NICE National Institute for Health and Care Excellence

**HIGHLY CONFIDENTIAL**

# HealthTech Programme

## Medical Technologies Advisory Committee (MTAC)

## GID-HTE10050 Bed frames for adults in acute settings: Late-Stage Assessment (LSA) – 2nd meeting

**Thursday 19 December 2024**

Clinical and economic evidence has been submitted to NICE by the companies in RFIs, and an external assessment group report has been completed by the EAG. Alongside this, a user preference report has been produced by NICE.
This pack presents the information required for the MTAC to make draft recommendations on this topic.

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|---|---|
| **Technical analyst:** | Sophie Harrison |
| **Technical adviser:** | Frances Nixon |
| **Committee lead:** | Avril McCarthy |
| **Specialist Committee member lead:** | Evelyn Otunbade<br>Ria Betteridge |
| **EAG leads:** | Robert Malcolm (YHEC)<br>Mary Chappell (YHEC) |
| **Link to SCM list for this topic** | specialist-committee-members-2.pdf |

The following documents are made available to the Committee:

1. Cover sheet
2. Updated External Assessment Report (EAR) – prepared by York Health Economics Consortium (YHEC). Note, this report is an updated version to the one issued to stakeholders on 02 December 2024. The updates are listed on page 5 of the report.
3. Assessment Report Overview (ARO) [NoACIC] – dated Dec 2024
4. EAR consultation comments from stakeholders and EAG responses
5. User preference report [NoACIC] – dated Dec 2024

Document cover sheet

Assessment report: Bed frames for adults in acute settings

EAG team: Hayden Holmes, Lavinia Ferrante Di Ruffano, Mary Chappell, Robert Malcolm, Laura Kelly, Luc Curtis-Gretton, Alice Sanderson, Paul Miller, Maisie Green, Katie Reddish

Project lead(s): Hayden Holmes and Lavinia Ferrante di Ruffano

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Economic evidence reviewer: Hayden Holmes, Robert Malcolm, Laura Kelly, Luc Curtis-Gretton, Maisie Green

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 |
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# 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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Date completed: 12.11.2024

Contains confidential information: Yes

Number of attached appendices: 5

**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

**Acknowledgements**

Copyright belongs to York Health Economics Consortium.

**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.<br><br>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<br>▪ Nurse control unit | ✓ | ▪ Oxygen cylinder holder | ✓ | ✓ | |
| **Apex OOK SNOW Falls bed** | | | | | | | |
| **Apex OOK SNOW mental health bed** | ✓ | ▪ Patient pendant<br>▪ Side-rail controls | ✓ | ▪ Oxygen cylinder holder | | | |
| **Arjo Enterprise 5000 X** | ✓ | ▪ Patient pendant<br>▪ Nurse controls | ✓ | ▪ Oxygen cylinder holder<br>▪ X-ray compartment<br>▪ Catheter bag hooks<br>▪ Drainage bag holder<br>▪ Pull-out linen tray | ✓ | ✓ | ✓ |
| **Arjo Enterprise 8000 X** | ✓ | ▪ Patient pendant<br>▪ Side-rail controls<br>▪ Nurse controls | ✓ | ▪ Oxygen cylinder holder<br>▪ X-ray compartment<br>▪ Catheter bag hooks<br>▪ Drainage bag holder<br>▪ Pull-out linen tray | ✓ | ✓ | ✓ |
| **Arjo Enterprise 9000 X** | ✓ | ▪ Patient pendant<br>▪ Side-rail controls<br>▪ Nurse controls | ✓ | ▪ Oxygen cylinder holder<br>▪ X-ray compartment<br>▪ Catheter bag hooks<br>▪ Drainage bag holder<br>▪ Pull-out linen tray | ✓ | ✓ | ✓ |
| **Baxter Centuris Pro** | ✓ | ▪ Patient pendant<br>▪ 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<br>▪ Drainage bag holder<br>▪ Pull-out linen tray | | | |
| **Baxter Hillrom 900 X2** | ✓ | ▪ Patient pendant<br>▪ Side-rail controls<br>▪ Nurse controls | ✓ | ▪ Oxygen cylinder holder | ✓ | ✓ | ✓ |
| **Baxter Hillrom 900 X3** | ✓ | ▪ Patient pendant<br>▪ Nurse controls<br>▪ Side-rail controls | ✓ | ▪ X-ray compartment<br>▪ oxygen cylinder holder<br>▪ Drainage bag holder<br>▪ Pull-out linen tray | ✓ | ✓ | ✓ |
| **Baxter Accella Hillrom 900** | ✓ | ▪ Patient pendant<br>▪ Side-rail controls<br>▪ Nurse controls | ✓ | ▪ X-ray compartment<br>▪ Oxygen cylinder holder<br>▪ Drainage bag holder<br>▪ Pull-out linen tray | ✓ | ✓ | ✓ |
| **Direct Healthcare Delta 4** | ✓ | ▪ Unspecified | ✓ | ▪ X-ray compartment<br>▪ Oxygen cylinder holder | | | ✓ |
| **Direct Healthcare Lago Hospital** | ✓ | ▪ Side-rail control panel<br>▪ Patent pendant | ✓ | ▪ Oxygen cylinder holder | ✓ | ✓ | ✓ |
| **Drive DeVilbiss Innov8** | ✓ | ▪ Side-rail control panel<br>▪ Patent pendant<br>▪ 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<br>▪ Patent pendant<br>▪ Nurse control unit. | ✓ | ▪ X-ray compartment<br>▪ Pull-out linen tray | ✓ | ✓ | |
| **Linet Eleganza 1** | ✓ | ▪ Side-rail control panel<br>▪ Patent pendant<br>▪ Satellite control panel | ✓ | ▪ Pull-out linen tray | ✓ | ✓ | |
| **Linet Eleganza 2** | ✓ | ▪ Side-rail control panel<br>▪ Nurse control unit | ✓ | ▪ X-ray compartment<br>▪ Pull-out linen tray | ✓ | ✓ | ✓ |
| **Linet Essenza 300** | ✓ | ▪ Side-rail control panel<br>▪ Patent pendant<br>▪ Nurse control unit | ✓ | ▪ X-ray compartment | ✓ | ✓ | ✓ |
| **Linet Essenza 300TL** | ✓ | ▪ Side-rail control panel<br>▪ Patent pendant<br>▪ Nurse control unit | ✓ | ▪ X-ray compartment | ✓ | ✓ | ✓ |
| **Linet Image 3** | ✓ | ▪ Patent pendant<br>▪ Nurse control unit | ✓ | ▪ Pull-out linen tray | ✓ | ✓ | |
| **Medstrom Solo** | ✓ | ▪ Patent pendant | ✓ | ▪ Oxygen cylinder holder<br>▪ Pull-out linen tray | ✓ | ✓ | ✓ |
| **Medstrom Solo+** | ✓ | ▪ Patent pendant<br>▪ Nurse control unit | ✓ | ▪ Oxygen cylinder holder<br>▪ X-ray compartment<br>▪ Drainage bag holder<br>▪ 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<br>▪ Nurse control unit | ✓ | ▪ Oxygen cylinder holder | ✓ | ✓ | ✓ |
| **Medstrom SoloMH** | ✓ | ▪ Patent pendant | | | ✓ | | |
| **OSKA OSKA Florence** | | | | | | ✓ | |
| **Stryker SV2 Electric Hospital Bed** | ✓ | ▪ Side-rail control panel<br>▪ Patent pendant<br>▪ Nurse control unit | ✓ | ▪ Oxygen cylinder holder<br>▪ X-ray compartment<br>▪ Pull-out linen tray<br>▪ Foley bag hooks | ✓ | ✓ | |
| **Stryker ProCuity™ L model** | ✓ | ▪ Side-rail control panel<br>▪ Nurse control unit | ✓ | ▪ Foley bag hooks | ✓ | ✓ | |
| **Stryker ProCuity™ LE model** | ✓ | ▪ Side-rail control panel<br>▪ Nurse control unit | ✓ | ▪ Foley bag hooks | ✓ | ✓ | |
| **Stryker ProCuity™ Z model** | ✓ | ▪ Side-rail control panel<br>▪ Nurse control unit | ✓ | ▪ Foley bag hooks | ✓ | ✓ | |
| **Talley Group IMO Matrix E30** | ✓ | ▪ Side-rail control panel<br>▪ Patient pendant<br>▪ Nurse control unit | ✓ | ▪ X-ray compartment<br>▪ Oxygen cylinder holder<br>▪ Pull-out linin tray | ✓ | ✓ | ✓ |
| **Talley Group IMO Matrix U24** | ✓ | ▪ Patient pendant<br>▪ Nurse control unit | ✓ | ▪ X-ray compartment<br>▪ 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)<br><br>**Location:** Australia<br>**Setting:** Public hospital wards | **Design:** Cluster RCT.<br><br>**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.<br><br>**Comparator:** Regular beds.<br><br>**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.<br><br>Wards were matched based on rate of falls.<br><br>**Intervention group (n=9) comprised:**<br>Five standalone regional hospitals<br>Two acute medicine wards<br>One rehabilitation ward<br>One orthopaedic ward<br><br>**Control group (n=9) comprised:**<br>Seven standalone regional hospitals<br>One rehabilitation ward<br>One general surgery ward | • Number of falls.<br>• Rate of falls per 1,000 occupied bed days per ward per month.<br>• Rate of falls with documented injury.<br>• Rate of falls resulting in head injury.<br>• Rate of falls in the bedroom per 1,000 occupied bed days per ward per month.<br>• 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.<br><br>Generalisability: Used in different wards, not only in an acute setting.<br><br>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)<br><br>**Location:** USA<br>**Setting:** Laboratory study in a university setting | **Design:** Prospective, experimental laboratory design (abstract).<br><br>**Intervention:**<br>Bed A: as the head-of-bed was raised the head section pivot slid backward while the head section simultaneously extended in length.<br>Bed B: the head section did not lengthen, and the pivot did not slide.<br>Bed C: the head section did not lengthen and pivoted at 2 hinge points that did not slide.<br><br>**Comparator:** study compared 3 different types of bed.<br><br>**Sample size:** 12<br>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.<br>• 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.<br><br>Generalisability: Took place in a laboratory setting using ICU beds.<br><br>Small sample size. |
| Davis 2015<br>(Davis & Kotowski, 2015)<br><br>**Location:** USA | **Design:** Prospective, experimental laboratory design.<br><br>**Intervention:**<br>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.<br><br>**Females** | • Net displacement.<br>• Cumulative movement.<br>• Torso compression.<br>• Perceived sliding.<br>• 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.<br>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.<br>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.<br>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.<br><br>**Comparator:** Study compared 4 different types of bed.<br><br>**Sample size:** 12<br>Each articulation condition was repeated 5 times in a random order. | Mean (SD) age, years:<br>35 (11.5)<br>Mean (SD) height, cm:<br>164.9 (5.9)<br>Mean (SD) weight. kg:<br>63.1 (14.1)<br><br>**Males**<br>Mean (SD) age, years:<br>23.8 (9.7)<br>Mean (SD) height, cm:<br>175.8 (9.5)<br>Mean (SD) weight. kg:<br>77.3 (11.2) | • Subject preference ranking. | measured were subjective.<br><br>Generalisability: Took place in a laboratory setting using ICU beds.<br><br>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.<br>• 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<br>**Setting:** Laboratory study in a university setting | **Intervention:**<br>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.<br>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.<br>Bed C: (Linet Multicare) had a simple stationary head pivot in which the head-of-bed section pivots around when articulated upward.<br>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.<br><br>**Comparator:** Study compared 4 different types of bed.<br><br>**Sample size:** 20<br>Single measurements made per participant per bed. | a Modified Barthel Index. Each patient was positioned in all 4 beds.<br><br>Patients were 16 females and 4 males with clinical diagnoses that reduced mobility level.<br><br>**Female patients**<br>**Mean (SD) age (years):** 55.2 (7.7)<br>**Mean (SD) height (cm):** 163.2 (7.2)<br>**Mean (SD) weight (kg):** 88.6 (24.4)<br>**Modified Barthel Index subscore (transfer):** 7.8 (3.0)<br>**Modified Barthel Index subscore (ambulation):**<br>5.9 (4.8)<br><br>**Male patients**<br>**Mean (SD) age (years):** 54.2 (17.0)<br>**Mean (SD) height (cm):** 182.5 (4.1)<br>**Mean (SD) weight (kg):** 113.6 (27.4) | • Perception of sliding.<br>• 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.<br><br>Generalisability: Took place in a laboratory setting using ICU beds.<br><br>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)<br>**Modified Barthel Index subscore (ambulation):** 4.0 (4.6) | | |
| Lustig 2020 (Lustig et al., 2020)<br><br>Location: NR<br><br>Setting: NR (laboratory study – ICU bed frame) | **Design:** Prospective, experimental laboratory design.<br><br>**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.<br><br>**Comparator:** Conventional bed without migration reduction technology (not specified).<br><br>**Sample size:** 10 healthy subjects<br>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).<br>**Mean (SD)**<br>**Height:** 1.72 (0.08), range 1.60 to 1.85 m<br>**Bodyweight**: 91.8 (24.3), range 62 to 144 kg<br>**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.<br><br>Generalisability: Took place in a laboratory setting using ICU bed.<br><br>Small sample size. |

| Study name and location | Design and intervention(s) – including bed feature | Participants | Outcomes | EAG comments |
|---|---|---|---|---|
| Rush 2018 (Rush, 2018)<br><br>**Location:** UK<br>**Setting:** NR (laboratory study) | **Design:** Prospective, experimental laboratory design.<br><br>**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.<br><br>**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.<br>**Sample size:** 1 | 1 healthy female, no other information given. | • Net migration.<br>• 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.<br><br>Generalisability: Took place in a laboratory setting on 8 beds (7 acute, 1 short-term care).<br><br>Only 1 participant was evaluated. |
| **Brake location and steering assistance** | | | | |
| Kim 2009<br>(Kim et al., 2009)<br><br>**Location:** USA | **Design:** Prospective, experimental laboratory design.<br><br>**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:<br>• Trunk flexion angle.<br>• Task completion time.<br>• 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<br>Bed B: Brake centrally located (brakeside), fifth wheel activated.<br><br>**Comparator:** For bed B, fifth wheel deactivated (patient transportation task only).<br><br>**Sample size:** 18<br>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.<br><br>**Mean (SD) age, years:** 31.8 (4.4)<br>**Mean (SD) weight, kg:** 67.4 (12.2)<br>**Mean (SD) height, cm:** 172.3 (8.8)<br><br>**Transportation task:**<br>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.<br><br>**Mean (SD) age, years:** 32 (4.2)<br>**Mean (SD) weight, kg:** 67.4 (12.2)<br>**Mean (SD) height, cm:** 171.8 (9) | • Whole body postural comfort.<br>• Confidence in using the brake system.<br><br>Patient transportation task (weights applied to simulate a patient):<br>• Hand forces.<br>• Overall physical demands.<br>• 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.<br><br>Small sample size. |

| Study name and location | Design and intervention(s) – including bed feature | Participants | Outcomes | EAG comments |
|---|---|---|---|---|
| Medstrom 2021 (Medstrom, 2021)<br><br>**Location:** NR<br>**Setting:** NR (laboratory study) | [redacted]<br><br>[redacted]<br>[redacted]<br><br>[redacted]<br>[redacted] | [redacted] | [redacted] | Study was judged to have an unclear risk of bias<br>[redacted] |
| **Power-drive/drive-assist** | | | | |
| Kotowski 2022 (Kotowski et al., 2022)<br><br>**Location:** USA<br>**Setting:** NR (laboratory study) | **Design:** Prospective, experimental laboratory design.<br><br>**Intervention:**<br>Standard medical-surgical bed (Advanta bed) with power-drive engaged<br>Transport stretcher bed with power-drive engaged.<br><br>**Comparator:**<br>Standard medical-surgical bed (Advanta bed) without power-drive engaged.<br>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.<br><br>**Males:**<br>Mean age, years: 25.8<br>Mean weight, kg: 70.2<br>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):<br>• Spine loading.<br>• Perceived exertion. | Study was judged to have a low risk of bias.<br><br>Generalisability: took place in a laboratory setting on a standard medical-surgical bed and stretcher. Tasks conducted by inexperienced general population.<br><br>Small sample size. |

| Study name and location | Design and intervention(s) – including bed feature | Participants | Outcomes | EAG comments |
|---|---|---|---|---|
| | **Sample size:** 12<br>Each condition was repeated twice. | **Females:**<br>Mean age, years: 28.5<br>Mean weight, kg: 65.2<br>Mean height, cm: 146.0 | | |
| Matz 2018 (Matz & Morgan, 2018)<br><br>**Location:** Sweden<br>**Setting:** NR (laboratory study) | **Design:** Prospective, experimental laboratory design.<br><br>**Intervention:**<br>4 Arjo beds with Power Assist Module (IndiGo drive):<br>Citadel bed frame system<br>Enterprise 5000x<br>Enterprise 8000x<br>Enterprise 9000x<br><br>**Comparator:**<br>4 Arjo beds without Power Assist module:<br>Citadel bed frame system<br>Enterprise 5000x<br>Enterprise 8000x<br>Enterprise 9000x<br><br>**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).<br>• Work reduction when accelerating up 4-degree slopes (target >40% reduction).<br>• Work reduction when decelerating on a flat surface (target >15% reduction).<br>• 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.<br><br>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<br>(Schneider et al., 2012)<br>(Associated publication (Schneider et al., 2012))<br><br>**Location:** Australia<br>**Setting:** ICU | **Design:** Prospective cohort study.<br><br>**Intervention:** Two electronic beds with inbuilt weighing scales (Hill-Rom Avant Guard 1600 and Total Care bed systems).<br><br>**Comparator:** Fluid balance charting.<br><br>**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).<br><br>**Median (IQR) age, years:** 69 (23)<br>**Male gender n (%):** 96 (63.6)<br>**Duration of ICU stay, days (IQR):** 5 (5.9)<br>**Intubated n (%):** 56 (35)<br>**In ICU mortality n (%):** 12 (7.9) | • Correlation between body weight from fluid balance and bed weighing.<br>• Changes in body weight from bed weighing and fluid balance. | Study was judged to have a low risk of bias.<br><br>Generalisability: Weighing function tested in critically ill patients. |
| Schneider 2013 (Schneider et al., 2013)<br><br>**Location:** Australia<br>**Setting:** ICU | **Design:** Prospective cohort study.<br><br>**Intervention:** Electronic beds with weighing capabilities (Hill-Rom Versacare bed systems).<br><br>**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).<br><br>**Median (IQR) age, years:** 68 (60.6 to 76) | • Correlation of body weight by electronic beds with conventional scales.<br>• Correlation of body weight between fluid balance and bed weighing.<br>• Cumulative fluid balance and overall | Study was judged to have a low risk of bias.<br><br>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)<br>**Median (IQR) duration of ICU stay, days:** 2 (2 to 3)<br>**Median (IQR) duration of mechanical ventilation, hours:** 8 (6 to 11)<br>**ICU mortality n (%):** 1 (1)<br>Weight, mean (SD)<br>Weight on ICU admission (electronic bed scale, kg; n=52): 84.6 (19.3)<br>Weight on ICU discharge (electronic bed scale, kg; n=85): 85.7 (19.1)<br>Weight on ICU discharge (conventional bed scale, kg): 85.6 (18.6) | change in bed weight. | |
| **Inbuilt bed exit alarm** | | | | |
| Seow 2022<br>(Seow et al., 2022a)<br><br>**Location:** Singapore | **Design:** Comparative cross-sectional study.<br><br>**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).<br><br>**Sample size:** 17,398 | exit alarm) from July 2016 to June 2017.<br><br>**Mean (SD) age:** 63 (16)<br>**Male gender n (%):** 9,066 (52)<br>**Mean (SD) length of stay, days:** 6 (7.5) | | Generalisability: Applicable to an acute setting.<br><br>Large sample size. |
| **Turn assist** | | | | |
| Budarick 2020a (Aleksandra R. Budarick et al., 2020)<br><br>**Location:** Canada<br>**Setting:** NR (laboratory study – ICU bed surfaces) | **Design:** Prospective, experimental laboratory design.<br><br>**Intervention:**<br>Stryker Isolibrium support surface and Hill-Rom Progressor Pulmonary surface with turn-assist activated.<br><br>**Comparator:**<br>Stryker Isolibrium support surface and Hill-Rom Progressor Pulmonary surface without turn-assist activated (patients were turned using a manual technique).<br><br>**Sample size:** 25 healthy individuals<br>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.<br><br>**Average age, mean (SD):** 25 years (6.6), range 18 to 51 years<br>**Average height, mean (SD):** 1.74m (0.1)<br>**Average weight, mean (SD):** 80.2kg (25.9), range 38.2 to 135.9 kg<br><br>Two trained patient handlers performed each turn. | • Interface pressure (contact area, average and peak pressure).<br>• 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.<br><br>Generalisability: ICU beds were used for the experiment.<br><br>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)<br><br>**Location:** Canada<br>**Setting:** NR (laboratory study – ICU bed surfaces) | **Design:** Prospective, experimental laboratory design.<br><br>**Intervention:**<br>Stryker Isolibrium support surface and Hill-Rom Progressor Pulmonary surface with turn-assist activated.<br><br>**Comparator:**<br>Stryker Isolibrium support surface and Hill-Rom Progressor Pulmonary surface without turn-assist activated (patients were turned using a manual technique).<br><br>**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.<br><br>Two caregivers performed each turn.<br><br>Healthy participant (for turning) was a $50^{th}$ percentile male patient (body mass = 82 kg; height 1.85 m) | • Hand force.<br>• Movement strategy (shoulder flexion/extension angle, spine flexion/extension angle).<br>• 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.<br><br>Generalisability: ICU beds were used for the experiment.<br><br>Took place in a laboratory setting. |
| Wiggermann 2016<br>(Wiggermann, 2016)<br><br>**Location:** USA | **Design:** Prospective, experimental laboratory design.<br><br>**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.<br><br>**Sample size:**<br>9 nurses<br>2 healthy participants<br>Each experimental condition measured once at each side of the bed. | **Nurses**<br>Mean height (SD): 165 cm (5.3 cm)<br>Mean weight (SD): 69.5 kg (15.3 kg)<br><br>**Healthy participant 1:**<br>Height: 170 cm<br>Weight: 63 kg<br><br>**Healthy participant 2:**<br>Height: 165 cm<br>Weight: 123 kg | horizontal hand distance). | Generalisability: An ICU bed was used for the experiment.<br><br>Took place in a laboratory setting. |
| Zhou 2021 (Zhou & Wiggermann, 2021)<br><br>**Location:** USA<br>**Setting:** NR (laboratory study – surgical hospital bed) | **Design:** Prospective, experimental laboratory design.<br><br>**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.<br><br>**Comparator:** Draw sheet without assisted feature.<br><br>**Sample size:**<br>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.<br><br>**Nurses**<br>Mean (SD) height: 169.8 cm (7.6 cm)<br>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.<br><br>Generalisability: A medical-surgical bed was used for the experiment.<br>Took place in a laboratory setting. |

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

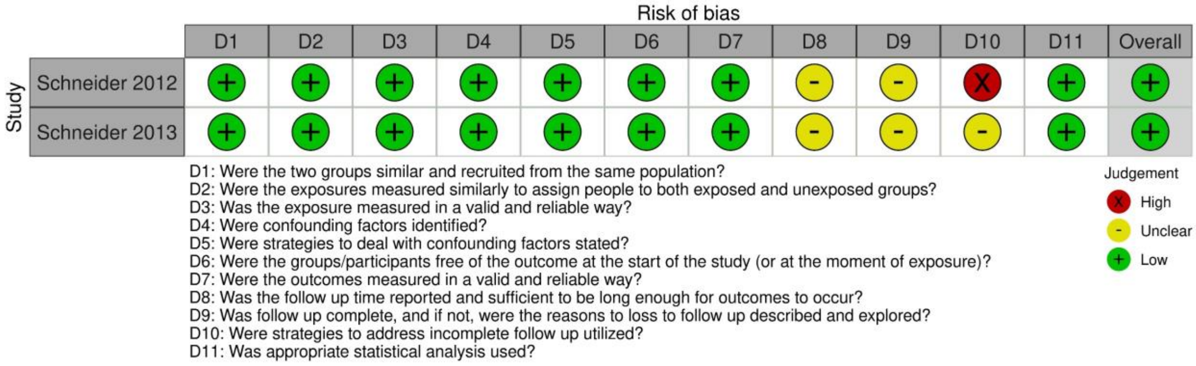
The following section reports the formal risk of bias assessment for the 14 included studies. Full risk of bias assessments can be found in Appendix D.

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).

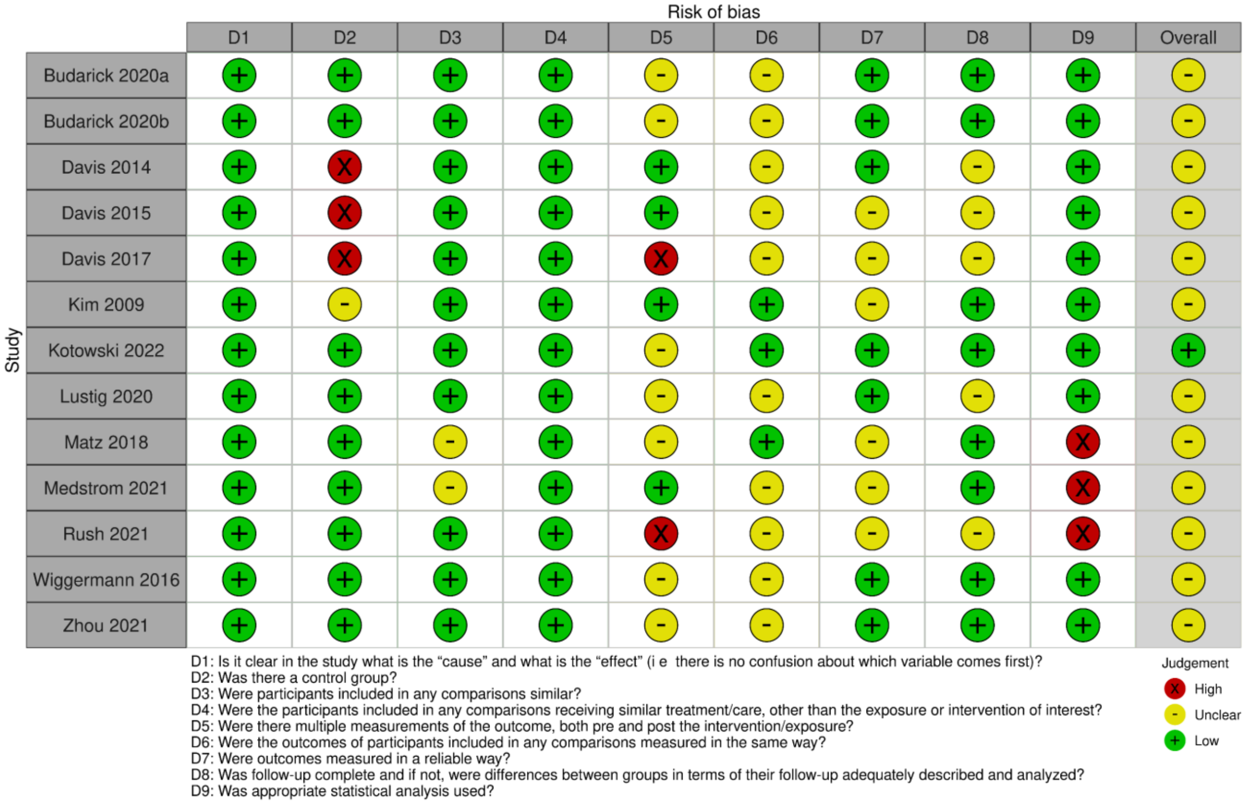
One comparative cross-sectional study was judged to have high risk of bias (Seow et al., 2022a) (Figure 5.4). Thirteen studies were judged to have some concerns/unclear risk of bias: 1 cluster RCT (Haines et al., 2010) (Figure 5.3), and 12 laboratory studies (A. R. Budarick et al., 2020; Aleksandra R. 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

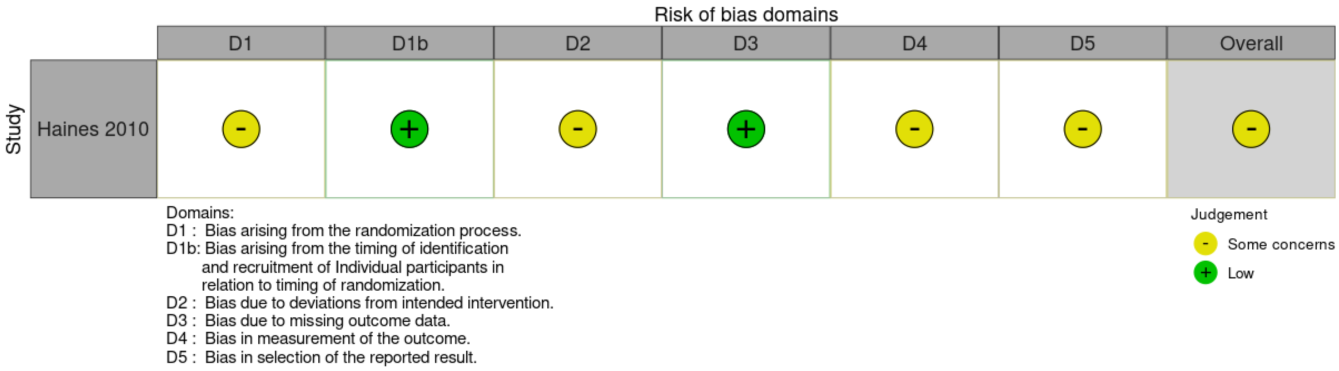
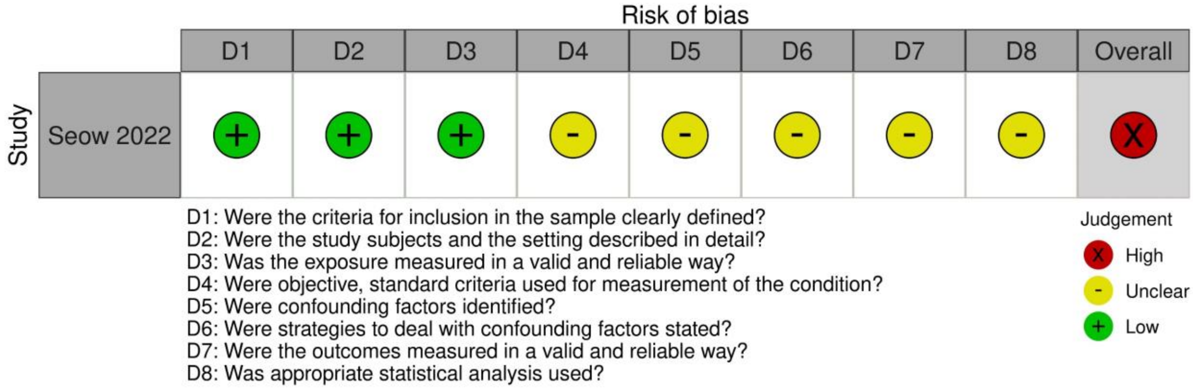


