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Health technologies for falls prevention and detection in adult hospital in-patients: a scoping review

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Health technologies for fall prevention and detection in adult hospital in-patients: a scoping review

Abstract

Objective: The objective of this scoping review was to examine and map the evidence relating to the reporting and evaluation of technologies for the prevention and detection of falls in adult hospital in-patients.

Introduction: Falls are a common cause of accidental injury, leading to a significant safety issue in hospitals globally, and resulting in substantial human and economic costs. Previous research has focused on community settings with less emphasis on hospital settings to date.

Inclusion criteria: Participants included adult inpatients, aged 18 years and over; Concept included the use of fall prevention or detection technologies; Context included any hospital ward setting.

Methods: This scoping review was conducted according to Joanna Briggs Institute (JBI) methodology for scoping reviews, guided by an a-priori protocol. A wide selection of databases including Medline, CINAHL, AMED, EmBASE, PEDro, Epistimonikos, and Science Direct were searched for records from inception to October 2019. Other sources included grey literature, trial registers, government health department websites and websites of professional bodies. Only studies in the English language were included. A three-step search strategy was employed with all records exported for subsequent title and abstract screening, prior to full text screening. Screening was performed by two independent reviewers and data extraction by one reviewer following agreement checks. Data is presented in narrative and tabular form.

Results: Over 13,000 records were identified with 404 included in the scoping review: 336 reported on fall prevention technologies, 51 targeted detection and 17 concerned both. The largest contributions of studies came from the USA (n=185), Australia (n=65), UK (n=36) and Canada (n=18). There was a variety of study designs including 77 prospective cohort studies, 33 before-after studies and a large number of systematic reviews (n=35). However, relatively few randomised controlled trials were conducted (n=25). The majority of records reported on multifactorial and multicomponent technologies (n=178), followed by fall detection devices (n=86). Few studies reported on the following interventions in isolation: fall risk assessment (n=6), environment design (n=8), sitters (n=5), rounding (n=3), exercise (n=3), medical/pharmaceutical (n=2), physiotherapy (n=1) and nutritional (n=1). The majority (56%) of studies reported clinical effectiveness outcomes with smaller numbers (14%) reporting feasibility and/or acceptability outcomes, or cost-effectiveness outcomes (5%).

Conclusions: This review has mapped the literature on falls prevention and detection technology and outcomes for adults in the hospital setting. Despite the volume of available literature, there remains a need for further high-quality research on fall prevention and detection technologies.

Keywords: Accidental falls; health technologies; hospital patients; fall detection; fall prevention.

Abstract word count: 399

Introduction

Falls are the second most common cause of accidental or unintentional injury resulting in around 646,000 deaths worldwide each year[1]. A fall is considered an event where a person comes to rest inadvertently on the ground or floor or other level, with adults aged over 65 most commonly affected[1]. Falls are a significant safety issue in hospitals, since individuals who may not be at full capacity are placed in an unfamiliar environment and faced with new challenges to performing activities of daily living. The fall rate in hospitals is high, with studies reporting rates of 18 falls per 1,000 occupied bed days in a UK general hospital[2]; 3.5 to 11.5 falls per 1,000 patient days across US hospitals[3] and 6.45 falls per 1,000 occupied bed days in Australian medical and surgical wards[4]. However, the true rates may be even higher as it has been documented that fall rates can be under-reported[5].

In cases where a fall is not fatal, many result in injuries which require medical attention (37.3 million globally)[1]. This can result in pain, loss of function and confidence, and therefore independence, long term disability, increased morbidity and admission into long-term care[6]. In addition to the human cost of falls, there are substantial economic costs. Globally, the yearly costs per fall victim range from 2,044 to 25,955 USD (2006 prices[7]) and overall annual costs of falls range from 23.3 billion USD (2008 prices) in the USA to 1.6 billion USD in the UK. In the UK, the estimated cost to the NHS alone is 2.3 billion GBP (2015)[6]. The ageing population is predicted to increase to almost 2.1 billion globally by 2050[8] and therefore the rate, and cost, of falls is consequently likely to rise.

One of the difficulties in preventing falls is the large number of contributing risk factors. For hospitals, those most highly associated with falls are old age, history of falls, cognitive impairment and sedative and antidepressant use[9]. Other commonly reported risk factors include gender, race, and chronic health conditions[10]. The use of multifactorial risk assessments, which identify an individual's risk factors for falls, are therefore advised[11]. However, these will not reduce the incidence of falls unless they are accompanied by appropriate and effective risk-reduction interventions.

There is a plethora of literature relating to fall prevention, particularly in community dwelling adults[12] with comparatively less literature relating to the in-patient setting. Fall prevention interventions that have been reported in care facilities and hospitals include patient education, exercise, rounding, environmental adaptation and individually tailored multicomponent interventions[13]. Equally important are fall detection interventions, which aim to detect falls early in order to reduce the likelihood of injury. These often involve some form of sensor or other detection device, which can alert healthcare staff of an impending or occurred fall[14]. The current scoping review included both prevention and detection. Although the majority of research has concerned community dwelling adults, an initial literature search identified a growing body of literature in the hospital setting, suggesting that a scoping review was worthwhile.

The concept of *health technologies* is gaining recognition as a tool for organisations to improve care. The term is often thought to relate to medical devices; however, the World Health Organisation define health technologies as "…the application of organized knowledge and skills in the form of devices, medicines, vaccines, procedures and systems developed to solve a health problem and improve

quality of lives" [15]. Examples of technologies used in hospitals to *prevent* falls include: patient and staff education; intentional rounding; environmental alterations (e.g. bathroom or bed modifications, clearing patient pathway); medication review; falls risk communication aids (e.g. identification wristbands, bed posters, door stickers); alarms and pagers; physiotherapy and exercise; multidisciplinary team approaches to prevention; and service model changes[13,16-18]. Whilst the broad definition of health technologies reflects the varied scope of practices that can and have been implemented in falls prevention, it also presents challenges for mapping the evidence. However, application of the ProFANE taxonomy developed through the Prevention of Falls Network Europe project, can be used to provide structure, and assist with synthesis of evidence[19]. In contrast, technologies that have been used for *detecting* falls comprise a narrower range and commonly include devices such as body worn sensors or stationary detection devices, including pressure sensors and video-based tracking[14,20].

Recent systematic reviews have focused on detection devices[14] or limited study design inclusion to randomised controlled trials (RCT's)[13]. Lapierre et al[14] conducted a scoping review to examine the extent and diversity of current technologies for fall detection in older adults. The review identified 118 studies, with technologies organised into ten categories ranging from wearable to ambient sensors. In contrast, the RCT based systematic review and meta-analysis conducted by Cameron et al[13] quantified effectiveness of interventions designed to reduce falls in older people in both care facilities and hospitals. Reviews of RCT's are valuable but considering RCT's are challenging to perform in this context, and therefore less common, the broader range of interventions and technologies available may have been missed. A scoping review allows for a broader area of literature to be examined and mapped. Rather than providing specific recommendations to healthcare providers, in keeping with scoping review methodology[21], the objective of this scoping review was to examine and map the evidence relating to the reporting and evaluation of technologies that are currently being used or developed for the prevention and detection of falls in adult hospital in-patients. This scoping review is the first stage in a project that will result in a series of systematic reviews on fall prevention and detection, to inform policy and practice in the UK hospital setting. Mapping the current evidence-base will inform the focus of the subsequent reviews, which we anticipate will focus on effectiveness of groups or individual technologies, and feasibility and acceptability of fall prevention technologies in the hospital setting.

Review questions

This review aimed to answer the following questions:

1. What fall prevention and detection technologies have been reported in the literature?
2. What outcomes have been reported that measure fall prevention and detection technologies in terms of clinical effectiveness, cost-effectiveness, acceptability and feasibility?

Inclusion Criteria

Participants

This scoping review considered literature that focused on adult inpatients admitted for care in a hospital setting. Much of the falls literature focusses on "older" adults, which is variably defined. However, we were interested in mapping fall prevention/detection technologies in any setting and any adult population, therefore adults were defined as 18 years and over. The settings included elective, non-elective (emergency admission and accident and emergency), day-case (ambulatory care) and hospitals providing acute or subacute care, with subacute care defined as "medical and skilled nursing services provided to patients who are not in an acute phase of illness".[22] In an amendment to our published protocol, we also included community or laboratory-based studies where technologies were being developed/tested for eventual use in the hospital setting. This enabled us to include in our map of technologies those that were emerging or near-ready for use in the hospital setting, as it will be important to track their development in order to provide contemporary evidence to inform policy and practice.

Concept

This scoping review considered literature that reported on the use of fall prevention or detection technologies as well as literature reporting on their clinical effectiveness, cost-effectiveness, feasibility and acceptability. Literature reporting on one or more of these aspects was considered. Literature discussing types of technologies was considered as well as studies reporting on the results of specific interventions. The World Health Organization definition of health technologies was employed. Following searching, we amended the protocol to include literature relating to "emerging technology" i.e. fall prevention or detection technologies being designed for the hospital setting but tested in mock in-patient settings in laboratories and/or with healthy participants. We felt it would be negligent to exclude this literature, particularly as some of the technologies were near-ready for in-patient setting studies.

Context

This scoping review considered literature from any hospital ward setting and any clinical specialism. In order for some homogeneity to be achieved, and for the results to be applicable to the UK setting where the larger project is being conducted, inclusion was limited to countries demonstrating very high human development[8], confirmed by their inclusion on the very high human development index (HDI) list[23]. As described above we also included laboratory settings, where the literature was relevant to the hospital setting. Whilst some systematic reviews have included residential care facilities in addition to hospital settings,[13] due to the volume of literature available on hospital settings alone, the potential (albeit subtle in some cases) difference in populations, and the aim of this scoping review being to directly inform policy and practice in the hospital setting, we did not include residential care facilities in this scoping review.

Types of sources

This scoping review considered published and unpublished literature including primary research studies (any type), systematic and narrative reviews, reports and expert opinion.

A range of quantitative study designs were considered including experimental, quasi-experimental, descriptive and observational studies reporting information on clinical or cost-effectiveness outcomes. Qualitative study designs including phenomenology, grounded theory, ethnography and action research were also considered to report on acceptability and feasibility of interventions. Systematic and narrative reviews that synthesised evidence on aspects of fall prevention and detection relevant to the review questions were also considered. We also considered government reports, expert opinion, discussion papers, position papers and other forms of text for inclusion.

Due to time and resource limitations, only studies published in English were included[25] and databases were searched from inception to 12.10.2019.

Exclusion criteria

Studies that focussed exclusively on residential settings such as care homes were excluded, as these have been reviewed elsewhere[24]. Protocols were excluded, as were studies originating from countries not on the very high HDI list.

Methods

This scoping review was conducted according to Joanna Briggs Institute (JBI) methodology for scoping reviews[21], guided by an a-priori protocol[25]. It is reported in accordance with the PRISMA-ScR extension for scoping reviews[26], with a checklist available in Appendix 1.

Search strategy

The search strategy was developed in consultation with an information scientist and aimed to identify published and unpublished literature. A three-step search strategy was employed[21]. Firstly, an initial limited search was performed in Medline and CINAHL followed by an analysis of the text words contained in the resulting titles and abstracts, and of the keywords and index terms used to describe the publications. Secondly, a search strategy tailored to each information source, was developed based on the identified keywords and index terms and a second search was performed in all databases. Finally, the reference lists of all included literature were hand-searched for additional sources. Given the scope of this review covers all health technologies, we deliberately opted for a broad search rather than including individual search terms for each technology (e.g. education, environment, exercise, medical, nutrition, sitters).

Information sources

The following databases were searched for published literature: Medline, JBI Database of Systematic Reviews and Implementation Reports, CINAHL, AMED, EmBASE, PEDro, Epistimonikos, EPPI-

Centre (DoPHER and TRoPHI), Cochrane Library (controlled trials and systematic reviews), ACM Digital, Compendex, IEEE Xplore, and Science Direct. Grey literature was identified from: Google Scholar, Ethos, Mednar, OpenGrey. The following trial registries were searched: Clinicaltrials.gov, ISRCTN Registry, The Research Registry, European Union Clinical Trials Registry (EU-CTR), and Australia New Zealand Clinical Trials Registry (ANZCTR). In addition, government health department websites and websites of professional bodies (Department of Health and Social Care (UK); The United States Department of Health and Human Services (USA); Health Resources and Services Administration (USA); Australian Government Department of Health (Australia); Royal College of General Practitioners (UK); Australian Medical Association (Australia); American Medical Association (USA); Royal College of Nursing (UK); American Nurses Association (USA); and the Chartered Society of Physiotherapy (UK)) were searched for information relating to fall prevention and detection. Additional databases and resources were searched in a deviation to the published protocol based on subsequent consultation with an information scientist. The detailed search strategy can be found in Appendix 2.

Study selection

Search results were imported to Proquest® Refworks (version 2.0) and duplicates were removed. Thereafter, in an amendment to the original protcol, search results were imported to Covidence (https://www.covidence.org/home; version 2018) to facilitate the review process. Titles and abstracts of all sources were screened by two independent reviewers for relevance to the review questions. Full-text manuscripts were retrieved for studies that potentially met the inclusion criteria. Disagreement between reviewers was resolved by a third reviewer. Full-text screening was likewise performed by two independent reviewers with disagreements resolved by a third reviewer where necessary. Studies identified from hand-searching of reference lists were assessed for relevance based on their titles and abstracts with those meeting inclusion criteria added to the full-text screening stage.

Data extraction

A bespoke extraction tool was piloted on 10 studies by two independent reviewers and discussed within the research team (KC, LA, AP). The tool was then edited to best inform the review questions. Ten percent of the extraction was initially performed by two independent reviewers. Based on good agreement and the need to facilitate extraction from the large number of included sources, the remaining extraction was conducted by one reviewer. Where uncertainties arose, these were discussed with another member of the review team. Discussions most occurred when categorising health technologies informed by the ProFane taxonomy, with categories including: Education/Training; Environment design; Exercise; Medical/Pharmaceutical; Multicomponent intervention; Multifactorial technologies; Nutritional; Physiotherapy; Rounding; Sitters: Stationary fall detection device; Wearable detection device; Other; or Unclassified. The extraction tool can be found in Appendix 3.

Data presentation

An Excel spreadsheet, formatted according to the extraction tool and which was used to extract data, included coding which was used to tabulate results and create figures for visual representation of results. Codes were provided for study designs, purpose and type of health technology, which were previously discussed and agreed upon within the study team. All categories are listed in the extraction tool (Appendix 3). A narrative summary accompanies the tabulated and charted results and describes how the results relate to the reviews objective and questions.

Results

Study inclusion

13,553 records were identified through database searching with a further 586 from other sources (Figure 1). Following the exclusion of 4,502 duplicates and 8,842 records that did not meet the inclusion criteria, a total of 795 studies were identified for full-text examination. Upon full-text examination a further 391 studies were excluded for the following reasons: Wrong Concept (133); wrong setting (e.g. not in-hospital; 99); not reporting on fall prevention or detection (92); protocol only (9); not in English (11); duplicate (10); full text inaccessible (19); wrong patient population (6); intervention not reported (12). Full reference list and reason for exclusion of individual studies are presented in Appendix 4. Therefore, 404 studies were included in the scoping review (full reference list of included studies is presented in Appendix 5 and summary of characteristics table is presented in Appendix 6).

***** Figure 1 recommended location *****

Characteristics of included studies

Year of publication

The two earliest studies identified were published in 1988 (Table 1). Publication numbers peaked in 2015 (37) and otherwise remained stable between 2014 (35) and 2017 (34), after which the number reduced again in 2018 to 21 relevant studies that year, and 7 studies in 2019 at the time of the search.

Country of origin

The included publications originated from 30 different countries with the majority of literature originating from the United States of America (185), Australia (65) and the United Kingdom (36), as shown in Table 2.

***** Tables 1 and 2 recommended location *****

Article type

Out of all included studies, 77 were prospective and 18 retrospective cohort studies, 35 systematic and 30 narrative reviews, 33 before-after designs, 11 descriptive studies, 30 text and opinion pieces, and 25 randomised controlled trials (RCTs). Twenty nine studies were not easily classified and were noted as 'other' which comprised: overview of one hospital's experience; educational article series; interrupted time series; research round table; case-control study; biomechanical evaluation of technology; case study; development and acceptability; usability and/or feasibility analysis; umbrella review; pilot study; incremental study; incremental design with pilot prospective RCT; retrospective comparative design. A summary of all included study designs can be found in Table 3.

A common research design (n=54) was coded as 'emerging technology development'. These studies were defined as describing or reporting on the technical development and testing of technological devices such as sensors[27], wearable devices[17] and cameras[28]. These studies commonly reported on studies conducted in controlled laboratory conditions using healthy volunteers.

Participants and settings

Two hundred and twenty-nine studies were studies that explicitly reported having patient participants, with a large number being aged ≥65. These studies were set in hospitals with some reporting on specific wards such as oncology[29] or stroke rehabilitation[30], while others included all patients admitted to hospital during the study period[31]. Twenty-four studies involved healthy volunteers, the majority being emerging technology studies[32]. Seventy studies included hospital staff[33], particularly nurses. The remaining studies included those reporting on general service changes (e.g. implementation projects) rather than reporting on patient outcomes, or were secondary research (narrative reviews, text and opinion studies).

***** Table 3 recommended location *****

Review findings

Technology purpose

Eighty three percent of included studies reported on technologies aimed at fall prevention (336), with 13% (51) targeting fall detection and 4% (17) aimed at both prevention *and* detection. The majority of detection studies came from the emerging technology development literature (Table 3).

Health technology type

The health technologies presented have been categorised by type and number (Figure 2). Most studies (n=178) reported on combined technologies, including multifactorial technologies (defined as health technologies tailored to each individual's risk factors[34]) and multicomponent technologies (the same set of health technologies applied to all at risk of falling[35]). Many of these interventions involved some form of fall risk assessment and a set of interventions from some or all of the categories detailed below (e.g. fall detection devices, rounding, environment changes, education, sitters, fall risk identification and signage). Other common elements included the introduction of fall safety teams or multidisciplinary fall teams[36] and fall safety champions[37] who were responsible for leading fall prevention efforts, reviewing progress and areas for improvement. However, it was often difficult to discern the technology type, whether multifactorial or multicomponent, especially where not explicitly stated. Therefore, for the purpose of this scoping review a combined technologies category was created including any health technology (both multifactorial or multicomponent) that included two or more components at the same time, whether linked to a risk assessment or not.

Fall detection devices (stationary and wearable) were the second most frequently reported (n=86 studies). A large number of these (n=54 studies) were emerging technologies which were not specifically tested on patients but were being developed in controlled laboratory or replicated environments with the aim of being used with patients in the near future. Examples include depth cameras for tracking patient movement and predicting fall behaviours[38]; accelerometer devices worn by participants on the wrist, chest, thighs and/or ankles which can alert staff if a fall is detected[39,40]; chair[41] or bed sensors[42] using pattern recognition to predict fall behaviour and send alarms; pressure sensor carpets or floor mats[43]; EMG-based sensors that can detect poor balance based on prediction algorithms[32]; smartphone-based sensors[44]; complex devices including sensors for markers of health in addition to accelerometer data[45] and a smart room which involves various sensors and signage[46].

Only a small number of studies involved wearable and stationary fall detection devices that were used on patients in clinical settings (n=12 studies). Stationary devices included bed or chair sensor alarms[47], video and image-based monitoring[48,49] while wearable devices were mostly accelerometer devices with integrated fall alarms often worn on the wrist, chest or ankles[50].

Twenty-four interventions focused on education or training of staff and/or patients and their families. These were in the form of written information such as leaflets or educational posters, short educational sessions and discussions with patients and families[50], which were sometimes with a fall prevention-trained physiotherapist or occupational therapist[51], 'caring cards'[52] and mandatory staff training[53] aimed at engaging staff in fall prevention strategies.

Alterations to the patient's environment were examined in eight studies, including the use of low-low beds[54] and bedrails[55]. Six studies reported on the use of fall risk assessments in fall prevention; these were often tailored to a specific department or patient population[56].

Interventions reporting on increased monitoring of patients included those using sitters (observers) in the rooms of patients considered at risk of falling (n=5 studies) and regular rounding on patients (n=3)

to assess pain, position, toileting and other personal needs which may cause the patient to fall whilst getting out of bed unaided[56].

There were a limited number of studies reporting on medical or pharmaceutical interventions (n=2) which involved medication review by a pharmacist to reduce the use of medicines associated with falls[57]; and exercise or physiotherapy-based interventions (n=3) where patients received individually tailored exercises from physiotherapists aimed at improving strength and balance[58,59]. One study reported on using a nutritional-based fall prevention intervention where patients received calcium and vitamin D supplementation[60].

Health technologies categorised as “other” were those that were not easily classified or were not sufficiently described. Examples of these include decision support systems and electronic health record systems to aid with falls management approaches[61]; changes to flooring[62]; line dancing[38]; staff meeting relating to falls prevention[63]; changes to staffing-to-patient ratios[64]; non-slip socks[65]; and falls safety agreement between staff and patients[66].

