80.0%	£0.00	£1,174.20	£2,348.40	£3,522.60	£4,696.79	£5,870.99	£7,045.19	£8,219.39	£9,393.59	£10,567.79	£11,741.99
85.0%	£0.00	£1,247.59	£2,495.17	£3,742.76	£4,990.34	£6,237.93	£7,485.52	£8,733.10	£9,980.69	£11,228.27	£12,475.86
90.0%	£0.00	£1,320.97	£2,641.95	£3,962.92	£5,283.89	£6,604.87	£7,925.84	£9,246.81	£10,567.79	£11,888.76	£13,209.74
95.0%	£0.00	£1,394.36	£2,788.72	£4,183.08	£5,577.44	£6,971.80	£8,366.17	£9,760.53	£11,154.89	£12,549.25	£13,943.61
100.0%	£0.00	£1,467.75	£2,935.50	£4,403.25	£5,870.99	£7,338.74	£8,806.49	£10,274.24	£11,741.99	£13,209.74	£14,677.48

Figure E10. Entrapments reduction and baseline (per 1,000 bed days) two-way sensitivity analysis

Reduction in number of entrapments	Baseline number of entrapments (per 1,000 bed days)										
	0.00	0.01	0.02	0.03	0.04	0.05	0.06	0.07	0.08	0.09	0.10
0.0%	£0.00	£0.00	£0.00	£0.00	£0.00	£0.00	£0.00	£0.00	£0.00	£0.00	£0.00
5.0%	£0.03	£1.96	£3.89	£5.82	£7.75	£9.68	£11.61	£13.54	£15.47	£17.39	£19.32
10.0%	£0.07	£3.92	£7.78	£11.64	£15.50	£19.36	£23.21	£27.07	£30.93	£34.79	£38.65
15.0%	£0.10	£5.89	£11.67	£17.46	£23.25	£29.03	£34.82	£40.61	£46.40	£52.18	£57.97
20.0%	£0.13	£7.85	£15.56	£23.28	£31.00	£38.71	£46.43	£54.15	£61.86	£69.58	£77.29
25.0%	£0.17	£9.81	£19.46	£29.10	£38.75	£48.39	£58.04	£67.68	£77.33	£86.97	£96.62
30.0%	£0.20	£11.77	£23.35	£34.92	£46.49	£58.07	£69.64	£81.22	£92.79	£104.37	£115.94
35.0%	£0.23	£13.73	£27.24	£40.74	£54.24	£67.75	£81.25	£94.75	£108.26	£121.76	£135.26
40.0%	£0.26	£15.70	£31.13	£46.56	£61.99	£77.43	£92.86	£108.29	£123.72	£139.15	£154.59
45.0%	£0.30	£17.66	£35.02	£52.38	£69.74	£87.10	£104.47	£121.83	£139.19	£156.55	£173.91
50.0%	£0.33	£19.62	£38.91	£58.20	£77.49	£96.78	£116.07	£135.36	£154.65	£173.94	£193.23
55.0%	£0.36	£21.58	£42.80	£64.02	£85.24	£106.46	£127.68	£148.90	£170.12	£191.34	£212.56
60.0%	£0.40	£23.54	£46.69	£69.84	£92.99	£116.14	£139.29	£162.44	£185.58	£208.73	£231.88
65.0%	£0.43	£25.51	£50.58	£75.66	£100.74	£125.82	£150.89	£175.97	£201.05	£226.13	£251.20
70.0%	£0.46	£27.47	£54.48	£81.48	£108.49	£135.49	£162.50	£189.51	£216.51	£243.52	£270.53
75.0%	£0.50	£29.43	£58.37	£87.30	£116.24	£145.17	£174.11	£203.04	£231.98	£260.92	£289.85
80.0%	£0.53	£31.39	£62.26	£93.12	£123.99	£154.85	£185.72	£216.58	£247.45	£278.31	£309.17
85.0%	£0.56	£33.35	£66.15	£98.94	£131.74	£164.53	£197.32	£230.12	£262.91	£295.70	£328.50
90.0%	£0.59	£35.32	£70.04	£104.76	£139.48	£174.21	£208.93	£243.65	£278.38	£313.10	£347.82
95.0%	£0.63	£37.28	£73.93	£110.58	£147.23	£183.89	£220.54	£257.19	£293.84	£330.49	£367.14
100.0%	£0.66	£39.24	£77.82	£116.40	£154.98	£193.56	£232.14	£270.73	£309.31	£347.89	£386.47