**Figure 5.4: Risk of bias in the cross-sectional study**




### *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)<br><br>**Location:** Australia<br>**Setting:** Public hospital wards | **Design:** Cluster RCT.<br><br>**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.<br><br>**Comparator:** Regular beds.<br><br>**Sample size:** 18 wards, 10,937 admissions. | **Number of falls**<br>Intervention group:<br>Preintervention: 257; Postintervention: 186<br>Control group:<br>Preintervention: 154; Postintervention: 114<br><br>**Falls per 1,000 occupied bed days, n**<br>Intervention group:<br>Preintervention: 7.1; Postintervention: 5.25<br>Control group:<br>Preintervention: 5.14; Postintervention: 3.77<br><br>**Falls per 1,000 occupied bed days, median (IQR)**<br>Intervention group:<br>Preintervention: 5.9 (2.0 to 8.7); Postintervention: 4.6 (2.6 to 7.8)<br>Control group:<br>Preintervention: 3.6 (1.5 to 10.0); Postintervention: 2.5 (1.1 to 5.6)<br>Group-by-period interaction effect, GEE coefficient (95% CI): 0.23 (-0.18 to 0.65) p=0.28<br>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 |
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| | | **Falls in the bedroom, n**<br>Intervention group:<br>Preintervention: 170; Postintervention: 109<br>Control group:<br>Preintervention: 100; Postintervention: 67<br><br>**Falls in bedroom per 1,000 occupied bed days, median (IQR)**<br>Intervention group:<br>Preintervention: 3.7 (0 to 6.6); Postintervention: 2.2 (0 to 4.3)<br>Control group:<br>Preintervention: 2.1 (0 to 5.3); Postintervention: 1.7 (0 to 3.8)<br>Group-by-period interaction effect, GEE coefficient (95% CI): 0.38 (-0.30 to 1.06) p=0.27<br>Per protocol comparison, group-by-period interaction effect, GEE coefficient (95% CI): 0.48 (-0.26 to 1.21) p=0.21<br><br>**Falls with injury, n**<br>Intervention group:<br>Preintervention: 84; Postintervention: 85<br>Control group:<br>Preintervention: 63; Postintervention: 51<br><br>**Falls with injury per 1,000 occupied bed days, median (IQR)**<br>Intervention group:<br>Preintervention: 1.5 (0 to 3.5); Postintervention: 1.7 (0 to 3.7)<br>Control group: | |

| Study name and location | Design and intervention(s) – including bed feature | Results | Author conclusions |
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| | | Preintervention: 1.7 (0 to 3.2); Postintervention: 1.2 (0 to 3.7)<br>Group-by-period interaction effect, GEE coefficient (95% CI): 0.30 (-0.39 to 0.99) p=0.39<br>Per protocol comparison, group-by-period interaction effect, GEE coefficient (95% CI): 0.37 (-0.39 to 1.12) p=0.34<br><br>**Falls with head injury, n**<br>Intervention group:<br>Preintervention: 7; Postintervention: 6<br>Control group:<br>Preintervention: 3; Postintervention: 2<br><br>**Falls with fracture, n**<br>Intervention group:<br>Preintervention: 0; Postintervention: 1<br>Control group:<br>Preintervention: 3; Postintervention: 1 | |
| **Design for preventing migration** | | | |
| Davis 2014 (Davis et al., 2014)<br><br>**Location:** USA<br>**Setting:** Laboratory study in a university setting | **Design:** Prospective, experimental laboratory design.<br><br>**Intervention:**<br>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:**<br>Bed A: 1.6<br>Bed B: 9.9<br>Bed C: 10.5<br>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 |
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| | backward while the head section simultaneously extended in length.<br>Bed B: the head section did not lengthen, and the pivot did not slide.<br>Bed C: the head section did not lengthen and pivoted at 2 hinge points that did not slide.<br><br>**Comparator:** NR, study compared 3 different types of bed.<br><br>**Sample size:** 12<br>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:**<br>Bed A: 5.3<br>Bed B: 6.8<br>Bed C: 8.1<br>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<br>(Davis & Kotowski, 2015)<br><br>**Location:** USA | **Design:** Prospective, experimental laboratory design.<br><br>**Intervention:** | **Net displacement (head-of-bed up)**<br>Mean (SD) trochanter migration distance at the upright position, 0-30-0 degrees, cm:<br>Bed A: 1.28 (2.18)<br>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 |
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| **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.<br>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.<br>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.<br>Bed D: (Stryker InTouch with XPRT mattress) | Bed C: 6.46 (1.54)<br>Bed D: 6.76 (1.60)<br>Trochanter migrated significantly more on beds C and D: p<0.0001<br><br>Mean (SD) trochanter migration distance at the upright position, 0-45-0 degrees, cm:<br>Bed A: 1.51 (1.12)<br>Bed B: 3.34 (1.49)<br>Bed C: 9.90 (3.14)<br>Bed D: 10.57 (2.36)<br>Trochanter migrated significantly more on beds C and D: p<0.0001<br><br>Mean (SD) ankle migration distance at the upright position, 0-30-0 degrees, cm:<br>Bed A: 1.63 (2.21)<br>Bed B: 2.05 (1.26)<br>Bed C: 6.79 (1.80)<br>Bed D: 7.10 (1.48)<br>Ankle migrated significantly more on beds C and D: p<0.0001<br><br>Mean (SD) ankle migration distance at the upright position, 0-45-0 degrees, cm:<br>Bed A: 1.61 (2.19)<br>Bed B: 3.57 (1.59)<br>Bed C: 9.91 (2.68)<br>Bed D: 10.49 (2.03) | elongate and slide backward. |

| Study name and location | Design and intervention(s) – including bed feature | Results | Author conclusions |
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| | 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.<br><br>**Comparator:** Study compared 4 different types of bed.<br><br>**Sample size:** 12<br>Each articulation condition was repeated 5 times in a random order. | Ankle migrated significantly more on beds C and D: $p<0.0001$<br><br>**Net displacement (returned to flat)**<br>Mean (SD) trochanter migration distance at the end of articulation, 0-30-0 degrees, cm:<br>Bed A: 0.85 (0.83)<br>Bed B: 0.48 (0.56)<br>Bed C: 1.45 (0.96)<br>Bed D: 0.89 (0.78)<br>Bed B had lower migration than beds C and D: $p<0.01$<br><br>Mean (SD) trochanter migration distance at the end of articulation, 0-45-0 degrees, cm:<br>Bed A: 1.22 (1.16)<br>Bed B: 1.14 (1.72)<br>Bed C: 2.32 (1.61)<br>Bed D: 1.08 (1.10)<br>Bed B had lower migration than beds C and D: $p<0.01$<br><br>Mean (SD) ankle migration distance at the end of articulation, 0-30-0 degrees, cm:<br>Bed A: 1.18 (1.70)<br>Bed B: 0.74 (0.73)<br>Bed C: 1.70 (1.31)<br>Bed D: 0.93 (0.93)<br>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 |
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| | | Mean (SD) ankle migration distance at the end of articulation, 0-45-0 degrees, cm:<br>Bed A: 1.34 (1.27)<br>Bed B: 1.17 (1.08)<br>Bed C: 2.59 (1.86)<br>Bed D: 1.31 (1.22)<br>Bed B had lower migration than beds C and D: p<0.01<br><br>**Cumulative movement**<br>Mean (SD) trochanter cumulative migration distance, 0-30-0 degrees, cm:<br>Bed A: 4.74 (4.10)<br>Bed B: 5.29 (1.41)<br>Bed C: 11.94 (2.52)<br>Bed D: 13.09 (2.75)<br>Beds C and D had significantly higher cumulative migration than beds A and B: p<0.0001<br><br>Mean (SD) trochanter cumulative migration distance, 0-45-0 degrees, cm:<br>Bed A: 7.45 (2.36)<br>Bed B: 7.70 (2.33)<br>Bed C: 18.25 (5.50)<br>Bed D: 20.49 (4.15)<br>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 |
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| | | Mean (SD) ankle cumulative migration distance, 0-30-0 degrees, cm:<br>Bed A: 6.97 (3.13)<br>Bed B: 8.20 (1.69)<br>Bed C: 12.47 (2.77)<br>Bed D: 13.57 (2.25)<br>Beds C and D had significantly higher cumulative migration than beds A and B: p<0.001<br><br>Mean (SD) ankle cumulative migration distance, 0-45-0 degrees, cm:<br>Bed A: 8.40 (3.39)<br>Bed B: 10.67 (3.00)<br>Bed C: 18.24 (3.79)<br>Bed D: 20.19 (3.54)<br>Beds C and D had significantly higher cumulative migration than beds A and B: p<0.001<br><br>**Torso compression**<br>Mean (SD) torso compression, 0-30-0 degrees, cm:<br>Bed A: 3.74 (1.08)<br>Bed B: 4.70 (1.31)<br>Bed C: 4.44 (1.97)<br>Bed D: 5.67 (1.04)<br>Bed A had significantly less torso compression than the other beds: p<0.001<br>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 |
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| | | Mean (SD) torso compression, 0-45-0 degrees, cm:<br>Bed A: 5.24 (1.62)<br>Bed B: 6.89 (2.28)<br>Bed C: 6.72 (1.96)<br>Bed D: 8.01 (1.48)<br>Bed A had significantly less torso compression than the other beds: $p<0.001$<br>Bed D had significantly more torso compression than bed A, B or C: $p<0.001$<br><br>**Perceived sliding**<br>Mean (SD) score for perception of sliding (scale: 0—no sliding to 10—a lot, moved many inches), 0-30-0 degrees:<br>Bed A: 1.22 (0.67)<br>Bed B: 1.28 (0.64)<br>Bed C: 2.07 (0.82)<br>Bed D: 2.12 (0.76)<br>Beds A and B were perceived to have significantly less sliding than beds C and D: $p<0.0001$<br><br>Mean (SD) score for Perception of sliding (scale: 0—no sliding to 10—a lot, moved many inches), 0-45-0 degrees:<br>Bed A: 1.43 (0.62)<br>Bed B: 1.72 (0.56)<br>Bed C: 2.63 (0.90) | |

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

| Study name and location | Design and intervention(s) – including bed feature | Results | Author conclusions |
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| | | Bed B: 2/12<br>Bed C: 1/12<br>Bed D: 0/12<br><br>Least preferred bed:<br>Bed A: 0/12<br>Bed B: 1/12<br>Bed C: 1/12<br>Bed D: 10/12 | |
| Davis 2017 (Davis et al., 2017)<br><br>**Location:** USA<br>**Setting:** Laboratory study in a University setting | **Design:** Prospective, experimental laboratory design.<br><br>**Intervention:**<br>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.<br>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**<br>Bed A: 3.6 (0.6)<br>Bed B: 5.8 (1.0)<br>Bed C: 13.2 (1.3)<br>Bed D: 13.8 (1.1)<br>Beds A and B had significantly less migration than beds C and D: $p<0.05$<br><br>**Mean (SD) active migration (ankle) after head-of-bed elevation, cm**<br>Bed A: 5.1 (0.9)<br>Bed B: 5.7 (0.7)<br>Bed C: 10.2 (1.0)<br>Bed D: 12 (1.0)<br>Beds A and B had significantly less migration than beds C and D: $p<0.05$<br><br>**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 |
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| | head section during the raising of the head-of-bed.<br>Bed C: (Linet Multicare) had a simple stationary head pivot in which the head-of-bed section pivots around when articulated upward.<br>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.<br><br>**Comparator:** NR, study compared 4 different types of bed.<br><br>**Sample size:** 20<br>Single measurements made per participant per bed. | Bed A: 5 (8)<br>Bed B: 7.5 (1.4)<br>Bed C: 19.6 (1.7)<br>Bed D: 16 (1.4)<br>Beds A and B had significantly less migration than beds C and D: $p<0.05$<br><br>**Mean (SD) total passive migration (ankle) at 2 hours, cm**<br>Bed A: 8.8 (1.9)<br>Bed B: 8.8 (1.3)<br>Bed C: 17.1 (1.7)<br>Bed D: 14.1 (1.2)<br>Beds A and B had significantly less migration than beds C and D: $p<0.05$<br><br>**Mean passive migration following active migration (trochanter), cm:**<br>Bed A: 1.4<br>Bed B: 1.7<br>Bed C: 6.4<br>Bed D: 2.2<br>Beds A, B and D had significantly lower migration than bed C: $p<0.05$<br><br>**Mean passive migration following active migration (ankle), cm:**<br>Bed A: 3.7<br>Bed B: 3.1<br>Bed C: 6.9<br>Bed D: 2.1 | |

| Study name and location | Design and intervention(s) – including bed feature | Results | Author conclusions |
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| | | Beds A, B and D had significantly lower migration than bed C: $p<0.05$<br><br>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)<br><br>**Torso compression**<br>Greatest for bed B, lowest for bed D.<br>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.<br><br>**Mean (SD) score for perception of sliding at 2-hours (0=none, 10=sliding many inches)**<br>Bed A: 2.4 (0.4)<br>Bed B: 2.0 (0.3)<br>Bed C: 6.3 (0.6)<br>Bed D: 3.7 (0.7)<br>Bed C was significantly higher for perceived sliding than beds A and B: $p<0.05$<br>There was no significant difference in perceived sliding between beds A, B and D<br><br>**Mean (SD) rating of discomfort at 2-hours (0=none, 10 = unbearable pain)**<br>Bed A: 2.2 (0.4) | |

| Study name and location | Design and intervention(s) – including bed feature | Results | Author conclusions |
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| | | Bed B: 2.3 (0.4)<br>Bed C: 5.8 (0.6)<br>Bed D: 3.1 (0.5)<br>Bed C was significantly higher for discomfort than beds A and B: p<0.05 | |
| Lustig 2020 (Lustig et al., 2020)<br><br>Location: NR<br><br>Setting: NR (laboratory study) | **Design:** Prospective, experimental laboratory design.<br><br>**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.<br><br>**Comparator:** Conventional bed without migration reduction technology (not specified).<br><br>**Sample size:** 10 healthy subjects.<br>Each test was repeated twice, which equalled 8 | **Trochanter migration**<br>**Head of bed elevation 45º:**<br>Conventional bed: mean 7 (SD 2.7) cm<br>Migration reduction technology bed: mean 4.0 (SD 1.9) cm<br>P<0.001 for the comparison<br><br>**Head of bed elevation 65º:**<br>Conventional bed: mean 7.5 (SD 3.7) cm<br>Migration reduction technology bed: mean 4.7 (SD 1.6) cm<br>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 |
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| | tests per participant (2 bed types, 2 HOB angles and 2 repetitions). | | |
| Rush 2018 (Rush, 2018)<br><br>**Location:** UK<br>**Setting:** NR (laboratory study) | **Design:** Prospective, experimental laboratory design.<br><br>**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.<br><br>**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.<br><br>**Sample size:** 1 participant testing beds, 1 measurement | **Net migration**<br>Without auto-contour function deactivated (head of bed up only):<br>• beds 1-8: 10 to 20.3cm heel migration<br><br>With auto-contour function activated:<br>• beds 1-6 and 8: 8.8 to 17.7cm heel migration<br>• bed 7 (MMO 500): 0 cm heel migration<br><br>**Patient comfort**<br>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 |
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| | for each bed condition. | | |
| **Brake location and steering assistance** | | | |
| Kim 2009<br>(Kim et al., 2009)<br><br>**Location:** USA<br>**Setting:** NR (laboratory study) | **Design:** Prospective, experimental laboratory design.<br><br>**Intervention:** 2 hospital beds.<br>Bed A: brake located at the head-end (BrakeHead) and foot-end (BrakeFoot)<br>Bed B: Brake centrally located (BrakeSide), fifth wheel activated.<br><br>**Comparator:** For bed B, fifth wheel deactivated (in-bed transportation task only).<br><br>**Sample size:** 18<br>A set of 10 replications of brake engagement was conducted in each of 6 conditions. For patient transportation | **Brake engagement task**<br>**Mean (SD) maximum trunk flexion angle (degrees):**<br>BrakeHead: 68 (27)<br>BrakeFoot: 39 (35)<br>BrakeSide: 21 (8)<br>Brake pedal location significantly affected maximum trunk flexion angle: $p<0.0001$<br><br>**Task completion time:**<br>Brakehead: Increased completion times by 53% to 74% compared with either brakefoot or brakeside (brake pedal location had significant effects on task completion time: $p<0.0001$)<br>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: $p=0.0085$)<br><br>**Perceived overall difficulty (questionnaire responses):**<br>Difference in brake pedal location had a significant impact on perceived difficulty: $p=0.0018$<br>Difference in hand condition had a significant impact on perceived difficulty: $p=0.0008$<br><br>**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 |
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| | (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<br>Difference in hand condition had a significant impact on perceived postural comfort: p=0.0084<br><br>**Confidence in using the brake system (questionnaire responses):**<br>Difference in brake pedal location had a significant impact on perceived confidence: p=0.0049<br>Difference in hand condition had a significant impact on perceived confidence: p=0.0087<br><br>**Patient transportation task (in-room transportation)**<br>**Pulling-out phase**<br>No difference in peak hand force for fifth wheel activated vs. fifth wheel deactivated: p= 0.39<br><br>**Pushing-in phase**<br>No difference in peak hand force for fifth wheel activated vs. fifth wheel deactivated: p=0.50<br><br>**Confidence in controlling bed movements (questionnaire responses):**<br>Difference in confidence for fifth wheel activated vs. fifth wheel deactivated : p=0.044<br><br>**Patient transportation task (corridor transportation)**<br>**Overall physical demands (questionnaire responses)** | |

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

| Study name and location | Design and intervention(s) – including bed feature | Results | Author conclusions |
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| **Power-drive/drive-assist** | | | |
| Kotowski 2022 (Kotowski et al., 2022)<br><br>**Location:** USA<br>**Setting:** NR (laboratory study) | **Intervention:**<br>Standard medical-surgical bed (Advanta bed) with power-drive engaged.<br>Transport stretcher bed with power-drive engaged.<br><br>**Comparator:**<br>Standard medical-surgical bed (Advanta bed) without power-drive engaged.<br>Transport stretcher bed without power-drive engaged.<br><br>**Sample size:** 12<br>Each condition was repeated twice. | **During patient transportation tasks:**<br>**Spine loading**<br>Power-drive vs. no power-drive:<br>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 ($p<0.05$).<br><br>Decrease in lateral shear for power-drive compared with no power-drive, reduction in newtons (%):<br>Bed: 200 (21)<br>Stretcher: 45 (6)<br><br>Decrease in A-P shear for power-drive compared with no power-drive, reduction in newtons (%):<br>Bed: 120 (8)<br>Stretcher: 125 (7)<br><br>Compression reduction for power-drive compared with no power-drive, in newtons (%):<br>Bed: 700 (17)<br>Stretcher: 270 (7)<br><br>Patient weight had no direct impact on spinal loads.<br><br>**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<br>No power-drive for the bed: 11<br>Stretcher power-drive: 8.9<br>No power-drive for the stretcher: 10<br><br>Transport tasks, highest rating of perceived exertion:<br>Up the ramp without power-drive: 11.7<br>Corner without power-drive: 10.6<br>Down the ramp without power-drive: 10.6<br><br>Transport tasks, lowest rating of perceived exertion:<br>Straight with power-drive: 9.2<br>Down the ramp with power-drive: 9.3 | |
| Matz 2018 (Matz & Morgan, 2018)<br><br>**Location:** Sweden<br>**Setting:** NR (laboratory study) | **Design:** Prospective, experimental laboratory design.<br><br>**Intervention:**<br>4 Arjo beds with Power Assist Module (IndiGo drive):<br>1. Citadel bed frame system<br>2. Enterprise 5000x | Mean work reduction with IndiGo drive compared with without IndiGo drive when accelerating on a flat surface (target >15% reduction)<br>Citadel*: 30.1%<br>Enterprise 9000x: 20.5%<br>Enterprise 8000x: 16.6%<br>Enterprise 5000x: 29.5%<br><br>Mean work reduction with IndiGo drive compared with without IndiGo drive when decelerating on a flat surface (target >15% reduction)<br>Citadel*: 55.8%<br>Enterprise 9000x: 53.6%<br>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.<br><br>Unlike bed power drive systems used in |

| Study name and location | Design and intervention(s) – including bed feature | Results | Author conclusions |
|---|---|---|---|
| | 3. Enterprise 8000x<br>4. Enterprise 9000x<br><br>**Comparator:**<br>4 Arjo beds without Power Assist module: Citadel bed frame system:<br>1. Enterprise 5000x<br>2. Enterprise 8000x<br>3. Enterprise 9000x<br><br>**Sample size:** NR (4 different test set-ups were analysed, 3 measurements per set-up). | Enterprise 5000x: 50.2%<br><br>Mean work reduction with IndiGo drive compared with without IndiGo drive when accelerating up 4-degree slopes (target >40% reduction)<br>Citadel*: 60.1%<br>Enterprise 9000x: 50.7%<br>Enterprise 8000x: 43.1%<br>Enterprise 5000x: 49.5%<br><br>Mean work reduction with IndiGo drive compared with without IndiGo drive while decelerating down 4-degree slopes (target >40% reduction)<br>Citadel*: 72.7%<br>Enterprise 9000x: 64.4%<br>Enterprise 8000x: 59.4%<br>Enterprise 5000x: 66.9%<br><br>*Citadel is the heaviest bed frame<br>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<br>(Schneider et al., 2012) | **Design:** Prospective cohort study.<br><br>**Intervention:** 2 electronic beds with | **Successful body weight measurements n (%):** 160/504 (31.7)<br><br>**Correlation between body weight from fluid balance and bed weighing:**<br>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<br>**Setting:** ICU | inbuilt weighing scales (Hill-Rom Avant Guard 1600 and Total Care bed systems).<br><br>**Comparator:** Fluid balance charting.<br><br>**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)<br>Bland-Altman:<br>Mean bias: 0.07 kg (95% interval of agreement (-5.9 to 6.0 kg)<br><br>**Difference in measurements, n (%)**<br>Difference by more than 3L (kg): 102 data pairs (24.2)<br>Difference by more than 7L (kg): 20 data pairs (4.7)<br><br>**Disagreement between data pairs, n (%)**<br>Less than 10%:<br>27 data pairs (6.9% of nonnull differences)<br>10% to 25%: 19 pairs (4.8)<br>25% to 50%: 36 pairs (9.1)<br>50% to 100%: 135 pairs (34.4)<br>>100%: 176 pairs (44.8)<br><br>**Changes in body weight from bed weighing and fluid balance:**<br>Same direction: 243 (57.4%) of 423 observations | reproducible daily weighing of ICU patients is feasible. |
| Schneider 2013 (Schneider et al., 2013)<br><br>**Location:** Australia<br>**Setting:** ICU | **Design:** Prospective cohort study.<br><br>**Intervention:** Electronic beds with weighing capabilities (Hill-Rom | **Correlation of body weight by electronic beds with conventional scales**: r = 0.98; P <0.001<br>Bland-Altman limits of agreement: −7.6 to 7.6 kg<br><br>**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).<br><br>**Comparator:** Regular weighing scales and fluid balance charting.<br><br>**Sample size:** 103 | Correlation between 12-hourly changes: r = 0.28; 95% CI, 0.17 to 0.39; p<0.001<br>After correction for insensible fluid losses: r = 0.27; 95% CI, 0.15 to 0.38; p<0.001<br>Values obtained in intubated patients: r = 0.34; 95% CI, 0.16 to 0.49; p<0.001<br>Bland-Altman:<br>Mean bias: 0.12 kg (95% agreement interval: −3.3 to 3.5 kg<br><br>**Cumulative fluid balance and overall change in bed weight, mean (SD):**<br>Correlation between cumulative fluid balance and overall changes in bed weight: r = 0.36; p<0.001<br>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.<br><br>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<br>(Seow et al., 2022a)<br><br>**Location:** Singapore<br>**Setting:** Acute tertiary teaching hospital | **Design:** Comparative cross-sectional study.<br><br>**Intervention:** Hill-Rom 1000 Medical-Surgical bed with in-built 3-mode bed exit alarm.<br><br>**Comparator:** NR (study explored before and | **Falls incidence:**<br>July 2016 (when bed exit alarm was first introduced): 0.23% (95% CI: 0.10% to 0.51%)<br>December 2016 (6-months post-implementation): 0.11% (95% CI: 0.05% to 0.25%)<br>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.<br>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).<br><br>**Sample size:** 17,398 | | mode/limits based on patient profiles. |
| **Turn assist** | | | |

| | | | |
|---|---|---|---|
| Budarick 2020 (Aleksandra R. Budarick et al., 2020)<br><br>**Location:** Canada<br>**Setting:** NR (laboratory study – ICU bedframes/surfaces) | **Design:** Prospective, experimental laboratory design.<br><br>**Intervention:**<br>Stryker Isolibrium support surface and Hill-Rom Progressor Pulmonary surface with turn-assist activated.<br><br>**Comparator:**<br>Stryker Isolibrium support surface and Hill-Rom Progressor Pulmonary surface without turn-assist activated (patients were turned using a manual technique).<br><br>**Sample size:** 25 healthy individuals<br>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**<br>Upper body region:<br>Difference between surfaces (Stryker vs. Hill-Rom surface): p<0.001,<br>Lower body region:<br>Difference between surfaces (Stryker vs. Hill-Rom surface): p<0.001,<br><br>Turn-assist (maximum inflation):<br>Average turn angle, Stryker: 6.98 degrees over the recommended 30 degrees<br>Average turn angle, Hill-Rom: 14.68 degrees below the recommended angle<br><br>Manual turn (final position):<br>Average turn angle, Stryker: 2.5 degrees below the recommended 30 degrees<br>Average turn angle, Hill-Rom: 5.41 degrees below the recommended angle<br><br>Manual turning produced more optimal (closer to 30 degrees) turn angles than both turn-assist surfaces and higher repeatability.<br><br>**Pressure distribution: Contact area (initial time point)**<br><br>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)<br>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)<br>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)<br><br>**Pressure distribution: Contact area (final time point)**<br><br>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)<br>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)<br>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)<br>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).<br><br>**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)<br>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)<br>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)<br><br>**Average pressure (maximum inflation) – initial time point**<br><br>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)<br>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)<br><br>**Average pressure (final time point)**<br><br>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<br>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).<br><br>**Peak pressure (initial position)**<br>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).<br>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)<br><br>**Peak pressure (maximum inflation)**<br><br>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)<br>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)<br><br>**Peak pressure (final time)**<br>Pairwise comparisons did not reveal significant differences between any 2 pairs. | |

| | | | |
|---|---|---|---|
| Budarick 2020b (A. R. Budarick et al., 2020)<br><br>**Location:** Canada<br>**Setting:** NR (laboratory study – ICU bed surfaces) | **Design:** Prospective, experimental laboratory design.<br><br>**Intervention:**<br>Stryker Isolibrium support surface and Hill-Rom Progressor Pulmonary surface with turn-assist activated.<br><br>**Comparator:**<br>Stryker Isolibrium support surface and Hill-Rom Progressor Pulmonary surface without turn-assist activated (patients were turned using a manual technique).<br><br>**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)**<br>Manual turning – 204 newtons (102 applied by each hand)<br>97% of the 105-newton maximum acceptable<br>Turn-assist – 0 newtons<br><br>**Hand force - turn-toward (pulling patient toward their body)**<br>Manual and turn-assist: 62 newtons (31 applied by each hand)<br>18% of the 176 newton maximum acceptable hand force<br><br>**Shoulder flexion/extension angle**<br>Turn away: manual turn required less shoulder flexion than turn-assist turns<br>Turn towards: manual turn required more shoulder flexion than turn-assist turns<br><br>**Shoulder movements**<br>Turn away: turn-assist reduced shoulder moments about the left and right shoulders compared to a manual turn.<br><br>**Compression for at L4/L5 spine**<br>Turn away: Turn assist resulted in more compression force compared to a manual turn.<br>Turn toward: Conversely, turn-assist decreased compression force compared to a manual turn.<br><br>**Anteroposterior shear force at L4/L5 spine**<br>Turn away: No difference between turn-assist and manual turn.<br>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.<br>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)<br><br>**Location:** USA<br>**Setting:** NR (laboratory study – ICU bed frame) | **Design:** Prospective, experimental laboratory design.<br><br>**Intervention:** Hill-Rom TotalCare ICU bed frame equipped with a Sp02rt+ mattress with turn assist activated.<br><br>**Comparator:** Hill-Rom TotalCare ICU bed frame equipped with a Sp02rt+ mattress with turn assist not activated.<br><br>**Sample size:**<br>9 nurses<br>2 healthy participants<br>Each experimental condition measured once at each side of the bed. | **Effects of turn assist for turning and lateral repositioning**<br><br>**Mean (SD) peak hand force (newtons), 63 kg patient:**<br>Turning:<br>Manual: 109 (13.8)<br>Turn assist: 70 (20.1)<br>Comparison: $p<0.001$<br><br>Lateral repositioning:<br>Manual: 340 (40)<br>Turn assist: 253 (25)<br>Comparison: $p<0.001$<br><br>**Mean (SD) peak spine compression force (newtons), 63 kg patient:**<br>Turning:<br>Manual: 459 (63)<br>Turn assist: 391 (67)<br>Comparison: $p<0.001$<br><br>Lateral repositioning:<br>Manual: 382 (180)<br>Turn assist: 278 (93)<br>Comparison: $p<0.05$<br><br>**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:<br>Manual: 235 (8.5)<br>Turn assist: 193 (9.1)<br>Comparison: p<0.001<br><br>Lateral repositioning:<br>Manual: 431 (17.0)<br>Turn assist: 352 (12.9)<br>Comparison: p<0.001<br><br>**Patient weight**<br><br>**Mean (SD) peak spine compression force (newtons), 123 kg patient:**<br>Turning:<br>Manual: 2474 (247)<br>Turn assist: 1956 (239)<br>Comparison: p<0.001<br><br>**Mean (SD) horizontal distance of the hands from L4/L5 when the maximum hand force was generated (mm), 63 kg patient:**<br>Manual: 605 (89)<br>Turn assist: 488 (145)<br>Comparison: p<0.001<br><br>**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)<br>Turn assist: 409 (118)<br>p<0.001<br><br>**Mean (SD) peak hand force (newtons), 123 kg patient:**<br>Turning:<br>Manual: 556 (56)<br>Turn assist: 440 (54)<br>Not significant | |
| Zhou 2021 (Zhou & Wiggermann, 2021)<br><br>**Location:** USA<br>**Setting:** NR (laboratory study – surgical hospital bed) | **Design:** Prospective, experimental laboratory design.<br><br>**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.<br><br>**Comparator:** Draw sheet without assisted feature. | **Effects of assistive features (ANOVA vs. no assistive features)**<br>**Boosting**<br>Trendelenberg:<br>Peak spinal L5/S1 compressive load: p=0.001<br>Peak hand force: p<0.001<br>Both favour Trendelenberg<br><br>**Lateral repositioning**<br>Turn assist:<br>Peak spinal L5/S1 compressive load: p=0.03<br>Peak hand force: p<0.001<br>Both favour turn assist<br><br>**Turning**<br>Turn assist:<br>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.<br>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:**<br>10 caregivers<br>2 healthy participants<br>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 **Error! Reference source not found.**).