Finally, there was a need to create an “unclassified” category for studies that did not report on specific health technologies or groups of technologies (i.e. reviews of multicomponent or multifactorial studies). Many of these were focused on fall prevention in general and included a mixture of text and opinion pieces[67], qualitative studies using focus groups and interviews[68], descriptive studies involving surveys[69], narrative reviews[70], and systematic reviews[13]. Systematic reviews that reported on a specific health technology or on multicomponent or multifactorial interventions were still categorised according to a specific technology.

***** Figure 2 recommended location *****

Outcomes reported

There was a variety of outcomes reported that assessed clinical effectiveness, cost-effectiveness, feasibility and acceptability of fall prevention and detection technologies in the hospital setting; with some studies reporting more than one outcome. A total of 232 (57%) studies reported outcomes relating to clinical effectiveness of fall prevention and detection technologies, summarised in Table 4. The clinical effectiveness of fall prevention efforts was often assessed by looking firstly at changes in fall rate, fall number and changes in the risk of falling. Secondary outcomes were commonly rates and number of fall-related injuries and staff compliance with interventions. Studies involving technological devices reported on the device performance in fall identification and detection (e.g. accuracy, sensitivity, specificity, precision).

Twenty studies (5%) reported on cost-effectiveness of fall prevention and detection technologies (Table 5). These were generally reported as the overall costs (e.g. net cost of intervention, annual

cost of falls); cost per item (e.g. cost per fall or per patient); and as costs saved as a result of an intervention or strategy (e.g. savings realised from avoided falls).

Fifty-seven studies (14%) reported outcomes relating to the feasibility and/or acceptability of fall prevention and detection technologies (Table 6). The most commonly reported feasibility/acceptability outcome was staff compliance with an intervention (n=14 studies), followed by staff attitudes (n=8 studies), and staff perceptions of usability and feasibility (n=8 studies). Other outcomes related to acceptability, attitude, perceptions, tolerance and barriers to participation from the patients' viewpoint, which were commonly collected via questionnaires or interviews.

***** Table 4/5/6 recommended location *****

Discussion

This scoping review examined and mapped the wide range of health technologies reported in the literature for fall prevention and detection in adult hospital in-patients. Furthermore, the outcomes used to measure clinical and cost-effectiveness, acceptability and feasibility of falls prevention and detection technologies in hospitals were summarised. A total of 404 studies were examined, demonstrating the abundance of fall prevention and detection research and the need for a scoping review to map the evidence, identify gaps and inform future research efforts.

Health technologies reported in the literature

The majority of included literature reported on efforts towards fall prevention with less on health technologies for the timely and accurate detection of falls. It is clearly preferable to prevent falls in the first instance to avoid injury, reduce the likelihood of long-term consequences for the patient, and decrease cost implications for health services[6,71]. However, considering the high incidence of falls in the community[1], the often-altered physical and psychological state of patients, as well as the unfamiliar hospital environment, it is unrealistic to expect that in-patient falls can be completely eradicated. It is therefore of vital importance that hospitals have effective methods and health technologies available for detecting falls in order to provide timeous assistance and care.

Categorisation of health technologies was informed through use of the ProFane taxonomy[19]. Developed by international experts in falls prevention and health services research, the consensus developed ProFane taxonomy[19] was created to describe and classify fall-prevention interventions to improve design and reporting of research. Mapping of the evidence from this scoping review identified a wide variety of health technologies reported. Most commonly these were implemented in the form of a combined intervention (whether multicomponent or multifactorial) with many different combinations of health technology ingredients, with or without falls risk assessment. The heterogeneity of these combined interventions makes direct comparison very difficult. Cumbler et al[72] previously compared 15 randomised studies including single, multicomponent and multifactorial interventions but were not able to identify one health technology type that was more effective than others. However, considering only 6.5% of the studies in this scoping review were RCT's it is likely that they limited themselves in terms of data availability. Furthermore, there was no meta-analysis conducted by the authors to

quantify effectiveness. Therefore, future work is required to compare multicomponent (same bundle for all) and multifactorial (different bundle based on falls risk assessment) interventions to determine which technologies and combinations thereof are most effective. Identifying the most effective intervention ingredients for fall prevention bundles would provide vital evidence for informing policy and practice. Education and training (of patients and staff), various forms of fall prevention leadership (e.g. fall safety teams and champions) and use of falls risk assessment tools are evident in practice, in keeping with the scoping review findings. However, due to the number of possible intervention ingredients identified, hospital staff would benefit from additional syntheses to identify those (individually and in combination) most likely to be beneficial.

Technological devices were highly prevalent in the literature, with 86 studies reporting on fall detection devices. A large proportion of these were technologies still in development and not yet being tested in patients in a hospital setting. Similarly, in a recent scoping review with a broad inclusion of settings and participants, Lapierre et al[14] identified a large number of studies on fall detection devices that were still at a low technology readiness level (on average 4.5/9). Given the rise in technology adoption around the world and the WHO vision statement to "Improve Health for everyone, everywhere by accelerating the adoption of appropriate Digital Health" [73], it will be important to monitor developments in this field as these technologies could have a significant impact on health technologies of choice for fall prevention and detection in the hospital setting. The synthesised findings from the limited number of studies reporting on fall detection devices with patients in the hospital setting[47,74,75] would be of great interest given the importance of fall prevention/detection and increasing adoption of devices such as sensors in the hospital setting.

Environmental adaptations were not commonly implemented in isolation but were often incorporated as part of combined interventions[34,76], which would make evaluation of environmental adaptations per se challenging.

Evaluation of education and training interventions, aimed at staff and/or patients, included a variety of approaches, often designed by staff for a particular hospital or ward setting. This heterogeneity in approach creates challenges for the evaluation of these interventions. However, future evaluation would be worthwhile, as most sources reported adherence with guidance or completion of falls risk assessment tools in addition to actual falls rates. This would enable the relationship between adherence to such activities and falls outcomes to be evaluated.

We found a small number of studies reporting on medical or pharmaceutical technologies[57,77] and on technologies targeting nutrition[60]. These were sometimes included in combined interventions; however, a limited number of studies involved medication review and management[34]. This is perhaps surprising considering that sedative use and drowsiness inducing medication are important risk factors for falls in older adults in hospital[9], suggesting this may be an area for future research.

Hospital-based exercise interventions were not commonly reported, either as single or part of combined interventions. Exercise is frequently used for community dwelling adults with moderate to high quality evidence that exercise is effective at reducing falls in this population[78]. A Cochrane review[13] was uncertain of the effect of exercise on falls in care facilities (low quality evidence) or hospitals (very low-quality evidence). The hospital setting may inevitably preclude exercise from being commonly implemented, particularly for very frail individuals and those in acute care, emergency and high dependency units. However, it would appear that exercise-based interventions for fall prevention in the hospital setting may be under-researched at present and may represent a further gap in the current evidence-base.

Outcomes reported in the literature

The effectiveness of interventions in preventing or detecting falls (and reducing the number, rate and risk of falls) were by far the most common outcomes studied, as might be expected. On the whole there was good homogeneity in terms of effectiveness outcomes which should facilitate meta-analyses in systematic reviews of effectiveness.

The cost-effectiveness of health technologies for fall prevention and detection appears to be somewhat under-researched, with only 5% of identified studies investigating cost-effectiveness. Most of these studies originated in the USA where healthcare is privatised. Given the substantial cost of falls and fall-related injuries[6,7] and the plethora of health technologies now available it would seem a logical priority for health care institutions to determine the best combination of clinical and cost-effectiveness.

Feasibility and/or acceptability of fall prevention and detection technologies was reported in 14% of included studies, suggesting that this may also be a priority for future research. Technologies need to not only be clinical and cost-effective but need to be feasible to deliver and acceptable to those delivering and receiving them.

Limitations

As with any review, these results should be interpreted with consideration of some limitations. The current scoping review is extensive and included a comprehensive search strategy involving multiple databases with broad inclusion criteria and only a handful of inaccessible studies. However, it is possible that some relevant studies or sources may have been omitted. The ProFaNE taxonomy was used to assist with extraction, categorisation and interpretation of results only, and was not included as part of the search strategy which is a limitation. Additionally, we only included studies published in English, as we did not have resources for translation, and may therefore have excluded relevant studies in other languages. Future reviews should be inclusive of all languages in order to provide a comprehensive map of technologies.

There were some difficulties in defining and classifying the type of health technology or combination of technologies (whether multicomponent or multifactorial). This could be in part a result of having no lower limit on publication dates, as the standardised ProFaNE taxonomy was not widely used before 2010/2011[19].

Conclusions

This scoping review provides a map of fall prevention and detection technologies and outcomes reported in the literature from 1988 to the present day. This map has informed the next phase of our study, indicating that it is appropriate to conduct evidence syntheses of the following subgroups of literature, for adults in hospital settings, to inform clinical practice: effectiveness of multicomponent/multifactorial interventions; effectiveness of wearable and non-wearable technologies (e.g. sensors, cameras); feasibility and acceptability of fall prevention and detection technologies. We encountered some difficulties in classifying technologies, although generally this was easier with more recent literature, and we recommend that researchers continue to use the ProFANE taxonomy[19].

Recommendations for research

It is clear from this scoping review that despite the volume of literature on fall prevention and detection in the hospital setting, there are some technologies with limited study and the overall lack of randomised controlled trials indicates a need for more high-quality research to be conducted. Priority areas include fall detection technologies; pharmaceutical fall prevention technologies; and exercise-based fall prevention technologies. In addition, further research on the cost-effectiveness, feasibility and acceptability of fall prevention and detection technologies for adults in the hospital setting is indicated.

Recommendations for practice

It would be inappropriate to make recommendations for practice from this scoping review since, in keeping with scoping review methodology, critical appraisal of the included literature was not conducted and study findings not examined in detail.

Acknowledgements

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Conflict of interest

We have no conflict of interest to declare.

Table 1. Number of articles included by year of publication

Year of publication	No. of articles per year of publication	Year of publication	No. of articles per year of publication
1988	2	2005	10
1991	2	2006	16
1992	1	2007	16
1993	2	2008	17
1994	2	2009	20
1996	2	2010	15
1997	2	2011	28
1998	4	2012	30
1999	4	2013	30
2000	2	2014	35
2001	8	2015	39
2002	4	2016	34
2003	4	2017	34
2004	14	2018	25
-	-	2019	9
		Total	**411**

Table 2. Number of articles per country of origin

Countries of Origin	No. of articles per country
Czech Republic, Finland, Hong-Kong (China), Israel, Saudi Arabia, Slovenia	1 study each (total 6)
Austria, Portugal	2 studies each (total 4)
Belgium, India, New Zealand, Norway, Poland, Sweden, Switzerland	3 studies each (total 21)
Spain	5
Netherlands	5
Korea	5
France	5
Germany	6
Ireland	7
Singapore	10
Italy	12
Japan	13
Canada	19
UK	36
Australia	70
USA	187

Table 3. Study design of included articles by purpose of technology

Study Design	Prevention	Detection	Both
Audit	8	-	-
Before-after	35	-	-
Cohort (Prospective)	43	5	3
Cohort (Retrospective)	14	1	1
Descriptive	28	2	2
Diagnostic test accuracy	-	3	-
Economic evaluation	4	-	-
Emerging technology development	12	36	7
Historically controlled trial	4	-	-
Implementation	12	-	-
Mixed methods	9	2	-
Observational	3	-	-
Other	15	-	-
Qualitative	11	-	1
Quality improvement	19	-	-
Quasi-experimental	9	-	-
Randomised controlled trial	25	-	2
Narrative review	25	2	2
Systematic review	36	1	-
Text and opinion	26	1	2
Total	*338*	*53*	*20*

Note: the category 'other' is described in the main body of the manuscript.

Table 4. The type of clinical effectiveness outcomes reported and number of articles reporting these.

Clinical Effectiveness Outcomes	Number of articles reporting these outcomes
Fall rate	107
Reported as:	
fall rate	43
falls per 1000 patient days	28
fall rate ratio	6
falls per 1000 occupied bed days	5
falls per 1000 bed days	4
falls per 1000 occupied beds	3
falls per 1000 hospital days	2
falls per 1000 admissions/patient encounters	2
falls per 100 patient days	8
falls per 100 bed days	3
falls per 1000 adjusted patient days	1
fall frequency rate	2
Fall number	92
Reported as:	
number of falls	72
number of fallers	10
number of fallers (risk ratio)	2
patients falling per 1000 admissions	1
number of recurrent fallers	1
average number of falls per fallen patient	1
patient falls per 100 discharges	1
percent of patients with a fall	1
percent of inpatient falls	1
percent of patients falling once, twice, 3 times	1
mean proportion of patients experiencing one fall per month	1
Injury outcomes	34
Reported as:	
number of injurious falls	10
rate of injurious falls per 1000 patient days	5
injury rate	5
fall related injuries	5
injury severity	4

fractures rate ratio	1
fall consequences	1
percent of patients sustaining injury	1
fall associated injuries per 1000 inpatient days	1
falls requiring life-sustaining intervention or resulting in permanent harm or death	1
Other measures:	
Prediction/detection reported as:	37
fall identification and detection (accuracy, sensitivity, predictability, specificity, precision)	20
number of true falls detected	7
fall prediction rate	1
number of predicted fallers	1
number of fallers who were not predicted	1
fall risk assessment predictive accuracy	3
fallers correctly identified by the screening tool (%)	1
lead time for fall detection	2
awakening detection	1
Fall occurrence reported as:	17
fall incidence	12
incidence of multiple falls	1
fall index	3
number of patients restrained	1
Fall risk reported as:	2
relative risk of falling	1
odds ratio for falling	1
Staff outcomes reported as:	5
staff knowledge (survey)	2
team members perception of team effectiveness	1
compliance with care bundle elements	1
use of fall prevention interventions by nursing staff	1

Note: Many articles reported on more than one outcome

Table 5. The type of cost effectiveness outcomes reported and number of articles reporting these.

Cost Effectiveness Outcomes	**Number of articles reporting these outcomes**
Overall costs:	
Net cost of intervention	3
Annual cost of falls	2
Cost estimates	1
Cost of care resulting from falls	2
Cost of overtime	1
Cost of volunteer hours	1
Costs of falls	1
Cost per...:	
Cost per fall	3
Cost per hospitalisation	1
Cost per patient (mean)	3
Cost of intervention per patient	1
Cost of activity per bed	2
Costs per 100 patients	1
Fallers prevented per 100 patients	1
Cost saving:	
Annual cost savings	1
Cost savings	1
Projected costs saved	1
Savings realised from avoided falls	2
Decrease in sitter costs (annually)	2
Incremental cost-effectiveness ratio	1
Estimated cost savings to hospital	1

Note: Some articles included several outcomes

Table 6. The type of feasibility and acceptability outcomes reported and number of articles reporting these.

Feasibility/Acceptability Outcomes	**Number of articles reporting these outcomes**
General:	
Device feasibility of use	1
Feasibility survey outcomes	1
Integration survey outcomes	1
Intervention acceptability (staff, patient and family)	1
Intervention fidelity (Barriers and facilitators, embedding and sustaining intervention)	1
Percentage of hospitals implementing the programme	1
Volunteer satisfaction	1
Device acceptability and usability (limited info, Han 2016, Wolf 2013)	2
Audit criteria (various)	2
Staff:	
Staff acceptability survey (suitability, practicality, benefits)	2
Staff attitudes (qualitative)	8
Staff compliance	14
Staff perceptions of patient safety culture (Hospital Survey on Patient Safety Culture (HOSPSC))	1
Staff satisfaction with intervention	1
Staff usability and feasibility (qualitative data from focus groups; survey)	8
Staff device acceptability (icon accuracy and representativeness)	1
Patient (and family):	
Patient acceptability	1
Patient attitudes (qualitative)	2
Patient barriers to participation	1
Patient knowledge (survey)	1
Patient participation in intervention	1
Patient perceptions	1
Patient satisfaction with care	4
Patient tolerance/acceptance of device	2
Patient usability	3
Patient's family perceptions on intervention (interviews, content analysis)	1

Patients opinions on responsiveness of staff and communication with nurses (Hospital Consumer Assessment of Healthcare Providers and Systems questionnaire)	1
Family satisfaction	1

Note: Articles often reported on more than one outcome.

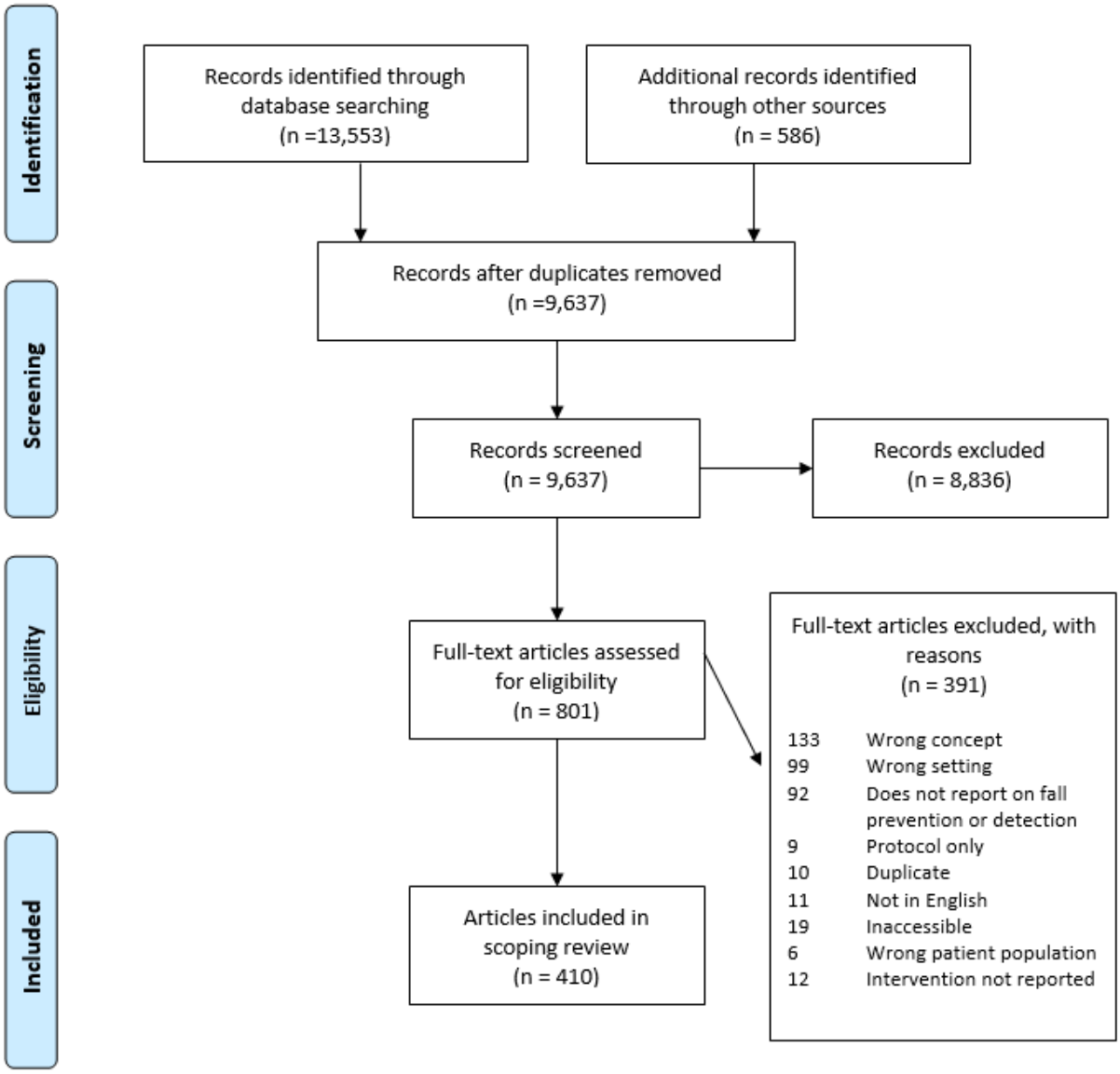
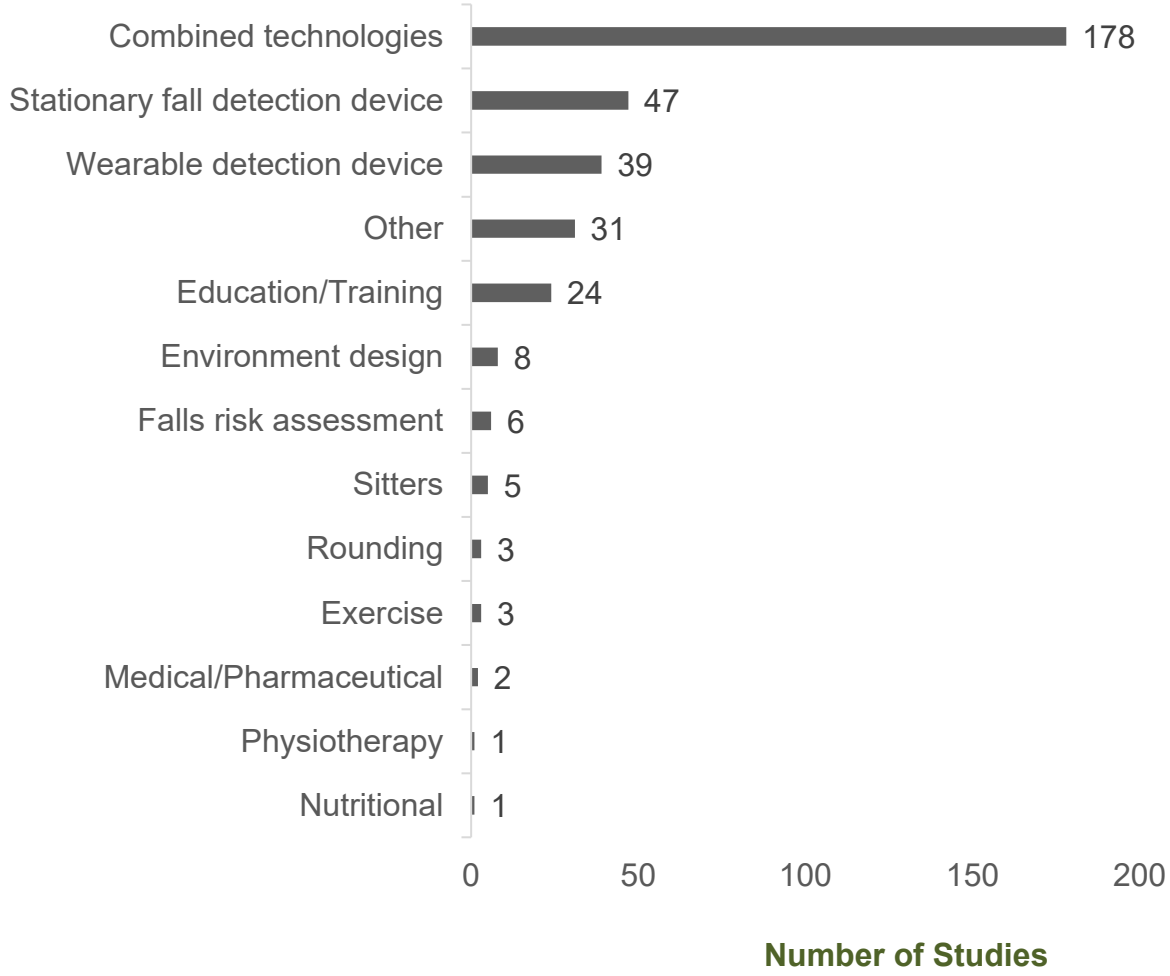


Figure 1. PRISMA flow diagram detailing the results of each search and screening stage. A final number of 410 articles were included in the scoping review.