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. **Error! Reference source not found.**

Figure 7.1 and Figure 7.2 outlines the modelling approach.

**Figure 7.1: Cost-utility model structure**

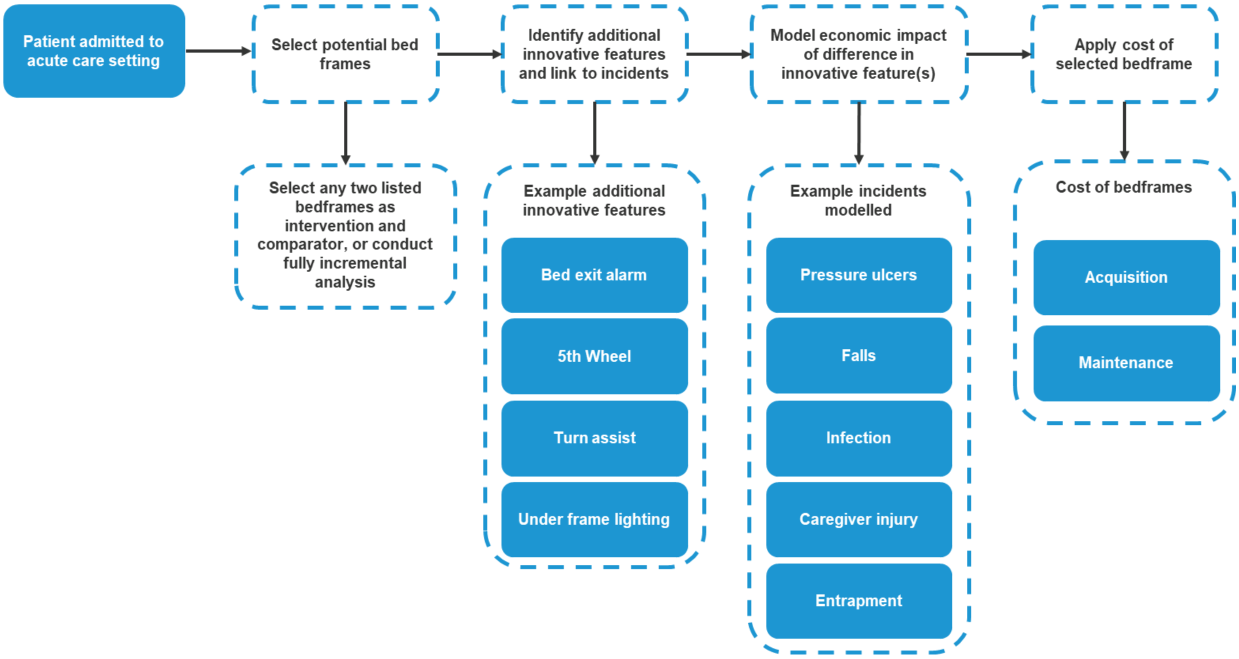
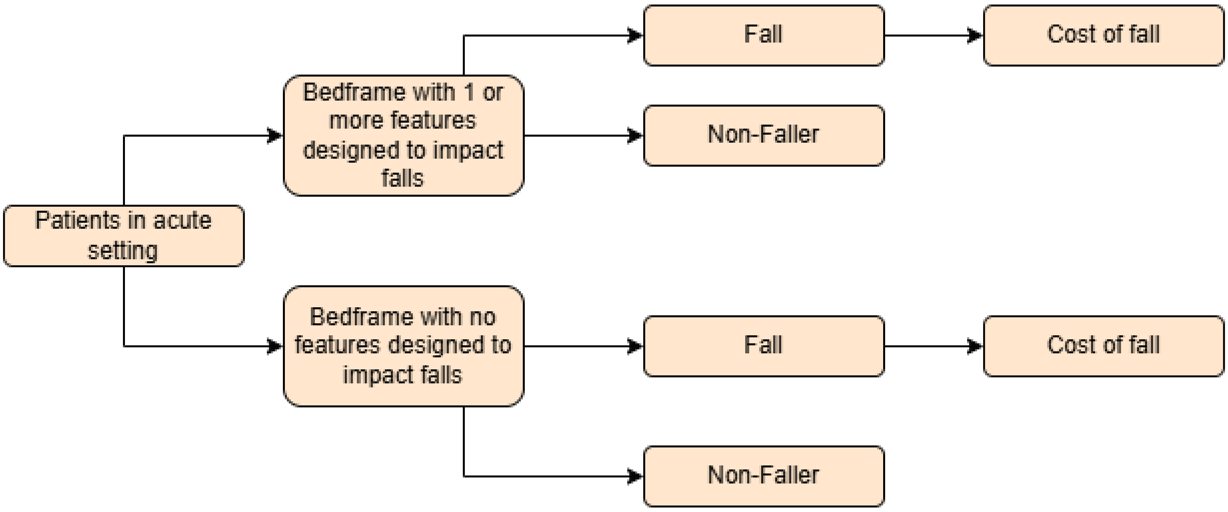



**Figure 7.2: Example of approach to modelling economic outcomes of feature**




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.<br><br>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.<br><br>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.<br><br>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.<br><br>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).<br><br>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 | 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 |

| 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)<br>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.<br>1553/203 = 7.65 hours worked per working day. |
| Additional patient bed day cost | £503 | (NHS Improvement, 2020)<br>Price inflated to 2023. (PSSRU, 2024b) | Archived 2017/2018 reference costs and guidance. Elective inpatient excess bed days cost = £431.<br>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.<br><br>Inflated to 2023 costing values using PSSRU inflation indices.<br><br>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.<br><br>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.

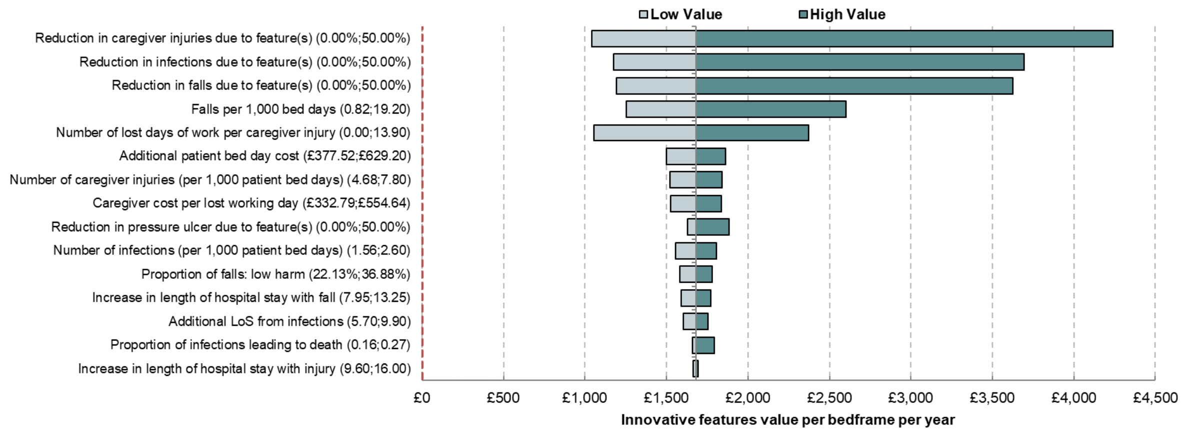
The analysis suggests the key drivers of the model results are:

- 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.

# 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,kw 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*)):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:

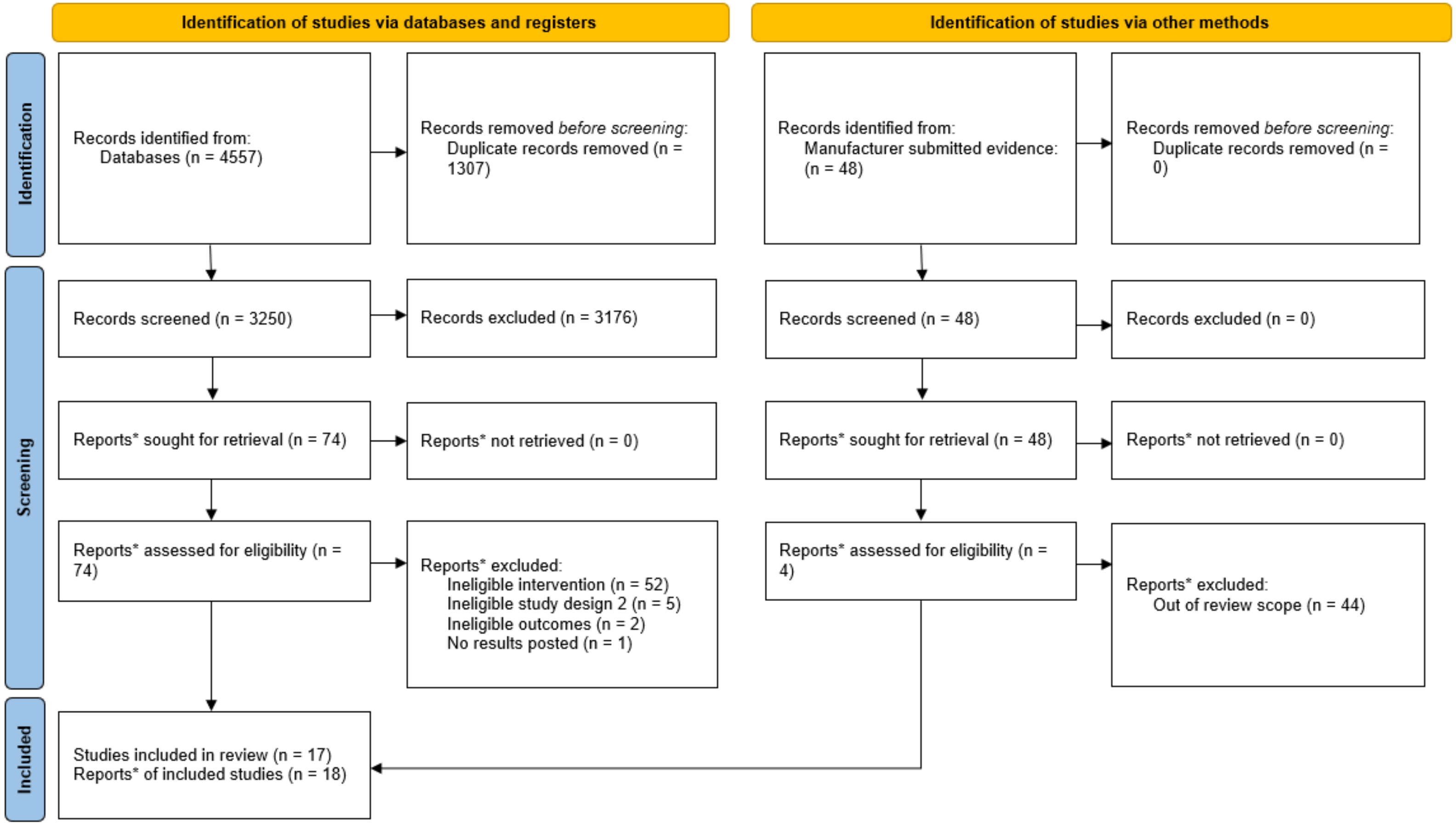
A pragmatic decision was taken in relation to translation of search lines #1 and #10. The field codes for these lines were retained to increase specificity.

| | | |
|---|---|---|
| #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 | | | | |
|---|---|---|---|---|---|
| | **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** | | | | |
| | **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.<br><br>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 If N/PN/NI to 3.1a or 3.1b: Is there evidence that the result was not biased by missing data?** | **3.3 If N/PN to 3.2 Could missingness in the outcome depend on its true value?** | **3.4 If Y/PY/NI to 3.3: 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<br>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. | | measure d 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**

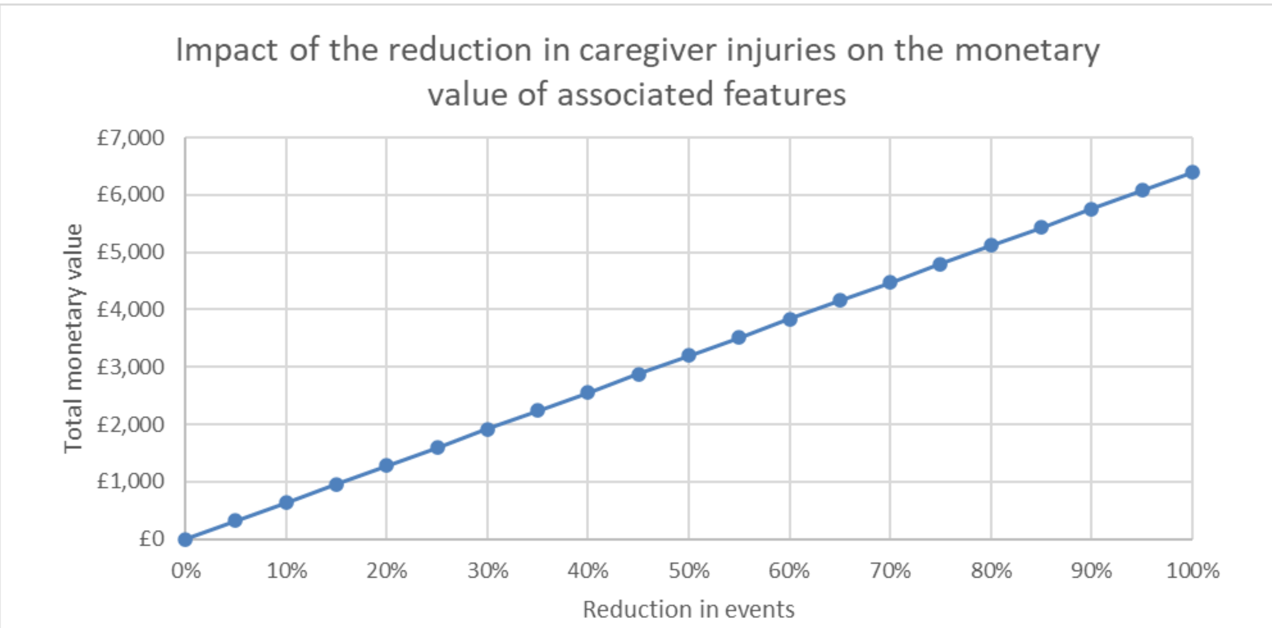


**Figure E2. Infections one-way sensitivity analysis**

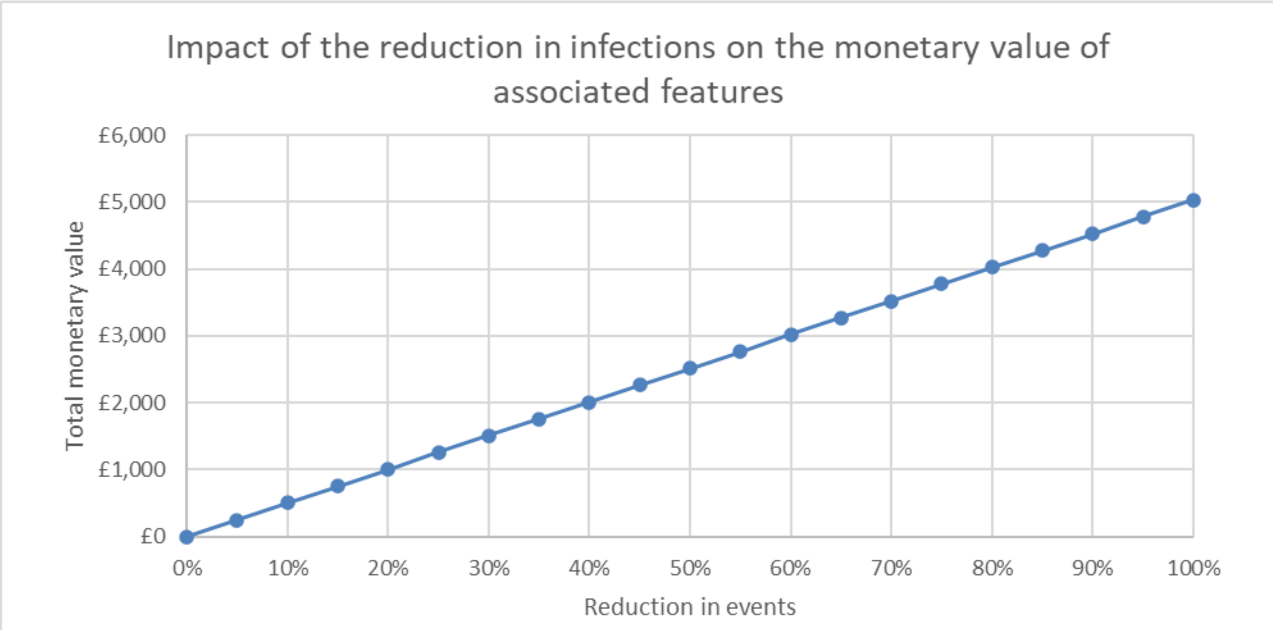



**Figure E3. Pressure ulcers one-way sensitivity analysis**

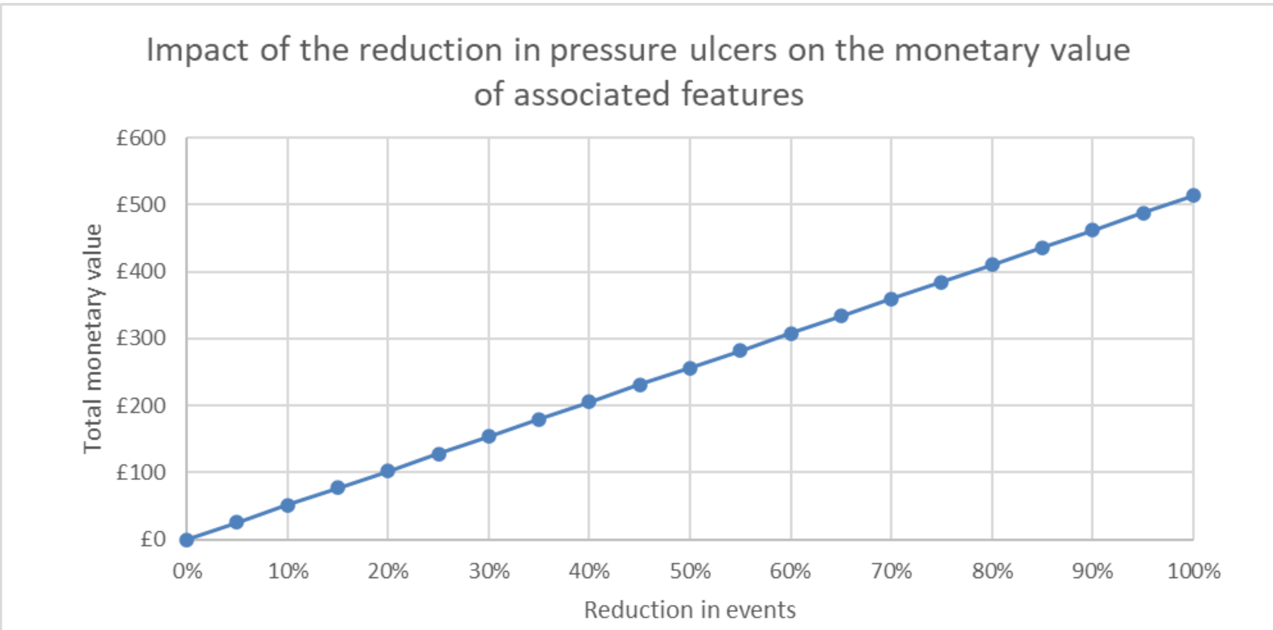


**Figure E4. Falls one-way sensitivity analysis**

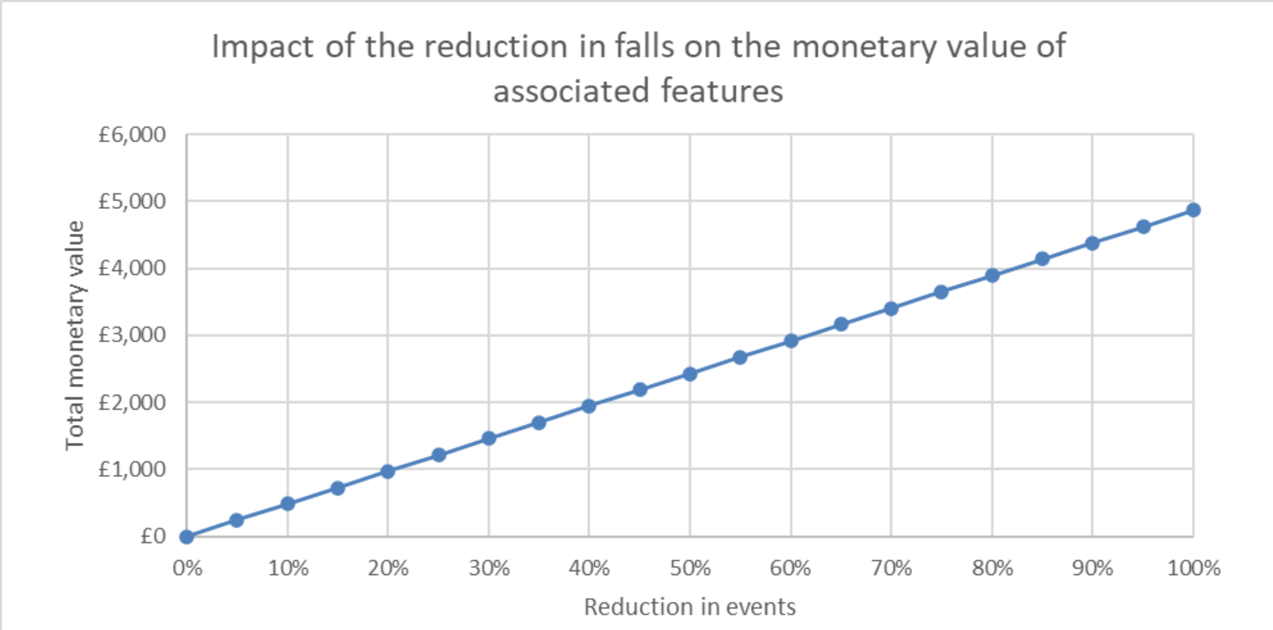
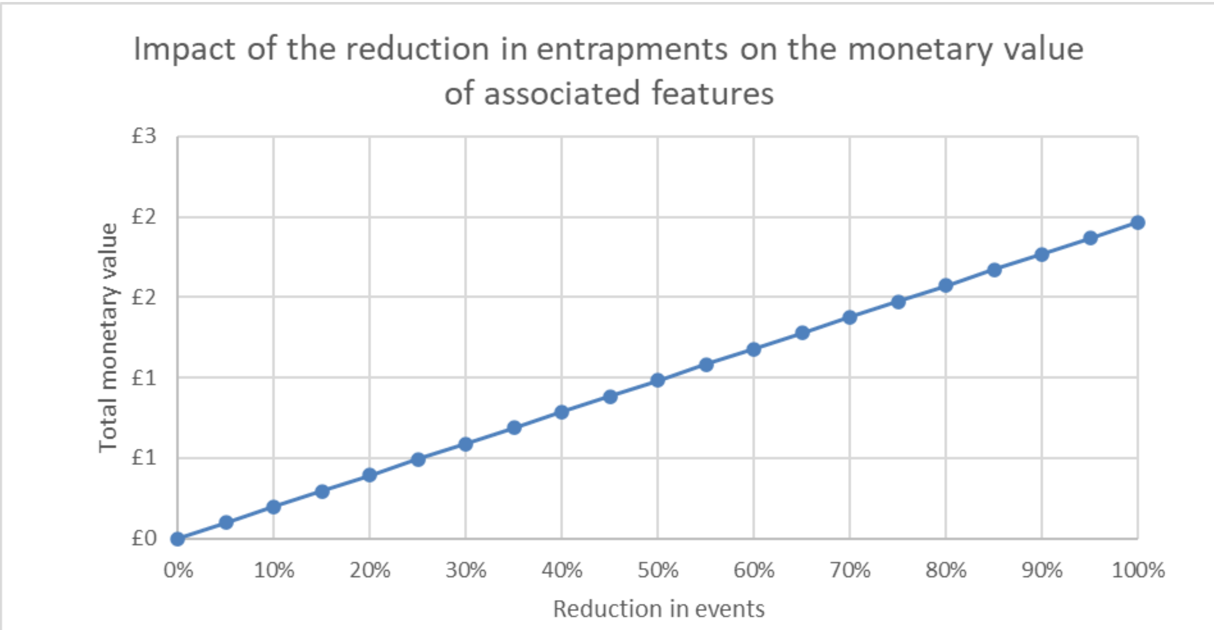



**Figure E5. Entrapments one-way sensitivity analysis**



## 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 |

NICE National Institute for Health and Care Excellence

## Late-stage assessment

# Bed frames for adults in acute settings

## Assessment report overview

This overview summarises key information from the assessment and sets out points for discussion in the committee meeting. It should be read together with the final scope, the external assessment report and the user preference report. List of abbreviations used in this overview is in appendix A.

## The technology

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

- Acute medical units (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.

There are 117 different acute bed frames and accessories currently available for purchase through NHS Supply Chain. All bed frames included in the assessment were available on NHS Supply Chain framework for Pressure Area Care and Patient Handling and were deemed to meet the minimum safety standards and legislation.

**Table 1: bed frames in-scope of this assessment.**

| Company | Product name |
|---|---|
| Apex | OOK SNOW ward bed, OOK SNOW falls bed, OOK SNOW mental health bed |
| Arjo | Enterprise 5000 X, Enterprise 8000 X, Enterprise 9000 X |
| Baxter | Centuris Pro X2, Hillrom 900 X2 (B2), Hillrom 900 X3 (C2), Accella Hillrom 900 |
| Direct Healthcare | Delta 4, Lago Hospital |
| Drive DeVilbiss | Innov8 |
| Innova Care | Interlude V3 |
| Linet | Eleganza 1, Eleganza 2, Essenza 300, Essenza 300LT, Image 3 |
| Medstrom | Solo, Solo+, SoloMH, Luxe |
| OSKA | OSKA Florence |
| Stryker | SV2 Electric Hospital Bed, ProCuity Bed Series |
| Talley Group | IMO Matrix E30, IMO Matrix U24 |

## Innovative aspects

This assessment is focussed on the innovative features of acute bed frames for adults. In the Department of Health and Social Care medical technology innovation classification framework, it is said that “for a device to be defined as an innovation it should demonstrate an incremental improvement, be a novel application or is a novel device that meets an unmet clinical need or provides improvements upon existing technology or models of care”.

The key considerations for a bed frame decision making process within a Trust were identified during the scoping workshop:

- Patient safety (falls, entrapment, respiratory function)
- Caregiver safety (entrapment, musculoskeletal injuries from repositioning patients and from moving the hospital bed)
- Adaptability
- Infection prevention

- Ease of use
- Facilitation of recovery, independence and rehabilitation
- Comfort
- Sustainability
- Maintenance and repair
- Connectivity

Innovative bed frame features were then identified and categorised according to the key considerations they could help to address. The anticipated benefits of innovative features are available in Table 2.8 of the external assessment report (EAR). Some of the innovative features identified may be able to help to address more than 1 of the key considerations. Full detail of the innovative bed frame features identified are in the final scope and user preference report. The innovative features of each bed frame in-scope of this assessment, organised by key consideration, are available in Tables 2.1 to 2.7 of the EAR.

## Clinical effectiveness

The external assessment group (EAG) did targeted literature searches to identify relevant published clinical evidence reporting on features of bed frame design in acute hospital settings, and their associated impact on incidents such as falls or pressure ulcers. The search and selection methods are in section 4.1 of the external assessment report (EAR). Additionally, the EAG considered literature that was submitted to NICE by bed frame companies in-scope of the assessment. Due to the limited amount of evidence identified during early scoping searches, the EAG took measures to broaden the review eligibility criteria to increase the number of eligible studies. This meant including:

- Studies conducted in intensive care units (ICUs)
- Studies conducted in any setting and population (for 'technical outcomes' derived from proof-of-concept studies)
- Conference abstracts

These measures are explained further in section 4.2 of the EAR.

## Overview of key studies

The EAG identified 14 studies (in 15 publications) which were eligible for inclusion in the review using the broadened eligibility criteria. Eleven studies (in 12 publications) were identified in the EAG's search, and 3 of the included studies were submitted by companies.

There was 1 cluster randomised controlled trial (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., 2022). The remaining 10 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; Matz & Morgan, 2018; Medstrom, 2021; Rush, 2021). Only 1 study was conducted in the UK (Rush, 2021). There was only 1 study which met the decision problem (Seow et al, 2022). It was considered that the other 13 included studies did not meet the decision problem, mainly due to the setting (taking place in an ICU, different non-acute ward or laboratory setting). See section 5.1.1 of the EAR.

The 14 included studies provided evidence on 8 innovative bed frame features:

- Low bed height position of 28.5cm from the ground (Haines et al., 2010)
- Bed frame designs for preventing patient migration (Davis et al., 2014; Davis & Kotowski, 2015; Davis et al., 2017; Rush, 2021)
- Alternative brake location (Kim et al., 2009)
- Steering assistance (fifth wheel, front caster lock or double bogie castor, Kim et al., 2009 and Medstrom, 2021)
- Power-drive (Kotowski et al., 2022; Matz & Morgan, 2018)
- In-built weighing scales (Schneider et al., 2012; Schneider et al., 2013)
- Bed exit alarms (Seow et al., 2022)
- Turn-assist (Wiggermann, 2016; Zhou & Wiggermann, 2021).

## Features with evidence for incidents

### Bed exit alarms

There was 1 innovative bed frame feature with evidence considered relevant to the decision problem, this was bed exit alarms. The 1 key study (Seow et al., 2022) found an adjusted odds ratio for pre- versus post-implementation falls of 0.50 (95% CI 0.27 to 0.94), suggesting that the use of bed exit alarm systems may be associated with a decrease in the incidence of falls. This study was found to have a high risk of bias, such that the EAG concluded that the benefit of bed exit alarms is unclear. See section 5.2.1.3 of the EAR.

### Low bed height position

The EAG identified 1 study that evaluated the effect of a low bed height position (minimum height of 28.5cm) on fall rates in public hospital wards (acute and rehabilitation) (Haines et al., 2010). The study concluded that the introduction of the beds with a low height position did not appear to reduce falls or falls with injury. However, there were some concerns regarding the risk of bias for this study and a lack of generalisability, and as such the EAG concluded that this study does not provide robust evidence that a low bed height position does not reduce falls. See section 5.2.1.1 of the EAR.

## Features with evidence for technical outcomes

Evidence for other innovative features reported ‘technical’ outcomes rather than reporting incidents such as falls or pressure ulcers directly. These studies may demonstrate proof-of-principle of some of these bed frame features, however there was no evidence identified which linked technical outcomes with incident rates.

### Brake location and steering assistance

The EAG identified 1 laboratory study (Kim et al., 2009) that evaluated whether brake pedal location influenced risk factors for low back disorders, work efficiency, perception of postural comfort and usability. This study found that head-of-bed brake location increased task completion time compared with side or foot-end brake locations. Head-of-bed brakes were reported as being more difficult to use and less comfortable than side or foot-end brakes, with participants feeling more confident using a brake located at the side of the bed. In this same study, participants were asked about steering assistance (fifth wheel and/or front wheel caster lock). 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). However, participants generally reported lower physical demands when a fifth wheel on the bed frame was activated, and also had significantly higher levels of confidence in controlling bed movements with the fifth wheel activated (p=0.044). Similar results were observed for a corridor transportation task with less perceived overall physical demands when a fifth wheel or front caster lock were activated than when they were deactivated. The study was judged to have an unclear risk of bias due to a lack of control group (features compared against each other without a no-feature control) and the use of subjective, self-reported, measures for some outcomes. It is unclear from this study whether brake location or the technical outcome of a decrease in physical demand with steering assistance (fifth wheel and/or front wheel caster lock) impacts outcomes related to caregiver musculoskeletal injuries. See section 5.2.1.6 of the EAR.

A second laboratory study assessed 2 general medical bed frames, 1 with a traditional single castor configuration and 1 with a double bogie castor configuration (Medstrom, 2021). Results suggested a double bogie castor design may reduce the force required to move beds. This study was assessed as having an unclear risk of bias. The EAG concluded that further data from larger studies would be needed to demonstrate whether a double bogie castor design consistently impacts force requirements. See section 5.2.1.6 of the EAR.

### Power-drive

The EAG identified a prospective laboratory study evaluating the impact of power-drive on spine loading and perceived exertion (Kotowski et al., 2022). This study demonstrated that power-drive is likely to reduce spine loading during patient transportation. Further data would be needed to demonstrate whether this reduction in loading due to power-drive would result in reduced caregiver injury in the acute hospital setting. The study was judged to have a low risk of bias as robust methods appear to have been used. See section 5.2.1.7 of the EAR.

A second laboratory study evaluated 4 beds that were either standard hospital or high-dependency beds (Matz & Morgan, 2018). The beds were assessed with and without the power assist module, observing the impact on work reduction with power drive. Reduction in mean force required to move the bed was greater than the targets that were set for all 4 beds when using power drive. This study was judged to have an unclear risk of bias as there was no information reported about the participants and no reporting of the variability between test results. See section 5.2.1.7 of the EAR.

### Turn-assist

The EAG identified 2 laboratory studies that evaluated the use of turn-assist and its impact on physical stresses for caregivers when compared with manual turning. The EAG concluded that while this evidence suggests that a turn-assist feature may reduce physical caregiver stresses, the impact of turn-assist on incidents such as musculoskeletal injury has yet to be demonstrated. The 2 studies were judged to have a low risk of bias as robust methods appear to have been used. See section 5.2.1.5 of the EAR.

### In-built weighing scales

The EAG identified 2 prospective cohort studies comparing beds with in-built weighing scales with fluid balance charting to evaluate changes in fluid status in ICU patients. The EAG concluded that this evidence shows poor correlation between the 2 methods of evaluating changes in fluid status. This suggests that the in-built weighing scales assessed in these studies do not give accurate measurements. The studies were judged to have a low risk of bias. See section 5.2.1.2 of the EAR.

### Designs for preventing migration

The EAG identified 4 prospective laboratory studies (Davis et al., 2014; Davis & Kotowski, 2015; Davis et al., 2017; Rush, 2021) comparing beds with different designs for preventing patient migration down the bed (for example, head pivots, head section lengthening and auto-contouring). The studies concluded that different bed types can impact migration, potentially leading to lower levels of migration. It should be considered that while these features may be able to reduce migration down the bed, no evidence was identified which demonstrated that reduced patient migration due to these features can impact pressure ulcer formation. The EAG had concerns about the generalisability of these studies to acute settings given they were conducted in laboratories. All 4 studies were judged to have an unclear risk of bias. See section 5.2.1.4 of the EAR.

# Health economic evaluation

The external assessment group (EAG) did a review to identify suitable health economic models. No economic evaluations or cost or resource studies meeting review eligibility criteria were identified.

## Health economic model

The EAG developed a de-novo cost-utility model with a 1-year time horizon. See section 7.2.2 of the external assessment report (EAR) for the rationale for this time horizon. The model captures 2 approaches: a decision tree feature-based analysis, and a decision tree technology-based analysis. Feature-based analysis observed the potential impact of innovative bed frame features, while technology-based analysis observed differences between specific bed frames.

The EAG conducted feature-based analysis which explored the potential impact of having a bed frame feature compared with not having that feature.

Net monetary benefit (NMB) was calculated for features included in this analysis, using a threshold of £20,000 per QALY. Bed exit alarms had evidence of their effect (in terms of reducing the number of falls) that was relevant to the decision problem. This meant that the NMB of bed exit alarms could be calculated from the data reported. No relevant evidence of reduction in incidents was identified for other specific bed frame features, so the EAG took an exploratory approach. This exploratory approach involved calculating the NMB of groups of features, assuming a 10% reduction in incidents from each group of features. The groups of features modelled were those that can reduce the following incidents:

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

By assuming the reduction in incidents for each generic group of features, it was possible to give an indication of which types of features may represent the highest value at different effectiveness rates. See Figure 1 as an example of the model structure used for a group of features in the exploratory analysis.

The EAG also did a technology-based fully incremental analysis for the bed frames in-scope of this assessment. This analysis considered the annual cost of bed frames available through NHS Supply Chain, along with the cost and QALY impact of having a bed exit alarm for any beds that have this feature. A bed exit alarm was the only feature to be included in the fully incremental analysis as it was the only feature for which relevant evidence of effect was identified. See Figure 2 for the model structure used in the fully incremental analysis.

In addition to the technology-based fully incremental analysis, the EAG's model allows users to do pairwise comparisons of 2 chosen bed frames.

Further details of the economic modelling are in section 7 of the EAR.

**Figure 1: example diagram of the EAG's exploratory feature-based model**

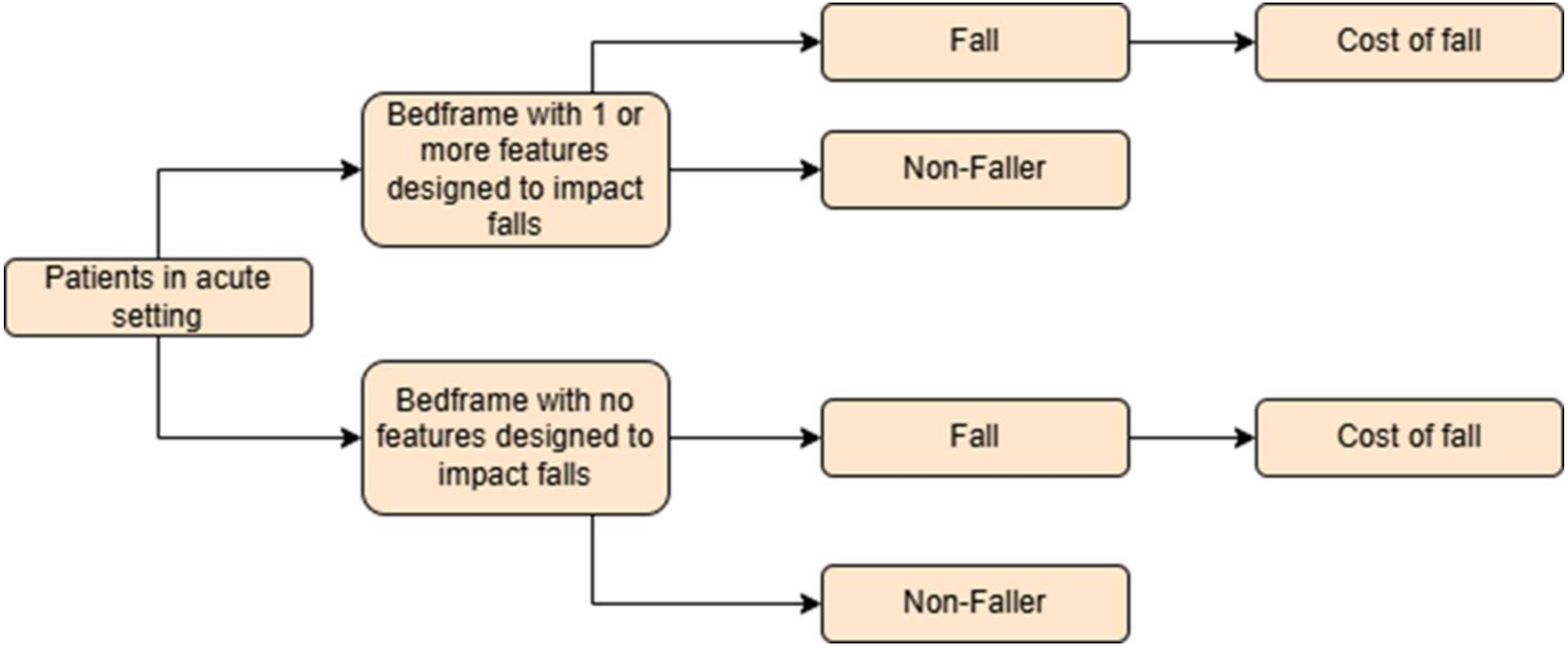
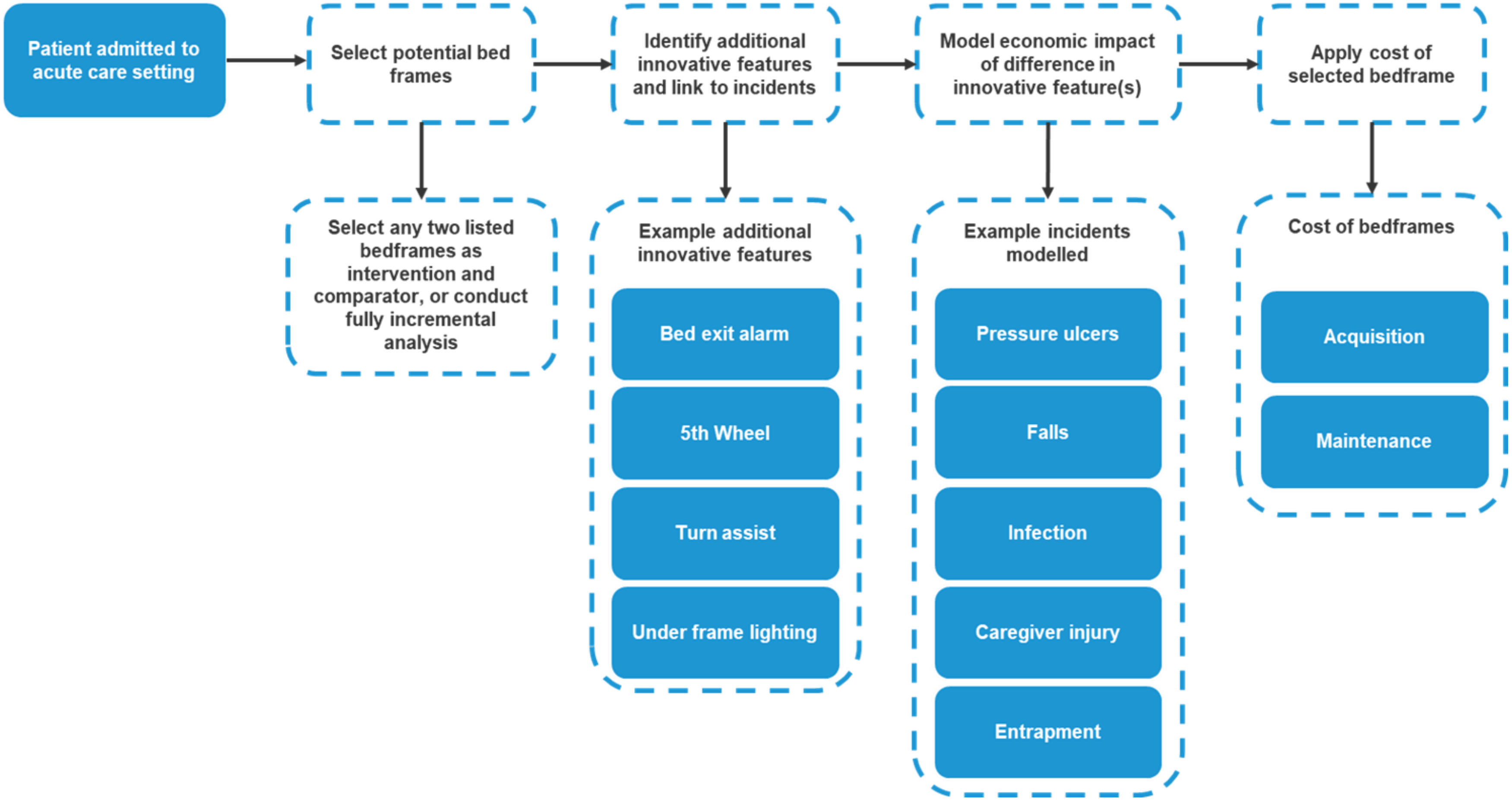


**Figure 2: model structure used for technology-based analysis**



### Population

The population in the model was 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.

### Comparator

The feature-based exploratory analysis in the model looks at the potential impact of having an innovative feature compared with not having the innovative feature. For technology-based fully incremental analysis, all bed frames in-scope were compared. For pairwise comparisons, 2 bed frames in the model can be compared.

## Model inputs

### Model assumptions

A number of assumptions were made regarding cost inputs in the model. Full detail of these assumptions is available in Table 7.1 of the EAR:

- Cost and QALY impact of innovative features can be scaled down to a per bed per year or per patient stay cost based on estimated occupancy rates and average length of patient stay
- All bed users have the same baseline probability of having an incident, sub-populations were not modelled
- Long-term outcomes, beyond the 1-year time horizon, are not captured
- The cost of bed frames are annutised assuming a life cycle of 10 years. In practice, some bed frames may not be in operation as long as this lifespan if they are broken beyond repair
- Cleaning costs for bed frames were not captured within the model
- Only entrapments which cause severe harm are included in the base case
- Training costs were not captured in the model
- The average cost to the NHS of caregiver injury is £58 per hour of lost work
- Potential connectivity benefits related to innovative features, such as reduced staff time, are not included in the model.

- For companies who have not provided maintenance costs, the value in the model is equal to the highest submitted value
- All costs are exclusive of VAT

### Incidents and efficacy parameters

For falls and pressure ulcers, the severity of incidents experienced amongst the modelled cohort was sourced from published literature. Experts suggested that the key consideration for reducing pressure ulcers is a pressure relieving mattress, rather than the bed frame or its features. However, innovative bed features may still be useful for reducing pressure ulcer formation, especially for frailer populations, or those defined at high risk of entrapment.

For caregiver injury, the proportion of caregiver injuries due to lifting or turning patients or moving beds was also sourced from published literature.

No evidence was identified for minor entrapment injuries related to bed frames, hence in the base case model it was assumed that 100% of entrapment injuries were serious. Experts suggested that cases of entrapments are rare and are primarily due to staff not following correct procedures. Therefore, features to prevent entrapments, in their experience, may not necessarily lead to a measurable reduction in entrapments.

See table 7.3 in the EAR for full detail of the parameters used in the model for the proportions of severity levels for each incident.

An odds ratio for falls with and without a bed exit alarm was available in the literature (odds ratio= 0.5), allowing the potential monetary value of this feature to be modelled. Due to the absence of evidence on features for each bed frame, an assumption of equivalence has been made for bed exit alarms across the different bed frames in-scope of this assessment. The EAG acknowledge that it is possible that features demonstrate different levels of efficacy in different beds.

Efficacy data was not available for any other specific bed frame features, hence the impact of groups of features was modelled separately. For each generic incident, the percentage reduction due to features was assumed to be 10% in the base case, with this value being explored in sensitivity analysis to test the potential impact.

## Resource use parameters

Length of stay values were sourced from the literature for the key model outcomes**.** The baseline number of incidents per 1,000 bed days were also used in the model. See table 7.4 in the EAR.

## Costs

Costs of the key incidents are outlined in Table 7.5 of the EAR. 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. In the sensitivity analysis, it was assumed that minor entrapments would result in an increase in staff time of 15 minutes, 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. 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. Bed frame unit costs were obtained from NHS Supply Chain. Full detail of the technology costs is available in section 7.2.7 and table 7.6 of the EAR.

### Health-related quality of life

Table 7.7 in the EAR displays the utility decrements for each incident. Utility decrements for falls and infections were derived from NICE clinical guideline 139, and decrements for pressure ulcer by grade of severity were sourced from Posnett et al. (2022). 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); approximately double the disutility of a severe fall. UK population EQ-5D-3L background utility values were also included in the model and were derived from the NICE Decision Support Unit (2022).

## Model results

### Exploratory feature-based analysis 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 2. The base case results are based on a theoretical 10% reduction in each incident. Net monetary benefit (NMB) is also reported in the table, which adds the monetary value of any QALY gains (valued at £20,000 per QALY) to any monetary cost savings.

The results give an indication of which innovative features may give the most value for money when selecting a bed frame. They also demonstrate at what cost features may 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. The EAG found that the largest driver of potential monetary value in their base case analysis for generic features was reduction in musculoskeletal injuries (NMB of £640). Reduction in infections and patient falls were also found to be key drivers in the economic model. Innovative features designed to reduce entrapments or pressure ulcers may offer less value for money to the NHS, when compared with other features, across all acute populations. The total monetary value of having a bed frame which has innovative features that can reduce all 5 of the incidents modelled by 10% is estimated at £1,681 in one year (excluding the cost of the bed frame itself).

**Table 2: base case model results for generic features**

| Generic outcome | Cost impact (per bed per year) | QALY impact (per bed per year) | NMB |
|---|---|---|---|
| Reduction in caregiver injuries due to feature(s) | £625 | 0.001 | £640 |
| Reduction in infections due to feature(s) | £280 | 0.01 | £503 |
| Reduction in falls due to feature(s) | £439 | 0.002 | £487 |
| Reduction in pressure ulcers due to feature(s) | £43 | 0.0004 | £51 |
| Reduction in entrapments due to feature(s) | £0 | 0.00001 | £0.20 |

Evidence was available to determine the potential impact of one specific feature, bed exit alarms. The economic impact of this feature is presented in Table 3. The results suggest that bed exit alarm could potentially lead to cost savings of £2,196 per bed frame per year, and 0.01 QALYs generated per bed frame per year. This gives an NMB of £2,433. The limitations of this analysis, including the correlation and interactions between features, and how the bed exit alarm is implemented is discussed in Sections 7.3.3 and 8.2 of the EAR.

**Table 3: base case results for bed exit alarms**

| Innovative feature | Cost impact (per bed per year) | QALY impact (per bed per year) | NMB |
|---|---|---|---|
| Reduction in falls due to bed exit alarms | £2,196 | 0.01 | £2,433 |

## Technology-based fully incremental analysis results

The fully incremental result was driven by the cheapest bed frame to have a bed exit alarm. The results of this analysis should be interpreted with caution due to the limited and uncertain evidence available to populate the model. The results of the fully incremental analysis are available in figures E1 and E2 in the appendices of the EAR.

## Sensitivity analyses

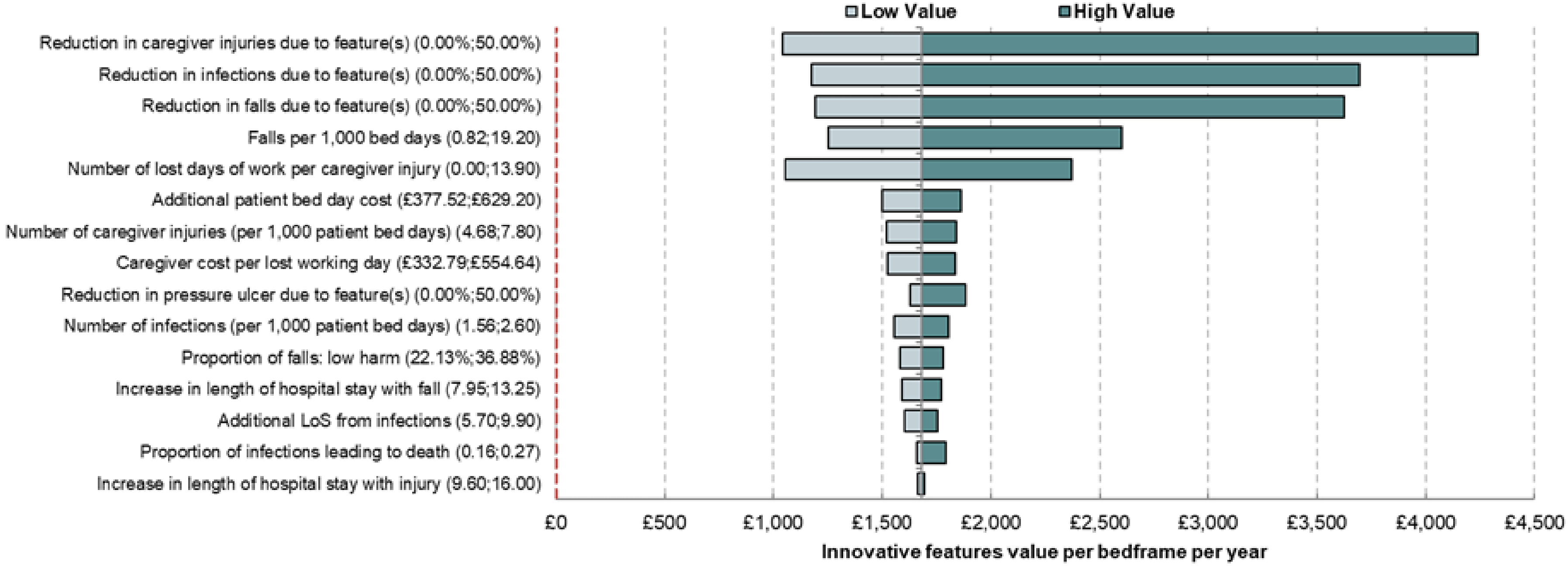
Probabilistic sensitivity analysis (PSA) was not conducted. This is because of the limited evidence available to populate an economic model. As a result, it was not possible to identify standard errors for over 90% of parameters, meaning it was not possible to understand the uncertainty of the parameter estimates within a PSA.

One-way and two-way deterministic sensitivity analysis (DSA) were conducted. DSA was done for both feature-based analysis and analysis of pairwise bed frame comparisons. Feature-based DSA explored the impact of varying each model parameter on the total monetary value of having a bed frame with innovative features which could reduce all incidents. The key drivers of this analysis were reductions in caregiver injuries, infections and falls due to innovative features, followed by the baseline number of falls per 1,000 bed days and the number of lost days of work due to caregiver injury (see Figure 3). 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. Sensitivity analysis results are in section 7.3.2 of the EAR.

Two-way exploratory analysis varied both the relative effectiveness of reducing events, as well as the baseline number of events, given that baseline numbers of events are likely to be heterogenous across different hospitals, wards and patient populations. Two-way sensitivity analysis is presented in Appendix E of the EAR.

The results of the sensitivity analysis reflect those of the base case analysis. Features reducing caregiver injury have the potential to have the most monetary value, followed by features reducing infections, falls, pressure ulcers and lastly entrapments.

Figure 3: tornado plot of DSA results



## User preferences

At the user preference workshop, a group of 12 users agreed on 12 key considerations that are important during the decision-making process to select 1 bed frame over another. For each of these considerations, users agreed on a list of innovative bed frame features which can help to address the consideration.

The findings of the user preference workshop were used to develop a user survey. The purpose of this survey was to understand the importance of each bed frame feature to users, for a given consideration. There were 36 submitted responses to the user survey. The survey results were used to calculate an average importance score for each innovative feature helping to address a key consideration. From the 82 survey questions across the 12 key considerations, there were 60 average importance scores that were between “4 – quite important” and “5 – very important”. This suggests that most of the identified innovative features were considered somewhat important for addressing user needs. Some bed frame features could help support user needs across multiple different considerations.

Of the features identified during the user preference assessment, only 1 had evidence in the External Assessment Report (EAR) that was considered relevant to the decision problem. Evidence from 1 study was identified for the innovative feature “bed exit alarm”, which was identified by users as helping to reduce patient falls. In the results of the user preference survey, bed exit alarms had an average importance score of 3.97 out of 5, suggesting that their importance is between “neither important or unimportant” and “quite important”. It should be noted that the standard deviation of responses around the average was considerable, indicating that the perceived importance of this feature may be different for different users. The study on bed exit alarms suggested that they may reduce falls incidence. However, the EAG had some concerns over the validity of outcome measures in this study (see section 5.2.1.3 of the EAR). The net monetary benefit of bed exit alarms has the potential to be considerable, so generating robust evidence may be worthwhile. The bed frames in-scope of this assessment that have bed exit alarms are presented in Table 2.1 of the EAR.

Features that do not currently have robust evidence to demonstrate their benefit may still be considered important by users. Table 16 of the user preference report gives the feature(s) with the highest average importance score for each consideration. The features with the top 10 average importance scores across all considerations are reported in Table 17 of the user preference report and presented again below in Table 4.

**Table 4: features with the top 10 average importance scores across all considerations in the user preference survey.**

| Consideration | Feature with the highest average importance score | Average importance score |
|---|---|---|
| Maintenance and repair | Availability of, and access to, spare parts | 5.00 |
| Maintenance and repair | Robust and durable frame construction | 5.00 |
| Pressure ulcer formation | Compatibility with pressure care mattresses | 4.90 |
| Patient falls | Frame structure that gives improved compatibility with accessories such as hoists, standing aids and tables, so that they easily fit underneath the bed frame | 4.87 |
| Pressure ulcer formation | Compatibility with mattresses that follow the contours of the bed | 4.83 |
| Patient falls | Side rails that are flush to the bed when folded down to reduce the distance between the edge of the bed and the edge of mattress | 4.80 |
| Patient recovery, independence and rehabilitation | Frame structure that gives improved compatibility with accessories, such as hoists | 4.80 |
| Caregiver musculoskeletal injuries from repositioning of patients. | Frame structure that gives improved compatibility with accessories, such as hoists | 4.80 |
| Infection prevention | Materials to withstand cleaning protocols | 4.78 |

| | | |
|---|---|---|
| Adaptability | Frame structure that gives improved compatibility with accessories, such as hoists | 4.77 |
| Adaptability | Compatibility with different types of mattresses | 4.77 |
| Adaptability | Compatibility with infusion poles, oxygen cylinders and catheter holders | 4.76 |
| Patient recovery, independence and rehabilitation | Variable bed length to allow for taller patients | 4.70 |
| Adaptability | Variable bed length to allow for taller patients | 4.69 |

In the absence of robust evidence on all innovative bed frame features, user preferences may serve as a valuable indication of which features should be considered important. For example, 1 study was identified by the EAG in which lower physical demands were reported when a fifth wheel was activated. It is unclear whether this reported decrease in physical demand due to the addition of a fifth wheel impacts outcomes related to caregiver musculoskeletal injuries. In the user preference survey, a fifth wheel had quite a high average importance score of 4.43 out of 5 for the consideration of caregiver musculoskeletal injuries from moving the hospital bed.