Figure 2. Summary categorising health technology featured in included studies and total numbers of each type.



'Other' includes health technologies that were not easily grouped or categorised.

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Appendix 1. PRISMA Scoping Review checklist

Preferred Reporting Items for Systematic reviews and Meta-Analyses extension for Scoping Reviews (PRISMA-ScR) Checklist

SECTION	ITEM	PRISMA-ScR CHECKLIST ITEM	REPORTED ON PAGE #
TITLE			
Title	1	Identify the report as a scoping review.	1
ABSTRACT			
Structured summary	2	Provide a structured summary that includes (as applicable): background, objectives, eligibility criteria, sources of evidence, charting methods, results, and conclusions that relate to the review questions and objectives.	1
INTRODUCTION			
Rationale	3	Describe the rationale for the review in the context of what is already known. Explain why the review questions/objectives lend themselves to a scoping review approach.	2-3
Objectives	4	Provide an explicit statement of the questions and objectives being addressed with reference to their key elements (e.g., population or participants, concepts, and context) or other relevant key elements used to conceptualize the review questions and/or objectives.	3
METHODS			
Protocol and registration	5	Indicate whether a review protocol exists; state if and where it can be accessed (e.g., a Web address); and if available, provide registration information, including the registration number.	5
Eligibility criteria	6	Specify characteristics of the sources of evidence used as eligibility criteria (e.g.,	5

SECTION	ITEM	PRISMA-ScR CHECKLIST ITEM	REPORTED ON PAGE #
		years considered, language, and publication status), and provide a rationale.	
Information sources*	7	Describe all information sources in the search (e.g., databases with dates of coverage and contact with authors to identify additional sources), as well as the date the most recent search was executed.	4
Search	8	Present the full electronic search strategy for at least 1 database, including any limits used, such that it could be repeated.	Appendix 1. page 39-40
Selection of sources of evidence†	9	State the process for selecting sources of evidence (i.e., screening and eligibility) included in the scoping review.	6
Data charting process‡	10	Describe the methods of charting data from the included sources of evidence (e.g., calibrated forms or forms that have been tested by the team before their use, and whether data charting was done independently or in duplicate) and any processes for obtaining and confirming data from investigators.	6
Data items	11	List and define all variables for which data were sought and any assumptions and simplifications made.	6 and Appendix 2 pages 42-45
Critical appraisal of individual sources of evidence§	12	If done, provide a rationale for conducting a critical appraisal of included sources of evidence; describe the methods used and how this information was used in any data synthesis (if appropriate).	NA
Synthesis of results	13	Describe the methods of handling and summarizing the data that were charted.	8
RESULTS			

SECTION	ITEM	PRISMA-ScR CHECKLIST ITEM	REPORTED ON PAGE #
Selection of sources of evidence	14	Give numbers of sources of evidence screened, assessed for eligibility, and included in the review, with reasons for exclusions at each stage, ideally using a flow diagram.	7 and Figure 1 on page 33
Characteristics of sources of evidence	15	For each source of evidence, present characteristics for which data were charted and provide the citations.	8-11
Critical appraisal within sources of evidence	16	If done, present data on critical appraisal of included sources of evidence (see item 12).	NA
Results of individual sources of evidence	17	For each included source of evidence, present the relevant data that were charted that relate to the review questions and objectives.	Not included – too many studies to present. However available on request from authors.
Synthesis of results	18	Summarize and/or present the charting results as they relate to the review questions and objectives.	Tables/figures pages 24-34
DISCUSSION			
Summary of evidence	19	Summarize the main results (including an overview of concepts, themes, and types of evidence available), link to the review questions and objectives, and consider the relevance to key groups.	11-12
Limitations	20	Discuss the limitations of the scoping review process.	13-14
Conclusions	21	Provide a general interpretation of the results with respect to the review questions and objectives, as well as potential implications and/or next steps.	14
FUNDING			

SECTION	ITEM	PRISMA-ScR CHECKLIST ITEM	REPORTED ON PAGE #
Funding	22	Describe sources of funding for the included sources of evidence, as well as sources of funding for the scoping review. Describe the role of the funders of the scoping review.	14

JBI = Joanna Briggs Institute; PRISMA-ScR = Preferred Reporting Items for Systematic reviews and Meta-Analyses extension for Scoping Reviews.

* Where *sources of evidence* (see second footnote) are compiled from, such as bibliographic databases, social media platforms, and Web sites.

† A more inclusive/heterogeneous term used to account for the different types of evidence or data sources (e.g., quantitative and/or qualitative research, expert opinion, and policy documents) that may be eligible in a scoping review as opposed to only studies. This is not to be confused with *information sources* (see first footnote).

‡ The JBI guidance refering to the process of data extraction in a scoping review as data charting.

§ The process of systematically examining research evidence to assess its validity, results, and relevance before using it to inform a decision. This term is used for items 12 and 19 instead of "risk of bias" (which is more applicable to systematic reviews of interventions) to include and acknowledge the various sources of evidence that may be used in a scoping review (e.g., quantitative and/or qualitative research, expert opinion, and policy document).

From: Tricco AC, Lillie E, Zarin W, O'Brien KK, Colquhoun H, Levac D, et al. PRISMA Extension for Scoping Reviews (PRISMA-ScR): Checklist and Explanation. Ann Intern Med. 169:467–473. doi: 10.7326/M18-0850

Appendix 2. Search Strategy

Source	Search	Hits
Medline	1. TX Hospital* AND MH (Accidental falls) OR TX ("fall* prevention" OR "fall* detection") 2. MH (Delivery of health care OR biomedical technology) OR TX (Technolog* OR device* OR intervention* OR strateg* OR system* OR organiz* OR organis* OR program*) 3. 1 AND 2	1. 9,384 2. 8,312,512 3. **2,822** (With limits applied)
JBISRIR	1. Hospital* AND fall*	1. **311**
CINAHL	1. TX Hospital* 2. MH (Accidental falls) OR TX ("fall* prevention" OR "fall* detection") 3. MH (Biomedical enhancement OR health care delivery) OR TX (technolog* OR device* OR intervention* OR strateg* OR program* system* OR organiz OR organis*) 4. 1 AND 2 AND 3	1. 1,211, 267 2. 16, 019 3. 1,843,131 4. **2,741** (limits applied)
AMED	1. Hospital* 2. Accidental falls OR ("fall* prevention" OR "fall* detection") 3. (Biomedical technology OR delivery of health care) OR TX (technolog* OR device* OR intervention* OR strateg* OR system* OR organiz* OR organis*) 4. 1 AND 2 AND 3	1. 13,167 2. 2,345 3. 77, 110 4. **155** (limits applied)

EMBASE	1. Hospital* 2. Accidental falls OR “fall* prevention” OR “fall* detection” 3. 1 AND 2	1. 7,601,622 2. 5,789 3. **2,749**
PEDro	1. Fall* AND hospital*	1. **280**
Epistimonikos	1. Hospital 2. Fall* prevention OR Fall* detection 3. 1 AND 2	1. 75,132 2. 37,963 3. **1401**
DoPHER	1. Fall* AND hospital*	1. **17**
TRoPHI	1. Fall* AND hospital*	1. **52**
Cochrane	1. Fall* AND hospital*	1. **146**
ACM Digital	1. Hospital* 2. Fall prevention 3. Hospital AND fall prevention	1. 2,523 2. 13,921 3. **68**
Compendex	1. Fall prevention 2. Hospital 3. 1 AND 2	1. 7,609 2. 19,2517 3. **371**
IEEE Xplore	1. Hospital* 2. Accidental falls OR “fall* prevention” OR “fall* detection” 3. 1 AND 2	1. 83, 356 2. 1,681 3. **144**
Science direct	1. Hospital 2. Technology 3. “fall prevention” OR “fall detection” 4. 1 AND 2 AND 3	1. 3,125,789 2. 3,781,771 3. 3,824 4. **2,296**

Search performed on 12.10.2019

Appendix 3. Data Extraction tool with fields used for the scoping review

Field	Instructions/Description
Title	Title of article
Author	'Smith' or 'Smith and Baker' if 2 authors or 'Smith et al' if ≥3 authors.
Year	Year of publication
Journal	Journal/Publication title
Country of Origin	Country the article originates from
Aims/Purpose	Aim/purpose of the article. (Those relevant to fall prevention and detection.)
Study Design	Select study type from dropdown list: ● Audit ● Before-after design ● Cohort study (Prospective) ● Cohort study (Retrospective) ● Controlled interrupted time series ● Descriptive ● Diagnostic test accuracy ● Economic evaluation ● Emerging technology development ● Historically controlled trial ● Implementation study ● Mixed methods ● Observational ● Other ● Qualitative study ● Quality improvement ● Quasi-experimental (non-randomised) ● RCT ● Review –Narrative ● Review – Systematic ● Text and Opinion

Study Design (if other, describe)	If 'Other' selected then detail the study design/type of article here.
Health Technology Purpose	Select from drop down list: ● Prevention ● Detection ● Prevention AND Detection.
Health Technology Category	Select from drop down list: ● Education/Training (of staff or patients) ● Environment design (any changes to the patient's environment, eg. Lighting, toilet redesign, addition of rails in shower, crash mat) ● Exercise ● Medical/Pharmaceutical (eg. Medication review, reduction of sedatives) ● Multicomponent intervention (involves a combination of health technologies) ● Multifactorial (one or more health technologies tailored to individuals' fall risks) ● Nutritional ● Physiotherapy ● Rounding (patients getting visited by staff) ● Sitters (people that stay with patient for supervision) ● Stationary fall detection device (fall detection devices that are not moveable with the patient, eg. video, bed sensors, motion detection alarms) ● Wearable detection device (any wearable fall detection device, eg. accelerometers) ● Other (any health technology which does not fit into above) ● Unclassified (not reporting on a specific technology or group of technologies eg. fall prevention in general)

	Even if 'other' is selected still continue onto next column and give details of intervention.
Health Technology Information	This is where the main description of the health technology intervention will go. Eg full description of health technology to be added.
Population	Who did they aim to recruit? Eg. adults, all elderly, patients, nurses
Study Sample	Sample size, age, % females, pathology (if available) of the study sample.
Setting	Study setting, eg. Hospital or specific ward. Some technological studies are tested in a lab/community but might be applicable to hospital.
Outcomes Reported	List all the outcomes they report relating to fall prevention and detection. Example: ● Fall number ● Incidence of falls: rate per 1000 patient days
Effectiveness Outcomes	This can be repetitive but please note any outcomes reported that are relevant to the effectiveness of the intervention
Cost-effectiveness Outcomes	Note any outcomes reported that are related to the cost-effectiveness of the intervention
Feasibility/Acceptability Outcomes	Note any outcomes reported that are related to the feasibility and/or acceptability of the intervention
Findings/Conclusions/Recommendations	Brief summary of main findings, without any statistics (*p*-numbers etc), and conclusions or recommendations related to fall prevention and detection.

	Aim to be concise
Reviewer Comments	Any additional comments
Initials and Date of Extraction	Please initial and date each study row

Appendix 4. Reference list and reason for exclusion of 391 excluded studies

Study ID	Reference	Reason for exclusion
1	Abdel-Rahman EM, Turgut F, Turkmen K, Balogun RA. Falls in elderly hemodialysis patients. QJM 2011;104(10):829-838.	Wrong Setting
2	Abley C, Hayes N, Lewis D, Mansfield S, Morgan A, Nazarko L, et al. Ask the experts? Integrated falls service. Nursing Older People 2005;17(3):14-15.	Does not report on fall prevention or detection
3	Abraham S. Managing Patient Falls in Psychiatric Inpatient Units: Part 2. Health Care Manag 2016;35(2):121-133.	Does not report on fall prevention or detection
4	Achkar ME, Lenoble-Hoskovec C, Major K, Paraschiv-Ionescu A, Bula C, Aminian K. Instrumented Shoes for Real-Time Activity Monitoring Applications. Stud Health Technol Inform 2016;225:663-667.	Wrong Setting
5	Ageron F, Ricard C, Perrin-Besson S, Picot F, Dumont O, Cabillic S, et al. Effectiveness of a Multimodal Intervention Program for Older Individuals Presenting to the Emergency Department After a Fall in the Northern French Alps Emergency Network. Academic Emergency Medicine: Official Journal of The Society For Academic Emergency Medicine 2016;23(9):1031-1039.	Wrong Setting
6	Aikpa R, Meunier S, Stroebel C, Lannoy V. Fall prevention in elderly people in follow-up and rehabilitation care units. Soins Gerontologie 2010(83):29-31.	Not in English
7	Alhimale L, Zedan H, Al-Bayatti A. The implementation of an intelligent and video-based fall detection system using a neural network. Applied Soft Computing 2014;18:59-69.	Wrong Setting
8	Allan-Gibbs R. Falls and hospitalized patients with cancer: a review of the literature. Clin J Oncol Nurs 2010;14(6):784-792.	Does not report on fall prevention or detection
9	Combining smart tags and body fixed sensors for disabled people assistance. Vietri sul Mare, Italy: Springer Verlag; 2007.	Wrong Setting
10	Alvord LS, Benninger MS, Stach BA. A preliminary study of the effectiveness of an otolaryngology-based multidisciplinary falls prevention clinic. Ear Nose Throat J 2008;87(9):510-513.	Wrong Setting
11	Ambrose AF, Cruz L, Paul G. Falls and Fractures: A systematic approach to screening and prevention. Maturitas 2015;82(1):85-93.	Wrong Setting
12	Anderson D, Luke RH, Keller JM, Skubic M, Rantz M, Aud M. Linguistic summarization of video for fall detection using voxel person and fuzzy logic. Comput Vision Image Understanding 2009;113(1):80-89.	Wrong Concept
13	Ang WY, Heryani N, Siew Tiang Lydia, L. A. D., Ying LAU. Evaluation of a fall prevention educational video on fall risk awareness, knowledge and help seeking behaviour among surgical patients. Singapore Nursing Journal 2018;45(1):27-33.	Does not report on fall prevention or detection
14	Anita JP, Lee HM, Suryani BS, Nur FB, Nazrin BB, Aines M. Does the use of low beds reduce the incidence of falls among the elderly in acute care settings?-a systematic review. Proceedings of Singapore Healthcare 2011;20:71.	Inaccessible
15	Ansryan LZ, Aronow HU, Borenstein JE, Mena V, Haus F, Palmer K, et al. Systems Addressing Frail Elder Care: Description of a Successful Model. J Nurs Adm 2018;48(1):11-17.	Does not report on fall prevention or detection

16	On-line distinction methods of human falling motions based on machine learning. : Society of Instrument and Control Engineers (SICE); 2010.	Wrong Setting
17	Arai H. Need for the comprehensive and multidisciplinary management of falls. European Geriatric Medicine 2016;7(6):499-500.	Wrong Concept
18	Araujo JNM, Fernandes, A. P. N. L., Silva ABD, Moura LA, Ferreira Junior MA, Vitor AF. Clinical validation of fall prevention behavior in a hospital environment. Rev Bras Enferm 2018;71(4):1841-1849.	Wrong Setting
19	Arbesman, M.C. A case control study of mechanical restraint use, rehabilitation therapies and staffing adequacy as risk factors for falls in an elderly hospitalized population. State University of New York at Buffalo; 1995.	Wrong Concept
20	Arbesman MC, Wright C. Mechanical restraints, rehabilitation therapies, and staffing adequacy as risk factors for falls in an elderly hospitalized population. Rehabilitation Nursing: The Official Journal of The Association Of Rehabilitation Nurses 1999;24(3):122-128.	Wrong Concept
21	Aydin C, Donaldson N, Aronow HU, Fridman M, Brown DS. Improving hospital patient falls: leveraging staffing characteristics and processes of care. J Nurs Adm 2015;45(5):254-262.	Wrong Concept
22	Babatsikou F, Kotsalou I, Koutis C. Falls in elderly population: Epidemiology, causes and preventive interventions. Review of Clinical Pharmacology and Pharmacokinetics, International Edition 2018;32(2):91-99.	Inaccessible
23	Babine RL, Hyrkäs KE, Hallen S, Wierman HR, Bachand DA, Chapman JL, et al. Falls and delirium in an acute care setting: A retrospective chart review before and after an organisation?wide interprofessional education. Journal of Clinical Nursing (John Wiley & Sons, Inc) 2018;27(7-8):e1429-e1441.	Wrong Setting
24	Bae S, Mark B, Fried B. Use of temporary nurses and nurse and patient safety outcomes in acute care hospital units. Health Care Manage Rev 2010;35(4):333-344.	Inaccessible
25	Bakarich A, McMillan V, Prosser R. The effect of a nursing intervention on the incidence of older patient falls. The Australian Journal of Advanced Nursing: A Quarterly Publication Of The Royal Australian Nursing Federation 1997;15(1):26-31.	Inaccessible
26	Baker T, Cooper C. What happens next? Hastings Cent Rep 1999;29(2):24-25.	Does not report on fall prevention or detection
27	Baldewijns G, Debard G, Mertes G, Vanrumste B, Croonenborghs T. Bridging the gap between real-life data and simulated data by providing a highly realistic Fall dataset for evaluating camera-based fall detection algorithms. Healthcare Technology Letters 2016;3(1):6-11.	Wrong Setting
28	Baraff LJ, Lee TJ, Kader S, Della Penna R. Effect of a practice guideline on the process of emergency department care of falls in elder patients. Academic Emergency Medicine: Official Journal of The Society For Academic Emergency Medicine 1999;6(12):1216-1223.	Wrong Setting
29	Barban F et al. ICT solutions to develop an effective motor and cognitive training to reduce risk of falls: The I-DONT-FALL project. Lisbon, Portugal: SciTePress; 2015.	Wrong Setting
30	Baris VK, Seren Intepeler S. Views of key stakeholders on the causes of patient falls and prevention interventions: A qualitative study using the international classification of functioning, disability and health. J Clin Nurs 2019;28(3-4):615-628.	Does not report on fall prevention or detection