Users at the workshop agreed that during the decision-making process to select 1 bed frame over another, each of the key considerations identified would be given equal importance. The results of the EAG's model suggest that the potential monetary value of having features that can reduce some incidents may be larger than the value of having features which reduce other incidents. For example, reduction in caregiver injuries has the largest potential monetary value, followed by reduction in infections, falls, pressure ulcer formation and lastly entrapments. However, features which are not linked to an improvement in incidents may still be valued by users.

## Equality considerations

The final scope and the scoping equality impact assessment describe potential equality considerations for this assessment. The key studies in this assessment did not report subgroup data or study participant information on any of the subgroups identified in the scope of this assessment. The external assessment group (EAG) did not identify additional potential equality issues.

## Limitations and key issues

### Clinical effectiveness

#### Limitations

- Some of the identified evidence was proof-of concept for bed frame features, linking features to a technical outcome. There was no evidence identified which directly linked these technical outcomes with incident rates, hence the impact of these bed frame features on incident rates could not be observed.
- Only bed exit alarms had evidence available that was relevant for the decision problem. The 1 key study for bed exit alarms was assessed as having a high risk of bias, hence the benefit of this feature is uncertain. This study was also not conducted in the UK.
- Due to the limited evidence base following the external assessment group's (EAG's) initial search, the eligibility criteria were broadened. The main issues with generalisability of the studies were patient populations and study settings not meeting the decision problem.
- Factors other than innovative features may impact on the number of incidents in practice. For example, staff training, suitable matching of patient size to bed design and appropriate maintenance of beds.

#### Key issues:

- For features with proof-of-concept using technical outcomes,
  - Is technical outcome information enough to draw a conclusion on these features?

  - If more evidence is needed, is it acceptable for this evidence to focus on the association between technical outcomes and incident rates? Or would evidence be required to directly demonstrate the impact of features on incident rates?
- What can the included studies tell us about the effectiveness of specific bed frame features?
  - Beds that can be adjusted to a low height
  - Bed frame designs for preventing patient migration
  - Alternative brake location
  - Steering assistance (fifth wheel, front caster lock and double bogie castor)
  - Power-drive
  - In-built weighing scales
  - Bed exit alarms
  - Turn-assist
- Is an assumption of equivalence of innovative features across bed frames reasonable? For example, can a bed exit alarm on one bed frame be assumed to have the same effectiveness as a bed exit alarm on a different bed frame? Would evidence be required to demonstrate the effectiveness of innovative bed frame features for each bed frame model?

## Economic evidence

### Limitations:

- The evidence review did not identify robust evidence of the impact of all innovative features on incident rates. Because of this, it was not possible to model each individual bed frame feature. Instead, generic incident rates were modelled to observe the impact that innovative bed frame features which reduce these incidents could have.
- The model assumes that each feature that can reduce a given incident has the same potential monetary value. For example, the model assumes that all features reducing falls (such as brake alarms, programmable custom height settings and under-frame lighting) would have the same net

monetary benefit of £487. In practice, different features for reducing falls may have different effectiveness.

- The model assumes that each incident is reduced by the same amount (10%), but in practice some features may reduce one type of incident more than other features reduce another type of incident. For example, a bed may have features that reduce falls by more than 10% and features that reduce entrapment by less than 10%. The total monetary value in the base case feature-based exploratory analysis is therefore unlikely to be representative of the total monetary value of features on all beds in practice.
- Fully incremental analysis of bed frames assumes clinical equivalence of innovative features. In practice, the effectiveness of innovative features is likely to differ by bed frame. For example, a brake alarm on one bed frame model may be more effective than the brake alarm on a different bed frame model.
- The model does not account for additive effects of having more than 1 innovative bed frame feature.
- No evidence was available for any population subgroups. Some features may be more beneficial or less beneficial for specific populations. The benefit (and total monetary value) of bed frame features may therefore be under or overestimated for some subgroups.

### Key issues:

- Are the economic model structure, assumptions and clinical and cost parameters suitable to answer the decision problem (see final scope) for this assessment?
- What can the model results tell us about the value of groups of bed frame features for reducing incidents?
  - Falls
  - Pressure ulcers
  - Entrapment
  - Infections

– Caregiver musculoskeletal injuries

### User preferences

**Limitations:**

- There were a range of opinions on the degree of importance of a number of innovative features. This may suggest that user needs vary by Trust.
- While efforts were made to engage bed frame users from all of the key user groups, there were no portering staff who took part in either the user preference workshop and user survey.

**Key issues:**

- Can user preferences from the survey be used to support decision making where evidence on features is weak?
  - Beds that can be adjusted to a low height
  - Bed frame designs for preventing patient migration
  - Alternative brake location
  - Steering assistance (fifth wheel, front caster lock and double bogie castor)
  - Power-drive
  - In-built weighing scales
  - Bed exit alarms
  - Turn-assist
- Where there is no evidence on features, can the findings from the user preference assessment be used to inform decision making?

## Appendix A Abbreviations

| | |
|---|---|
| EAG | External assessment group |
| EAR | External assessment report |
| ICER | Incremental cost-effectiveness ratio |
| LSA | Late-stage assessment |
| NMB | Net monetary benefit |
| QALY | Quality-adjusted life year |

NICE National Institute for Health and Care Excellence

**Health Tech Programme**

**GID-HTE10050 Bed frames for adults in acute settings: Late-stage assessment**

**External Assessment Report (EAR) & User Preference Report**

## Collated comments table

## Section A: redacted External Assessment Report – Collated comments table:

| Comment no. | Stakeholder | Page no. | Section no. | Comment | EAG Response |
|---|---|---|---|---|---|
| 1 | Medstrom | 33 | Table 2.88: The anticipated benefits of innovative features of acute bed frames | Adaptability "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". **Consideration should be given to potential for patient entrapment as a result of having adjustable width and range of surfaces available.** | Thank you for your comment. 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. This table is indicative of some of the potential benefits but may not describe every eventuality. Variable bed width and length is included as a subheading under adaptability. We have made no further change. |
| 2 | Medstrom | 39 | The following consideratio ns were identified as important contextual information, raised by clinical experts and | "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." The articulation of the bed frame may affect the performance of the mattress and is worth noting, for example a bed with no regression when the head of bed is elevated may crush/distort cells (especially in the sacral region) and therefore affecting performance of the mattress. | Thank you, this is noted. A sentence has been added to this section to highlight this point. |

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| | | | identified in relevant literature, to determine the effectiveness of different types of acute bed frames for the NHS: | | |
| 3 | Medstrom | 69 | 5.2.2.1 Low-low beds | "However, a rehabilitation ward was also included in the analysis, potentially making finding less applicable to an acute setting." Many acute hospitals have frailty assessment units and community assessment units which would consider themselves rehabilitation settings. The need to mobilise patients occurs in all wards, deconditioning is considered an adverse condition and so all wards aim to mobilise patients as early as possible to prevent muscle loss. | Many thanks. The decision problem focussed on acute medical settings. The initial review eligibility criteria excluded geriatric wards and other non-acute settings, but inclusion was broadened to include other settings.<br><br>We agree that the needs of patients varies and acute care beds may be used in non-acute settings. However, in our review, it was important to highlight where studies were not in line with the decision problem. |
| 4 | Medstrom | 112 | 7.2.2 Model structure | "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 | Thank you for your comment. Training costs were excluded from the analysis due to a lack of evidence that different bed frames would require more or less staff training time.<br><br>All companies who submitted evidence indicated that training and support would be offered at no extra cost. Therefore, additional training costs may be incurred for more |

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| | | | | would underestimate the true cost of implementing them in clinical practice" More complex bed frames will take longer to train on from both a service and clinical training point of view. Lack of evidence for clinical training may be because some companies such as Medstrom do not levy additional charges for clinical training/support. Were costs for technical/service or clinical training requested? | complex bed frames with more innovative features. However, it is not clear how much extra staff time this would take, and which features may actually require more training. We acknowledge this as a limitation and have noted this in Section 7.2.3. We have since expanded the point in this section to add further clarification. |
| 5 | Medstrom | 117 | Table 7.11: Assumptions and limitations of the model | "For this reason, it is assumed that for companies who have not provided maintenance costs, the value is equal to the highest submitted value ********* This is varied within sensitivity analysis, given in the first year, bed frames are still under warranty." We understand pragmatically the rationale behind this decision, as with the point above, beds with high complexity both training and maintenance costs will be higher as a reflection of the complex nature of the technology. | Thank you for your comment. As per comment 4, we have explained our rationale for not including training costs in the analysis. |
| 6 | Medstrom | 141 | 7.3.3 Summary and interpretation of the economic evidence | "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." As per point 2 above the articulation of a bed frame can impinge mattress cells (especially in sacral region) and therefore affect the way they function, and impact on pressure area care. | Thank you for your comment. Our analysis was exploratory and considered if a bed frame could reduce any incident by an equal amount, which would represent the greatest value for money based on costs, health impact, and prevalence. Bed frames may reduce pressure ulcers by their interaction with the mattress, but this would not change the conclusions of the exploratory analysis. |
| 7 | Medstrom | 8 | Quality and relevance of the clinical and technological evidence | Medstrom submitted in their evidence for review, Barker et al. 2012. Reducing serious fall-related injuries in acute hospitals: are low-low beds a critical success factor? JAN.69(1):112-21. doi: 10.1111/j.1365-2648.2012.05997. Was this beyond the scope of the search? | Thank you for your comment. This study was identified from both the EAG's literature search and from company submissions. However, the beds used in this study were |

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| | | | | | considered out of scope for this assessment (they are ultra-low i.e. lower to the floor). |
| 8 | Medstrom | 136 | Table 7.99: Specific innovative features total monetary value (per bed, per year) | Bed exit alarm research: The paper Seow et al, 2022a was conducted in Singapore with one bed exit alarm system. Is the core technology infrastructure, as well as the patient population and healthcare environment comparable/transferrable to the NHS? This report notes that the study was judged to have a high risk of bias (Figure 5.44, page 65), and also noted 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" (page 117, Table 7.11). The authors of the paper note that the correct alarm mode would have to be selected, which means the results are dependent on the caregiver selecting and setting the correct mode. It also notes that staff may suffer "alarm fatigue". **We would like to note that many bed exit alarms are dependent on the patient being weighed once placed on the bed and the alarm will trigger once 30kg of weight has exited the bed. Many clinicians feel this is too late to prevent fall or patient egress.** Therefore, the addition of a bed with alarm is heavily dependent on human factors in addition to the infrastructure to provide ability to reduce patient falls and may alarm too late (once 30kg has moved off the bed frame) to prevent patient falls. | Thank you for your comment. We acknowledge Seow et al. to be a study with a high risk of bias and have discussed the limitations of the paper further in Section 7.3.4. This paper was used due to the absence of any other evidence and we have made it clear the limitations of using this evidence. |
| 9 | Medstrom | 227 | Table 7.55: Key clinical outcome cost parameters | The cost of falls are based on a 2013 reference (NICE 2013a) but inflated to reflect today's costs. There is a more up-to-date reference on cost of falls (NHS Improvement, 2017, page 10, Table 3, Average estimates of the cost per fall by age) which calculates direct and indirect costs to be:<br>**Over 65s:** No harm - £2621; Low harm - £2949; Moderate harm: £8519; Severe harm: £14197.<br>**Under 65s:** No harm - £1337; Low harm - £1540; Moderate harm - £5779; Severe harm - £10847. | Thank you for your comment. A scenario has been run with these costs and severity distributions. See section 7.3.3 for the results of this scenario analysis. We have conducted this as an additional scenario given the high uncertainty over the estimates. This is because the assumptions around length of stay are much higher in the |

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| | | | | **Pdf NHS Improvement paper included in response.** | alternative source, and it is not clear which one is more representative. Furthermore, the 2017 NHS improvement report has been removed from the website, which may indicate an error in the findings. However, we believe it is still worth exploring, and this scenario does not significantly change the results, that features designed to reduce falls are likely to represent higher value to the NHS. |
| 10 | Medstrom | 123 | Table 7.33: Proportions for each clinical outcome | The falls percentages of no/low/moderate/severe harm (Table 7.33, sourced from Healey et al 2008) differ from the more recent NHS Improvement 2017 paper (Table 1):<br>No harm: Healey – 66.5%, NHS Improvement – 71.9%<br>Low harm: Healey – 29.5%, NHS Improvement – 25.5%<br>Moderate harm: Healey – 3.3%, NHS Improvement – 2.0%<br>Severe harm: Healey – 0.7%, NHS Improvement – 0.6%<br>**Pdf NHS Improvement paper included in response.** | Thank you for your comment. Please see the reply to question 9 for further consideration. |
| Updated11 | Medstrom | 16 | Table 2.11: Patient safety bed frame features | The Solo range of beds have been noted as not having an anti-entrapment feature, however, all beds in this range pause at 23cm and alarm as an aid to the caregiver/patient to check for entrapment before lowering to the final descent. We would therefore class this as an anti-entrapment feature. | Thank you for your comment. We have reviewed this and believe that this should be ticked, so have corrected this in the updated report. |
| 12 | Medstrom | 16 | Table 2.11: Patient safety bed frame features | SoloMH has been noted as not having innovative side rails, however, this bed still has a rail in position that supports the security of the patient in a mental health environment. | Thank you for your comment. In this analysis a rail in itself is not considered innovative, but a basic bed feature. Therefore, no further changes have been made. |
| 13 | Medstrom | 18 | Table 2.22: Bed frame features for caregiver safety | The Solo Luxe and the SoloMH have the same castor design as the other beds in the Solo range, so this needs amending to having a tick box. | Thank you for your comment. Ticks for the castor design feature have been added for the Solo Luxe and SoloMH bed frames. |

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| 14 | Medstrom | 20 | Table 2.33: Bed frame features for adaptability | The Solo, Solo+ and Solo Luxe have removable head and footboards, so this needs amending to have a tick box. | Thank you for your comment. This has been updated in Table 2.3. |
| 15 | Medstrom | 20 | Table 2.33: Bed frame features for adaptability | The SoloMH can be used with the Medstrom MOGO to allow for easy transport and storage in a horizontal capacity, therefore this needs amending to include a tick box. | Thank you for your comment. This has been updated in Table 2.3. |
| 16 | Medstrom | 21 | Table 2.44: Bed features for facilitation of recovery | Customisable height is a feature that is unique to the Medstrom Solo range. It describes the ability to programme the bed to pause at a specific height that is either dependent on a patient's popliteal height (therefore safe for individualised patient mobilisation), or to assists therapists to work at the patient's bed height at home to ensure safe discharge. Most of the beds in this table have been noted as having a 'Programmable custom height settings', however the bed frames listed do not have this feature. This feature is to be differentiated from the ability to raise or lower the height between the bed frames lowest and highest height. | Thank you for your comment. We have re-reviewed the way we describe programmable custom height settings and adjusted the ticks accordingly within this table. We agree that the bed frames need the ability to specified height settings for this feature, not just a low or high setting. |
| 17 | Medstrom | 23 | Table 2.44: Bed features for facilitation of recovery | Linen tray is missing from the list of accessories under Solo and Solo+. The Solo, Solo+, Solo Luxe also have connection point for IV pole/lifting pole so needs to have a tick in this box. | Thank you for your comment. We have updated Table 2.4 to include these features. |
| 18 | Medstrom | 26 | Table 2.55: Bed frame features for health-related considerations, infection prevention and comfort | SoloMH and Solo Luxe have dual wheel castors which improve stability when the bed is moving, therefore needs a tick box. | Thank you for your comment. This has been updated in the report. |
| 19 | Medstrom | 28 | Table 2.66: Bed frame features for sustainability | All of the Solo range of beds have recycling options and recyclable materials, therefore needs a tick box. All of the Solo range of beds also have a durable frame constructed | Thank you for your comment. This has been updated in the report. |

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| | | | and maintenance and repair | with integrated components to reduce hospital-acquired damage, therefore needs a tick box for this category. | |
| 20 | Medstrom | 30 | Table 2.77: Bed features for connectivity | All of the Solo range of beds have the option of RFID tags, therefore do have features to track and locate beds and therefore needs a tick in this box. | Thank you for your comment. We have added these ticks to Table 2.7. |
| 21 | Medstrom | 61 | 5.2.2.1 Low-low beds | The terminology 'low-low beds' isn't used in the UK. The decision early in the LSA process was made not to differentiate or have a separate classification of low beds as there are beds that can achieve low heights and high/standard heights. The UK tends to use the terminology 'ultra-low beds' for beds that achieve a height lower than standard medical/surgical beds, therefore we would recommend a change of terminology here as "low-low" bed will cause confusion and lack of understanding as no bed is referred to as a low-low bed. | Many thanks. We have amended the text to refer to refer to beds with a low height position. We have not referred to ultra-low beds as this may include beds that can be lowered to the floor, and these are out of scope. |
| 22 | Baxter | 8 | Exec Summary | Information for clarity Low low beds are defined as lowered to at least 28cm from the ground. Could information be added to report at which point does a bed become an ultra-low bed and is therefore excluded from scope? | Many thanks. Beds that lowered to 19cm were considered eligible for inclusion. We have clarified this eligibility criteria in section 5.1.1. In the included study, the bed was lowered to 28cm, so was eligible for inclusion. |
| 23 | Baxter | 13 | Bullet point 2 | Inaccurate description of Baxter Accella Therapy HR900. Acella Therapy is not a mattress alone; it is an integrated system bed and mattress; however both the bed frame and the mattress can be purchased separately. Suggested wording: The Accella Therapy bed system comprises the Accella HR900 bedframe with the Accella Therapy surface. Both the bedframe and the surface can be purchased separately. The Accella HR900 bedframe is included in the assessment and only features relating to the bed frame (and not the surface) are assessed. | Thank you for your comment. We have removed this bullet point, since the HR900 is included separately. |

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| 24 | Baxter | 15 | Table 2.11, row 7-10 | Omission in table for two Baxter products. All Baxter 4 bed frames have corner bumpers as noted in the instructions for use (IFU) documents previously provided (e.g. HR900 IFUs, page 13 item O in table), please add ✓ for Baxter Hillrom 900 x2 and Accella HR900 | Many thanks. Ticks for these features have been added to Table 2.1. |
| 25 | Baxter | 15 | Table 2.11, row 10 | Omission in table relating to bed features for Baxter Accella HR900. Baxter Accella HR900 does have Bed Exit Alarm & Under Frame Lighting, please add ✓ to the table for these features. Please see IFU (e.g. Nightlight description on page 66 and Accella Brochure 2019 for bed exit alarm) | Thank you for your comment. We have added ticks for the bed exit alarm and under bed light features for the Baxter Accella Hillrom 900 bed frame. |
| 26 | Baxter | 19 | Table 2.33, row 7-10 | Correction to information in table relating to Baxter products and adjustable bed width. The bed width is not variable on any Baxter bed. We have adjustable mattress retainers to accommodate different widths of mattress. Please add this information for clarity and completeness. | Thank you for your comment. This has been added as a note to Table 2.3 for clarity. |
| 27 | Baxter | 19 | Table 2.33, row 7-10 | Collapsible Frame for easy transport and storage, multiple providers 'ticked'. It is unclear what a 'Collapsible frame' means in this context? Please include a definition for 'collapsible frame' in the report. | Thank you for your comment. A definition for 'collapsible frame' has been added as a note to Table 2.3 for clarity. |
| 28 | Baxter | 21 | Table 2.44, row 7-10 | Omission in table relating to Bed Controls. Baxter beds do have the option of additional nurse controls at the foot end of the bed frame. Please add this information to the table. Please see IFU or Product Brochures | Thank you for your comment. This has been updated in Table 2.4. |
| 29 | Baxter | 22 | Table 2.44, row 10 | Omission in table relating to IV pole connection point. Baxter Accella Hillrom 900 does have connection point for IV pole (IFU page 15, item C in table), please add ✓ to the table. | Thank you for your comment. This has been updated in Table 2.4. |
| 30 | Baxter | 25 | Table 2.55 | It is not clear what the feature 'indication of safe position light' relates to? Baxter beds have the safe position lighting on all beds with the addition of intelligent nightlight on the Hillrom 900 and Accella Bed which includes lighting colour changes to indicate when beds are at the lowest position or possible height adjustment or bed exit (e.g. Accella Brochure), please add ✓ to the table. | Thank you for your comment. We have added ticks for the indication of safe position light feature for all of the Baxter bed frames. |

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| 31 | Baxter | 27 | Table 2.66, row 7-10 | Omission in table relating to recycling options. All Baxter bed frames contain the same recycle options and recyclable materials, please add ✓ to Hillrom 900 X2. Please see IFU | Thank you for your comment. This has been updated in table 2.6. |
| 32 | Baxter | 27 | Table 2.66, row 9-10 | Omission in table relating to hospital acquired damage. Baxter Hillrom 900 X3 and Baxter Accella Hillrom 900 have integrated components to reduce hospital acquired damage, please add ✓ to both. | Thank you for your comment. This has been updated in table 2.6. |
| 33 | Baxter | 31 | Table 2.88, row 2 | Suggest adding healthcare providers to groups benefiting from nightlight. Under bed lighting – Baxter intelligence nightlight indicates lowest bed height is active, a clear benefit to caregivers when used with a falls prevention strategy. | Thank you for your comment. This has been updated in table 2.8. |
| 34 | Baxter | 31 | Table 2.88, row 6 | Query on inclusion/exclusion of different methods of connectivity. There is reference to Bluetooth connectivity but no other forms of connectivity e.g. Wi-Fi | Thank you for your comment. This should say Bluetooth or WIFI, so have corrected this in the table. |
| 35 | Baxter | 32 | Table 2.88, row 19 | Omission relating to benefits of in-built weighing scales. Missing the benefit of time to weigh and number of caregivers required to weigh with relation to inbuilt weighing scales. | Many thanks. This point has been added to Table 2.8. |
| 36 | Baxter | 33 | Table 2.88, row 22 (Collapsible Frame) | Suggest that the group benefiting from a collapsible frame is not the patient group but rather the healthcare providers and/or operational staff. | Thank you for highlighting this. We agree with your point and has changed this in the Table. |
| 37 | Baxter | 33 | Table 2.88, rows 24, 25, 26 | Query whether removeable headboards, battery power back up, and compatibility with wider range of mattresses are primarily patient benefits. Suggest that healthcare providers and/or operational staff should also be included as groups possibly benefiting from features. | Thank you for your comment. This point has been added to Table 2.8. |
| 38 | Baxter | 33 | Table 2.88, row 28 | Include healthcare providers and/or operations staff and groups of people who may benefit from infection prevention measures. | Thank you for your comment. This point has been added to Table 2.8. |
| 39 | Baxter | 33-34 | Table 2.88, row 29-33 | Include healthcare providers and/or operations staff and groups of people who may benefit from features linked with 'Ease of Care' | Thank you for your comment. This point has been added to Table 2.8. |

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| 40 | Baxter | 35 | Table 2.88, rows 42-47 | Query whether 'patients needing an acute hospital bed' is the group most likely to benefit from sustainability, and maintenance and repair features? Suggest that operational staff/procurement staff are likely to be the group which benefits the most from these particular features. | Thank you for highlighting this. We agree with your point and have updated Table 2.8 in line with this. |
| 41 | Baxter | 35 | Table 2.88, rows 42-47 | Locally produced and locally sourced are two separate topics – a lifecycle analysis would be required in order for a fair comparison to be made. | Thank you for your comment. Yes, we agree there are many factors which would impact sustainability and environmental outcomes. However, it is not possible to detail them all as potential benefits. Therefore, we have simplified this to local sourcing, as per the NICE scope, given that sourcing of materials is likely to be a key driver. However, we do agree that a full life cycle is needed to assess sustainability across different bed frames providers. We have further reiterated this point within the text in Section 2 and in Section 8. |
| 42 | Baxter | 37 | Paragraph 2, first bullet point | AMU is not defined in the text. Please add Acute medical unit (AMU). | The definition of AMU is given higher in the document on pg12. No further changes made. |
| 43 | Baxter | 38 | Paragraph 2, first bullet point | Include healthcare providers. The additional innovative features impact clinical or safety outcomes in adults receiving care and healthcare providers in acute settings | Thank you for your comment. We have outlined that healthcare providers are likely to benefit throughout the document. However, we do not believe it needs to be repeated in every instance and have made this clear already. No further change. |
| 44 | Baxter | 38 | Paragraph 3, first bullet point | Couple of missing words in the 2nd and 3rd sentences. | Thank you for your comment. We have re-checked these sentences for grammar. |
| 45 | Baxter | 39 | Bullet 3, last 2 sentences | 'All acute bed frames will all have some degree of compatibility with different mattresses (NHS Supply Chain, | Thank you for your comment. NHS Supply chain indicate minimum standards for |

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| | | | | 2021)'. It is unclear where this statement has been derived from? Baxter mattresses will be compatible with Baxter bedframes and while Baxter is aware that in the real world, there will be a degree of interchangeability with bedframes and mattresses from different companies being used together, this would not be supported by companies who could not guarantee that mixing of company products in this way would not impact safety, functionality or lifespan of the individual products. | mattresses and bed frames. These standards mean that not every mattress is specific to a type of bed frame, and there is therefore some interchangeability. The point we are highlighting here is that level of interchangeability will differ between companies, and the type of frame used. |
| 46 | Baxter | 40 | Section 3.0 | Factual inaccuracy relating to warranty timescales. The statement on warranty period of 1 year for many bedframes is inaccurate. Baxter provides a 2-year warranty and believe that other providers could provide similar – please can this be corrected. | Thank you for your comment. This statement was based on the information companies have provided. In general, 1 year warranty appears to be the standard. However, we are aware of instances of higher warranty. We have caveated this statement in the text. |
| 47 | Baxter | 41 | Section 4.2, first bullet | Define ICU. | Thank you for your comment. We have added a definition for this. |
| 48 | Baxter | 53, 59, 102-104 | Table 4.11 and section 5.1.2.5, section 5.3.5, table 5.11 (studies related to turn assist) | Baxter queries the exclusion of Budarick et al. 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. The rationale for exclusion is that no innovative bed feature was assessed (table C1) however Baxter notes that the study investigates the impact of 'Turn Assist' features which is within the scope of the assessment. A second study by the same author, Budarick AR, et al. Evaluating patient turn effectiveness using turn assist technologies. J Med Eng Technol. 2020;44(1):1-11. has also been excluded on the basis that the intervention in not within scope. Both studies evaluate 'turn assist' though Baxter recognises that the intervention is 'turn assist surfaces' which may fall outside the topic scope but would welcome clarity around the rational for the exclusion of both of these studies. | Thank you for flagging these studies. They were excluded due to the evaluation of both bedframe and mattress systems. This was an exclusion criterion for the review as we focussed on evidence for bed frame systems alone.<br>However, we recognise that turn-assist can only be evaluated alongside specialist mattresses. We have therefore now included these studies. |
| 49 | Baxter | 51, 52, 58, | Table 4.11, section 5.1.2.2, | Agree with this inclusion. Baxter originally excluded these studies due to the ICU setting which is out of scope but support their inclusion in the EAG report. | Thank you for your comment. |

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| | | 72, 99-101 | section 5.3.2, table 5.11 | | |
| 50 | Baxter | 47, 59, 74, 93 | Table 4.11, section 5.1.2.4, section 5.3.4, | The reference provided for Rush 2021 does not provide any of the details reported in this section or through the EAG report. The study provided by Medstrom as an unpublished laboratory study (table C1) is Rush 2018 and has not been included in the reference list. | Thank you for your comment. We have amended this reference. |
| 51 | Baxter | 53, 59, 73, 101-102, 174, 180 | Table 4.11, section 5.1.2.3, section 5.3.3, table 5.11, table B9.11 and table C1 | Albuquerque et al 2020 has been excluded as there was an education component included; however, Baxter considers that use of innovative bed features will necessarily require an educational/instructional component to ensure correct implementation/use of the feature even where studies may not report specific education/training aspects. The company considers that this study should be included.<br>Cuttler et al 2017 has been excluded from the review and is described in table B9.11 as having an ineligible intervention however table C1 states Cuttler et al has been included. Baxter considers this publication should be included in the review as while the VersaCare bedframe is not available in the UK, the three-mode bed exit alarm technology is the same as is included in the Hillrom 900 X3 (optional) Hillrom 900 Accella and Hillrom 900 Accella Therapy & Progressa and the evidence from this study is considered be relevant to these models. | Thank you for your comment. The Albuquerque 2020 study was excluded, not because of the educational component on the use of the innovative feature, but because of the additional falls protocol instituted by the hospital fall prevention committee.<br><br>We agree that training on the use of alarms may be considered part of an exit alarm intervention. However, additional falls prevention interventions, such as patient education, are an additional intervention. We therefore cannot use these studies to derive estimates of the effectiveness of the use of exit alarms.<br><br>We apologise, the Cuttler 2017 study should be marked as excluded in table C1. As for the Albuquerque study, although bed exit alarms are evaluated pre- post- intervention, the main element of the intervention is the patient education. |

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| 52 | Baxter | 180 | Table C1 | 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. has been excluded with the rationale 'No innovative feature evaluated' (table C3) however Baxter would like to highlight that the technology in this publication is StayInPlace (HillRom Inc.), a commercial migration-reduction technology (MRT) and consider this study should be included in the assessment. | Thank you for highlighting this. We had previously excluded this study as it evaluates the relationship between migration and stresses. However, it also reports data comparing a conventional bed with a bed with a migration reduction feature. We have therefore included this study in the review of clinical evidence. |
| 53 | Baxter | 108, 112, 138, 143 | References | Instances of references have not added correctly to the text 'Error! Reference source not found' | Thank you for highlighting this, this referencing error has now been corrected. |
| 54 | Baxter | 112 | Paragraph 2 | Baxter notes that training does have an impact on user experience and preference elicitation and therefore the operability of bed frames with innovative features resulting in reduction of listed outcomes and is therefore linked to health economic impacts. | Thank you for this comment. While we are unable to capture the specific impact of this, we have included some text in the report to acknowledge it. |
| 55 | Baxter | 115 | Table 7.11 | Appreciating that 10% is being used due to the lack of evidence and that sensitivity analysis has been conducted. It would be helpful to add some more detail to note the rationale behind choosing this particular value in the base case as it feels somewhat arbitrary. It may help to provide some context around 'generic features' and how these are defined as compared with innovative features and generic innovative features (reported in section 7.3.1, table 7.88)? | Thank you for your comment. 10% is used as an arbitrary figure as there is no evidence to give a rationale of what this percentage should be.<br><br>The importance is that it is set to be consistent across all the generic features, so that the impact can be compared between them if a reduction could be made, which would have the largest impact. Only features with evidence are included in the bed frame fully incremental analysis. Therefore, the generic 10% reduction is only applied in the exploratory analysis to determine the value of reducing different types of incidents. |

| Comment no. | Stakeholder | Page no. | Section no. | Comment | EAG Response |
|---|---|---|---|---|---|
| | | | | | Generic innovative feature is used as it describes a group of innovative features impacting a health outcome e.g. an innovative feature which impacts falls. |
| 56 | Baxter | 127 | Table 7.44 | Missing units. Increase length of stay from infections – "days" as value measurement is missing | Thank you for spotting this, we have now added this in. |
| 57 | Baxter | 140 | Tornado Plot | Confirm the tornado plot (Figure 7.44) has been redacted for confidentiality purposes and is not missing. | Thank you for your comment. We can confirm this has been redacted. |
| 58 | Baxter | 142 | First bullet | Missing word in second sentence to be added for clarity. "An absence of evidence does not necessarily [indicate/mean?] there is no effect from these other innovative features, and the likely impact should be considered by the committee when making a recommendation" | Thank you for spotting this, we have now resolved this in the report |
| 59 | Baxter | 144 | First bullet | Although Baxter acknowledges that there is a need to make some simplifications in the model, the company has reservations around the approach to including lifespan of bedframes and the rationale behind this. While the rationale for a 10-year life span has been attributed to it being the most commonly indicated lifespan from company RFIs, there is no indication how many companies provided this detail or what variation existed in the provided lifespans. Lifespans of bedframes will be impacted by a number of factors, not limited to those noted by clinical experts. This may include manufacturing methods and materials used, which may in turn impact the robustness of the bedframe to damage caused by collisions (highlighted by clinical experts), or other factors such as improper use or storage of bedframes. 7 of 9 Baxter considers that the lifespan of specific bedframes will have an impact on cost savings as some bedframes have a shorter lifespan and/or require more regular replacement. Was there any sensitivity analysis performed to explore the impact of different bedframe lifespans on outcomes? | Thank you for this comment. The analysis has to include a lifespan of the bed frame, to determine the cost of the bed frame per person and per year. A 10 year lifespan was used based on the stated evidence from companies, and there was no evidence to differentiate between companies. We acknowledge that durability is likely to differ between bedframes. We have conducted sensitivity analysis in the reported and highlighted that the cost of the bed frame is a key driver of the results. Therefore, shorter life spans will increase the cost of the bed. As a result, the life span of the bed is also a key driver. We have added in further text to Section 7.3 to clarify this. |
| 60 | Baxter | 149-155 | Reference list | The DOI links for the following references included in the reference list are broken – an additional 'https://doi.org/' has been included. • Davis, K., Kotowski, S., Coombs, M., & | Thank you for your comment, this has been corrected in the EAR. |

| Comment no. | Stakeholder | Page no. | Section no. | Comment | EAG Response |
|---|---|---|---|---|---|
| | | | | Meyer, S. (2014). Influence of hospital bed design on patient migration. INTENSIVE CARE MEDICINE, 40(1 SUPPL. 1), S242. https://doi.org/https://dx.doi.org/10.1007/s00134-013-3451-5 (27th Annual Congress of the European Society of Intensive Care Medicine, ESICM 2014. Barcelona Spain. • Davis, K. G., & Kotowski, S. E. (2015). Role of Bed Design and Head-of-Bed Articulation on Patient Migration [Research Support, Non-U.S. Gov't]. JOURNAL OF NURSING CARE QUALITY, 30(3), E1-9. https://doi.org/https://dx.doi.org/10.1097/NCQ.0000000000000115 • Davis, K. G., Kotowski, S. E., & Coombs, M. T. (2017). Stopping the Slide: How Hospital Bed Design Can Minimize Active and Passive Patient Migration. JOURNAL OF NURSING CARE QUALITY, 32(1), E11-E19. https://doi.org/https://dx.doi.org/10.1097/NCQ.0000000000000205 • Research Support, Non-U.S. Gov't]. JOURNAL OF THE AMERICAN GERIATRICS SOCIETY, 58(3), 435-441. https://doi.org/https://dx.doi.org/10.1111/j.1532-5415.2010.02735.x • Research Support, Non-U.S. Gov't]. INTERNATIONAL JOURNAL OF NURSING STUDIES, 46(3), 317-325. https://doi.org/https://dx.doi.org/10.1016/j.ijnurstu.2008.10.005 • Kotowski, S. E., Davis, K. G., & Marras, W. S. (2022). Patient handling through moving of the beds and stretchers. INTERNATIONAL JOURNAL OF INDUSTRIAL ERGONOMICS, 87((Kotowski) Department of Rehabilitation, Exercise and Nutrition Sciences, College of Allied Health Sciences, University of Cincinnati, United States), 103252. https://doi.org/https://dx.doi.org/10.1016/j.ergon.2021.103252 • Schneider, A. G., Baldwin, I., Freitag, E., Glassford, N., & Bellomo, R. (2012). Estimation of fluid status changes in critically ill patients: fluid balance chart or electronic bed weight? JOURNAL OF CRITICAL CARE, 27(6), 745.e747-712. https://doi.org/https://dx.doi.org/10.1016/j.jcrc.2011.12.017 • Research Support, Non-U.S. Gov't]. JOURNAL OF CRITICAL | |

| Comment no. | Stakeholder | Page no. | Section no. | Comment | EAG Response |
|---|---|---|---|---|---|
| | | | | CARE, 28(6), 1113.e1111-1115. https://doi.org/https://dx.doi.org/10.1016/j.jcrc.2013.07.056 • Seow, J. P., Chua, T. L., Aloweni, F., Lim, S. H., & Ang, S. Y. (2022a). Effectiveness of an integrated three-mode bed exit alarm system in reducing inpatient falls within an acute care setting. JAPAN JOURNAL OF NURSING SCIENCE, 19(1), e12446. https://doi.org/https://dx.doi.org/10.1111/jjns.12446 8 of 9 • Wiggermann, N. (2016). Biomechanical Evaluation of a Bed Feature to Assist in Turning and Laterally Repositioning Patients. HUMAN FACTORS, 58(5), 748-757. https://doi.org/https://dx.doi.org/10.1177/0018720815612625 • Zhou, J., & Wiggermann, N. (2021). The effects of hospital bed features on physical stresses on caregivers when repositioning patients in bed. APPLIED ERGONOMICS, 90, 103259. https://doi.org/https://dx.doi.org/10.1016/j.apergo.2020.103259 | |
| 61 | Arjo UK Ltd | 69 | 5.2.17 | EAR: bullet point: Unclear whether bed frames fully align with specification for acute-care bed frames. Ref Comment: Please note that 3 of the 4 beds (Enterprise 5000x, Enterprise 8000x, 9000x) that were tested and reported in this paper (Matz, 2018) are indicated for use in the acute care environment i.e. Acute bed frames used in Acute Medical Units (AMUs), general and surgical wards. | Thank you for your comment. We have amended to state "…and power drive (ref) some high dependency beds were used". |
| 62 | Arjo UK Ltd | 17 | 2.22 | Specification incorrect for Arjo Enterprise 8000x and Arjo Enterprise 9000x. Currently States High Height 78 cm for both Models. Correct Height for Arjo Enterprise 8000x and Arjo Enterprise 9000x 76cm | Thank you for your comment. This has been updated in Table 2.2. |
| 63 | Arjo UK Ltd | 21 | 2.44 | Arjo Enterprise 5000x, 8000x and 9000x offers the following features Oxygen Cylinder holder, Xray Compartment, Catheter Bag hooks, Drainage bag holder, Pull out linen tray. Currently under **Ease-of-use Acessories** this is not displayed correctly only showing some of the above options across each model.<br>Please adjust to show all listed options (Oxygen Cylinder holder, Xray Compartment, Catheter Bag hooks, Drainage | Thank you for your comment. The ease of use features have been added to Table 2.4. The bed control features have also been added for the Arjo 8000x and 9000x bed frames. We have not stated that these are optional since multiple features listed in the tables are optional. Instead we have added a |

| Comment no. | Stakeholder | Page no. | Section no. | Comment | EAG Response |
|---|---|---|---|---|---|
| | | | | bag holder, Pull out linen tray.) Under Arjo Enterprise 5000x, 8000x and 9000x<br><br>Additionally displayed within Section **Bed Controls Arjo Enterprise 8000x and Bed Controls Arjo Enterprise 9000x** Patient Pendant and Nurse controls are an optional item. This should be adjusted to show the following: Arjo Enterprise 8000x Patient Pendant Optional, Nurse Controls optional Side rail Controls and Arjo 9000x Patient Pendant Optional, Nurse Controls optional Side rail Controls | note to each of the tables to highlight this point. |
| 64 | Arjo UK Ltd | 27 | 2.66 | **Durable Frame Construction with integrated components to reduce hospital-acquired damage.** Arjo Enterprise bed range is built within Durable Materials and supporting features such as anti-static castors, x4 roller buffers located at each corner of the frame to reduce potential damage to the frames. The Enterprise range has also been designed and constructed to offer a pit stop maintenance allowing for access to each bed component for service and repair therefore reducing time to which the frame is not in service.<br><br>Can NICE define this further than what is displayed on page 35 Maintenance and Repair as Arjo appears to meet these standards based within this clarification. | Thank you for your comment. We agree that Arjo bed frames meet the requirements for a durable frame feature and have added ticks accordingly. In line with your comment, we have also updated the definition on page 35 to provide more clarity. |
| 65 | Arjo UK Ltd | 31,32,33,34,35, 36 | 2.88 | **Groups of People who may benefit from the feature.** This section needs to be reviewed to included not only **Patient safety** but also include **Carer Safety** as this is something suppliers are assessed upon based on the innovations displayed within section 2.22 page 17 and section 2.44 page 21. The features which are contained within this section should be considered both as features and benefits to all groups. | Thank you for highlighting this. We have updated the 'groups of people who may benefit from the feature' column to include healthcare providers where appropriate. |

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## Section B: Economic model – Collated comments table:

| Comment no. | Stakeholder | Page no. | Section no. | Comment | EAG Response |
|---|---|---|---|---|---|
| 1 | Arjo UK Ltd | Summary | Summary results. Fully incremental analysis for cohort (per person) | Clarity on the Meaning of Dominance Results and Efficacy Frontier contained within LSA bed Frame Features Model V2 redacted. Under Tab Summary within the economic model, it currently displays the Arjo Enterprise 9000 x and Not Dominated and Referent. From the EAG Report it is referenced within Page 217 appendix E5 but without an understanding of what this means positively or negatively | Thank you for your comment. The version of the model shared with stakeholders is a redacted version of the original model, as the original model contains confidential inputs regarding technology costs.<br><br>In this redacted version of the model, dummy data inputs have been used which means that the costs and quality-adjusted life years (QALYs) in this version are different to those in the original model. The purpose of sharing the redacted model is to allow stakeholders to understand how the model operates. However, true interpretation of results is not possible from this redacted model given the dummy inputs used.<br><br>In this particular dummy data scenario with the model settings as they are in the redacted model, the results would be interpreted as this Arjo bed being cost-effective. However, the original results of this fully incremental analysis are not available to stakeholders due to the confidential nature of the costs used to calculate the results. Therefore, the redacted model cannot be used to make conclusions about the original model results, and as such these dummy results should not be interpreted as positive or negative |

## Section C: User Preference Report – Collated comments table:

| Comment no. | Stakeholder | Page no. | Section no. | Comment | NICE Response |
|---|---|---|---|---|---|
| 1 | Medstrom | 34 | Limitations | A frame structure that gives improved compatibility with accessories such as hoists example and 'A frame structure' gives better access underneath the frame for improved cleaning, therefore the phrase "For example, a frame structure that gives improved compatibility with accessories such as hoist, standing aids and tables might create might make some parts of the bed difficult to access to clean" is not factually correct. | Thank you for your comment. The wording of this example has been updated in the user preference report: "For example, a frame structure with improved compatibility with accessories such as hoists, standing aids and tables might mean some parts of the bed frame structure are difficult to access for cleaning." This was an opinion given by one of the workshop attendees, and is not intended to be a factual statement. This opinion was included to give readers one example of how some feature combinations may be counterproductive in practice. |
| 2 | Baxter | 8 | | It is noted that a total of 12 users took part in the first workshop, including a broad sample of job titles. Please may you confirm that a broad selection of participants and survey respondents that represent all bed technologies have been included to give a balanced user experience? There is a potential risk of bias if there is not a broad spectrum of bed frames users from all companies included in the assessment, and generalisability of the findings from the user preference survey to all bed frames/company products will be limited. | Thank you for your comment. Efforts were made to reach out to users across different Trusts to capture the varied experiences and preferences of users. In the user survey, respondents who did not have experience with a particular bed frame feature were asked to consider how desirable a feature would be to have on a bed frame. This meant that users could express their preferences on bed frame features even if they work in a Trust that does not currently have beds with these features. NICE acknowledged that a limitation of the user preference assessment is volunteer bias. Users volunteered to take part in the assessment, and so the sample of users and people with lived experience may not be fully representative of the wider population. |
| 3 | Baxter | 9 | | Making a statement that a low bed height of 21cm reduces the number of falls, no evidence. Baxter has no issue with the statement that a low bed height reduces the number of falls though would argue that evidence may suggest otherwise, the | Thank you for your comment. In the user preference workshop, users were asked to indicate the lowest height position that they would consider desirable for reducing patient |

| Comment no. | Stakeholder | Page no. | Section no. | Comment | NICE Response |
|---|---|---|---|---|---|
| | | | | inclusion of a definitive bed height of 21cm is problematic as there is no evidence to support this figure specifically and this may be interpreted as a bias towards a specific bed frame. | falls. Users agreed that a low-height position of 21cm was desirable for reducing the number of falls. This was the opinion expressed by the attendees of the user preference workshop, and is not a factual statement that is supported by evidence. The height of 21cm has been included in the report to give an indication of the preferences for the lower limit of bed frame height. It is acknowledged that beds may have a lowest height position that is above 21cm, but may still be able to reduce falls. The committee will consider this when making their recommendations.<br><br>We acknowledge that different wording could have been used to describe the innovative feature of low bed height. We will consider the wording used to describe innovative features in future late-stage assessments. |
| 4 | Baxter | 9 | | Making a statement that high height of 83cm reduces the number of MSK incidences, no evidence 9 of 9 Baxter has no issue with the statement that a high bed height reduces the number of MSK incidences. However, the inclusion of a definitive bed height of 83cm is problematic as there is no evidence to support this figure specifically, and this may be interpreted as a bias towards a specific bed frame. | Thank you for your comment. In the user preference workshop, users were asked to indicate the high-height position that they would consider desirable for reducing caregiver musculoskeletal injuries. Users agreed that a high-height position of 83cm was desirable for reducing the number of caregiver musculoskeletal injuries. This was the opinion expressed by the attendees of the user preference workshop, and is not a factual statement that is supported by evidence. The height of 83cm has been included in the report to give an indication of the preferences for high-height position. It is |

| Comment no. | Stakeholder | Page no. | Section no. | Comment | NICE Response |
|---|---|---|---|---|---|
| | | | | | acknowledged that beds may have a high-height position that is below or above 83cm, but may still be able to reduce caregiver musculoskeletal injuries. The committee will consider this when making their recommendations.<br><br>We acknowledge that different wording could have been used to describe the innovative feature of high bed height. We will consider the wording used to describe innovative features in future late-stage assessments. |
| 5 | Baxter | 9 | | No representation from Portering may introduce bias and limit generalisability of the findings for certain bed features. | Thank you for your comment. Portering staff were acknowledged as an important user group, and efforts were made to seek workshop participation and survey responses from portering staff. NICE acknowledged that a limitation of the user preference assessment is volunteer bias. Users volunteered to take part in the assessment, and so the sample of users and people with lived experience may not be fully representative of the wider population. |
| 6 | Baxter | 9 | | No representation from Clinical Informatics, Digital Transformation Leads – this could be the reason that connectivity is not scoring well in the user preference report | Thank you for your comment. NICE acknowledged that a limitation of the user preference assessment is volunteer bias. Users volunteered to take part in the assessment, and so the sample of users and people with lived experience may not be fully representative of the wider population. |

| Comment no. | Stakeholder | Page no. | Section no. | Comment | NICE Response |
|---|---|---|---|---|---|
| 7 | Baxter | 10 | Last paragraph, 2nd sentence | The standard deviation for Bluetooth connectivity is 0.26, should this be 1.26 as in table 2? | Thank you for your comment. This error has been corrected in the updated user preference report. |
| 8 | Arjo UK Ltd | 9<br><br>11<br><br>16<br><br>21 | Table 1: Bed frame considerations and definitions,<br><br>Table 2: summary of user survey results for patient falls.,<br><br>Table 6: summary of user survey results for patient recovery, independence and rehabilitation.<br><br>Table 10: summary of user survey results for | We recognise the significance of both low and high bed frame heights and appreciate the user feedback and scoring that has been provided. We fully understand the methodology used to capture this feedback, as outlined in the 'NATIONAL INSTITUTE FOR HEALTH AND CARE EXCELLENCE Interim Methods and Process Statement for Late-Stage Assessment.'<br><br>However, we seek further clarification regarding the current user groups' knowledge of the marketplace and the manner in which they were informed about the differentiating specifications. This information is crucial to support the preference claims of a 21cm low height within the user feedback groups. As per the Study referenced on page 36 the language used should be given consideration for words such as **BETWEEN HEIGHTS 21cm AND ABOVE** rather than a preference of 21cm.<br><br>Given that 21cm is the lowest height offered by a minority within the current supplier group, we believe that, without additional justification beyond the questions posed to the user group, this preference should not be highlighted as a key point within the Late-Stage Assessment (LSA) due to this being misunderstood in the future and set as potential bench mark for procuring equipment. Further consideration should be made towards evaluating heights in isolation due to different mechanisms which could impact other elements for example stability and or movability.<br><br>Ensuring that the user feedback is comprehensive and accurately reflects the needs and preferences of the user | Thank you for your comment. Late-stage assessment (LSA) is currently in the pilot phase of the programme, and as such new methods are being trialled to assess their suitability for addressing the aims of LSA.<br><br>We acknowledge that different wording could have been used to describe the innovative feature of low bed height. We will consider the wording used to describe innovative features in future late-stage assessments.<br><br>Due to the large number of questions in the user survey, it was not considered appropriate to ask users to express preferences on the low height and high height positions of each of the bed frames in scope of the assessment. In the user preference survey, users were asked to express preferences for 1 low height position (21cm) and 1 high height position (83cm). At the user preference workshop, these heights were chosen as examples based on the specifications for bed frames included in the scope. However, this is not to conclude that other low and high height positions cannot reduce incidents, and Trusts may consider other heights acceptable during the bed |

| Comment no. | Stakeholder | Page no. | Section no. | Comment | NICE Response |
|---|---|---|---|---|---|
| | | 40-42-43 | adaptability, <br><br> Table 18: key considerations and innovative features identified at the user preference workshop. | groups, we would like to better understand and have consideration to the following.<br><br>• **Market Awareness**: Assessing the level of market awareness among the user groups is essential. This includes understanding their familiarity with different bed frame heights and the benefits and drawbacks associated with each option. Providing detailed information and educational resources can help bridge any knowledge gaps and ensure that users make informed decisions.<br>• **Information Dissemination**: How information about bed frame specifications was disseminated to the user groups. This includes the clarity, accuracy, and comprehensiveness of the information provided. Ensuring that users have access to comparison charts, product descriptions, and other educational materials can help them understand the differences between various bed frame heights.<br>• **Rationale for Preferences**: Gathering qualitative data on the reasons behind the preference for a 21cm bed frame height is crucial. This could involve conducting follow-up surveys or interviews to understand the specific needs and motivations of the users who prefer this height. Factors such as ease of access, aesthetic preferences, and ergonomic considerations should be explored in detail.<br>• **Supplier Offerings**: Considering that 21cm is the lowest height provided by a minority within the current supplier group, it is important to understand the context of this offering. This includes evaluating whether the 21cm height meets specific user needs that are not addressed by other available options and whether it aligns | frame decision making process. The committee will consider this when making their recommendations. |

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| | | | | with broader market trends and demands. Consideration must be made to evaluating such an important function of the device in Isolation which can limit a potential holistic approach<br><br>From this we would like hope to better understand the user preference feedback robustness and well-supported information providing a solid foundation for any preference claims made within the Late-Stage Assessment. | |
| 9 | Arjo UK Ltd | 9<br><br>18 | Table 1: Bed frame considerations and definitions,<br>Table 7: summary of user survey results for caregiver musculoskeletal injuries from repositioning of patients. Caregiver entrapment injuries<br><br>Table 9: summary | We recognise the significance of both low and high bed frame heights and appreciate the user feedback and scoring that has been provided. We fully understand the methodology used to capture this feedback, as outlined in the 'NATIONAL INSTITUTE FOR HEALTH AND CARE EXCELLENCE Interim Methods and Process Statement for Late-Stage Assessment.'<br><br>However, we seek further clarification regarding the current user groups' knowledge of the marketplace and the manner in which they were informed about the differentiating specifications. This information is crucial to support the preference claims of an 83cm height within the user feedback groups.<br><br>Given that 83cm is offered by a minority within the current supplier group, we believe that, without additional justification beyond the questions posed to the user group, this preference should not be highlighted as a key point within the Late-Stage Assessment (LSA) due to this being misunderstood in the future and set as potential bench mark for procuring equipment. Further consideration should be made towards evaluating heights in isolation due to different mechanisms which could impact other elements for example stability and or movability. | Thank you for your comment.<br><br>Late-stage assessment (LSA) is currently in the pilot phase of the programme, and as such new methods are being trialled to assess their suitability for addressing the aims of LSA.<br><br>We acknowledge that different wording could have been used to describe the innovative feature of high bed height. We will consider the wording used to describe innovative features in future late-stage assessments.<br><br>Due to the large number of questions in the user survey, it was not considered appropriate to ask users to express preferences on the low height and high height positions of each of the bed frames in scope of the assessment. In the user preference survey, users were asked to express preferences for 1 low height position |

| Comment no. | Stakeholder | Page no. | Section no. | Comment | NICE Response |
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| | | | of user survey results for caregiver entrapment injuries<br><br>Table 10: summary of user survey results for adaptability.<br><br>Table 16: feature with the highest average importance score for each consideration.<br><br>Table 18: key considerations and innovative features identified at the user | Ensuring that the user feedback is comprehensive and accurately reflects the needs and preferences of the user groups, we would like to better understand and have consideration to the following.<br><br>• **Market Awareness**: Assessing the level of market awareness among the user groups is essential. This includes understanding their familiarity with different bed frame heights and the benefits and drawbacks associated with each option. Providing detailed information and educational resources can help bridge any knowledge gaps and ensure that users make informed decisions.<br><br>• **Information Dissemination**: How information about bed frame specifications was disseminated to the user groups. This includes the clarity, accuracy, and comprehensiveness of the information provided. Ensuring that users have access to comparison charts, product descriptions, and other educational materials can help them understand the differences between various bed frame heights.<br>• **Rationale for Preferences**: Gathering qualitative data on the reasons behind the preference for a 83cm bed frame height is crucial. This could involve conducting follow-up surveys or interviews to understand the specific needs and motivations of the users who prefer this height. Factors such as ease of access, aesthetic preferences, and ergonomic considerations should be explored in detail.<br><br>• **Supplier Offerings**: Considering that 83cm height provided by a minority within the current supplier group, it is important to understand the context of | (21cm) and 1 high height position (83cm). At the user preference workshop, these heights were chosen as examples based on the specifications for bed frames included in the scope. However, this is not to conclude that other low and high height positions cannot reduce incidents, and Trusts may consider other heights acceptable during the bed frame decision making process. The committee will consider this when making their recommendations. |

| Comment no. | Stakeholder | Page no. | Section no. | Comment | NICE Response |
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| | | | preference workshop | this offering. This includes evaluating whether the 83cm height meets specific user needs that are not addressed by other available options and whether it aligns with broader market trends and demands. Consideration must be made to evaluating such an important function of the device in Isolation which can limit a potential holistic approach<br><br>From this we would like hope to better understand the user preference feedback robustness and well-supported information providing a solid foundation for any preference claims made within the Late-Stage Assessment. | |

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## Late-stage assessment

# GID-HTE10050 Bed frames for adults in acute settings

## User preference report


**Produced by:** NICE

**Authors**: **Sophie Harrison**, Analyst, NICE

**Frances Nixon**, Adviser, NICE



**Date completed:** December 2024


**Contains confidential information:** No

**Number of attached appendices:** 3

Following a period of consultation on the user preference report, the report has been updated in line with stakeholder comments.

| Description of change | Page number containing the change |
|---|---|
| More detail has been added regarding the user preferences for low bed height and high bed height positions. | 10 |
| Corrected the standard deviation for Bluetooth connectivity | 12 |
| More detail has been added regarding user preferences for connectivity features | 25 |
| Detail has been added regarding IT infrastructure for the connectivity consideration | 32 |
| A limitation has been added regarding low and hight bed height positions | 34 |
| A limitation has been added regarding the assumption of equivalent importance of key considerations | 35 |
| A limitation has been added regarding external factors potentially influencing user preferences | 35 |
| An example of feature counterproductivity has been amended for clarity | 35 |
| More detail has been added to the section on the EAG findings for low bed height position | 38 |
| Reference to external factors added | 40 |
| Replaced “intermediate outcomes” with “technical outcomes” | 41 |
| Replaced “clinical events” with “incidents” | Throughout |
| Replaced “5$^{th}$” with “fifth” | Throughout |

# Table of Contents

## Introduction

Alongside the assessment of a technology's value based on costs and effectiveness, the late-stage assessment on bed frames for adults in acute settings includes an assessment of user preferences that influence decision making when selecting which technology to use (NICE's Interim methods and process statement for late-stage assessment). This report presents the key findings from the user preference assessment that was done to understand:

- the considerations that are important to users during the decision-making process for selecting a bed frame
- the innovative bed frame features which can help to address each of the considerations
- the importance of the innovative features for each consideration

In the Department of Health and Social Care medical technology innovation classification framework, it is said that "for a device to be defined as an innovation it should demonstrate an incremental improvement, be a novel application or is a novel device that meets an unmet clinical need or provides improvements upon existing technology or models of care". The user preference report should be read alongside the final scope and the external assessment report.

## Background

This late-stage assessment focusses on bed frames for adults in acute settings. Bed frame design and local procurement considers the needs and preferences of people involved at all stages of the product's lifecycle. There are a number of bed frame user groups who make up the multidisciplinary teams delivering care to patients. The decision-making process for selecting a bed frame is collaborative, and considers the preferences of these different user groups within a trust. When a person is admitted to an acute setting, the bed they are placed in will be determined by a risk assessment, and will depend on the beds that the trust has available in its portfolio. Patients will not be asked to give their preferences on which type of bed they are placed in, therefore patients are not part of the bed frame decision making process within a trust.

# Methods

This user preference assessment was done in line with NICE's Interim methods and process statement for late-stage assessment. The aim of capturing user preferences is to transparently collect and present information to the committee on the considerations that are important to users during the decision-making process for selecting a bed frame.

## Participants

As per section 4.28 of the late-stage assessment interim methods and processes, "users are defined as those who will use the technology and are directly involved in the decision to choose one technology over another". For this assessment, user groups were identified as groups who are involved in a bed frame procurement exercise within a trust and therefore have the knowledge and experience to assess the different user preferences and needs. This includes:

- Procurement teams
- Nurses
- Manual handling teams
- Tissue viability teams
- Infection control teams
- Falls prevention teams
- Physiotherapists
- Occupational therapists
- Clinical engineers
- Porters

Bed frame decision-making is done at a procurement level, and patients are not involved in the decision-making process for selecting a bed frame. For this reason, patients are not considered users of bed frames for this user preference assessment.

NICE's policy on declaring and managing interests for NICE advisory committees was considered during the recruitment process. Users who were directly employed by a company whose technologies are being evaluated were excluded from the user preference workshop. A declarations of interest register of users who attended the user preference workshop will be published alongside the guidance document on NICE's topic page.

## Assessment stages

The user preference assessment was done through participation in 1 online workshop, 1 user survey task and a patient survey:

- Workshop 1: identifying and defining the considerations that are made during the decision-making process for selecting a bed frame, and identifying innovative bed frame features that can help to address each consideration
- User survey: rating the importance or desirability of each innovative bed frame feature for a given consideration
- Patient survey: to understand the views of patients on which bed frame features are most important to them

### Workshop 1

Users were asked to agree on a list of considerations that are important during the decision-making process for selecting a bed frame. For each of these considerations, users were asked to agree on a list of innovative bed frame features that can help to address the consideration. Some innovative bed frame features may help to address more than 1 consideration.

At this workshop, users indicated that each consideration would be given equal importance and weighting in a bed frame procurement exercise. Each user group would have their own priorities and preferences when contributing to a bed frame procurement exercise, so it was not feasible to ask the different user groups to collectively agree on an importance ranking of the different considerations.

At the user preference workshop, users were asked to indicate the key user groups for each of the considerations agreed on. This was to ensure that in the follow-up user survey, each user group could be asked to express preferences on the bed frame features addressing the considerations that are most relevant to their role.