31	Barker SM, O'Brien CN, Carey D, Weissman GK. Quality improvement in action: a falls prevention and management program. Mt Sinai J Med 1993;60(5):387-390.	Inaccessible
32	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 [with consumer summary]. Injury Prevention: Journal of the International Society for Child and Adolescent Injury Prevention 2011.	Protocol only
33	Barrett JA, Bradshaw M, Hutchinson K, Akpan A, Reese A, Metcalfe L, et al. Reduction of falls-related injuries using a hospital inpatient falls prevention program. J Am Geriatr Soc 2004;52(11):1969-1970.	Wrong Concept
34	Batchelor FA, Mackintosh SF, Said CM, Hill KD. Falls after stroke. International Journal of Stroke 2012;7(6):482-490.	Wrong Setting
35	Bates D, Brennan PF, Flory J. Leveraging Evidence Across the Care Continuum. The Joint Commission Journal on Quality and Patient Safety 2015;41(2):87-96.	Inaccessible
36	Bates J. Loose footing. Nursing Standard 2014;28(37):28-29.	Does not report on fall prevention or detection
37	Battiato R, Owens C. Prevent Falls and Strengthen Confidence. Rehab Management: The Interdisciplinary Journal of Rehabilitation 2012;25(1):16-19.	Wrong Setting
38	Bauer J. RN news watch: specialty news bulletin. Elderly patients fall less often after having their meds reduced. RN 2003;66(8):98-57.	Wrong Setting
39	Bayne CG. Technology assessment. Falling: why and what to do about it. Nurs Manage 1997;28(12):22-23.	Wrong Concept
40	Beaucamp F, Pardessus V, Pollez B, Marissal J-, Puisieux F, Thevenon A. Private practice-hospital patient pathways for elderly people with falls or at risk of falls: A study in Lille (northern France). Annals of Physical and Rehabilitation Medicine 2016;59:e100-e101.	Wrong Setting
41	Ben Natan M, Heyman N, Ben Israel J. Identifying Risk Factors for Elder Falls in Geriatric Rehabilitation in Israel. Rehabilitation Nursing: The Official Journal of The Association Of Rehabilitation Nurses 2016;41(1):54-59.	Does not report on fall prevention or detection
42	Bennett PN, Ockerby C, Stinson J, Willcocks K, Chalmers C. Measuring hospital falls prevention safety climate. Contemporary nurse 2014;47(1-2):27-35.	Wrong Concept
43	Berg KO, Kairy D. Balance interventions to prevent falls. Generations 2002;26(4):75-78.	Wrong Setting
44	Bergman K, Papendick L. Falls in the neurologic illness population. Journal of trauma nursing: the official journal of the Society of Trauma Nurses 2014;21(4):182-185.	Does not report on fall prevention or detection
45	Berman S. To Our Readers. The Joint Commission Journal on Quality and Patient Safety 2009;35(1):3-4.	Does not report on fall prevention or detection
46	Biley A. National Service Framework for Older People: management of falls. British Journal of Nursing 2001;10(20):1351-1356.	Wrong Setting
47	Blain H. S-16: Joint symposium EUGMS SIG Falls Prevention and Fracture/ProFouND/EIP on AHA/EUNAAPA. European Geriatric Medicine 2015;6:S170-S172.	Wrong Setting
48	Blain H, Abecassis F, Adnet PA, Alomene B, Amouyal M, Bardy B, et al. Living lab falls-MACVIA-LR: The falls prevention initiative of the European innovation partnership on active and healthy ageing (EIP on AHA) in Languedoc-Roussillon. European Geriatric Medicine 2014;5(6):416-425.	Wrong Setting

49	Blakemore S. Medical and environmental factors play part in falls in hospital. Nursing Older People 2008;20(10):7.	Inaccessible
50	Blakemore S. Hospitals need a dedicated team. Nursing Older People 2008;20(10):7.	Inaccessible
51	Bogomolskiy D, Buttar A, Gonzalez-Stark L, Ho R, Perskin M, Zweig Y. A novel geriatric/cardiology/nursing partnership to assess inpatient falls. J Am Geriatr Soc 2017;65:S169.	Inaccessible
52	Boraas D. Fall prevention: a challenge to the health care team. S D J Med 1993;46(2):63.	Inaccessible
53	Bosley E. Implementation and Evaluation of Teach-back as a Pedagogical Method for Delivering Fall Prevention Education to Older Adults in an Inpatient Hospital Setting. Implementation & Evaluation of Teach-back as a Pedagogical Method for Delivering Fall Prevention Education to Older Adults in an Inpatient Hospital Setting 2016:1.	Inaccessible
54	Botvin JD. Facts about falls inspire safety program at St. Marys. Wisconsin hospital collaborates with community agencies. Profiles Healthc Mark 2001;17(1):13.	Inaccessible
55	Boulton E, Hawley-Hague H, Vereijken B, Clifford A, Guldemond N, Pfeiffer K, et al. Developing the FARSEEING Taxonomy of Technologies: Classification and description of technology use (including ICT) in falls prevention studies. J Biomed Inform 2016;61:132-140.	Wrong Concept
56	Boutellaa E, Kerdjidj O, Ghanem K. Covariance matrix based fall detection from multiple wearable sensors. J Biomed Inform 2019;94.	Wrong Setting
57	Bowden V, Bradas C, McNett M. Impact of level of nurse experience on falls in medical surgical units. J Nurs Manag 2019;27(4):833-839.	Intervention not Reported
58	Brabcová I, Bártlová S, Hajduchová H, Tóthová V. Prevention of patient falls in hospitals in the Czech Republic. Neuro Endocrinology Letters 2015;36 Suppl 2:23-28.	Does not report on fall prevention or detection
59	Breckenridge-Sproat S, Johantgen M, Patrician P. Influence of Unit-Level Staffing on Medication Errors and Falls in Military Hospitals. West J Nurs Res 2012;34(4):455-474.	Wrong Concept
60	Brownsell S, Fowler-Davis S. Continuing professional development. Assistive technologies in falls management. Therapy Weekly 2005;32(23):7-10.	Inaccessible
61	Brungardt GS. Patient restraints: new guidelines for a less restrictive approach. Geriatrics 1994;49(6):43.	Does not report on fall prevention or detection
62	Bsching F, Kulau U, Gietzelt M, Wolf L. Comparison and validation of capacitive accelerometers for health care applications. Comput Methods Programs Biomed 2012;106(2):79-88.	Wrong Concept
63	Burgon C, Darby J, Pollock K, Van Der Wardt V, Peach T, Beck L, et al. Perspectives of healthcare professionals in England on falls interventions for people with dementia: a qualitative interview study. BMJ Open 2019;9(2).	Wrong Setting
64	Burhan A. Implementation of intelligent fall detection and personal emergency response system in psychogeriatric inpatient units. International Psychogeriatrics 2013;25:S49.	Wrong Concept
65	Buri H. A group programme to prevent falls in elderly hospital patients. British Journal of Therapy & Rehabilitation 1997;4(10):550-556.	Wrong Setting
66	Butt C. Developing everyone's capacity: a resource kit supporting workforce capacity in reducing falls risk in the older person. Aust J Rural Health 2005;13(1):8-9.	Wrong Setting

67	Byszewski AM, Cranney A, Man-Son-Hing M, Azad N, Amos S. Evaluation of in-hospital management of fracture risk in older patients: a chart review study of tertiary prevention. Arch Gerontol Geriatr 2006;42(3):319-328.	Wrong Concept
68	Cameron ID, Murray GR, Gillespie LD, Robertson MC, Hill KD, Cumming RG, et al. Interventions for preventing falls in older people in nursing care facilities and hospitals. The Cochrane Database of Systematic Reviews 2010(1):CD005465.	Duplicate
69	Campagna G, Khandelwal S, Biggerstaff K, Orengo-Nania S. Predicting the likelihood of an inpatient fall as a function of visual pathology, visual acuity, and constitutive health. Invest Ophthalmol Visual Sci 2017;58(8).	Does not report on fall prevention or detection
70	Campanelli T. Risk Management and analysis of an adverse event: accidental patients falls. Prof Inferm 2005;58(3):151-172.	Wrong Concept
71	Campbell AJ, Robertson MC. Comprehensive Approach to Fall Prevention on a National Level: New Zealand. Clin Geriatr Med 2010;26(4):719-731.	Wrong Setting
72	Capezuti E. Minimizing the use of restrictive devices in dementia patients at risk for falling. Nurs Clin North Am 2004;39(3):625-647.	Wrong Setting
73	Capezuti E. Building the Science of Falls-Prevention Research. J Am Geriatr Soc 2004;52(3):461-462.	Does not report on fall prevention or detection
74	Carpenter CR, Lo AX. Falling behind? Understanding implementation science in future emergency department management strategies for geriatric fall prevention. Acad Emerg Med 2015;22(4):478-480.	Wrong Setting
75	Carpenter CR, Shah MN, Hustey FM, Heard K, Gerson LW, Miller DK. High yield research opportunities in geriatric emergency medicine: prehospital care, delirium, adverse drug events, and falls. The Journals Of Gerontology Series A, Biological Sciences And Medical Sciences 2011;66(7):775-783.	Does not report on fall prevention or detection
76	Casilari E, Luque R, Moron M-. Analysis of Android Device-Based Solutions for Fall Detection. Sensors (Basel, Switzerland) 2015;15(8):17827-17894.	Wrong Setting
77	Casilari E, Santoyo-Ramn J, Cano-Garca J. UMAFall: A Multisensor Dataset for the Research on Automatic Fall Detection. Procedia Computer Science 2017;110:32-39.	Wrong Concept
78	Castellini G, Demarchi A, Lanzoni M, Castaldi S. Fall prevention: is the STRATIFY tool the right instrument in Italian Hospital inpatient? A retrospective observational study. BMC Health Services Research 2017;17(1):656.	Wrong Concept
79	Chaccour K, Darazi R, El Hassani AH, Andres E. From Fall Detection to Fall Prevention: A Generic Classification of Fall-Related Systems. IEEE Sensors Journal 2017;17(3):812-822.	Wrong Setting
80	Chan D, Diu E, Loh K, Hossain M, Verick D, Nguyen H. Pilot study into impaired judgement, self-toileting behaviour in fallers and non-fallers. European Journal of Ageing 2013;10(3):257-260.	Wrong Concept
81	Chao P-, Chan H-, Tang F-, Chen Y-, Wong M-. A comparison of automatic fall detection by the cross-product and magnitude of tri-axial acceleration. Physiol Meas 2009;30(10):1027-1037.	Wrong Concept
82	Chari S. Participatory design improves hospital safety interventions Lessons from co-creating a night lighting solution to prevent falls. Gold Coast, QLD, Australia: Human Factors and Ergonomics Society of Australia Inc. (HFESA); 2016.	Wrong Concept
83	Chari SR. Point prevalence of suboptimal footwear features among ambulant older hospital patients: implications for fall prevention. Australian Health Review: A Publication of The Australian Hospital Association 2016;40(4):399-404.	Wrong Concept

84	Chen P. Elderly Falls in Hospitals. International Journal of Gerontology 2016;10(3):125.	Wrong Concept
85	Chen T, Nguyen B, Chandra A, Schultz K, Mathew P, Santry H. Patient perspectives on fall risks and actual fall causes. J Am Geriatr Soc 2018;66:S306.	Wrong Concept
86	Chiappetta D, Digby R. Call bell response times...Digby R, Bloomer M, Howard T (2011) Improving call bell response times. Nursing Older People. 23, 6, 22-27. Nursing Older People 2011;23(9):8.	Does not report on fall prevention or detection
87	Cho I, Jin I. Responses of Staff Nurses to an EMR-Based Clinical Decision Support Service for Predicting Inpatient Fall Risk. Stud Health Technol Inform 2019;264:1650-1651.	Does not report on fall prevention or detection
88	Choi J, Choi JE. Enhancing Patient Safety Using Clinical Nursing Data: A Pilot Study. Stud Health Technol Inform 2016;225:103-107.	Wrong Setting
89	Choi J, Lapp C, Hagle ME. Developing a Web-Based Nursing Practice and Research Information Management System: A Pilot Study. Computers, informatics, nursing : CIN 2015;33(9):410-416.	Wrong Setting
90	Choi SD, Guo L, Kang D, Xiong S. Exergame technology and interactive interventions for elderly fall prevention: A systematic literature review. Appl Ergon 2017;65:570-581.	Wrong Setting
91	Chung, H. The lived experience of older adults who fall during hospitalization. Texas Woman's University; 2009.	Does not report on fall prevention or detection
92	Clemson L, Finch CF, Hill KD, Lewin G. Fall Prevention in Australia: Policies and Activities. Clin Geriatr Med 2010;26(4):733-749.	Wrong Concept
93	Close JC, Glucksman E. Falls in the elderly: what can be done? Med J Aust 2000;173(4):176-177.	Wrong Concept
94	Cloutier A, Yang J, Pati D, Valipoor S. Experimental identification of potential falls in older adult hospital patients. J Biomech 2016;49(7):1016-1020.	Wrong Setting
95	Identifying possible patient slips and falls using motion capture experiments. Boston, MA, United states: American Society of Mechanical Engineers (ASME); 2015.	Wrong Concept
96	CominoSanz IM, SanchezPablo C, AlbornosMunoz L, Alejandre IB, Marin, M. J. D. V., Pagalday LU, et al. Falls prevention strategies for patients over 65 years in a neurology ward: A best practice implementation project. JBI Database of Systematic Reviews and Implementation Reports 2018;16(7):1582-1589.	Does not report on fall prevention or detection
97	Conn L. Mind your step! A falls prevention programme designed to reduce falls in those over 75 years. Quality in Ageing 2007;8(1):10-22.	Wrong Setting
98	Cooper JW, Burfield AH. Medication interventions for fall prevention in the older adult. Journal of the American Pharmacists Association 2009;49(3):e70-e84.	Wrong Setting
99	Correa Paula MF, Martins EPM. P175: Evaluation of an individualized educational program for prevention of falls of hospitalized elderly. European Geriatric Medicine 2014;5:S139.	Duplicate
100	Cox J, Newton D. Clinical update. Developing an integrated falls service. Primary Health Care 2005;15(2):25-28.	Wrong Setting
101	Cox J, Thomas-Hawkins C, Pajarillo E, DeGennaro S, Cadmus E, Martinez M. Factors associated with falls in hospitalized adult patients. Applied Nursing Research: ANR 2015;28(2):78-82.	Wrong Concept
102	Cox RS, Bradas C, Bowden V, Buckholz B, Kerber K, McNett M. Fall risk in acute ischemic stroke. Stroke 2017;48.	Wrong Concept

103	Cox R, Buckholtz B, Bradas C, Bowden V, Kerber K, McNett MM. Risk Factors for Falls Among Hospitalized Acute Post-Ischemic Stroke Patients. The Journal of Neuroscience Nursing: Journal Of The American Association Of Neuroscience Nurses 2017;49(6):355-360.	Does not report on fall prevention or detection
104	Cozart H. Environmental effects on incidence of falls in the hospitalized elderly. Texas Woman's University; 2009.	Inaccessible
105	Craighead J, Fletcher R, Maxwell J. Seven steps for fall prevention. Dimens Health Serv 1991;68(4):25-26.	Inaccessible
106	Crawford M, Wood S. Reducing falls risk. Prof Nurse 2001;16(7):S9.	Inaccessible
107	Dadabhoy FZ, Lautar A, Schlaudecker J. Impact of fall reduction interventions added to interprofessional bedside rounds on an ACE unit. J Am Geriatr Soc 2017;65:S102.	Wrong Concept
108	de Jong LD, Kitchen S, Foo Z, Hill AM. Exploring falls prevention capabilities, barriers and training needs among patient sitters in a hospital setting: A pilot survey. Geriatric nursing (New York, N.Y.) 2018;39(3):263-270.	Does not report on fall prevention or detection
109	de Jong LD, Weselman T, Kitchen S, Hill AM. Exploring hospital patient sitters' fall prevention task readiness: A cross-sectional survey. J Eval Clin Pract 2019.	Does not report on fall prevention or detection
110	Dellinger AM, Stevens JA. Injury prevention for older adults. Generations 2005;29(2):60-64.	Patient population wrong
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255	Lu N, Wu Y, Feng L, Song J. Deep Learning for Fall Detection: 3D-CNN Combined with LSTM on Video Kinematic Data. IEEE Journal of Biomedical and Health Informatics 2018.	Wrong Setting
256	Lutzler P, Faraldi O, Rethore V, Heurteux G, Billon M, Cosquier P, et al. A bracelet for the detection of accidental falls in the aged. Soins Gerontologie 2001(27):32-34.	Not in English
257	Luxton T, Riglin J. Preventing falls in older people: a multi-agency approach. Nursing Older People 2003;15(2):18-21.	Wrong Setting
258	Lyons SS. Evidence-based protocol fall prevention for older adults. J Gerontol Nurs 2005;31(11):9-14.	Wrong Setting
259	Maestri A, Monica CM, Federica CF, Antonio MA, Cristina OC, Silvia Priori, . S. G. P. Prevention of falls in patients admitted to a cardiac rehabilitation unit after a acute cardiac event. European Journal of Cardiovascular Nursing 2013;12:S38-S39.	Does not report on fall prevention or detection

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264	McMurdo MET. Falls prevention. Age Ageing 2001;30:4-6.	Wrong Setting
265	Mecugni D, Friggeri F, Mastrangelo S, Gradellini C. Accidental falls prevention in the elderly: a post intervention survey in Italian hospitals...Fourth European Nursing Congress. J Clin Nurs 2010;19:31.	Wrong Concept
266	Mellone S, Tacconi C, Schwickert L, Klenk J, Becker C, Chiari L. Smartphone-based solutions for fall detection and prevention: The farseeing approach. Zeitschrift fur Gerontologie und Geriatrie 2012;45(8):722-727.	Wrong Setting
267	Melnyk BM. Fall prevention in hospitals and long-term care settings: Commentary. Worldviews on Evidence-Based Nursing 2007;4(2):117-118.	Wrong Concept
268	Merrett A, Thomas P, Stephens A, Moghabghab R, Gruneir M. A collaborative approach to fall prevention. Can Nurse 2011;107(8):24-29.	Wrong Setting
269	Meyer R. Stepping On: A Fall Prevention Program A How-To Guide for Volunteers. GeriNotes 2018;25(3):12-13.	Wrong Setting
270	Midori Sakai A, Rossaneis MÂ, Fernandez Lourenço Haddad, Maria,do Carmo, Willamowius Vituri D. Risk of bed falls in adult patients and prevention measures. Journal of Nursing UFPE / Revista de Enfermagem UFPE 2016;10:4720-4726.	Not in English
271	Mir F, Zafar F, Rodin MB. Falls in Older Adults with Cancer. Current Geriatrics Reports 2014;3(3):175-181.	Does not report on fall prevention or detection
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274	Mubashir M, Shao L, Seed L. A survey on fall detection: Principles and approaches. Neurocomputing 2013;100:144-152.	Wrong Setting
275	Mulvihill C, Nolan E, Sweeney A, Marshall S, Szarata A, Armstrong F. Occupational therapy effectively providing holistic care in a frail elderly active rehabilitation unit (ARU). Ir J Med Sci 2014;183(7):S357-S358.	Wrong Setting
276	Muray M, Belanger CH, Razmak J. Fall prevention strategy in an emergency department. Int J Health Care Qual Assur 2018;31(1):2-9.	Wrong Concept

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279	Nelson CA, Burnfield JM, Gu L. Mobility-enhancing fall-prevention device for physical rehabilitation. Journal of Medical Devices, Transactions of the ASME 2014;8(2):020929.	Wrong Concept
280	Nguyen Gia T, Sarker VK, Tcarenko I, Rahmani AM, Westerlund T, Liljeberg P, et al. Energy efficient wearable sensor node for IoT-based fall detection systems. Microprocessors and Microsystems 2018;56:34-46.	Wrong Setting
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283	Nyman SR, Victor CR. Older people's participation and engagement in falls prevention interventions: Comparing rates and settings. European Geriatric Medicine 2014;5(1):18-20.	Does not report on fall prevention or detection
284	Oliver AS, Anuradha M, Justus JJ, Maheshwari N. Optimized low computational algorithm for elderly fall detection based on machine learning techniques. Biomedical Research (India) 2018;29(20):3715-3722.	Wrong Concept
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288	Overcash JA, Beckstead J. Predicting falls in older patients using components of a comprehensive geriatric assessment. Clin J Oncol Nurs 2008;12(6):941-949.	Wrong Concept
289	Park BM, Ryu HS, Kwon KE, Lee CY. Development and Effect of a Fall Prevention Program Based on the King's Goal Attainment Theory for Fall High-Risk Elderly Patients in Long-Term Care Hospital. Journal of Korean Academy of Nursing 2019;49(2):203-214.	Not in English
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291	Perell KL, Nelson A, Goldman RL, Luter SL, Prieto-Lewis N, Rubenstein LZ. Fall risk assessment measures: An analytic review. Journals of Gerontology - Series A Biological Sciences and Medical Sciences 2001;56(12):M761-M766.	Wrong Concept
292	Pervez T, McNamara R. Falls prevention: Starting at the beginning (QIP). European Geriatric Medicine 2016;7:S44.	Intervention not Reported
293	Pierce J, Kearney D, Cumbler E. Development of a post-fall multidisciplinary checklist to evaluate the inpatient fall. Journal of Hospital Medicine 2011;6(4):S125.	Does not report on fall prevention or detection