## User survey

A user survey was developed using the output of the user preference workshop. The survey was sent out to those who attended the user preference workshop, with a request for the survey to be shared with any colleagues who are in in the user groups of this assessment. A number of other professionals from relevant disciplines were identified and asked to complete the survey also.

Users were asked to rate the importance or desirability of each innovative feature identified for a given consideration. Survey questions were targeted so that user groups were presented with questions on the considerations that are most relevant to them in their role. For example, users agreed that clinical engineers are not best placed to express preferences for innovative bed frame features helping to address patient falls, and also agreed that only clinical engineers should be asked to express preferences on bed frame features related to maintenance and repair.

For each consideration, users were asked to rate the importance or desirability of a list of innovative features which was agreed at the user preference workshop. Users were asked to use the following scoring scale when considering feature importance/desirability:

- 1 – not at all important
- 2 – not very important
- 3 – neither important or unimportant
- 4 – quite important
- 5 – very important

Trusts may not have beds with certain features, but users of these beds would be able to indicate which features would meet their needs. For this reason, users were asked to consider how desirable a feature would be even if they did not have direct experience with using the feature.

A free-text box was given for each consideration, to allow users to add in any other innovative features that may help to address a consideration that were not on the list agreed at the user preference workshop. An importance score was not calculated for any features identified in the free-text boxes, since they were flagged by individual responders and were not therefore part of the questions shared with all users.

Survey results were collated, and average importance scores were calculated (with a minimum of 1 and maximum of 5) for each bed frame feature addressing each consideration. Average importance scores were often in-between discrete points on the scoring scale. It was not considered to be appropriate to round average importance scores to the nearest whole number score. Average importance scores for each feature have been rounded to 2 decimal places, allowing a clearer indication of the importance order of features based on their average importance scores. The interpretation of an average importance score than is in-between 2 whole number scores is that the feature was, on average, more important than the lower bound of the 2 scores, but not considered to be as important as the upper bound. Standard deviations were calculated for each feature, to show the spread of results around the mean importance score.

### Patient survey

As discussed previously in this report, patients were not considered users of bed frames for the purpose of this assessment. Patients may, however, still have views on which bed frame features are important to them when spending time in a hospital bed. To capture this patient experience, a short survey was sent out to patients to ask them to indicate their top 5 most important bed frame features in their experience. The patient survey did not categorise bed frame features by the considerations agreed at the user preference workshop, and instead patients were given a single list of bed frame features and asked to consider their most important. The list of innovative features in the patient survey was smaller than that of the user survey, as the patient survey focussed on features which would directly impact them during their stay in an acute bed.

# Results

## User preference workshop

A total of 12 users took part in the first workshop, some of whom had experience covering multiple user groups. This included 4 people with experience in clinical engineering, 2 occupational therapists, 3 people with job roles focussing on moving and handling, 2 people with job roles focussing on nursing, 2 people with job roles focussing on falls prevention, and 1 person with experience as a health and safety services manager.

Users agreed on 12 key areas of consideration during the decision-making process for selecting a bed frame. For each of these considerations, the users agreed on a definition for what bed frame features must do to help to address the consideration. These considerations and their agreed definitions are shown in Table 1. For each consideration, users discussed and agreed on a list of innovative features which could help to address the consideration. These features can be seen in the results section for each consideration.

**Table 1: Bed frame considerations and definitions**

| Consideration | Definition of features |
|---|---|
| Patient falls | Help to reduce the frequency of patients falling from their bed or in the area around their bed |
| Patient entrapment | Help to reduce the frequency of patient entrapment injuries. |
| Patient respiratory function | Help to improve patient respiratory function when in bed |
| Pressure ulcer formation | Help to prevent hospital-acquired pressure injuries (HAPI) |
| Caregiver musculoskeletal injuries | Help to reduce caregiver musculoskeletal injuries |

| | |
|---|---|
| Caregiver entrapment injuries | Help to reduce caregiver entrapment injuries occurring within the frame structure and during manual handling tasks |
| Adaptability | Allow the bed to be changed to meet the needs of different patients, caregivers and scenarios |
| Infection prevention | Contribute to easy cleaning of a bed |
| Maintenance and repair | Contribute to easy maintenance and repair of the beds |
| Facilitation of recovery, independence and rehabilitation | Help to encourage patients to self-mobilise |
| Sustainability | Contribute to the NHS' commitment to a net zero health service |
| Connectivity | Allow connectivity between beds and other systems or applications |

Discussion took place to refine the descriptions of innovative features related to bed height. Users agreed that a low-height position of 21cm was desirable for reducing the number of falls, and a high-height position of 83cm or above would be desirable for reducing the number of caregiver musculoskeletal injuries by allowing the bed to be placed at a safe working height. A low height position of 21cm is lower than that of other beds in-scope of this assessment, however, Trusts may consider other low bed height positions acceptable for reducing falls. Some ultra-low or floor beds can be placed at a position that is lower than 21cm, but these beds fall outside of the scope of this assessment. As for a high height position of 83cm, this is higher than many of the beds in-scope of this assessment, however, Trusts may consider lower high height positions acceptable for reducing caregiver musculoskeletal injuries.

## User preference survey

The output of the user preference workshop was used to set up a user survey. A total of 36 users submitted responses to the user survey. To begin with, users were asked to write out their full job title. So that users could be directed to answer questions on the considerations most relevant to their area of expertise, they were then asked to select a discipline area that most closely related to their role. Two respondents who completed the survey selected procurement officer, 10 selected nurse, 5 selected manual handling lead, 2 selected tissue viability lead, 2 selected infection control team, 3 selected falls prevention team, 3 selected physiotherapist, 3 selected occupational therapist and 6 selected clinical engineer. This meant that there was at least 1 respondent representing each of the user group perspectives sought for, except for porters. There were 6 people who selected the “other” option from the list of disciplines which meant that they were automatically screened out of the survey, since they did not meet the inclusion criteria for the survey.

For each consideration, relevant user groups were presented with the list of innovative features that was agreed at the user preference workshop. They were asked to rate the importance/desirability of each feature. Once all survey responses had been collected, an average importance score was calculated for each feature, for a given consideration. A copy of anonymised survey results can be provided upon request.

In total, there were 82 survey questions on the features addressing the 12 key considerations. There were a number of features that were identified as addressing multiple considerations, so there were fewer than 82 unique innovative features identified.

### Patient falls

A total of 30 users responded to the questions on the bed frame features helping to address patient falls. There were 11 innovative features identified as helping to address patient falls. A summary of the results is shown in Table 2.

Seven features had an average importance score of between 4 (quite important) and 5 (very important). The feature with the highest average importance score (4.87) was “a frame structure that gives improved compatibility with accessories such as hoists, so that they easily fit underneath the bed frame”. The standard deviation for the responses on this feature was one of the smallest of all features addressing patient falls, with 28 respondents rating this feature as quite or very important. This shows that there was good overall agreement on the importance of this feature.

The feature with the lowest average importance score (3.07) was “Bluetooth connectivity to reduce the number of leads/cables required and potentially reduce trip hazards”. The standard deviation for the responses on this feature is considerable (1.26), as there was a spread of importance ratings across the full range of response options. These findings suggest that, on average, this feature is rated as being neither important or unimportant, but there were different views from different users on the overall importance of this feature.

**Table 2: summary of user survey results for patient falls.**

| Importance order based on average scores | Feature | Average importance score | Standard deviation |
|---|---|---|---|
| 1 | Frame structure that gives improved compatibility with accessories such as hoists, standing aids and tables, so that they easily fit underneath the bed frame | 4.87 | 0.43 |
| 2 | Side rails that are flush to the bed when folded down to reduce the distance between the edge of the bed and the edge of mattress | 4.80 | 0.40 |
| 3 | Low height position of 21cm | 4.60 | 0.71 |
| 4 | Ability to lock-out controls to prevent patients from accidentally changing the height of the bed | 4.57 | 0.72 |
| 5 | Ergonomic side rail grip to support patients getting in and out of bed | 4.47 | 0.62 |
| 6 | Brake alarm to indicate when the brakes are off | 4.43 | 0.67 |
| 7 | Visual brake indicator to indicate when the brakes are off | 4.23 | 0.85 |
| 8 | Bed exit alarms | 3.97 | 1.05 |
| 9 | Programmable custom height settings for when the patient is getting in or out of bed | 3.77 | 1.05 |
| 10 | Under-frame lighting | 3.645 | 1.03 |
| 11 | Bluetooth connectivity to reduce the number of leads/cables required and potentially reduce trip hazards | 3.07 | 1.26 |

## Patient entrapment

A total of 30 users responded to the questions on the bed frame features helping to address patient entrapment. There were 3 innovative features identified as helping to address patient entrapment. A summary of the results is shown in Table 3.

Two of the 3 features had an average importance score of between 4 (quite important) and 5 (very important). The feature with the highest average importance score (4.47) is "Ability to lock-out controls to prevent patients from accidentally changing the height of the bed". The results for this feature had the smallest standard deviation of the features for patient entrapment (0.76), with 19 respondents rating this feature as "5 - very important". This suggests that there was good overall agreement on the importance of this feature.

The feature with the lowest average importance score (3.73) is "warning tone and pauses as the bed moves to its lowest position". This feature had the largest standard deviation (1.19), and there was a spread of responses across the full importance scale. These findings suggest that, on average, this feature is somewhat important when considering patient entrapment. However, there were different views from different users on the overall importance of this feature.

**Table 3: summary of user survey results for patient entrapment.**

| Importance order based on average scores | Feature | Average importance score | Standard deviation |
|---|---|---|---|
| 1 | Ability to lock-out controls to prevent patients from accidentally changing the height of the bed | 4.47 | 0.76 |
| 2 | Anti-entrapment systems to automatically stop the bed lowering if an obstruction is detected | 4.40 | 0.95 |
| 3 | Warning tone and pauses as the bed moves to its lowest position | 3.73 | 1.19 |

## Patient respiratory function

A total of 30 users responded to the questions on the bed frame features helping to address patient respiratory function. There were 4 innovative features identified as helping to address patient respiratory function. A summary of the results is shown in Table 4.

There were 2 features with an average importance score of between 4 (quite important) and 5 (very important). The feature with the highest average importance score (4.53) was “Autoregression to reduce torso compression (features that increase surface area for the patient’s sacral area and eliminate heel travel when the head of bed is profiled)”. There were 19 respondents who rated this feature as “5 – very important”, indicating good overall agreement of the degree of importance of this feature.

The feature with the lowest average importance score (3.73) is “Auto backrest angle pauses (such as at 30 degrees)”. Responses for importance of this feature ranged from “2 – not very important” to “5 – very important”. The mode rating was “4 – quite important”, for which there were 14 responses. These findings suggest that, on average, this feature is somewhat important when considering patient respiratory function. However, there was not an overall majority of responses that agreed on the degree of importance of this feature.

**Table 4: summary of user survey results for patient respiratory function.**

| Importance order based on average scores | Feature | Average importance score | Standard deviation |
|---|---|---|---|
| 1 | Autoregression to reduce torso compression (features that increase surface area for the patient’s sacral area and eliminate heel travel when the head of bed is profiled) | 4.53 | 0.67 |
| 2 | Cardiac chair position | 4.47 | 0.61 |
| 3 | Head of bed angle indicator | 3.9 | 0.98 |
| 4 | Auto backrest angle pauses (such as at 30 degrees) | 3.73 | 0.81 |

## Pressure ulcer formation

A total of 30 users responded to the questions on the bed frame features helping to address pressure ulcer formation. There were 6 innovative features identified as helping to address pressure ulcer formation. A summary of the results is shown in Table 5.

All 6 features had an average importance score of between 4 (quite important) and 5 (very important), suggesting that all of these features are important when thinking about pressure ulcer formation. The feature with the highest average importance score (4.9) was "Compatibility with pressure care mattresses". The standard deviation for this feature was low (0.3), with 28 respondents rating this feature as quite or very important. These findings suggest that there is good overall agreement on the importance of this feature.

The feature with the lowest average importance score (4.37) is "Patient access to handset to reposition the bed". The standard deviation for this feature was 0.55, with 29 respondents rating this feature as quite or very important. These findings suggest that there was good overall agreement on the degree of importance of this feature.

**Table 5: summary of user survey results for pressure ulcer formation.**

| Importance order based on average scores | Feature | Average importance score | Standard deviation |
|---|---|---|---|
| 1 | Compatibility with pressure care mattresses | 4.90 | 0.30 |
| 2 | Compatibility with mattresses that follow the contours of the bed | 4.83 | 0.37 |
| 3 | Side rails that are flush to the bed when folded down to reduce the distance between the edge of the bed and the edge of mattress | 4.63 | 0.48 |
| 4 | Ergonomic side rail grip to help patients reposition themselves | 4.57 | 0.56 |
| 5 | Autoregression to prevent migration down the bed (features that increase surface area for the patient's sacral area and eliminate heel travel when the head of bed is profiled) | 4.50 | 0.62 |
| 6 | Patient access to handset to reposition the bed | 4.37 | 0.55 |

## Patient recovery, independence and rehabilitation

A total of 30 users responded to the questions on the bed frame features helping to address patient recovery, independence and rehabilitation. There were 9 innovative features identified as helping to address patient recovery, independence and rehabilitation. A summary of the results is shown in Table 6.

There were 7 features with an average importance score of between 4 (quite important) and 5 (very important). The feature with the highest average importance score (4.8) was "Frame structure that gives improved compatibility with accessories, such as hoists". The standard deviation for this feature was low (0.4), with 24 respondents rating this feature as "5 – very important" and 6 responses of "4 – quite important". These findings show that there was good overall agreement with the degree of importance of this feature.

The feature with the lowest average importance score (3.77) was “Features that enable connection between patients and caregivers when assistance is required”. The responses for this feature ranged from “2 – not very important” to “5 – very important”, with 24 people responding either “3 – neither important or unimportant” or “4 – quite important”. These findings show that there was a range of opinions regarding the degree of importance of this feature.

**Table 6: summary of user survey results for patient recovery, independence and rehabilitation.**

| Importance order based on average scores | Feature | Average importance score | Standard deviation |
|---|---|---|---|
| 1 | Frame structure that gives improved compatibility with accessories, such as hoists | 4.80 | 0.40 |
| 2 | Variable bed length to allow for taller patients | 4.70 | 0.46 |
| 3 | Side rails that are flush to the bed when folded down to reduce the distance between the edge of the bed and the edge of mattress | 4.67 | 0.47 |
| 4 | Ergonomic side rail grip or bed lever compatibility to support patients getting in and out of bed | 4.57 | 0.50 |
| 5 | Autoregression (features that increase surface area for the patient’s sacral area and eliminate heel travel when the head of bed is profiled) | 4.50 | 0.72 |
| 6 | Bed controls that are in an accessible location and have an intuitive design, to encourage patients to become more independent | 4.47 | 0.62 |
| 7 | Low height position achievable of 21cm | 4.33 | 0.98 |
| 8 | Programmable custom height settings for when the patient is getting in or out of bed | 3.90 | 0.98 |
| 9 | Features that enable connection between patients and caregivers when assistance is required | 3.77 | 0.76 |

## Caregiver musculoskeletal injuries from repositioning of patients

A total of 30 users responded to the questions on the bed frame features helping to address caregiver musculoskeletal injuries. There were 7 innovative features identified as helping to address caregiver musculoskeletal injuries from repositioning of patients (Table 7).

For caregiver musculoskeletal injuries from repositioning of patients, there were 5 features with an average importance score of between 4 (quite important) and 5 (very important). The other 2 features had average importance scores between 3 (neither important or unimportant) and 4 (quite important).

The feature with the highest average importance score (4.8) was “Frame structure that gives improved compatibility with accessories, such as hoists”. The standard deviation for this feature was low, with 25 people giving a rating of “5 - very important”. These findings show that there was good overall agreement with the degree of importance of this feature.

The feature with the lowest average importance score (3.77) was “Lightweight mattress deck”. The responses for this feature ranged from “2 – not very important” to “5 – very important”, which shows that there was a range of opinions regarding the degree of importance of this feature.

**Table 7: summary of user survey results for caregiver musculoskeletal injuries from repositioning of patients.**

| Importance order based on average scores | Feature | Average importance score | Standard deviation |
|---|---|---|---|
| 1 | Frame structure that gives improved compatibility with accessories, such as hoists | 4.80 | 0.48 |
| 2 | Side rails that are flush to the side of the bed when folded down, to reduce the distance that caregivers must reach over | 4.57 | 0.56 |

| | | | |
|---|---|---|---|
| 2 | High height position of 83cm or higher, to enable a safe working height for caregivers | 4.57 | 0.56 |
| 2 | Autoregression to prevent migration down the bed (features that increase surface area for the patient's sacral area and eliminate heel travel when the head of bed is profiled) | 4.57 | 0.67 |
| 5 | Features that can help with the manual task of turning patients | 4.33 | 0.83 |
| 6 | In-built bed weighing scales | 3.93 | 0.89 |
| 7 | Lightweight mattress deck | 3.77 | 0.84 |

## Caregiver musculoskeletal injuries from moving the hospital bed

There were 5 innovative features identified at the user preference workshop as helping to address caregiver musculoskeletal injuries from moving the hospital bed (Table 8). There were 3 features with an average importance score of between 4 (quite important) and 5 (very important). The other 2 features had average importance scores between 3 (neither important or unimportant) and 4 (quite important).

The feature with the highest average importance score (4.53) was "Ergonomic brake system that is easy to operate with the foot". There were 29 responses rating this feature as "5 – very important" or "4 – quite important", showing that there was good overall agreement with the degree of importance of this feature.

The feature with the lowest average importance score (3.5) was "Gyro movement technology". The responses for this feature ranged from "2 – not very important" to "5 – very important", with 28 people responding either "3 – neither important or unimportant" or "4 – quite important". These findings show that there was a range of opinions regarding the degree of importance of this feature.

**Table 8: summary of user survey results for caregiver musculoskeletal injuries from moving the hospital bed.**

| Importance order based on average scores | Feature | Average importance score | Standard deviation |
|---|---|---|---|
| 1 | Ergonomic brake system that is easy to operate with the foot | 4.53 | 0.56 |
| 2 | Headboard and footboard design (lightweight and easy to remove) | 4.50 | 0.50 |
| 3 | Wheel systems to reduce the force required to move the bed and to facilitate transport (such as shock absorption or double castors or a fifth wheel to aid steering) | 4.43 | 0.56 |
| 4 | Electric power-assisted steering | 3.83 | 0.86 |
| 5 | Gyro movement technology | 3.50 | 0.62 |

## Caregiver entrapment injuries

A total of 30 users responded to the questions on the bed frame features helping to address caregiver entrapment injuries. There were 5 innovative features identified as helping to address entrapment injuries. A summary of the results is shown in Table 9.

There were 4 features with an average importance score of between 4 (quite important) and 5 (very important). The feature with the highest average importance score (4.66) was “High height position of 83cm or higher, to enable a safe working height for caregivers”. There were 20 responses rating this feature as “5 – very important”. These findings show that there was good overall agreement with the degree of importance of this feature.

The feature with the lowest average importance score (4.17) was “Warning tone and pauses as the bed goes to its lowest position, to prevent caregiver feet getting trapped by the side rails”. The responses for this feature ranged from “2 – not very important” to “5 – very important”, with 25 people responding either “4 – quite important” or “5 – very important”. These findings suggest that, on average, this feature is somewhat important when considering caregiver entrapment. However, there was not an overall majority of responses that agreed on the degree of importance of this feature

**Table 9: summary of user survey results for caregiver entrapment injuries.**

| Importance order based on average scores | Feature | Average importance score | Standard deviation |
|---|---|---|---|
| 1 | High height position of 83cm or higher, to enable a safe working height for caregivers | 4.66 | 0.54 |
| 2 | Intuitive side rail lowering mechanisms that are easy to use so that hands and fingers are less likely to get trapped | 4.55 | 0.62 |
| 3 | Headboard and footboard design (lightweight, easy to remove & a place for storage) | 4.43 | 0.50 |
| 4 | Warning tone and pauses as the bed goes to its lowest position, to prevent caregiver feet getting trapped by the side rails | 4.17 | 0.86 |

## Adaptability

A total of 30 users responded to the questions on the bed frame features helping with adaptability. There were 9 innovative features identified as helping with adaptability. A summary of the results is shown in Table 10.

There were 8 features with an average importance score of between 4 (quite important) and 5 (very important). The features with the highest average importance score were “Frame structure that gives improved compatibility with accessories, such as hoists” and “Compatibility with different types of mattresses”, both of which had an average importance score of 4.77. Both of these features had the same standard deviation and distribution of responses, with 24 responses rating each feature “5 – very important”. These findings show that there was good overall agreement with the degree of importance of these features.

The feature with the lowest average importance score (3.43) was “Collapsible or rotatable frame for easy transport and storage”, The standard deviation for the responses on this feature was considerable (1.23), as there was a spread of importance ratings across the full range of response options. These findings suggest that, on average, this feature was rated as being of lowest importance when considering adaptability, but there were different views from different users on the overall importance of this feature.

**Table 10: summary of user survey results for adaptability.**

| Importance order based on average scores | Feature | Average importance score | Standard deviation |
|---|---|---|---|
| 1 | Frame structure that gives improved compatibility with accessories, such as hoists | 4.77 | 0.50 |
| 1 | Compatibility with different types of mattresses | 4.77 | 0.50 |
| 3 | Compatibility with infusion poles, oxygen cylinders and catheter holders | 4.76 | 0.43 |
| 4 | Variable bed length to allow for taller patients | 4.69 | 0.46 |
| 5 | Cardiac chair position | 4.50 | 0.67 |
| 5 | Expanded range of heights (low height position achievable of 21cm, and high height position achievable of 83cm or above) | 4.50 | 0.72 |
| 7 | Headboard and footboard design (lightweight, easy to remove & a place for storage) | 4.43 | 0.72 |
| 8 | In-bed X-ray facility or compatibility with X-ray cassette tray | 4.07 | 0.81 |
| 9 | Collapsible or rotatable frame for easy transport and storage | 3.43 | 1.23 |

## Infection prevention

A total of 30 users responded to the questions on the bed frame features helping to address infection prevention. There were 4 innovative features identified as helping to address infection prevention. A summary of the results is shown in Table 11.

All 4 features had an average importance score of between 4 (quite important) and 5 (very important). The feature with the highest average importance score (4.78) was “Materials to withstand cleaning protocols”. There were 24 responses rating this feature as “5 – very important”. These findings show that there was good overall agreement with the degree of importance of this feature.

The feature with the lowest average importance score (4.17) was “Storage space so components do not need to be placed on the floor. The standard deviation for the responses on this feature was considerable (1.00), as there was a spread of importance ratings across the full range of response options. These findings suggest that, on average, this feature was rated as being of lowest importance when considering infection prevention, but there were different views from different users on the overall importance of this feature.

**Table 11: summary of user survey results for infection prevention.**

| Importance order based on average scores | Feature | Average importance score | Standard deviation |
|---|---|---|---|
| 1 | Materials to withstand cleaning protocols | 4.78 | 0.50 |
| 2 | Durable handset to withstand frequent cleaning process | 4.70 | 0.64 |
| 3 | Frame structure that has unrestricted access to all parts (such as an open architecture and/or removable mattress deck) | 4.40 | 0.84 |
| 4 | Storage space so components do not need to be placed on the floor | 4.17 | 1.00 |

## Maintenance and repair

A total of 6 users responded to the questions on the bed frame features helping to address maintenance and repair. There were 9 innovative features identified as helping to address maintenance and repair. A summary of the results is shown in Table 12.

There were 7 features with an average importance score of 4 (quite important) or higher. The other 2 features had average importance scores between 3 and 4. The features with the highest average importance scores were “Availability of, and access to, spare parts” and “Robust and durable frame construction”. For both of these features, all 6 respondents rated “5 - very important”. These findings show that there was a high level of confidence in the degree of importance of these features.

The feature with the lowest average importance score was “Durable and integrated, semi-integrated or magnetic components to reduce hospital-acquired damage”. Responses for importance of this feature ranged from “2 – not very important” to “5 – very important”. The mode rating for this feature was “3 – neither important unimportant”, for which there were 3 responses.

**Table 12: summary of user survey results for maintenance and repair.**

| Importance order based on average scores | Feature | Average importance score | Standard deviation |
|---|---|---|---|
| 1 | Availability of, and access to, spare parts | 5.00 | 0.00 |
| 1 | Robust and durable frame construction | 5.00 | 0.00 |
| 3 | Frame structure that has unrestricted access to all parts (such as an open architecture and/or removable mattress deck) | 4.50 | 0.50 |
| 4 | Ability for bed to maintained in-house (such as access to spare parts, technical training and knowledge) | 4.17 | 0.90 |
| 5 | Modular design to easily replace parts (for example, cables) | 4.17 | 1.07 |
| 6 | Compatibility with standard tools rather than the need for specialist tools | 4.00 | 1.15 |
| 7 | Features to track and locate beds | 4.00 | 0.817 |

| | | | |
|---|---|---|---|
| 8 | Collapsible or rotatable frame for easy transport and storage | 3.83 | 0.90 |
| 9 | Durable and integrated, semi-integrated or magnetic components to reduce hospital-acquired damage | 3.67 | 0.94 |

## Connectivity

A total of 36 users responded to the questions on the bed frame features helping to address connectivity. There were 5 innovative features identified as helping to address connectivity. Some of the user workshop attendees indicated that successful implementation of connectivity features may rely on IT services within the Trust being adequate. Trusts may therefore consider connectivity features to have higher importance in the context of adequate IT services to support their implementation.

There were 2 features with an average importance score of between 3 (neither important nor unimportant) and 4 (quite important). The other 2 features had average importance scores between 2 (not very important) and 3 (neither important nor unimportant).

The feature with the highest average importance score (3.75) was “Features to track and locate beds”. The standard deviation for the responses on this feature is considerable (1.06), as there was a spread of importance ratings across the full range of response options. These findings suggest that there were different views from different users on the overall importance of this feature.

The features with the lowest average importance score were “Features that enable patient data to be sent to electronic medical records, subject to national cyber security measures” and “Power outlets and USB ports for patients to charge their personal devices”, both of which had an average importance score of 2.83. Both features had a spread of importance ratings across the full range of response options. These findings suggest that there were different views from different users on the overall importance of this feature.

**Table 13: summary of user survey results for connectivity.**

| Importance order based on average scores | Feature | Average importance score | Standard deviation |
|---|---|---|---|
| 1 | Features to track and locate beds | 3.75 | 1.06 |
| 2 | Features that enable connection between patients and caregivers when assistance is required | 3.61 | 0.89 |
| 3 | Smart bed features such as status data and event logs | 2.94 | 1.03 |
| 4 | Features that enable patient data to be sent to electronic medical records, subject to national cyber security measures | 2.83 | 1.07 |
| 4 | Power outlets and USB ports for patients to charge their personal devices | 2.83 | 1.19 |

## Sustainability

A total of 36 users responded to the questions on the bed frame features helping to address sustainability. There were 6 innovative features identified as helping to address sustainability.

There were 5 features with an average importance score of between 4 (quite important) and 5 (very important). The feature with the highest average importance score (4.69) was “Durable frame construction to prolong the lifespan of the bed”. There were 26 responses of “5 - very important” for this feature, and 9 responses for “4 - quite important”. These findings show that there was good overall agreement with the degree of importance of this feature.

The feature with the lowest average importance score (3.44) was “Local sourcing of materials and bed frame production”. The standard deviation for the responses on this feature was considerable (1.11), as there was a spread of importance ratings across the full range of response options. These findings suggest that there were different views from different users on the overall importance of this feature.

**Table 14: summary of user survey results for sustainability.**

| Importance order based on average scores | Feature | Average importance score | Standard deviation |
|---|---|---|---|
| 1 | Durable frame construction to prolong the lifespan of the bed | 4.69 | 0.52 |
| 2 | Modular design to easily replace parts | 4.67 | 0.56 |
| 3 | Manufacturer demonstration of commitment to NHS' net zero | 4.22 | 0.67 |
| 4 | Recycling and disposal options | 4.11 | 0.84 |
| 5 | Durable and integrated, semi-integrated or magnetic components to reduce hospital-acquired damage | 4.08 | 0.92 |
| 6 | Local sourcing of materials and bed frame production | 3.44 | 1.11 |

## Patient survey

There were 23 people who responded to the patient survey. There were 20 people who responded that they have had experience staying in an acute hospital bed, and 2 people who have acted as a carer for somebody who has had experience staying in an acute hospital bed. Respondents were asked to select their top 5 most important bed frame features in their experience from a list of 12 features. The results are shown in Table 15.

There were 5 innovative features for which more than half of the respondents selected as being in their top 5 most important features. Both bed controls that are in an easy place to reach, and height settings so that the bed can be lowered to the right height for when the patient is getting in or out of bed were in 18 people's top 5 most important features. In the user survey, bed controls that are in an accessible location and have an intuitive design had an average importance score of 4.47 out of 5 for the consideration 'patient recovery, independence and rehabilitation'. The importance of this feature is therefore recognised by both patients and caregivers. The feature "programmable custom height settings for when the patient is getting in or out of bed" appeared for 2 of the considerations in the user survey. For both considerations, this feature was quite low down in terms of importance order based on average importance score, with scores of 3.77 and 3.90 out of 5. This may demonstrate that the perceived importance of this feature is greater to patients based on their experience than may be recognised by caregivers. Patients may prioritise having this feature more than caregivers.

There were just 2 respondents of the patient survey who included under-frame lighting in their top 5 features. In the user preference survey, this feature had an average importance score of 3.45 out of 5 for the consideration of patient falls, indicating that this feature may have weak importance. This may suggest that both patients and caregivers would consider under-frame lighting to be a less of a priority.

One feature did not appear in any of the respondents' top 5 most important features in the patient survey, this was the ability to lock-out controls to prevent accidental changing of the height or position of the bed. This feature had the highest average importance score for the consideration of patient entrapment in the user survey, with a score of 4.47 out of 5. The benefits of this preventative feature may not be recognised by patients who have not experienced an entrapment injury, which may explain why this feature was rated highly by users but not patients themselves.