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295	Quigley P. Tailoring falls-prevention interventions to each patient. American Nurse Today 2015:8-10.	Wrong Concept
296	Radecki B, Reynolds S, Kara A. Inpatient fall prevention from the patient's perspective: A qualitative study. Appl Nurs Res 2018;43:114-119.	Does not report on fall prevention or detection
297	Raeder K, Siegmund U, Grittner U, Dassen T, Heinze C. The use of fall prevention guidelines in German hospitals - A multilevel analysis. J Eval Clin Pract 2010;16(3):464-469.	Wrong Concept
298	Rainville NG. Effect of an implemented fall prevention program on the frequency of patient falls. QRB Quality Review Bulletin 1984;10(9):287-291.	Inaccessible
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301	Ravi A, Racine E, Moriarty E, Murphy R-, Wall O, O'Connor K, et al. Implementing a falls prevention initiative in community hospitals: A cross-sectional study of leadership and organisational climate. Age Ageing 2017;46.	Wrong Concept
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305	Resnick B. Learning from our history: Prevention of falls in acute care. Geriatr Nurs 2015;36(5):339-340.	Wrong Concept
306	Rheaume J. Retrospective Case Reviews of Adult Inpatient Falls in the Acute Care Setting. MEDSURG Nursing 2015;24(5):318-324.	Wrong Concept
307	Richard L, Den EE, Vova J. A multidisciplinary approach to decreasing falls in an inpatient rehabilitation setting: A case report. PM and R 2012;4(10):S304.	Patient population wrong
308	Robertson K, Logan PA, Conroy S, Dods V, Gordon A, Challands L, et al. Thinking falls - taking action: a guide to action for falls prevention. Br J Community Nurs 2010;15(8):406-410.	Wrong Setting
309	Rodger D, Brent L. Preventing falls and fractures. World of Irish Nursing & Midwifery 2015;23(8):60-61.	Wrong Concept
310	Rogers S. Reducing falls in a rehabilitation setting: a safer environment through team effort. Rehabilitation nursing : the official journal of the Association of Rehabilitation Nurses 1994;19(5):274-276.	Does not report on fall prevention or detection
311	Rossetti S, Posca T, Lattuada S, Torazzo R, Rugge E, Di CA, et al. New trends in prevention and detection of falls: Preliminary results. Annals of Oncology 2015;26.	Wrong Concept

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313	Rubenstein LZ, Josephson KR. Falls and Their Prevention in Elderly People: What Does the Evidence Show? Med Clin North Am 2006;90(5):807-824.	Wrong Concept
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315	Saiz-Vinuesa MD, Munoz-Mansilla E, Munoz-Serrano T, Corcoles-Jimenez MP, Ruiz-Garcia MV, Fernandez-Pallares P, et al. Implementation of a best practice guideline for the prevention of falls: Perception among hospitalized patients and its caregivers. Revista de calidad asistencial: organo de la Sociedad Espanola de Calidad Asistencial 2016;31(6):329-337.	Not in English
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321	Schoberer D, Breimaier HE, Mandl M, Halfens RJG, Lohrmann C. Involving the consumers: An exploration of users' and caregivers' needs and expectations on a fall prevention brochure: A qualitative study. Geriatr Nurs 2016;37(3):207-214.	Wrong Setting
322	Schwendimann R. Prevention of falls in acute hospital care. Review of the literature. Pflege 2000;13(3):169-179.	Not in English
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325	Shah C, Suthar V. Effect of two different exercises protocol for fall preventation in elderly. Indian Journal of Physiotherapy & Occupational Therapy 2011;5(4):24-28.	Wrong Concept
326	Shah H, Streelman M, Gobel B. A root cause analysis-driven initiative to reduce hospital falls. Journal of Hospital Medicine 2010;5:103-104.	Wrong Setting
327	Shelby M, Malloch K, Shellenberger T, Byrum S, Mackie L, Dilli S, et al. Addressing Falls Among Older Oncology Patients Through Complexity Science. Nurs Adm Q 2019;43(3):280-288.	Wrong Setting

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330	Shi C. Interventions for preventing falls in older people in care facilities and hospitals. Orthopedic Nursing 2014;33(1):48-49.	Duplicate
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336	Steen C. No more refusals: Multidisciplinary approach to addressing patients refusing high risk fall status. Biology of Blood and Marrow Transplantation 2017;23(3):S376.	Intervention not Reported
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338	Steen G, Fitzgerald K, Fallon N, Maher N, Casey M, Harbison J, et al. Falls management in an acute hospital. Ir J Med Sci 2012;181:S283.	Wrong Concept
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341	Stenberg M, Wann-Hansson C. Health care professionals' attitudes and compliance to clinical practice guidelines to prevent falls and fall injuries. Worldviews On Evidence-Based Nursing 2011;8(2):87-95.	Wrong Concept
342	Stephenson M. Editorial Tackling a Persistent problem: In-Hospital falls Prevention. JBI Database of Systematic Reviews and Implementation Reports 2014;12(10):1-2.	Wrong Concept
343	Stevens JA. Falls among older adults--risk factors and prevention strategies. J Saf Res 2005;36(4):409-411.	Wrong Setting
344	Sullivan RP, Badros KK. Recognize risk factors to prevent patient falls. Nurs Manage 1999;30(5):37-40.	Wrong Concept
345	Sze TW, Leng CY, Lin SKS. The effectiveness of physical restraints in reducing falls among adults in acute care hospitals and nursing homes: a systematic review. JBI Database of Systematic Reviews and Implementation Reports 2012;10(5).	Protocol only
346	Szymaniak S. Accurate falls risk assessment and interventions for preventing falls in patients in the acute care setting within a private hospital in a large capital city: A best practice implementation	Wrong Concept

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348	Tan PJ, Khoo EM, Chinna K, Saedon NI, Zakaria MI, Ahmad Zahedi AZ, et al. Individually-tailored multifactorial intervention to reduce falls in the Malaysian Falls Assessment and Intervention Trial (MyFAIT): A randomized controlled trial. Plos One 2018;13(8).	Patient population wrong
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351	Thilo FJS, Hürlimann B, Hahn S, Bilger S, Schols, Jos M. G. A., Halfens RJG. Involvement of older people in the development of fall detection systems: a scoping review. BMC Geriatrics 2016;16:42.	Does not report on fall prevention or detection
352	Thomas JI, Lane JV. A pilot study to explore the predictive validity of 4 measures of falls risk in frail elderly patients. Arch Phys Med Rehabil 2005;86(8):1636-1640.	Does not report on fall prevention or detection
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354	Tinetti M. 2012 - Review: Acute geriatric unit care reduces falls, delirium, and functional decline. ACP J Club 2013;158(12):1.	Wrong Concept
355	Tricco AC, Cogo E, Holroyd-Leduc J, Sibley KM, Feldman F, Kerr G, et al. Efficacy of falls prevention interventions: protocol for a systematic review and network meta-analysis. Systematic reviews 2013;2:38.	Does not report on fall prevention or detection
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357	Tricco AC, Thomas SM, Veroniki AA, Hamid JS, Cogo E, Strifler L, et al. Comparisons of Interventions for Preventing Falls in Older Adults: A Systematic Review and Meta-analysis. JAMA 2017;318(17):1687-1699.	Wrong Setting
358	Trombetti A, Hars M, Marcant D, Rizzoli R, Ferrari S. Fall prevention: A challenge in the strategy of fracture prevention in the elderly. Revue Medicale Suisse 2009;5(207):1318-1324.	Not in English
359	Tucker S, Sheikholeslami D, Farrington M, Picone D, Johnson J, Matthews G, et al. Patient, Nurse, and Organizational Factors That Influence Evidence-Based Fall Prevention for Hospitalized Oncology Patients: An Exploratory Study. Worldviews on evidence-based nursing 2019;16(2):111-120.	Intervention not Reported
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363	Tzeng H, Yin C. Nurses' solutions to prevent inpatient falls in hospital patient rooms. Nurs Econ 2008;26(3):179-187.	Wrong Concept
364	Tzeng H, Yin C. Nurses' response time to call lights and fall occurrences. Medsurg Nursing: Official Journal Of The Academy Of Medical-Surgical Nurses 2010;19(5):266-272.	Does not report on fall prevention or detection
365	Tzeng H, Yin C. Exploring post-fall audit report data in an acute care setting. Clin Nurs Res 2015;24(3):284-298.	Wrong Concept
366	Vallabh P, Malekian R, Ye N, Bogatinoska DC, Karadimce A, Ritonja J. Classification of fall detection in elderly persons based on smart phone data. J Biotechnol 2016;231:S29-S30.	Wrong Concept
367	van der Kamp S. Stop falls. Intervention works. World of Irish Nursing & Midwifery 2008;16(4):49-50.	Wrong Concept
368	Vass CD, Sahota O, Drummond A, Kendrick D, Gladman J, Sach T, et al. REFINE (Reducing Falls in In-patient Elderly)--a randomised controlled trial. Trials 2009;10:83.	Protocol only
369	Vieira ER, Berean C, Paches D, Costa L, Décombas-Deschamps N, Caveny P, et al. Risks and suggestions to prevent falls in geriatric rehabilitation: a participatory approach. BMJ Quality & Safety 2011;20(5):440-448.	Does not report on fall prevention or detection
370	Vitale A. Falls prevention program keeps elderly patients' feet on the ground. Nursing Spectrum -- Philadelphia Tri -- State Edition 2000;9(17):29.	Inaccessible
371	Vuillerme N, Pinsault N, Chenu O, Fleury A, Payan Y, Demongeot J. A wireless embedded tongue tactile biofeedback system for balance control. Pervasive and Mobile Computing 2009;5(3):268-275.	Does not report on fall prevention or detection
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373	Weaver D. Effective strategies in managing falls prevention. Nursing & Residential Care 2008;10(5):217-222.	Wrong Concept
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375	Weed-Pfaff S, Nutter B, Bena JF, Forney J, Field R, Szoka L, et al. Validation of Predictors of Fall Events in Hospitalized Patients With Cancer. Clin J Oncol Nurs 2016;20(5):E126-E131.	Wrong Concept
376	Wells A, Gray S. Following NICE guidance to take positive steps to prevent falls. Nursing & Residential Care 2013;15(11):729-732.	Wrong Setting
377	West GF, Rose T, Throop M. Assessing nursing interventions to reduce patient falls. Nursing 2018;48(8):59-60.	Wrong Concept
378	White SV. Patient safety--new falls prevention initiative. Fla Nurse 2002;50(1):28.	Wrong Concept
379	Willett LE, Sullivan BT. Falling between the cracks: a community hospital's efforts to prevent fall-related injuries. Generations 2002;26(4):86-88.	Wrong Concept
380	Williams B, Young S, Williams D, Schindel D. Effectiveness of a fall awareness and education program in acute care. Journal for Nurses in Staff Development 2011;27(3):143-147.	Wrong Concept

381	Williams C, Bowles K-, Kiegaldie D, Maloney S, Nestel D, Kaplonyi J, et al. Establishing the effectiveness, cost-effectiveness and student experience of a Simulation-based education Training program On the Prevention of Falls (STOP-Falls) among hospitalised inpatients: A protocol for a randomised controlled trial. BMJ Open 2016;6(6):e010192.	Duplicate
382	Williams ME, Hadler NM. In hospital rehabilitation units, adding individualized fall-prevention education to usual care reduced falls. Ann Intern Med 2015;163(4):JC14.	Wrong Concept
383	Williams ME, Hadler NM. 2015 - In hospital rehabilitation units, adding individualized fall-prevention education to usual care reduced falls. ACP J Club 2015;163(4):1.	Protocol only
384	Winslow EH. Research for practice. Reducing falls in older patients. AJN American Journal of Nursing 1998;98(10):22.	Wrong Concept
385	Wood B, Bennie A, Armstrong M, Michael S, Cameron I. Falls: a coordinated strategy. Australian Health Review: A Publication Of The Australian Hospital Association 1999;22(3):144-154.	Wrong Concept
386	Wright KM. Falls prevention strategies among acute neurosurgical and aged care inpatients in a tertiary hospital in sydney: A best practice implementation report. JBI Database of Systematic Reviews and Implementation Reports 2014;12(10):199-217.	Wrong Concept
387	Xu C, Audrey TXN, Shi SLH, Shanel YWT, Tan JM, Premarani K, et al. Effectiveness of interventions for the assessment and prevention of falls in adult psychiatric patients: A systematic review. JBI Database of Systematic Reviews and Implementation Reports 2012;10(9).	Duplicate
388	Yang Y, Feldman F, Leung PM, Scott V, Robinovitch SN. Agreement Between Video Footage and Fall Incident Reports on the Circumstances of Falls in Long-Term Care. Journal of the American Medical Directors Association 2015;16(5):388-394.	Wrong Setting
389	Yokota S, Shinohara E, Ohe K. Can Staff Distinguish Falls: Experimental Hypothesis Verification Using Japanese Incident Reports and Natural Language Processing. Stud Health Technol Inform 2018;250:159-163.	Wrong Concept
390	Yokota S, Tomotaki A, Mohri O, Endo M, Ohe K. Evaluation of a Fall Risk Prediction Tool Using Large-Scale Data. Stud Health Technol Inform 2016;225:800-801.	Intervention not Reported
391	Yun Y, Yu-Hua Gu I. Chapter 15 - Visual Information-Based Activity Recognition and Fall Detection for Assisted Living and eHealthCare. : Butterworth-Heinemann; 2017. p. 395-425.	Wrong Setting

Appendix 5. Reference list for 404 Included studies

1. Abdalla, A., Adhaduk, M., Haddad, R. A., Alnimer, Y., Ros-Bedoya, C., & Bachuwa, G. (2017). Does acute care for the elderly (ACE) unit decrease the incidence of falls? *Geriatric Nursing,* doi://doi-org.ezproxy.rgu.ac.uk/10.1016/j.gerinurse.2017.10.011

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Appendix 6. Summary of characteristics table of 404 included studies organised by study design.

Author/year	Country	Study design	Purpose	Population	Health technology Category	Health technology information	Findings/Conclusions/ Recommendations
Lee 2013	USA	Cohort study (Prospective)	Influence of staff education on fall rate in hospitalized elders	Inpatients	Education/ Training	An eight-hour workshop was provided for all Certified Nursing Assistants. After the education, CNAs spent the latter half of the workshop developing a new infrastructure, or daily intentional pattern of care, that would promote patient independence and function.	There was no decrease in fall rate. Findings suggest the education may be helpful in patients' return home, functional status & hospital complications.
Haines 2013	Australia	Economic evaluation	Economic evaluation (incremental cost-effectiveness analysis) conducted in parallel with a multicenter randomized controlled trial conducted from the health service perspective.	Adults ages over 60	Education/ Training	Two patient education models were tested in the randomized controlled trial; provision of multimedia patient education materials in addition to usual care (that is, materials only), and provision of multimedia patient education materials combined with trained health professional follow-up (that is, complete program) in addition to usual care. These were compared to usual care alone.	Provision of the complete program in addition to usual care will likely both prevent falls and reduce costs for a health service.
Haines 2006	Australia	RCT	To evaluate the effectiveness of a patient education programme for preventing falls in the subacute hospital setting	Older adults subacute care	Education/ Training	The education programme consisted of one-to-one education sessions with an occupational therapist working as a part of the research team. Sessions were conducted twice weekly at the participant's bedside. Sessions were not intended to be didactic in nature, rather the intention was to facilitate discussion between the participant and the research occupational therapist so that participants would feel free to disclose difficulties they may have had in complying with specific instructions provided to them by hospital staff members.	Intervention group participants in this subgroup analysis had a significantly lower incidence of falls than their control group counterparts (control: 16.0 falls/1000 participant-days, intervention: 8.2 falls/1000 participant-days, log-rank test: P =0.007). However, the difference in the proportion of fallers was not significant (relative risk 1.21, 95% confidence interval 0.68 to 2.14). Patient education is an important part of a multiple intervention falls prevention approach for the subacute hospital setting

Barker 2017	Australia	Other	To explore acceptability of the 6-PACK programme by nurses and senior staff.	Nurses working a minimum of 7.5 hours per week 2 months prior to the survey and senior hospital staff including: nurse unit managers, senior physicians, directors of nursing and senior 'falls prevention' personnel.	Education/ Training	Acceptability on 6-PACK intervention tested via survey (sustainability, practicality, benefits), focus groups and interviews.	Staff perceived the 6-PACK suitable and mostly practical and beneficial.
Gibbons 2013	New Zealand	Audit	To audit current practice in relation to the utilisation of the Fall Risk Management Process, implement a plan of action based on findings, and to re-audit practice post-implementation to identify change and to inform further work.	Patients in the Acute Assessment Unit of the Internal Medicine department	Education/ Training	Focus board located on the ward showing the fall prevention strategies and hospital policies and containing fall resources (to be used in discussions with staff, patients and family). Staff training (2hrs) addressing the 3P's -predict, prevent, protect - along with a self-directed training package.	Following a re-audit of practice there were improvements in most audit criteria relating to fall prevention. This approach was successful in improving practice.
Reich 2017	USA	Before-after design	To create and develop a Certified Falls Prevention Advocate (CFPA) programme, to involve nursing support staff in falls prevention and decrease the number of falls with injury.	Patients and staff (specifically the patient care technicians (PCTs)) on the medical-surgical unit	Education/ Training	The intervention aimed at involving nursing support staff (patient care technicians, PCT's) in fall prevention initiatives. An internal certification programme (Certified Falls Prevention Advocate, CFPA) was created to standardise PCT involvement and engage them as part of the interdisciplinary team. The 1-hour training session focused on the PCT's role in preventing injuries related to falls and interventions that can be performed independently of the RN, while highlighting the importance of communication,	There was a significant decrease in falls with injury in the year following an intervention aimed at encouraging nursing support staff participation in fall prevention. Support staff knowledge improved and the authors reported a change in the safety culture of the unit.

						teamwork and collaboration with all the team members. PCT interventions included: Place the patient on falls precautions; bed/chair alarm; non-slip socks; falls ID wristband; door sign; transfer to specialty bed; contact the falls team; post–falls debrief.	
Ringquist 2015	USA	Before-after design	Evaluate the effectiveness of a fall prevention programme on an acute rehabilitation unit and decrease the number of falls on the unit from the 90th to 50th percentile in six months.	Staff on the rehabilitation unit	Education/ Training	The multidisciplinary staff on the unit were motivated to perform fall prevention measures by having a daily Key Performance Indicator (KPI) board in the hallway which included a calendar showing green for fall free days and red for a day with a fall; as well as the number of consecutive fall free days, which the staff updated daily. Post-fall multidisciplinary Root Cause Analysis (RCA) was performed on all falls and results communicated to staff.	The implementation of a key performance indicator board and post-fall root cause analysis decreased the total fall rate in the rehabilitation unit. The unit also reached their goal of decreasing the fall rate from above the 9th percentile to just above the 25th percentile in 6 months. The success of the programme was accredited to daily awareness, improved communication and identification of further prevention strategies.
Johnson 2015	Australia	Cohort study (Prospective)	This study investigated the impact of an e-learning education programme for nurses on falls risk screening, falls prevention and post-falls management	Inpatients	Education/ Training	e-learning education programme and Falls Management Flip Chart The content of the programme focused on four key elements of the Falls Policy, including falls risk screening using the STRATIFY, falls prevention strategies, post-fall assessment and management procedures, and documentation and accountability of falls-related clinical issues	Initial risk screening of patients and improvements in preventive interventions were demonstrated.

Lange 2009	USA	Cohort study (Prospective)	This study educated nurses in best geriatric nursing practices to enhance effective management of common geriatric problems	Nurses	Education/ Training	30-hour online training program consisting of 10 modules: (1) The Aging of America; (2) Geriatric Assessment; (3) Health Policy, Reimbursement, and Cultural Shifts in Aging; (4) Health Promotion in the Elderly; (5) Common Problems of Aging I (falls, restraints, and nutrition); (6) Common Problems of Aging II (sexuality); (7) Cognitive and Psychological Disorders Among Older Adults; (8) Pathological Changes of Aging; (9)Pharmacological Considerations in the Elderly; and (10) Spirituality and End-of-Life Care.	Declining trend in falls observed
Clarke 2012	USA	Cohort study Retrospective	To determine if a nurse-led pre-operative patient education programme reduced patient falls after primary total knee replacement.	Hospital patients who underwent primary total knee replacement surgery	Education/ Training	Nurse-led pre-operative patient education session focusing on fall prevention after surgery.	Patients in the intervention group had less falls than controls. Identified need for further research to identify whether this beneficial effect is maintained after discharge.
Lohse 2012	USA	Historically controlled trial	A systems-based fall prevention program targeting high-risk situations would result in fewer falls with injury	Inpatients	Education/ Training	Initial education and training targeted registered nurses and took place during periodic education days. Separate sessions were conducted for therapists and nursing assistants. Education was performed by teams composed of both physicians and nurses to stress the importance of partnership in creating the desired culture of safety. A focus was placed on process improvement and not individual fault. Educational responsibilities were shared by the nurse manager and participating surgeons.	Statistically significant reduction in falls
Campbell 2006	USA	Other	To describe the identification and multidisciplinary approach to reduce transfer related falls in	Patients and staff from a stoke unit	Education/ Training	A 'transfer clinic' was set up once weekly for multidisciplinary staff to meet together with patient requiring transfer and together discuss and practice a safe transfer technique. Includes formal communication of results (techniques, recommended equipment, level of assistance for each type of transfer).	Falls related to patient transfers decreased, with anecdotal evidence of positive feedback from patients and families.

			hospital patients.				
Hill 2015	Australia	Qualitative study	To explore the educators' perspectives of delivering the Safe Recovery patient education program and to conceptualise how the programme worked to prevent falls among older patients who received the education	Nursing, allied health and medical staff.	Education/ Training	Educators' perspective of delivering falls prevention education intervention (Hill 2015 above)	Patient, staff & environment must interact effectively to facilitate engagement in falls prevention behaviours. Future research should also seek to understand this successful education programme from patient and staff perspectives, which will provide further understanding of how effective falls prevention education can be delivered on hospital wards.
Hill 2016	Australia	Qualitative study	To understand how staff responded to individualised patient falls prevention education delivered as part of a cluster randomised trial, including how they perceived the education contributed to falls prevention on their wards.	Nurse, physiotherapists & quality improvement staff	Education/ Training	Clinical staff perspectives of the intervention employed by Hill et al (2015) above	Staff perceived that a positive culture was created around falls prevention and that staff and patients could work effectively as a team to engage in falls prevention strategies.
Gould 2018	USA	Quality Improvement	QI project using lean methodology to implement & evaluate use of "Caring Cards"	Adult neurological patients	Education/ Training	Caring Cards: "conversations between leaders and staff provide a way for the nurse to describe his or her critical thinking about fall prevention that is individualized to a patient. Leaders collect information on barriers to care and demonstrate follow-up actions to staff members who raise	Dramatic reduction in falls rate

			for falls prevention			concerns. The system allows for structured leader and staff interactions that are coaching and mentoring in nature"	
Johnston 2019	USA	Quality Improvement	To improve adherence to falls prevention protocol	Nursing staff	Education/ Training	Staff education on falls prevention protocol	Sharp decline in falls rate
Melin 2018	USA	Quality Improvement	A QI project to introduce and assess a process change and its ability to reduce fall rates on a medical-surgical unit.	Adult inpatients	Education/ Training	Education session for staff regarding current fall prevention strategies and importance of risk stratification for bed/chair alarms use (especially those not knowing their limitations).	Fall rates decreased following the intervention
Ryu 2009	USA	Quality Improvement	The paper describes a project to implement and evaluate patient and family education on fall prevention on a neuroscience unit in an acute care hospital.	Patients with a Hendrich fall risk score of 5 and above and family	Education/ Training	A performance improvement project was initiated to improve the nurses use of fall prevention education for patients but to also to include family in the education. One to one education sessions, lasting 5-20 minutes, were performed by a nurse with patient and family members using the Information About Fall Prevention pamphlet to guide the topics. Some patients had more than one session.	None of the patients that received the education programme fell during the course of the study. A 'call, don't fall' poster was also implemented but results not yet reported.
Opsahl 2017	USA	Quasi-experimental (non-randomised)	To examine the outcomes of adding patient & family engagement education (video) to fall prevention bundled interventions	Inpatients	Education/ Training	Quality improvement project with various aspects, including: All unit staff reviewed a fall prevention nursing educational video prior to the start of the project through the internal staff electronic education system. Educational video aimed at patients.	Trend towards reduced fall rate following implementation of fall prevention bundle with video engagement for the patient.
Spiva 2014	USA	Quasi-experimental (non-randomised)	Effect of training curriculum on safety culture, teamwork, behaviour & fall prevention	Caregivers, including nurses, pharmacists, physical therapists & physicians	Education/ Training	TeamSTEPPS training programme & video vignettes covering: communication; situational monitoring; mutual support; leadership	Fall rates & injury rates reduced in intervention group. Most measures improved in intervention group.

Hill 2015	Australia	RCT	To evaluate whether individualised patient and staff education as well as support provided by trained physiotherapist falls educators could prevent falls.	Adults in rehabilitation units	Education/ Training	Individualised education from trained falls prevention physiotherapist + follow-up support + usual care. Intervention used behaviour change theory & adult learning principles,	Substantial reduction in falls, fall injuries, and proportion of people who fell in hospital rehabilitation units.
Lovarini 2010	Australia	RCT	To evaluate the effectiveness of falls prevention education delivered to hospitalised older people via digital video disc (DVD) or written workbook on perceived falls risk, knowledge of falls prevention strategies and motivation to engage in them	Older adults	Education/ Training	Participants received the DVD (14 minutes in duration) or workbook education at their bedside for up to one hour. Both formats contained identical content, which included information on the risk of falls, fall related harms and falls prevention strategies that could be undertaken within the hospital setting to reduce the risk of falling. The content aimed to foster participant belief and motivation to undertake falls prevention strategies.	After the education, there was no significant difference between the education groups in self-perceived falls risk or knowledge of falls. A higher proportion of participants in the DVD group were strongly motivated to prevent themselves from falling compared with the workbook group and had greater confidence in their ability to do so
Lee 2014	Australia	Review - Systematic	To assess the effectiveness of patient education in reducing falls, promoting behavioural change and the uptake of prevention activities in older adults during and after hospitalization.	Inpatients aged 60+	Education/ Training	Patient education interventions & multicomponent intervention that included patient education were reviewed	Falls prevention programmes that contained patient education were effective in reducing fall rates. Should be recommended for older adults. Should consider use of intensive face-to-face education with multimedia materials in preference to provision of written information alone or brief amounts of interpersonal contact.
Ali 2018	UK	Cohort study (Prospective)	Evaluate whether monthly inpatient falls	Adult inpatients	Environment Design	Portable nursing station on wheels with computer system & secure drawer for patient records. One station placed in each	Relative reduction of 26.71% in monthly falls rate

			rate changed after "Stay in the Bay" intervention aimed at increasing nurse-patient contact time			bay on the ward. In wards with single rooms, station placed outside each room where possible. Staff encouraged to use portable stations rather than main nursing station.	
Yun 2016	Sweden	Descriptive	to describe a novel video system to detect falls	Not stated	Environment design	Video dynamic shape and motion analysis	Test results demonstrated a high detection rate (average 99.38%) and low false alarm (average 1.84%). Comparisons with eight state-of-the-art methods provided further support to the proposed method.
Tzeng 2013	USA	Other	examines the feasibility of a bed-height alert system as a fall-prevention strategy in an acute surgical in-patient unit	Staff 21 years or older, able to communicate in English, employed as regular staff members for the study unit, and responsible for directly delivering patient care.	Environment design	The alpha prototype of the bed-height sensor network composed of 15 wireless sensors was developed to measure and record bed height. This system is meant to increase staff adherence to keeping beds in a low position as a fall prevention strategy. This system generates computerized reminders to enhance staff adherence to bed height recommendations. A sensor located under each bed collects bed height measurement and sends information to a central touch-screen computer in the nurse's station that displays the state of the bed. A sensor located under each bed measures the bed height every 10 minutes and sends the information through a wireless relay to a central computer in the nurse's station.	Bed-height alert system is somewhat useful, feasible, appropriate, and accurate. Further refinement of the system and staff training in guideline adherence is required
Haines 2010	Australia	RCT	To evaluate the efficacy of a policy to introduce low-low beds for the prevention of falls and fall injuries on wards that had not previously accessed low-low beds.	Publicly funded hospitals which had not previously had low-low beds	Environment design	A low-low bed (Huntleigh Healthcare "Sorrento" model) was provided for every 12 existing beds on the ward and was used for patients identified as high risk of falling. Staff were educated on how to prioritise patients to be put in low-low beds.	The introduction of low-low beds for patients at high risk of falling did not appear to have an effect on fall rates. Intervention and control hospital wards had comparable reductions in fall rates and therefore these cannot be attributable to low-low beds. Authors suggest that there may be other benefits to low-low beds and further research is required.

Healey 2008	UK	Review - Systematic	To summarise and critically evaluate evidence on the effect of bedrails on falls and injury	Adults	Environment design	The effect of bedrails on falls and injury, including studies of bedrail reduction	It is difficult to perform conventional clinical trials of an intervention already embedded in practice, and all included studies had methodological limitations. However, this review concludes that serious direct injury from bedrails is usually related to use of outmoded designs and incorrect assembly rather than being inherent, and bedrails do not appear to increase the risk of falls or injury from falls.
Ng 2008	Singapore	Review - Systematic	To evaluate the role of restrictive bedrails in preventing falls in the acute hospital setting.	Hospital patients	Environment design	Bedrails – various types	Limited primary studies and no supportive evidence for the use of bedrails.
Hignett 2006	UK	Review - Narrative	Review of falls prevention literature and proposal of theoretical framework for environmental assessment model.	N/A	Environmental	Bed rails; bed height & alarms; attachment to equipment; footwear; flooring; lighting; patient assessment; environmental marking (cues); staffing levels	Poor evidence-base in general. Most robust evidence relates to bed rails, which may not reduce falls and may increase risk of injury. Environment assessment model proposed.

Pappas 2015	USA	Before-after design	Development of a Patient Risk Assessment Profile tool to identify high risk patients and assign appropriate nursing care.	Surgical inpatients	Falls risk assessment	A Patient Risk Assessment Profile tool was developed which included 4 high risk categories (high fall risk and age greater than 78, transplant received on current admission, hepatic failure, and first 24 hours after gynaecology surgery). Patients were scored every 12-hour shift. Patients in high risk categories were assigned a score of 2, moderate risk categories scored 1 and other patients scored a zero. Nurse patient assignments were not to score higher than 4, if they did then the staff to patient ratio was altered (1:4 day, 1:5 night, or one less patient than normal for that nurse).	Following the implementation of a Patient Risk Assessment Profile, and subsequent alterations to nursing assignment, the fall rate was reduced. Overall, there was a reduction in costs per case and nurses 'incidental' overtime. The authors highlight the importance of tailoring staffing to unit specific data and the nurses view of the required amount of surveillance to prevent harm.

Browne 2004	USA	Cohort study (Prospective)	To present the redesign of a fall prevention programme using a computerised information system, the ADAPT Fall Tool, which assesses patient fall risk.	Patients from pediatric, adult, rehabilitation maternal-child, and psychiatric services inpatient facilities.	Falls risk assessment	ADAPT Fall Assessment Tool for the acronym Assess: Disorientation, Activity Post medication, and Toileting.	Preliminary results show a decrease in fall rates but monitoring is continuing. The ADAPT tool accurately reflected the patients' fall risk and saved extra paperwork.
Haines 2006	Australia	Cohort study (Prospective)	To describe the diagnostic accuracy and practical application of the Peter James Centre Falls Risk assessment Tool (PJC-FRAT), a multidisciplinary falls risk screening and intervention deployment instrument.	Metropolitan rehabilitation and aged care hospital	Falls risk assessment	he accuracy of the PJC-FRAT was prospectively compared to a gold standard (the STRATIFY) on a cohort of subacute hospital patients (n=122)	The PJC-FRAT was practical and relatively accurate as a predictor of falls and a deployment instrument for falls prevention interventions, although continued staff education may be necessary to maintain its accuracy.
Haines 2009	Australia	Cohort study (Prospective)	To evaluate the ability of physiotherapists working on geriatric rehabilitation wards to accurately predict which patients will fall during their inpatient stay.	Patients admitted for rehabilitation to geriatric and rehabilitation units and referred for physiotherapy	Falls risk assessment	At a patient's initial assessment physiotherapists classified whether a patient would fall or not (yes/no answer) during their hospital stay. The assessment was not standardised but typically involved subjective (patient medical history, mobility, balance, function, and previous falls) and objective (patient balance, gait, and mobility after) measures to aid in classification.	Less than half of the patients classified at risk fell and a further 81 patients not classified at risk fell. Resources can be saved if a physiotherapist clinical judgement approach is used to deploy an education based intervention, compare with none.
Walsh 2011	Australia	Cohort study (Prospective)	To determine whether locally adapting a falls risk factor assessment tool results in an instrument with	consecutive patients for cohort study & convenience sample for reliability study	Falls risk assessment	To develop a falls risk screen and assessment instrument through local adaptation of an existing tool. Clinometric property analysis of new instrument (Western Health Falls Risk Assessment, WHeFRA) and comparison with ‘gold standard tool’ (STRATIFY). The WHeFRA is	Local adaptation of an existing tool resulted in an instrument with favourable clinometric properties and may be a viable procedure for facilitating falls prevention program development and implementation in acute hospital settings

			clinometric properties sufficient to support an acute hospital's falls prevention program			a two-stage falls risk screening and falls risk-factor assessment tool.	
Incalcaterra 2015	USA	Cohort study Retrospective	To compare falls in 18-64 and 65+ age-groups using pre-existing data	Adult patients	Falls risk assessment	The JHFRAT is an instrument that calculates a total risk score by combining scores for known risk parameters: age, fall history, elimination needs, medication usage, patient care equipment, mobility, cognitive status, and the use of assistive devices.	Overall, the results showed very little statistically significant differences in falls between the 2 age groups, although there was a statistically significant relationship between the presence of a fall safety agreement and fall injury severity. Fall education in the form of a safety agreement, regardless of age, may reduce the degree of injury sustained from a fall.
Guzzo 2015	Italy	Other	To identify factors that can significantly influence falls in hospital and describe conditions in which falls occur through monitoring the application of the Conley Scale.	Patients who had a fall in hospital and controls who did not fall	Falls risk assessment	A retrospective analysis of patients who fell and those who didn't and presence of a completed Conley Scale.	Analysis of patients that had fallen compared to those that hadn't revealed several risk factors predisposing to a fall, most notably the use of restraints and failure to complete the Conley Scale form.
Changqing 2015	Singapore	Review - Systematic	A review to identify best available evidence for effectiveness of nursing fall risk assessment tools, interventions to reduce incidence of falls and common risk factors of adult psychiatric falls patients.	Patients aged 18-65 years old and diagnosed with a mental illness	Falls risk assessment	Present evidence relating to fall risk assessment tools and prevention strategies.	Evidence for the effectiveness of fall risk assessment tools and prevention strategies in psychiatric patients was inconclusive. Reviewing medications may be important in this group. Authors identify need for more research.

Patrick 1999	Canada	Text and Opinion	To describe the interdisciplinary intervention protocol established on a hospital based geriatric rehabilitation programme.	Geriatric inpatients & staff	Falls risk assessment	A falls risk assessment with three levels of risk (high, moderate, low) and 7 risk factors (assessing for previous falls, visual/sensory impairment, secondary medical diagnoses, mental state, balance, mobility, medication) was implemented, with each risk factor being assessed by the member of the interdisciplinary team that has the most expertise assessing that risk factor. Patients were also assessed to be independent or dependent. Based on their scores patients received interventions addressing patient supervision; identification of risk; visual alerts regarding risk; mobility and transfers; toileting schedules; patient/family education; medication management.	This study describes the development and implementation of a Falls Risk Assessment and accompanying interventions used on a geriatric rehabilitation ward. Authors suggest that the implementation of empirically based and standardized nursing intervention protocols for fall prevention is an important aspect of supporting patients in reaching their goals of autonomy & independence.
Ferguson 2018	USA	Quality Improvement	Evaluation of a multiyear, multidisciplinary organisation-wide delirium initiative	Adult patients	Multicomponent	Delirium prevention, identification & treatment intervention	Delirium falls reduced over study period
Barker 2009	Australia	Audit	Evaluate the effectiveness of a multi-factorial fall prevention programme in reducing falls and fall injuries in an acute care hospital.	Patients admitted to the acute hospital between 1999 and 2007	Multicomponent intervention	Patients were assessed using a modified STRATIFY risk tool and targeted interventions (selected from a pre-defined list) were given to high risk patients. List included: ‘‘falls-risk’’ alert sign above bed; supervision in the bathroom; high–low bed, lowered to floor level; walking aid within reach at all times; two-hourly or four-hourly toileting regime; bed/chair alarm.	Fall rates fluctuated during the study and in the follow up period, with no consistent decreases.
Zammit 2014	Australia	Audit	To audit practice, implement change and re-audit practice in order to enhance fall prevention	Inpatients	Multicomponent intervention	Risk assessment & various interventions	The findings showed a generally positive result at the initial follow-up audit phase; staff education levels increased and more appropriate action was taking place within the clinical setting. However, due to barriers out of the control of the falls team, there were less positive results in the second follow-up audit. However, with more support, time, and resources, the compliance of implementation strategies may be sustainable and falls within the acute clinical setting could be prevented and better health outcomes achieved.
Sutton 2014	UK	Audit	Evaluate FallSafe - falls prevention interventions	All in-patients in 14 wards.	Multicomponent intervention	2 care bundles - one for all patients & one for those at risk of falling.	25% reduction in falls using Bundles - unclear if this is for bundle A, B or A&B combined.

			rigorously applied in care bundles into an acute hospital				
Albornos-Munoz 2018	Spain	Before-after design	To promote evidence-based practice in fall prevention and management in a Spanish hospital, and to reduce fall rates and associated injuries.	Patients aged 65+ admitted for at least 24 hours and discharged during the measurement period.	Multicomponent intervention	Multicomponent strategies, including regular falls risk assessments (on admission & after a fall), nurse-led multi-faceted fall prevention interventions and patient/staff education.	Patient falls increased in the medical wards but decreased in the surgical ward
Andreoli 2010	Canada	Before-after design	To implement the Situation Background Assessment Recommendation (SBAR) tool in rehabilitation hospital wards and evaluate its processes and outcomes.	Clinical & non-clinical staff in the geriatric and rehabilitation wards (admitting older adults with multiple co-morbidities)	Multicomponent intervention	Staff were provided with educational sessions, including role play, regarding the use of the SBAR (Situation Background Assessment Recommendation) tool to facilitate communication with other staff regarding patient care. Local champions and reminders (pocket cards, posters, telephone prompts, educational binders) also used.	Number of reported falls increased, although 'major falls' had a decreasing trend
Breimaier 2015	Austria	Before-after design	Assess the effectiveness and required time investment of multifaceted and tailored strategies for implementing an evidence-based fall-prevention guideline (Falls CPG) into nursing practice in an acute care hospital setting.	Graduate and assistant nurses, ophthalmic and accident surgery departments	Multicomponent intervention	Multicomponent intervention aimed at staff including six implementation strategies: educational meetings (for staff), distribution of written materials, local opinion leaders, audit and feedback, adaptation of nursing record systems and changes in physical structure, facilities and equipment.	Tailored multifaceted strategies were found to be effective in implementing clinical practice guidelines into nursing practice in an acute hospital.
Cabilan 2014	Australia	Before-after design	Implementation project aiming to highlight importance of accurate falls risk assessment,	Patients and staff in the medical oncology and neurosurgical departments	Multicomponent intervention	Prompt falls risk assessment using STRATIFY tool, identify high risk patients, review falls prevention strategy frequently, medication review, routine UTI screening, toileting plan of care, routine physiotherapy review, mobility limitations communicated to staff and patients, education, encourage	Appears to be a small reduction in falls pre-post project implementation, however no statistical test were performed.

			promptness of risk assessment, implementation and adherence to falls prevention strategies.			functional activities and exercise, safe environment, minimise use of restraints and bed rails. Shift falls champion nominated; falls badges worn by staff and educational pamphlet.	
Coyle 2016	USA	Before-after design	To describe one hospital's process improvement model to change culture and prevent patient falls.	Hospital staff and patients	Multicomponent intervention	An improvement strategy was used called DMAIC (define, measure, analyse, improve and control) to improve the process and effectiveness of a fall prevention strategy. Interventions included: bed and chair alarms for high risk; reinforcing a "no-pass zone" ensuring all call lights are answered; supervised toileting for high risk patients; hourly rounding; diversional activity bags for confused high risk fallers; standard set of communication aids (falling star on door, coloured wristband, stop sign within view of patient/family as reminder to call for assistance, fall risk stickers on medical notes and records); daily huddles; continuous education; access to and training on high-low beds; updating fall prevention policy; multidisciplinary involvement; post-fall debriefs.	Following implementation of the fall prevention programme fall rates have decreased. The programme was so successful that other hospitals have now adopted this approach. The authors emphasise the importance of a strong partnership between patients, family and medical team.
Digby 2011	Australia	Before-after design	To explore and compare call bell response times between two geriatric facilities before and after the introduction of several interventions aimed at fall prevention.	Aimed at nurses and adult patients, hospital	Multicomponent intervention	Interventions were implemented with the aim of answering call bells promptly while at the same time reducing the need for patients to call for nurses. Call bell response data was displayed and discussed frequently to increase awareness; other non-nursing staff were encouraged to answer calls and tend to minor queries not requiring a nurse; scheduled nurse breaks; hourly rounding (pain relief, change in position, toileting); nursing handover performed at bedside including the patient; physiotherapy assistants used in peak morning time for extra assistance.	Only one ward had a decrease in the rate of falls (from 69 to 54). A greater percentage of calls were answered in less than 5 minutes post intervention compared to pre-intervention.
Dover 2006	Australia	Before-after design	To ensure ongoing success and sustainability of a locally driven multidisciplinary falls	Staff from the aged care and rehabilitation wards	Multicomponent intervention	Education of all staff in use of Falls Risk Assessment Tool, falls minimisation interventions and further resources. Falls data reports split up by individual wards to encourage ownership of fall prevention and displayed on notice boards on wards. Falls minimisation steering committee.	Decrease in falls following the implementation of a multidisciplinary approach to fall prevention, although the numbers are not stated.