**Table 15: results of the patient survey.**

| Importance order based on number of responses | Feature | Number of responses (%) |
|---|---|---|
| 1 | Bed controls that are in an easy place to reach, to encourage independence | 18 (81.8) |
| 1 | Height settings so the bed can be lowered to the right height to support you when you are getting in or out of bed | 18 (81.8) |
| 3 | Side rails that are flush to the bed when folded down to reduce the distance between the edge of the bed | 15 (72.2) |
| 4 | Side rail grip to support you getting in and out of bed | 14 (63.3) |

| | | |
|---|---|---|
| 5 | Alert button to let caregivers know when you require assistance | 13 (59.1) |
| 6 | Bed controls that have an intuitive design, so that they are easy for you to use | 8 (36.4) |
| 7 | Power outlets and USB ports for you to charge your personal devices | 6 (27.3) |
| 7 | Variable bed length to allow for taller patients to lie comfortably in their bed | 6 (27.3) |
| 9 | A bed that doesn’t have a lot of leads/cables, to reduce trip hazards | 4 (18.2) |
| 10 | Under-frame lighting to reduce the risk of falls around the bed | 2 (9.1) |
| 11 | Minimal vibrations when you are moved around the hospital whilst in bed | 1 (4.5) |
| 12 | Lock-out controls to prevent you from accidentally changing the height or position of the bed | 0 (0) |

## Discussion

Representatives of the user groups that are typically involved in the decision-making process for selecting bed frames participated in this user preference assessment to explore which user needs and bed frame features could influence choice. A group of 12 members agreed on 12 key considerations, and a list of innovative features which can help to address each of these considerations was identified. The findings of the user preference workshop were used to develop a user survey.

There were 36 submitted responses to the user survey. The survey results were used to calculate an average importance score for each innovative feature helping to address a key consideration. From the 82 survey questions across the 12 key considerations, there were 60 average importance scores that were between “4 – quite important” and “5 – very important”. This suggests that most of the identified features were considered important for addressing user needs. Some bed frame features could help support user needs across multiple different considerations. The feature with the highest average importance score for each of the considerations is presented in Table 16.

**Table 16: feature with the highest average importance score for each consideration.**

| Consideration | Feature with the highest average importance score | Average importance score |
|---|---|---|
| Patient falls | Frame structure that gives improved compatibility with accessories such as hoists, standing aids and tables, so that they easily fit underneath the bed frame | 4.87 |
| Patient entrapment | Ability to lock-out controls to prevent patients from accidentally changing the height of the bed | 4.47 |
| Patient respiratory function | Autoregression to reduce torso compression (features that increase surface area for the patient's sacral area and eliminate heel travel when the head of bed is profiled) | 4.53 |
| Pressure ulcer formation | Compatibility with pressure care mattresses | 4.90 |
| Patient recovery, independence and rehabilitation | Frame structure that gives improved compatibility with accessories, such as hoists | 4.80 |
| Caregiver musculoskeletal injuries from repositioning of patients | Frame structure that gives improved compatibility with accessories, such as hoists | 4.80 |
| Caregiver musculoskeletal injuries from moving the hospital bed | Ergonomic brake system that is easy to operate with the foot | 4.53 |
| Caregiver entrapment injuries | High height position of 83cm or higher, to enable a safe working height for caregivers | 4.66 |
| Adaptability | Frame structure that gives improved compatibility with accessories, such as hoists | 4.77 |
| Infection prevention | Materials to withstand cleaning protocols | 4.78 |
| Maintenance and repair | Availability of, and access to, spare parts | 5.00 |
| | Robust and durable frame construction | 5.00 |
| Connectivity | Features to track and locate beds | 3.75 |

| | | |
|---|---|---|
| Sustainability | Durable frame construction to prolong the lifespan of the bed | 4.69 |

The feature “Frame structure that gives improved compatibility with accessories, such as hoists” had the highest average importance score for 4 of the 12 considerations (patient falls, patient recovery, independence and rehabilitation, caregiver musculoskeletal injuries from repositioning of patients, and adaptability). “Side rails that are flush to the side of the bed when folded down” was also in the top 3 features for 4 considerations (patient falls, pressure ulcer formation, patient recovery, independence and rehabilitation and caregiver musculoskeletal injuries from repositioning of patients). The consistency in the degree of importance of these features across multiple considerations demonstrates how important they are perceived to be.

The average importance score for a feature is only relevant for a particular consideration. It may, therefore, not be appropriate to compare the average importance scores of features addressing different considerations. A list of the features with the top 10 highest average importance scores across all considerations has been presented in Table 17. This has been presented for information only, as the user preference survey was designed to identify the importance of bed frame features for a given consideration, rather than their importance overall in the decision-making process to select 1 bed frame over another. Trusts should still consider selecting features that can help to address all considerations, rather than just those with features in Table 17.

**Table 17: features with the top 10 average importance scores across all considerations in the user preference survey.**

| Consideration | Feature with the highest average importance score | Average importance score |
|---|---|---|
| Maintenance and repair | Availability of, and access to, spare parts | 5.00 |
| Maintenance and repair | Robust and durable frame construction | 5.00 |

| | | |
|---|---|---|
| Pressure ulcer formation | Compatibility with pressure care mattresses | 4.90 |
| Patient falls | Frame structure that gives improved compatibility with accessories such as hoists, standing aids and tables, so that they easily fit underneath the bed frame | 4.87 |
| Pressure ulcer formation | Compatibility with mattresses that follow the contours of the bed | 4.83 |
| Patient falls | Side rails that are flush to the bed when folded down to reduce the distance between the edge of the bed and the edge of mattress | 4.80 |
| Patient recovery, independence and rehabilitation | Frame structure that gives improved compatibility with accessories, such as hoists | 4.80 |
| Caregiver musculoskeletal injuries from repositioning of patients. | Frame structure that gives improved compatibility with accessories, such as hoists | 4.80 |
| Infection prevention | Materials to withstand cleaning protocols | 4.78 |
| Adaptability | Frame structure that gives improved compatibility with accessories, such as hoists | 4.77 |
| Adaptability | Compatibility with different types of mattresses | 4.77 |
| Adaptability | Compatibility with infusion poles, oxygen cylinders and catheter holders | 4.76 |
| Patient recovery, independence and rehabilitation | Variable bed length to allow for taller patients | 4.70 |
| Adaptability | Variable bed length to allow for taller patients | 4.69 |

Users agreed that the key considerations would be given equal importance weighting overall in a procurement exercise. However, there may be some external factors which could influence user preferences and the perceived importance of some considerations. For example, clinical experts suggested that the benefits of features addressing connectivity may not be realised if Trusts do not have adequate IT infrastructure in place to support this. In the user survey, the average importance scores for some features helping to address the connectivity consideration were lower than the average importance scores for features addressing other considerations:

- Across the considerations, the features which had the lowest average importance scores (2.83) were “Features that enable patient data to be sent to electronic medical records, subject to national cyber security measures” and “Power outlets and USB ports for patients to charge their personal devices”
- “Smart bed features such as status data and event logs” had the next lowest average importance score (2.94).

There were different views from different users on the overall importance of these features, with some users rating these features as quite or very important despite their low average scores. This shows that user preferences can vary between users and between Trusts, with the features that are considered important for addressing user needs potentially differing.

Uncertainty in the results for features with lower average scores was a consistent finding across the considerations. For a number of considerations, standard deviation increased as average feature importance decreased. This suggests that there was greater certainty in the importance of features rated highly, and less certainty around the importance of features rated as having lower importance.

There were 23 respondents of the patient survey. There were just 2 features that appeared in both the patient survey results and the list of the top 10 average importance scores in the user survey, these were side rails that are flush to the side of the bed and variable bed length. This suggests that the importance of these features is mutually recognised by patients and caregivers. There were other features which appeared frequently in the patient survey results but had lower average importance scores in the user preference survey. The suggests that patient preferences may be different to caregiver preferences, and there may be uncaptured patient benefits of certain innovative features which are given less priority during the decision-making process to select a bed frame within a Trust.

## Strengths

This user preference assessment has several strengths. The assessment represents the preferences and experience of user groups involved in bed frame procurement decisions within a trust. This is important because each user has their own priorities and preferences. Each consideration has been identified and presented separately, so that people can use this report to see a breakdown of the perceived importance of the innovative bed frame features for the considerations that are most relevant to their role.

For some bed frame features, the strength of the overall opinion the degree of their importance was uncertain from the user survey results. This was indicated by different users having different views on a feature, with responses covering the full scale of “1 - not at all important” to “5 - very important”. It may not be reasonable to use such findings to directly support a procurement exercise given this uncertainty. Uncertain results indicate that Trusts should focus on capturing the opinions on these features of their users locally, to understand the degree of importance of the feature within their Trust.

In contrast, some bed frame features had a strong overall agreement in opinion on the degree of their importance. This was indicated by a small standard deviation around the average importance score for a feature, with most responses falling into a minimal number of response options. The results for these features suggest that there is agreement on the degree of importance across users from different Trusts within the UK, suggesting that factors such as Trust size are unlikely to influence the importance of these features. Trusts may feel that they can use the survey findings of these features to directly support their procurement exercise.

## Limitations

Users were asked to express preferences for 1 low height position (21cm) and 1 high height position (83cm). At the user preference workshop, these heights were chosen as examples based on the specifications for bed frames included in the scope. However, this is not to conclude that other low and high height positions cannot reduce incidents, and Trusts may consider other heights acceptable during the bed frame decision making process.

At the user preference workshop, users agreed that the key considerations would be given equal importance weighting overall in a procurement exercise. This assumption was made throughout the user preference assessment. However, there is heterogeneity across different groups of bed frame users, with each user group potentially having different priorities during a bed frame decision making process. Within individual Trusts, some considerations may be more important than others and hence some features may be prioritised more than others.

There may be some external factors which could influence user preferences for features and the perceived importance of some considerations. For example, clinical experts suggested that the benefits of features addressing connectivity may not be realised if Trusts do not have adequate IT infrastructure in place to support this. Additionally, an expert indicated that staff training, suitable matching of patient size to bed design and appropriate maintenance of beds are all important factors in ensuring bed frame features are used to their full potential.

It should be noted that the user survey includes responses from a small group of bed frame users relative to the total number of bed frame users in the UK. While efforts were made to encourage workshop participation and survey responses from a wide range of users from all of the different user groups, it was not possible to obtain any volunteers who are portering staff. Portering staff are known to make up a significant proportion of bed frame users. Individual trusts may find that the perceived importance of bed frame features as indicated by their user groups is different to the reported findings of this user preference assessment. It should also be noted that the effect of having a combination of innovative features is not captured in this user preference assessment, as each innovative feature was rated independently. In practice, some innovative features may be counterproductive to others. For example, one user commented that a frame structure with improved compatibility with accessories such as hoists, standing aids and tables might mean some parts of the bed frame structure are difficult to access for cleaning.

Due to the large number of considerations identified and the time available to complete, it was not feasible to ask users to rank and give relative importance weighting to the features for each consideration. Instead, users were asked to consider a feature's importance in isolation of any other features addressing the same consideration. An order of average importance was calculated for each consideration by averaging the importance scores for each feature across all survey responses.

An order of average feature importance has been presented for each consideration in this report. The degree by which a feature was more or less important than its nearest neighbour was not investigated in this user preference assessment.

## Criteria captured by the EAG's clinical review and economic modelling

The External Assessment Group (EAG) identified evidence on 8 of the innovative bed frame features discussed during the user-preference work.

For the consideration of patient falls, bed exit alarms had an average importance score of 3.97 out of 5 in the user survey. The standard deviation around this average was considerable, suggestion that there were different opinions on the degree of importance of bed exit alarms. The EAG identified evidence that was relevant to the decision problem for bed exit alarms. The study found a reduction in fall incidence between the bed exit alarm being introduced and six months post-implementation, concluding that the use of bed exit alarm systems was associated with a decrease in the incidence of falls. The EAG acknowledged that bed exit alarms may differ between different bed frames. This study was found to have concerns regarding the risk of bias, such that the EAG concluded that the benefit of bed exit alarms is unclear.

For the consideration of caregiver musculoskeletal injuries from moving the hospital bed, ergonomic brake system that is easy to operate with the foot had an average importance score of 4.53 out of 5 in the user survey. The EAG identified 1 study that evaluated whether brake pedal location influenced risk factors for low back disorders, work efficiency, perception of postural comfort and usability. This study found that head-of-bed brake location increased task completion time compared to side or foot-end brake locations. Head-of-bed brakes were reported as being more difficult to use and less comfortable than side or foot-end brakes, with participants feeling most comfortable using a brake located at the side of the bed. The study findings did not link brake location with the impact on caregiver musculoskeletal injuries.

For the consideration of caregiver musculoskeletal injuries from moving the hospital bed, wheel systems to reduce the force required to move the bed and to facilitate transport (such as shock absorption or double castors or a fifth wheel to aid steering) had an average importance score of 4.43 out of 5 in the user survey. The EAG identified 1 study in which participants generally reported lower physical demands when a fifth wheel on the bed frame was activated. Risk of bias of this study was a concern as it was a laboratory study with self-reported measures. A second prospective laboratory study compared a bed with a single castor configuration with a bed with a double bogie castor configuration. Evidence suggested that a double bogie castor design may reduce the force to move beds from a static position. It is unclear from these studies whether the intermediate outcome of a decrease in physical demand with the addition of these features (fifth wheel or double bogie castor) impacts outcomes related to caregiver musculoskeletal injuries.

For the consideration of caregiver musculoskeletal injuries from moving the hospital bed, electric power-assisted steering had an average importance score of 3.83 out of 5 in the user survey. The EAG identified 1 prospective laboratory study evaluating the impact of power-drive on spine loading and perceived exertion. This study demonstrated proof-of-concept that power-drive is likely to reduce spine loading during patient transportation. A second study examined the proportion of work reduction while accelerating or decelerating 4 beds, with and without a power assist module. Mean work reduction was greater than the established target for all 4 beds in each condition. Further data would be needed to demonstrate whether this intermediate outcome of reduction in loading due to power-assisted steering would result in reduced caregiver injury in the acute hospital setting.

For the consideration of patient falls, low height position of 21cm had an average importance score of 4.60 out of 5 in the user survey. These user survey results may give an indication of the preferences for the lower limit of bed frame heights in-scope of this assessment, as it is acknowledged that many beds have a low height position that is above 21cm. The EAG identified 1 study that evaluated the effect of beds lowered to at least 28.5 cm from the ground on fall rates in public hospital wards. The study concluded that the introduction of the beds lowered to at least 28.5 cm from the ground did not appear to reduce falls or falls with injury. However, there were some concerns regarding the risk of bias for this study, and as such this study does not provide robust evidence that beds lowered to at least 28.5 cm from the ground do not improve outcomes. Therefore, there is no robust evidence to indicate that beds that can be adjusted to a low height position cannot reduce falls.

For the consideration of caregiver musculoskeletal injuries from repositioning patients, features that can help with the manual task of turning patients had an average importance score of 4.33 out of 5. The EAG identified 2 laboratory studies that evaluated the use of turn-assist and its impact on physical stresses for caregivers when compared with manual turning. The EAG concluded that while this evidence suggests that a turn-assist feature may reduce physical caregiver stresses, the impact on incidents such as musculoskeletal injury has yet to be demonstrated.

For the consideration of caregiver musculoskeletal injuries from repositioning patients, in-built bed weighing scales had an average importance score of 3.93 out of 5 in the user survey. The EAG identified 2 prospective cohort studies comparing beds with inbuilt weighing scales with fluid balance charting to evaluate changes in fluid status in ICU patients. The EAG concluded that this evidence shows poor correlation with weight measurement by fluid balance. These findings suggest that in-built weighing scales may not be a high priority for Trusts when making purchasing decisions, with studies showing that they may not give accurate measurements.

Autoregression to prevent migration was identified as helping to address 4 of the key considerations: patient respiratory function, pressure ulcer formation, caregiver musculoskeletal injuries and facilitation of recovery, independence and rehabilitation. The average importance score for this feature ranged from 4.50 to 4.57 across these 4 considerations, showing that there is consistency in the degree of its perceived importance for different considerations. The EAG identified 4 prospective laboratory studies comparing beds with different designs for preventing migration (head pivots and head section lengthening). The studies concluded that different bed types can impact migration, with sliding pivot heads and elongation features leading to lower levels of migration. It should be considered that while these features may be able to reduce migration down the bed, the EAG did not report any evidence which demonstrated that reduced migration due to these features has an impact on incidents (such as respiratory function, pressure ulcers and caregiver musculoskeletal injuries).

## Conclusion

A total of 12 users took part in a user preference workshop, to agree on and define the considerations that are made during a bed frame procurement exercise. Some users had experience covering multiple user groups. This included 4 people with experience in clinical engineering, 2 occupational therapists, 3 people with job roles focussing on moving and handling, 2 people with job roles focussing on nursing, 2 people with job roles focussing on falls prevention, and 1 person with experience as a health and safety services manager. The users agreed on 12 key considerations, and for each of these they identified a list of innovative bed frame features which could help to address this consideration. The outcome of the user preference workshop was used to develop a user preference survey. A total of 36 people from a range of disciplines submitted a response to this user preference survey.

Most of the bed frame features identified had an average importance score that was between “4 – quite important” to “5 – very important”. For these features with high average importance scores, there was a trend of good overall agreement on the degree of their importance. This suggests that there are many bed frame features that are important to a wide range of users and Trusts during the decision-making process for selecting a bed frame. Trusts may be willing to pay more to have bed frames with these features in their portfolio.

There were 3 bed frame features which had an average importance score that was below “3 - neither important or unimportant”, all of which were identified as contributing to the “connectivity” consideration. This may indicate that these features are somewhat unimportant when making considerations during a bed frame procurement exercise. However, there was a range of opinions regarding the degree of importance of these features, with some users indicating that these features are in fact very important. Trusts should consider the views of their users locally, along with the impact of any external factors on feature preferences, to understand the perceived importance of a feature and decide whether they should pay more money to have beds with these features in their portfolio.

This user preference work clearly outlines the key areas of consideration during the decision-making process for selecting a bed frame. This work captures the views and preferences of key user groups on which innovative bed frame features are important for addressing each consideration. Many innovative bed frame features were found to be important to users. The findings of this user preference assessment may be used to support local decision-making processes for selecting a bed frame. It should be noted that the findings of the user preference survey may not align with the views of users in every Trust, even where there was strong agreement on feature importance. Trusts should still place value on the views and preferences on bed frame features of their users locally, to ensure that the decision-making process for selecting a bed frame reflects user needs within the Trust.

The EAG did not identify robust evidence to demonstrate clinical effectiveness of any of the bed frame features when used in an acute clinical setting. Some features did have evidence to demonstrate proof of concept, but lacked evidence to link the technical outcomes measured with incidents such as falls and caregiver musculoskeletal injuries. Risk of bias in some studies meant that the study results were considered to be uncertain. The EAG commented that despite the acknowledged limitations of the evidence for bed frame features, the direction of results in the exploratory analysis could still be used to aid the decision-making process to select one bed over another when tied with clinical expert advice.

This user preference assessment is one part of NICE's late-stage assessment of bed frames for adults in acute settings. This user preference assessment not intended to replicate or replace the need for trusts to conduct a bed frame procurement exercise involving users within their trust. This report may however act as a tool to support Trusts during the decision-making process to select 1 bed frame over another.

# Appendix A. Results of the user preference workshop

**Table 18: key considerations and innovative features identified at the user preference workshop.**

| Consideration | Definition of features | Number of innovative features |
|---|---|---|
| Patient falls | Help to reduce the frequency of patients falling from their bed or in the area around their bed | • Under-frame lighting<br>• Bed exit alarms<br>• Low height position of 21cm<br>• Ergonomic side rail grip to support patients getting in and out of bed<br>• Side rails that are flush to the bed when folded down to reduce the distance between the edge of the bed and the edge of mattress<br>• Bluetooth connectivity to reduce the number of leads/cables required and potentially reduce trip hazards<br>• Frame structure that gives improved compatibility with accessories such as hoists, standing aids and tables, so that they easily fit underneath the bed frame<br>• Programmable custom height settings for when the patient is getting in or out of bed<br>• Ability to lock-out controls to prevent patients from accidentally changing the height of the bed<br>• Brake alarm to indicate when the brakes are off<br>• Visual brake indicator to indicate when the brakes are off |
| Patient entrapment | Help to reduce the frequency of patient entrapment injuries. | • Anti-entrapment systems to automatically stop the bed lowering if an obstruction is detected<br>• Ability to lock-out controls to prevent patients from accidentally changing the height of the bed<br>• Warning tone and pauses as the bed moves to its lowest position |

| | | |
|---|---|---|
| Patient respiratory function | Help to improve patient respiratory function when in bed | • Auto backrest angle pauses (such as at 30 degrees)<br>• Head of bed angle indicator<br>• Cardiac chair position<br>• Autoregression to reduce torso compression (features that increase surface area for the patient's sacral area and eliminate heel travel when the head of bed is profiled) |
| Pressure ulcer formation | Help to prevent hospital-acquired pressure injuries (HAPI) | • Autoregression to prevent migration down the bed (features that increase surface area for the patient's sacral area and eliminate heel travel when the head of bed is profiled)<br>• Compatibility with pressure care mattresses<br>• Compatibility with mattresses that follow the contours of the bed<br>• Ergonomic side rail grip to help patients reposition themselves<br>• Patient access to handset to reposition the bed<br>• Side rails that are flush to the bed when folded down to reduce the distance between the edge of the bed and the edge of mattress |
| Caregiver musculoskeletal injuries | Help to reduce caregiver musculoskeletal injuries | • Autoregression to prevent migration down the bed (features that increase surface area for the patient's sacral area and eliminate heel travel when the head of bed is profiled)<br>• Features that can help with the manual task of turning patients<br>• A frame structure that gives improved compatibility with accessories such as hoists, to support patient moving tasks<br>• In-built bed weighing scales<br>• Lightweight mattress deck (if it can be removed)<br>• Side rails that are flush to the side of the bed when lowered, to reduce the distance that caregivers must reach over<br>• High height position of 83cm or higher, to enable a safe working height for caregivers<br>• Wheel systems to reduce the force required to move the bed and to facilitate transport (such as shock absorption or double castors or a fifth wheel to aid steering) |

| | | |
|---|---|---|
| | | • Electric power-assisted steering<br>• Gyro movement technology<br>• Ergonomic brake system that is easy to operate with the foot<br>• Headboard and footboard design (lightweight and easy to remove) |
| Caregiver entrapment injuries | Help to reduce caregiver entrapment injuries occurring within the frame structure and during manual handling tasks | • Warning tone and pauses as the bed goes to its lowest position, to prevent caregiver feet getting trapped by the side rails<br>• High height position of 83cm or higher, to enable a safe working height for caregivers<br>• Intuitive side rail lowering mechanisms that are easy to use so that hands and fingers are less likely to get trapped<br>• Headboard and footboard design (lightweight, easy to remove & a place for storage) |
| Adaptability | Allow the bed to be changed to meet the needs of different patients, caregivers and scenarios | • Expanded range of heights (low height position achievable of 21cm, and high height position achievable of 83cm or above)<br>• Collapsible or rotatable frame for easy transport and storage<br>• Variable bed length to allow for taller patients<br>• Headboard and footboard design (lightweight, easy to remove & a place for storage)<br>• Cardiac chair position<br>• Frame structure that gives improved compatibility with accessories, such as hoists<br>• Compatibility with infusion poles, oxygen cylinders and catheter holders<br>• Compatibility with different types of mattresses<br>• In-bed X-ray facility or compatibility with X-ray cassette tray |
| Infection prevention | Contribute to easy cleaning of a bed | • Frame structure that has unrestricted access to all parts (such as an open architecture and/or removable mattress deck)<br>• Materials to withstand cleaning protocols<br>• Storage space so components do not need to be placed on the floor |

| | | |
|---|---|---|
| | | • Durable handset to withstand frequent cleaning process |
| Maintenance and repair | Contribute to easy maintenance and repair of the beds | • Collapsible or rotatable frame for easy transport and storage<br>• Frame structure that has unrestricted access to all parts (such as an open architecture and/or removable mattress deck)<br>• Robust and durable frame construction<br>• Availability of, and access to, spare parts<br>• Ability for bed to maintained in-house (such as access to spare parts, technical training and knowledge)<br>• Durable and integrated, semi-integrated or magnetic components to reduce hospital-acquired damage<br>• Features to track and locate beds<br>• Compatibility with standard tools rather than the need for specialist tools<br>• Modular design to easily replace parts (for example, cables) |
| Facilitation of recovery, independence and rehabilitation | Help to encourage patients to self-mobilise | • Low height position achievable of 21cm<br>• Autoregression (features that increase surface area for the patient's sacral area and eliminate heel travel when the head of bed is profiled)<br>• Variable bed length to allow for taller patients<br>• Frame structure that gives improved compatibility with accessories, such as hoists<br>• Ergonomic side rail grip or bed lever compatibility to support patients getting in and out of bed<br>• Programmable custom height settings for when the patient is getting in or out of bed<br>• Bed controls that are in an accessible location and have an intuitive design, to encourage patients to become more independent<br>• Features that enable connection between patients and caregivers when assistance is required |

| | | |
|---|---|---|
| | | • Side rails that are flush to the bed when folded down to reduce the distance between the edge of the bed and the edge of mattress |
| Sustainability | Contribute to the NHS' commitment to a net zero health service | • Local sourcing of materials and bed frame production<br>• Recycling and disposal options<br>• Manufacturer demonstration of commitment to NHS' net zero<br>• Durable frame construction to prolong the lifespan of the bed<br>• Durable and integrated, semi-integrated or magnetic components to reduce hospital-acquired damage<br>• Modular design to easily replace parts |
| Connectivity | Allow connectivity between beds and other systems or applications | • Features that enable connection between patients and caregivers when assistance is required<br>• Smart bed features such as status data and event logs<br>• Features to track and locate beds<br>• Features that enable patient data to be sent to electronic medical records, subject to national cyber security measures<br>• Power outlets and USB ports for patients to charge their personal devices |

# Appendix B. Additional survey comments

| Consideration | User comments |
|---|---|
| Patient falls | • Having side rails that are too easy to raise may lead to poor staff habits being formed<br>• If a tilt feature is included on the bed it should only be allowed to progress past a certain angle with a safety feature, such as 2 buttons pressed at the same time or a code being entered |
| Patient entrapment | • Side rails should be rigid with no gaps<br>• Mesh or metal railings depend on suitability for a patient |
| Pressure ulcer formation | • Handset accessibility is important for patients when they have the capacity to understand how to function and use this appropriately<br>• How and where the handset is stored is an important factor for patient access to the handset |
| Caregiver musculoskeletal injuries | • In-built weighing scales should be calibrated regularly to ensure accuracy<br>• Brakes should be easily accessible with audio/visual control<br>• Gyro movement technology will be more relevant in some settings with more dependent patients |
| Infection prevention | • The complexity of the under-frame structure and headboard design can impact the ability to clean the bed properly |
| Facilitation of recovery, independence and rehabilitation | • Bed controls need to be available for patients, but only simple features can be used - features such as tilt or bed height should be controlled so that patients who are cognitively impaired are not able to use these features<br>• A visual indication of when the bed is in its lowest setting may be helpful for patients and their family members |
| Sustainability | • UK-based manufacturing would speed up the supply chain process |
| Connectivity | • Data transfer should be enabled through WiFi in existing infrastructure, without using the bed<br>• Weight and position changes would be useful to be automatically transferred to medical records, however, there are many risks with this type of data transfer too, such as inappropriately recorded information<br>• Power outlets would be nice for patients to have, but they could increase the cost of the bed frame which may make hospitals unlikely to invest in them<br>• Tracking beds is part of the job of portering staff - beds are not moved further from the ward by any ward staff unless faulty, in which case the bed must be placed outside the ward. Interhospital transfer is done by porters so they should be able to track the highest activity on site. |

# Appendix C. Participants

Angharad Ralley, Clinical Lead Occupational Therapist

Anna Skipper, Falls Lead

Carol Buckley, Falls Prevention Lead

Chloe Cowburn, Medical Devices Safety Officer

Clare Greenwood, Clinical Academic Tissue Viability Nurse Specialist

Dan Lethbridge, Head of Therapies

Donna Button, Tissue viability CNS

Eilidh Henderson, Tissue Viability nurse

Esther Lockwood, Falls Prevention Lead

Evelyn Otunbade, Moving and Handling Lead

Francis Quinon, Site Nurse Practitioner

Georgina de Vries, Principal Clinical Scientist (Medical Devices Safety Officer)

Hanna Wilkinson, Falls and Moving & Handling Lead

Heather Bertasius, Patient Moving and Handling Service Lead

Helen Williams, Lead Nurse Tissue Viability

Helene White, AHP Deconditioning Lead

Jan Christian, Registered Nurse / PhD student

Jenny Murphy, Manual Handling Lead

Jenny Pinkerton, Clinical Lead Occupational Therapist

Jim Kennett, Clinical Procurement Specialist Nurse

Liam Horkan, Clinical Procurement Nurse - head of Clinical Procurement

Liz Winter, Divisional Chief Nurse for Medicine and ED

Martin Keeney, Project & Contract Compliance Officer

Neale webster, Clinical Engineer Team Lead

Nesta Featherstone, Associate Nurse Director- Infection prevention & Control

Nia Giles, physiotherapist

Nick Howlett, Health and Safety Services Manager (Retired)

Novuroze Fazal, Head of Clinical Engineering

Philip Agambisa, Equipment Library Engineer

Rachael Aitken, Lead nurse for patient support services

Rebecca Pratt, falls prevention practitioner

Rob Harris, Lead Back care Advisor

Sharon Bond, Falls Prevention Team Leader

Shibin Thomas, Specialist Clinical Engineer

Stephen Bond, Head of Operations

Su Learmonth, Occupational Therapist

Tracy Dring, Lead for Training & Clinical Advisor for Medical Equipment

William Newsholme, Consultant, Infectious Diseases & Infection Control