			minimisation process.				
Godlock 2016	USA	Before-after design	Report on a project emphasising shared accountability and adherence to a standardised process by a patient safety team to prevent falls in inpatients.	Staff from 6 inpatient nursing hospital units, including RN's, licenced vocational nurses and certified nursing assistants.	Multicomponent intervention	A Fall Safety Team was formed, including a fall champion. The team were educated on fall prevention interventions and regular meetings held to review the team's progress. Interventions included a post-fall checklist and multidisciplinary review including the family/patient.	Following the implementation of a Patient Safety Team the fall rate fell from a baseline rate of 1.9 to 0.69 falls per 1000 bed days soon after the intervention and remained just below the baseline rate after a year. The authors conclude that the safety team were successful in implementing change.
Hoke 2016	USA	Before-after design	To reduce rate of patient falls and falls with injury on a cardiac intermediate care unit.	Adult patients coming through the cardiac intermediate care unit	Multicomponent intervention	Clinical nurses developed an accountability care program that required nurses to use reflective practice to evaluate each fall, including sending reflective emails (including nurses' and patients' perceptions of the fall; contributing factors and nurses' self-reflection); post fall huddle; call bell response; and guidelines for assisting and remaining with fall risk patients for the duration of their toileting.	Fall rates and falls with injury decreased following the implementation of the 'Prevent One Fall at a Time' intervention. Patients' ratings of staff responsiveness and communication improved.
Mitchell 1996	Australia	Before-after design	To assess whether a structured intervention would assist in preventing falls in an acute setting	Inpatients	Multicomponent intervention	Assessment of falls risk, alert system, preventative actions, staff education, alarms and audit.	Falls rate reduced post-intervention.
Mosley 1998	USA	Before-after design	To evaluate the effectiveness of a new fall prevention programme and describe fall incidents during its effect.	Adult inpatients	Multicomponent intervention	Staff education; Fall risk-assessment. Those deemed as high risk were given the following interventions: reassessment of falls risk with any medication or other changes; plan of care; fall risk stickers on chart, bed, care plan and wristband; green sign on door if patient fell in hospital; patient education; low bed; bed rails; call bell within reach and working; dim night light; regular assists to toilet; identify patients with orthostatic hypotension; encourage to ask for help standing up; close supervision of confused patients; non-skid footwear;	Two years after the implementation of a hospital-wide fall prevention strategy there was a reduction in fall rate in 72% of the units studied.

						family/sitters; instructional posters; "buddy system" when buddy patient calls a nurse if patient is attempting to get up; medication review.	
O'Connor 2006	USA	Before-after design	To describe and report on a falls prevention program.	Inpatients	Multicomponent intervention	Morse fall risk, individualised risk profile, falls prevention focus, post-fall debriefing, environment and equipment audits, medication audits, staff training, patient and family education.	Falls rates increased slightly; significant improvements in injury rates.
Robinson 2016	USA	Before-after design	To reduce the fall rate in two medical/surgical units using a multimodal intervention programme focused on improving patients' perception of staff responsiveness to calls for help.	Patients on 2 medical/surgical units	Multicomponent intervention	(Plan-Do-Study-Act methods) A multicomponent intervention was implemented and fall rate reassessed after 7 months. Interventions included the following: fall prevention brochure; fall contract between nurse/patient; mobility/activity huddles; hourly rounding addressing 4Ps (pain, potty, position, personal belongings); a mobility tech programme (assisted ambulation 3 times a day) in just one unit.	Following 7 month of the fall prevention programme the fall rate reduced on one unit but increased on another. The provision, or not, of regular assisted ambulation was the main difference between the units and may have contributed to the decline in fall rates on the participating unit. Patient satisfaction increased on both units.
Savage 2001	Canada	Before-after design	Evaluation of multifactorial fall prevention programme	Nursing staff & Geroatric psychiatric patients	Multicomponent intervention	Multicomponent, including: Educational intervention (for nursing staff); Risk factors assessment SAFE protocol assessment (Safety Assessment for the Frail Elderly); Fall log	Falls reduced post-intervention
Szumlas 2004	USA	Before-after design	Evaluation of falls prevention intervention	All patients	Multicomponent intervention	Fall assessment tool + multifactorial intervention: Environmental; Patient/family education; Sign on patient's door; Assistance with toileting; PT/OT consultation; Hourly checks; 1:1 monitoring	Reduction in falls following implementation of intervention
Williams 2007	Australia	Before-after design	To evaluate a systematic, coordinated approach to limit the severity and minimize the number of falls	All patients admitted to three medical wards and a geriatric evaluation management unit were	Multicomponent intervention	Patients' risk of falling was assessed using a falls risk assessment tool and appropriate interventions implemented using a falls care plan based on falls risk.	We evaluated a systematic, coordinated approach to falls management that included a falls risk assessment tool and falls care plan in the acute care setting. Although a significant reduction in falls was found in this study, it could not be attributed to any specific interventions

			in an acute care hospital	enrolled over a six-month period			
Alexander 2013	USA	Cohort study (Prospective)	Develop a falls risk assessment tool for use in an emergency department, compare with standard tool and implement in practice.	Patients admitted to emergency department	Multicomponent intervention	A fall risk screening tool (KINDER1 Fall Risk Assessment Tool) revised especially for the emergency department was implemented, following department-wide staff education. Involves 4 risk factors; patient is identified as high risk once there is a 'yes' for any one factor. Monthly staff meetings, poster on bulletin board along with fall rates and days without a fall. Improving practice: Staff encouraged to input and ask questions. Nurses encouraged to take ownership of the safety of their patients.	55% improvement in falls risk identification, compared to the old tool, following implementation of the KINDER1 falls risk tool
Bolger 2016	Ireland	Cohort study (Prospective)	To determine adherence with falls prevention education in an acute setting.	Patients aged 50+	Multicomponent intervention	Audit of the hospital and patient's compliance with the principles taught by the falls prevention mnemonic FALLS (Footwear, call bell, glasses, toileting and walking aids).	A morning audit of hospital practices revealed that in many cases aspects of fall prevention were not adhered to, including unsafe footwear, glasses and walking aids out of reach and call bells not working.
Bonuel 2011	USA	Cohort study (Prospective)	To implement the CATCH falls prevention approach at a Veterans hospital.	Patients in the veteran hospital	Multicomponent intervention	A 'fall bundle' with 5 main principle elements 'CATCH': collaborative interdisciplinary practice, active leadership engagement, use of technology to support processes, carefully executed communication strategy and house-wide change. Unit fall champions.	Compared to hospitals of similar size and bed numbers they showed lower number of falls per 1000 days after implementing the CATCH programme house-wide culture change.
Brown 2017	USA	Cohort study (Prospective)	A quality improvement project to reduce falls in patients undergoing electroconvulsive therapy (ECT) by enhancing safety measures through education and a post ECT treatment protocol.	Patients aged 60+ in the psychiatric ward that had received ECT.	Multicomponent intervention	Multicomponent intervention including staff and patient education, observation rounds, partnerships between psychiatric nurses and mental health technicians, and dissemination of patient outcome data to inform nursing practice. Close proximity to nursing station, coloured wristbands, calling for assistance. Portable call bells, continual assessment, assistance with ambulation/toileting.	Fall rate was decreasing/increasing inconsistently. Authors report that this is the first time this intervention has been used in ECT patients.

Brown 2004	Australia	Cohort study (Prospective)	To present the development and implementation of a fall and fall injury prevention strategy in a South Australian country region.	Adults aged 65+ living in the Limestone Coast region of South Australia. Intervention targeted various setting including hospitals	Multicomponent intervention	Falls prevention policy; falls risk assessment; multidisciplinary assessment of 'high risk fallers'; hip protectors; regular review of medication	Although number of falls were not compared with a pre-intervention figure the authors reported a decrease in hospital admissions after a fall. Authors make recommendations including 'fall prevention champions', stakeholder committee meetings, good collaboration, and skilled admin officer.
Burston 2015	Australia	Cohort study (Prospective)	To examine the relationship between the implementation of a transforming care initiative and inpatient falls.	Patients from acute care surgical units	Multicomponent intervention	A 'bundle of interventions' was used including: behind the bed whiteboards, bedside handover, colour coded charts, multidisciplinary team meetings, clinical communication strategies, staff identification signs, protected meal times, staff reward/recognition, poster showing acceptable staff behaviour, staff resource traffic light	Inconsistent results regarding falls and practice changes between surgical units. More focus on how each unit adapts the practice changes.
Cangany 2015	USA	Cohort study (Prospective)	To describe the Clinical Scene Investigator (CSI) Academy project "No Fall Zone", which aimed to determine whether improved education together with a falls contract and bed fall prevention signs would reduce fall numbers.	All staff and patients in the medical progressive care unit	Multicomponent intervention	Staff education related to falls policy, documentation requirements, the Morse Fall Scale (MFS); education via video examples. Development and implementation of a patient/family fall teaching contract. Fall signs on ceiling above patient's bed.	The total number of falls, fall rates and cost per fall all decreased after implementing the intervention.
Chattopadhyay 2011	UK	Cohort study (Prospective)	To report on a falls prevention programme introduced in an elderly care ward.	Patients in an elderly ward	Multicomponent intervention	Used four prevention principles: falls history, medication review, appropriate footwear, call bell in sight and reach. Practice reviewed on monthly basis.	After 4 months of implementation over 50% of patients were receiving all the components of the prevention strategy. Monthly fall number reduced.
Coles 2005	USA	Cohort study (Prospective)	To apply the Failure Mode Effects and Criticality Analysis (FMECA) to reduce the	Hospital patients	Multicomponent intervention	Following an FMECA approach improvements to a patient fall prevention program were identified and applied including: Staff orientation and training procedures on patient fall risk, fall risk assessment and reassessment, fall prevention patient care plan developed,	There was a 42% reduction in the number of patient falls following implementation of the improvements identified using the FMECA.

			occurrence of falls in hospital.			patient care implementation (educate patient/family in fall prevention and on patient fall risk, fall risk tag on door and patients chart, orient patient to surroundings, prompt respond to call lights, bed alarm, toileting assistance), incident reports after a fall.	
Coppedge 2016	USA	Cohort study (Prospective)	To describe the development and implementation of a falls prevention tool in hospital.	Piloted on hospital patients from medical-renal unit and oncology unit	Multicomponent intervention	A yellow fall prevention tool, in the form of a poster placed at the patient's bed, was designed to facilitate patient/family fall prevention education, fall risk assessment, individualised fall prevention plan of care, communication of the fall risk and plan of care. Four key risk factors are addressed (history of falls, toileting needs, mobility problems/assistive devices needed, condition changes that may contribute to falls.	The yellow fall prevention tool facilitated good communication and guided discussion of individual patient's risk and plan of care and resulted in a reduction in fall rate on both wards.
Corbett 1992	USA	Cohort study (Prospective)	To describe the application of systematic methods and principles of continuous quality improvement to establish a fall prevention programme.	Hospital patients	Multicomponent intervention	Quality improvement team process used to identify risks for falls and corrective actions to be taken. Risk assessment on admission with flow chart completed every 8 hours to reassess patient risk and nursing interventions. Coloured wristbands, chair stickers and signs on doors and beds of at risk patients. Pamphlet on fall prevention given to patient on admission and to take home. All employees given a card reviewing their role in fall prevention.	The fall numbers reduced dramatically after the first year, however they began to increase in the second year. Following a further review and corrective actions the number of falls decreased again.
Dacenko-Grawe 2008	USA	Cohort study (Prospective)	To describe the development of the Saint Francis Hospital Fall Prevention Tool (SFH) and report on the effect on fall rate.	Hospital patients	Multicomponent intervention	SFH Safety Assessment tool scored patients on each of 10 areas (history of falls, age 65 and older, impaired cognition, active bowel preparation, activity intolerance, elimination, impaired mobility, sensory deficits, medications, sleep patterns) and reassessed on every shift. Fall risk coloured bracelet and door sign; accompanied to toilet and beds; bed alarm; non-skid footwear; multilingual safety instruction handout to patients/families; signs advising not to get out of bed alone.	Fall number decreased following implementation of the fall prevention protocol. The number of falls per 1000 patient days decreased by 50% without rebound over 5 years.
France 2017	USA	Cohort study (Prospective)	To describe the development and implementation of a multicomponent fall prevention	Patients from the neuroscience acute care, stem cell transplant, acute care of	Multicomponent intervention	Multidisciplinary quality improvement teams formed to implement intervention using Plan-Do-Study-Act cycles. Following six cycles a series of interventions were released. Signage was provided targeting both patients and staff to communicate the aims of the intervention and intervention	A multidisciplinary approach to falls prevention resulted in a reduction in the number and rate of falls, with a 47% reduction in falls with harm in the year following hospital wide rollout of the intervention.

			strategy in a Tennessee hospital.	the elderly units, Hospital		specifics including purposeful rounding and targeted toileting.	
Hathaway 2001	Australia	Cohort study (Prospective)	The aim of the project was to ascertain the overall effectiveness of the falls prevention Program and to explore the usefulness of the assessment criteria in predicting falls.	Adults	Multicomponent intervention	The data collection instrument used in the present study included demographic information, medical diagnosis and risk factors for falling. Staff would choose interventions from a list of fall prevention interventions obtained from the literature. Interventions included placing visual cue cards about the patients' fall risk on the medical record and at patients' bedsides. An education program for staff was also implemented	The Falls Prevention Program reduced the incidence of falls and was found to be effective for those patients requiring minimal assistance with walking. However, it was less effective for those using pick-up frames or forearm support frames. The patients who fell were more likely to be in the high risk category and it was concluded that while the assessment criteria was useful in predicting falls, the Falls Prevention Program could only limit the number of falls but not prevent them altogether. Age, mental status and mobility of patients in combination with time and location of falls suggested a pattern that was possibly peculiar to this rural hospital, which has implications for funding and staffing.
Healey 2014	UK	Cohort study (Prospective)	An extended evaluation of the FallSafe quality improvement project, which presented key components of multi-factorial assessment and intervention as a care bundle	Adults	Multicomponent intervention	FallSafe leads collected process measures for nine care bundle components from up to 20 patients per unit per month as an integral part of their quality improvement efforts, using formats that defined collection methods and evidence of compliance	Twelve-month moving average of reported fall rates showed a consistent downward trend in FallSafe units but not controls. No significant changes in injurious fall rate were found in FallSafe units (or controls.
Hefner 2015	USA	Cohort study (Prospective)	Evaluation of a multifaceted fall prevention initiative.	Adults	Multicomponent intervention	The Falls Wheel was developed by a team of patients, family members, and health system leaders. The Falls Wheel was implemented in all inpatient units of the medical center starting from August 2013 (including cardiovascular, medical surgical, and progressive care units). The nursing staff were instructed to update the wheel every shift or if the patient's status changed based on the criteria for determining fall risk and injury risk printed on the front of the wheel.	During the yearlong implementation, the rate of falls with harm dropped by almost 50%. A process audit revealed that there was high fidelity to the intervention components, including displaying the wheel correctly 95% of the time, and the Falls Wheel was updated to match the risk level in the electronic health record 70% of the time.

HirokoKiyoshi-Teo 2017	USA	Cohort study (Prospective)	Identify important practice gaps, gain interest from the staff, and increase the credibility of quality improvement initiatives that would follow	Adults on two medical-surgical units	Multicomponent intervention	Fall prevention education, fall risks, call light use, and patient room environment	Using a multi-method data collection approach that included patient interviews was critical to identify important practice gaps, gain interest from the staff, and increase the credibility of quality improvement initiatives that would follow. The Fall Prevention Workgroup continues to explore interventions to address gaps identified in this project
Issac 2018	Australia	Cohort study (prospective)	Evaluation of TOP5 - intervention that involves engaging carers of people with dementia in 5 strategies to assist staff to provide person-centred care & communication	Adults aged 70+ with cognitive impairment	Multicomponent intervention	Personalised care strategies (up to 5) using non-clinical information obtained from carers. Strategy form located in prominent position for staff to action.	45% reduction in falls
Jenkins 2012	USA	Cohort study (Prospective)	To reduce fall rate below benchmark target	Bone Marrow Transplant patients	Multicomponent intervention	Education on fall risk; fall video; packet with door sign, yellow bracelet, socks & blanket; hourly rounds; assistance to bathroom at night; environmental adaptations; staff communication.	Increase in knowledge and training, with early identification of high fall risk, made a significant improvement in fall rates and patient safety. Yellow blankets are used for fall risk patients and surveys showed increased awareness by staff. Audits showed increased compliance and documentation of 90%.
Jeske 2006	USA	Cohort study (Prospective)	As part of a comprehensive program, nursing staff in a medical telemetry unit partnered with patients and their families to design and implement an educational poster to prevent fells.	Older adults	Multicomponent intervention	Development of educational poster	The implementation of this poster project, in addition to other fall prevention interventions, has been associated with a reduction in fall rates. The poster also provides an open door for further patient and family education on fall prevention at the hospital and in the home. Patients and family members expressed appreciation for being asked their opinion about what would make an effective poster and the importance of partnering with them to find solutions.

Johnson 2011	USA	Cohort study (Prospective)	Evaluation of: The Helping Hands program, a nurse-directed falls prevention program designed to support a hospital-wide culture of safety and reduce harm from falls.	Inpatients	Multicomponent intervention	Interventions included: removing clutter, keeping personal belongings and bedside tables in the patient's reach, ensuring prompt spill clean-up, reorganizing wires and cords, using signs to indicate wet floor danger, keeping side rails up, locking beds and wheelchairs, providing adequate light, and encouraging patients and families to call for assistance when needed. A nursing care plan was initiated for patients at moderate or high risk.	The data offer a hopeful perspective on the role of nursing engagement in developing a hospital-wide culture of safety and protecting patients from permanent harm caused by fall events.
Jones 2015	USA	Cohort study (Prospective)	To assess the prevalence of evidence-based fall risk reduction structures and processes in Nebraska hospitals;	Inpatients	Multicomponent intervention	Multiple interventions across different hospitals	Hospital type was a significant predictor of fall rates. However, shifting the paradigm for fall risk reduction from a nursing-centric approach to one in which teams implement evidence-based practices and learn from data may decrease fall risk regardless of hospital type.
Kilpack 1991	USA	Cohort study (Prospective)	To decrease patient falls by applying relevant interventions found in the nursing research literature	Adult inpatients in neuroscience & oncology/ renal units	Multicomponent intervention	An educational program was implemented to increase staff's cognizance of fall prevention. It consisted of (a) initial in-service about patient falls & the project; (b) posting on the intervention units each month the number of fails compared with the previous year; (c) quarterly in-services to present a summary of fall statistics to date; (d) posting of relevant journal articles, and (e) short continuing education programs	The fall rate decreased during the study year, while the all-hospital patient fall rate increased.

HirokoKiyoshi-Teo 2017	USA	Cohort study (Prospective)	Identify important practice gaps, gain interest from the staff, and increase the credibility of quality improvement initiatives that would follow	Inpatients in 2 medical-surgical units	Multicomponent intervention	Fall prevention education, fall risks, call light use, and patient room environment adjustments	Using a multi-method data collection approach that included patient interviews was critical to identify important practice gaps, gain interest from the staff, and increase the credibility of quality improvement initiatives that would follow. The Fall Prevention Workgroup continues to explore interventions to address gaps identified in this project
Krauss 2008	USA	Cohort study (Prospective)	To evaluate an intervention to prevent falls at a hospital.	Nursing staff + medical inpatients	Multicomponent intervention	1. Alert other staff to the patient's risk of falling; 2. Reinforce fall prevention teaching with the patient and family; 3. Implement a toileting schedule and/or safety rounds (every 2 hours during the day and every 4 hours at night); 4. Review medications that may contribute to a patient's fall risk, and discuss the effects of these medications with the patient and/or family; 5. Ask the doctor to order a physical therapy and/or occupational therapy consultation (or to provide the patient with a walking aid if they already used one at home).	Post intervention fall knowledge test scores for the nursing staff were greater than pre-intervention test scores. Use of prevention strategies was greater on intervention floors than control floors. Reduction in fall rates (not statistically significant)
Lancaster 2007	USA	Cohort study (Prospective)	Evaluation of falls prevention initiative	Inpatients	Multicomponent intervention	Four key strategies: 1) Assessment and Re-assessment of Patient Risk Factors for Falls; 2) Visual Identification of Patients at High Risk 3) Communication of Patient Fall Risk Status; 4) Education of Patients, Families, and Staff about Fall Prevention.	9.9% system wide reduction in acute care fall rates Compared with national rates, falls with serious injury at Ascension Health were less than 10% of the expected rate.

Lee 2002	Hong-Kong	Cohort study (Prospective)	The project implemented a fall prevention guideline in an acute care hospital. Fall preventive nursing practice of the hospital was compared before and after implementation of the guidelines	Inpatients	Multicomponent intervention	The fall prevention guideline used in this project highlights four key aspects: (1) assessment and reassessment of clients' risk of falling, (2) implementation of a formal fall prevention program using multiple interventions to minimize the risk of falling, (3) increasing staff and client awareness of fall risk factors and potential prevention strategies, and (4) evaluation of the effectiveness of the implemented interventions and development of needed modifications.	No significant difference was found in fall rates. Change in fall prevention nursing practice was not strongly evident.
Lockwood 2013	USA	Cohort study (Prospective)	To decrease rates of postpartum falls	Female patients	Multicomponent intervention	A patient entered approach to fall prevention was implemented. A "Call for a Helping Hand" letter was placed in each patient's admission folder. The letter briefly and simply explained the risk of falling in the initial postpartum period. Using low-literacy concepts for developing educational material for women, the letter instructed the patient to call for assistance before getting out of bed. A Spanish translation of the letter was also available. The admission folder including the letter and a purple fall risk armband was to be placed at the bedside when preparing the postpartum room for the patient's arrival. The admitting nurse would thus be prompted to initiate the fall prevention strategy during initial communication and assessment.	Since implementation of the postpartum fall prevention program, the women's hospital has decreased their fall rate by 50% and maintained a postpartum fall rate below the 50th percentile for the national mean of adult surgical patient falls per 1,000 patient days.
Loria 2013	India	Cohort study (Prospective)	To improve patient safety by reducing falls	Inpatients.	Multicomponent intervention	Modified Morse fall Risk Assessment was made a part of the admission record. Training of the nursing team was done by the Quality Team. Intervention was tailored to the risk of the patient and included patient education, nursing tasks (provide adequate lighting, positioning of the bed etc), documentation, assessment of medications etc.	Incident reporting improved, therefore reported falls initially increased. Falls rates subsequently decreased as education rolled-out across hospital.
McCarter-Bayer 2005	USA	Cohort study (Prospective)	To describe a fall prevention program instituted in an acute care	Inpatients	Multicomponent intervention	An Interdisciplinary Falls Team was developed for the purpose of defining what constituted a fall, educating staff on falls prevention, identifying patients at	Authors suggest that, based on the results of this study, institutions should consider fall prevention protocols that stress staff education, consistent control chart presentation of fall data, and a comprehensive information feedback loop

			setting in southern Arizona that has produced encouraging results.			high risk for falls, and preventing falls among inpatients.	that outlines clear causes of falls to focus fall prevention interventions specific to patient needs.
McFarlane-Kolb 2004	Australia	Cohort study (Prospective)	Described differences in falls data within and between two study cohorts before and after a multitargeted intervention was introduced	Adult inpatients	Multicomponent intervention	Staff Training Orientation Program (STOP) derived in part from previous research and the FRAT Pack. The content had a practical focus, was modified to address older patients and falls risk within acute settings while highlighting the importance of assessment, recording systems and follow-up procedures. It had a core objective to effectively communicate knowledge regarding the process of fall risk assessment and implementation of targeted interventions based on the results of the screening process	Fall incidence among the intervention cohort did not increase significantly despite a rise in the number of hospital admissions and a significantly higher reported fall risk potential.
McKinley 2007	Australia	Cohort study (Prospective)	Focus on reporting the development of a falls prevention program and short report on its effects	Inpatients	Multicomponent intervention	Baseline data collected to identify issues, formal post-fall assessment protocol, developing a flagging system, brightly coloured cards were issued, alert system for pharmacist, purchase of specialised beds and chairs, development of a staff awareness program,	Reduced fall and multiple fall rates.
Mullin 2011	USA	Cohort study (Prospective)	Report of the development and effects of a falls prevention program.	Inpatients	Multicomponent intervention	Fall protocol developed, multicomponent intervention for at-risk patients, staff education, regular evaluation. .	The prevention and reduction of falls and delirium were the focus of the program. Decrease in falls and an increase in awareness of fall risk factors was demonstrated

Petrucci 2014	Australia	Cohort study (Prospective)	To audit current compliance with falls risk assessment including accuracy of documentation, the implementation of targeted interventions and compliance with mandatory education.	Inpatients	Multicomponent intervention	Implementation of standardised falls risk assessment screening tool, with regular re-audit	With better communication in key areas, compliance improved to desired levels.
Pinto 2017	USA	Cohort study (Prospective)	To decrease falls and improve patient outcomes through implementation of an interdisciplinary fall reduction program	Inpatients	Multicomponent intervention	A multidisciplinary approach was taken involving leadership, staff nurses and ancillary staff. Education was focused on the importance of decreasing fall and injury rates using different strategies to prevent falls. This included the implementation of a new hourly rounding sheet, scheduled toileting, fall debriefs/huddles and teaching points emailed to all staff to reinforce education. District nursing allowed nurses to be in closer proximity to their patients, thus being more accessible. The implementation of new hourly rounding sheets, which were more concise, reinforced purposeful hourly rounding. In addition, staff were educated to utilize a concise message of “call, don’t fall,” which was reinforced with education material and visible signage in every room. Detailed fall debriefs were emailed to all staff following every fall that examined the specific incident and provided learning points to reinforce practice change.	Findings show that falls decrease when properly implementing all interventions. There was a decrease in falls by 50% since the start of this falls initiative. Findings also proved that when certain interventions, such as scheduled toileting were not being followed, falls were more likely to occur. Nursing staff became more aware of causes of falls and improved practice as far as preventing falls.
Poe 2005	USA	Cohort study (Prospective)	To outline and evaluation a pilot study of a falls prevention program.	Inpatients	Multicomponent intervention	Fall risk identification, fall-prevention strategy: Evidence-based and risk stratified including for high fall risks: Flagging system, accompany patient to toilet, observed every 60 minutes, use rail protectors, transport through hospital, bed/chair alarm etc.	Need for a simple, guided and time-efficient approach to implementation of the best evidence into clinical practice.

Quigley 2014	USA	Cohort study (Prospective)	Developed and implemented an operational strategic plan to address each falls prevention program element and enhance program infrastructure and capacity	Inpatients in psychiatry	Multicomponent intervention	Several projects across multiple hospitals: 1. Fall prevention programme customized for inpatient psychiatry 2. Unit peer leader program for falls 3. Customization of hip protectors & floor mats	Fall rates variable. Authors suggest that findings support continued efforts to integrate measures to reduce serious fall-related injuries.
Rauch 2009	USA	Cohort study (Prospective)	Designed, implemented, and monitored a new fall prevention program.	Inpatients	Multicomponent intervention	First steps were comprised of a collaborative evaluation of current program findings. These findings included: past fall history, current policy language and clinical understanding of the written policy, compliance and implementation of policy guidelines, and frontline staff members' understanding, as well as perception of program significance in everyday practice. From the initial collaborative evaluation, a plan was designed and change began.	Early results promising with reduced falls. Additionally, the pilot unit staff compliance with the program is steadily improving
Von Renteln-Kruse 2007	Germany	Cohort study (Prospective)	To evaluate the effect of an interdisciplinary team approach on reducing the number off all falls.		Multicomponent intervention	The intervention included fall-risk assessment on admission and reassessment after a fall; risk alert; additional supervision and assistance with the patients' transfer and use of the toilet; provision of an information leaflet; individual patient and caregiver counseling; encouragement of appropriate use of eyeglasses, hearing aids, footwear, and mobility devices; and staff education	A structured multifactorial intervention reduced the incidence of falls, but not injurious falls, in a hospital ward setting with existing geriatric multidisciplinary care.
Barker 2013	Australia	Cohort study Retrospective	Investigate associations between serious fall-related injuries and use of low-low beds	Northern Hospital inpatients admitted between 1999-2009.	Multicomponent intervention	6-PACK falls prevention programme with main focus being low-low beds. FLOORCARE beds placed in medical and surgical wards; increasing number of low-low beds as the study progressed. Intervention also included: falls alert sign; supervision in the bathroom; low-low beds; walking aid within reach; toileting regimes; bed/chair alarm.	The rate of falls increased during the study, however, rate of fall-related injuries decreased.

Iijima 2016	Tokyo	Cohort study Retrospective	To examine the effects of fall prevention interventions by adjusting for the fall-risk with a propensity score	Adult patients	Multicomponent intervention	Falls risk assessment + standard falls prevention interventions + 49 specific interventions listed on a screen displaying the patient's medical records.	The results showed that three interventions to prevent falls in accordance with the patients' risks improved the fall ratio by 0.43 - 0.56 times. However, results also revealed that such interventions are implemented at a low rate. Thus, interventions to prevent falls should be implemented at a higher rate.
Leone 2016	USA	Cohort study Retrospective	Quality improvement project aimed to examine how nurse leaders in an inpatient rehabilitation unit can reduce number of falls by implementing multiple fall prevention interventions,	Inpatients	Multicomponent intervention	Safety huddles were introduced to improve shift-to-shift communication regarding safety issues. Shortly thereafter, signage, strategically placed in the bathroom, was used to address the problem of toileting related falls. Hourly rounding was then implemented hospital-wide in	The largest decrease in fall rate was noted after initial revitalization efforts of the unit's culture of safety concurrently with hourly rounding. Conclusions: Fall rates rise and fall despite multiple fall prevention interventions and encouraging a positive shift in the culture of safety.
McQuaid-Bascon 2018	Canada	Cohort study Retrospective	Overview of a recently integrated health care system's experience in evolving their multi-component interprofessional approach to falls prevention.	Inpatients	Multicomponent intervention	A falls strategy was developed, involved overview of high risk medications, communication process, purchase and prevention of falls prevention equipment, patient education.	Falls Prevention Policy was completed and approved, and other documents on fall risk assessment and intervention approaches for inpatient and ambulatory areas were posted on the hospital's internal website. Notable improvement in fall rates.
Milisen 2013	Belgium	Cohort study Retrospective	This multicentre study aimed to determine the feasibility of a previously developed guideline.	Healthcare workers	Multicomponent intervention	The guideline includes four consecutive parts: (A) case finding, i.e. identification of persons at risk for falling, (B) in-depth multifactorial assessment of risk factors, (C) targeted interventions and (D) transfer of information at discharge.	The majority (more than 69%) of respondents judged the practice guideline as useful, but only a small majority (62.3%) believed that the guideline could be successfully integrated into their daily practice over a longer period. Barriers for implementation included a large time investment, lack of communication between the different disciplines, lack of motivation of the patient, lack of multidisciplinary teamwork, and lack of interest from the hospital management

Miller 2008	USA	Cohort study Retrospective	Outline of the development and short report on the effectiveness of an evidence-based falls program.	Inpatients	Multicomponent intervention	Sign on door regarding fall risk, green identification band, educational pamphlet to patients and families, nursing checklist, medication, bed alarm, bed adjustment, nursing rounds, call lights etc.	Results inconclusive – falls reduced one-month after the intervention but rose again in second month
Noel 2013	Ireland	Cohort study Retrospective	The aim of the committee was to implement a Hospital Falls Initiative	Inpatients	Multicomponent intervention	A hospital wide falls prevention programme was introduced which incorporated a Risk assessment tool known as 'Stratify', a nursing care plan and staff education.	Reduction in falls rate.
Quigley 2009	USA	Cohort study Retrospective	Tests of change on 2 medical-surgical units focused on engaging unit-based staff and combining innovations for vulnerable populations at greatest risk for injury if they fall.	Inpatients	Multicomponent intervention	The interventions implemented to prevent falls were Teach Back and Toileting Prior to Pain Medication; the intervention to prevent repeat falls and injuries was a Safety Huddle Post Fall; and the interventions to reduce injurious falls were Toileting and Turns Rounds, Comfort Care and Safety Rounds, and Automatic High Risk Falls Identification.	Total fall rates per 1000 patient days displayed a slight downward trend in all acute care units.
Rosete 2015	USA	Cohort study Retrospective	To examine the fall rate and percentage of falls for stroke and TIA (transient ischemic attack) patients after the implementation of a successful fall prevention programme in a nursing unit.	Hospitalised stroke patients	Multicomponent intervention	Abstract reports on a fall prevention programme called "No One Walks Alone (NIWA)" which involves a team approach (inc. desk clerk, primary nurse, patient, family) and the following interventions: bed alarms; all patients identified as a fall risk; routine rounding.	Following the implementation of a multicomponent intervention in stroke patients on a nursing ward, there was no significant change in fall number and rates, although it tended to increase. The authors recommend further studies with a larger cohort and consideration of patient population specific risk factors.

McCarty 2018	USA	Descriptive	To identify and implement an evidence-based fall-risk assessment tool for use in emergency departments	Emergency Department patients	Multicomponent intervention	Iowa Model employed: Falls risk-assessment tool selected and built in to electronic medical record, including scoring and provision for selecting interventions recommended for the 2 fall-risk levels. Included: signs outside door, socks, hourly rounding, bed in low position, and call light within reach.	The Iowa Model was a useful framework to select an evidence-based tool and then engage nurses in the process of implementing evidence-based practice changes in emergency departments across a diverse health care system serving a largely rural population. Ongoing follow-up will determine if this process results in fewer falls.
Ward 2004	USA	Descriptive	An interdisciplinary team was developed to review patient falls, interventions designed to protect these patients	Medicare patients either over 65 years or with a disability and at high risk of falls	Multicomponent intervention	yellow caution signs, the Guardian Program badges and handout, and the "safety with dignity" flyer, Falls Interdisciplinary Conference form, Quality Care/Patient Fall Assessment form	although patients fall for a variety of reasons, utilizing performance improvement data specific to staff and patient populations could direct the development of a successful falls reduction program
Zuyev 2011	USA	Descriptive	development and usability testing of the Fall TIPS toolkit	Not stated	Multicomponent intervention	The Fall TIPS application aims to prevent patient falls by translating routine nursing fall risk assessment into a decision support intervention that communicates fall risk status and creates a tailored evidence-based plan of care that is accessible to the care team, patients, and family members. The evidence-based interventions included in the Fall TIPS logic have been identified and validated by practicing nurses, physicians, physical therapists, and other interdisciplinary care providers. The Fall TIPS toolkit aims to provide a workflow-friendly solution that overcomes the usual silos associated with communication of fall risk status and evidence-based, feasible interventions to prevent patient falls in hospitals	The next step for the research team is implementation of the FPTK on the pilot-testing units. While it was believed that the Fall TIPS tool-kit is "ready" for implementation, pilot testing was viewed as an additional opportunity to evaluate.
Ohde 2012	Japan	Historically controlled trial	To describe the effectiveness of a multidisciplinary quality improvement (QI) activity for accidental fall prevention, with particular focus on staff compliance in a	Inpatients	Multicomponent intervention	The QI activity for in-patient falls prevention consisted of: 1) the fall risk assessment tool, 2) an intervention protocol to prevent in-patient falls, 3) specific environmental safety interventions, 4) staff education, and 5) multidisciplinary healthcare staff compliance monitoring and feedback mechanisms.	Fall rate significantly decreased. Compliance with use of the fall risk assessment tool at admission increased. The staff compliance rate of implementing an appropriate intervention plan increased

			non-experimental clinical setting.				
Primmer 2015	USA	Historically controlled trial	Innovative program that involves educating unlicensed assistive personnel (UAP) to act as Safe Patient Observation Technicians, or “spotters,” for up to four patients grouped in a safety zone	Inpatients	Multicomponent intervention	Education session for all nurses, spotters, and other unit-based UAP was created. Key messages addressed the need to keep patients safe, and spotters were taught safety-enhancing interventions such as reorienting patients and providing diversional activities.	The pilot unit has produced a sustained reduction in falls since the initiation of the spotter program. No falls resulting in injury occurred during the initial pilot period
Zammit 2014	Australia	Implementation study	to audit current practice of falls prevention within the acute clinical setting, to improve practice in the prevention of falls in accordance to the best available evidence.	not stated	Multicomponent intervention	FRAT, education (health professionals, patients and families) & targeted interventions	a generally positive result at the initial follow-up audit phase; staff education levels increased and more appropriate action was taking place within the clinical setting. However, due to barriers out of the control of the falls team, there were less positive results in the second follow-up audit
Schwendimann 2006	Switzerland	Observational	Examine in-patient fall rates & consequent injuries before & after implementation of interdisciplinary	Adult in-patients	Multicomponent intervention	Multicomponent: Falls risk assessment; Physician assessment; general safety measures & specific interventions	No substantial decrease in fall frequency or injuries following interdisciplinary fall prevention intervention

			fall prevention programme				
Gooday 2004	UK	Other	To study factors contributing to falls in recent lower limb amputees and to reduce falls and resulting injuries during inpatient rehabilitation.	All lower limb amputees admitted to the rehabilitation unit	Multicomponent intervention	Simple risk assessment performed on admission; education (notices on wards about safe transfers, patients educated on safe transfers); environmental modifications (patients with cognitive impairment were not given wheelchairs and placed in safe rooms where possible); bivalve plaster stump protection given to transtibial amputees.	The number of falls on an amputee rehabilitation ward remained consistent despite the introduction of fall prevention interventions. However, the proportion of falls leading to injury and stump trauma were significantly reduced.
Huey-MingTzeng 2017	USA	Other	To identify highly effective interventions to prevent fall injuries as perceived by RN staff for adult inpatients in acute hospital settings.	Registered nursing staff	Multicomponent intervention	Survey to explore use of multiple falls prevention interventions.	21 nurse-perceived effective interventions were identified. 10 interventions related to improving the patient environment & 11 related to increasing registered nurse vigilance. Further work is required.
Stephenson 2016	Australia	Other	To assess falls prevention practices in Australian hospitals & implement interventions to promote best practice	Hospital staff	Multicomponent intervention	Range of interventions used at different sites designed to address barriers to compliance - staff & patient education common interventions.	Clinical audit & feedback effective strategy for promoting quality improvement in fall prevention in acute hospital settings
Walsh 2018	USA	Other	to describe the interventions and evaluate whether they were associated with a sustained decline in falls and fall related injuries from 2003 to 2014.	all patients within included wards	Multicomponent intervention	The medical center's series of fall prevention interventions were as follows: reorganized the Falls Committee (2001), started flagging high-risk patients (2001), improved fall reporting (2002), increased scrutiny of falls (2005), institutedhourlynursingrounds(2006),reorganizedleadershipsystems(2007),standardized fallpreventionequipment(2008), adapted to a move to a new hospital building (2008), routinely investigated root causes (2009),	This multidimensional fall prevention program involved instituting a series of incremental changes every few years over about a decade.This was associated with a sustained decline in falls from 2003 through 2014. Hospitals interested in achieving meaningful reductions in falls but concerned about overburdening frontline nurses or with competing financial priorities may, too, find that an incremental approach and persistence pay off

						mitigated fall risk during hourly nursing rounds (2009), educated patients about falls (2011), and taught nurses to think critically about risk (2012).	
Wexler 2011	USA	Other		50bed medical oncology unit, 33-bed orthopaedic/neurology unit patients	Multicomponent intervention	The program consisted of 3 days (22.5 hours) of didactic content taught by a doctorally prepared expert in gerontologic nursing. The nurse expert followed the education with ongoing consultation, mentoring, journal clubs, and rounding on the units on a biweekly basis for 3 months in order to reinforce the education and support the unit based teams. content included: education (focused on team building, fall prevention, injury prevention, fall risk assessment, and fall prevention strategies, data collection, post fall analysis, and data presentation and communication), bright red non-skid slipper socks that would be used for all high-risk patients, communication form, the Ticket to Ride, signs uses universally understood symbols to transmit the message of fall risk without words, fall impact mats, bed exit alarms, unit based falls champion	Make fall prevention a responsibility of all individuals who worked on the patient care unit. Staff also learned teams are not just individuals who work in the same location; members needed to learn how to function as a team
Yates 2012	USA	Other	To compare falls in psychiatric and mdeical in-patients prior to, during and after revisions to falls policy were made. Secondly assessed nursing perceived effectiveness of policy and knowledge	Psychiatric and medical in-patients aged 18 years or older. Nurses in clinical areas	Multicomponent intervention	Medication review, education, non-slip socks. Nurses completed a survey	inconsistent adherence to fall interventions

Ireland 2013	Canada	Qualitative study	Using case study methodology, ninety-five administrative and point-of-care nurses at three hospitals participated in interviews or focus groups and provided documents and artefacts that described their implementation of a falls prevention guideline.	Nurses	Multicomponent intervention	N/A	Four recommendations with potential to guide others in fall prevention were identified: (1) the need to listen to and recognize the expertise and clinical realities of staff (2) the importance of keeping the implementation process simple (3) the need to recognize that what seems simple becomes complex when meeting individual patient needs, and (4) the need to view the process as one of continuous quality improvement.
Huda 1998	USA	Quality Improvement	The paper describes a series of audits and programme modifications performed in a medical-surgical unit to reduce falls, evaluate staff compliance with prevention procedures and increase staff awareness.	Adults	Multicomponent intervention	Nurses completed a 17-item risk assessment and those at risk (above a set threshold) were placed on the fall risk protocol & re-assessed daily. Protocol includes: bed and room risk signage, orange arm band; fall risk insert in ALL patients care records; inform patient/family/staff that care plan is in effect. Three audit/intervention phases took place with various staff incentives/motivation in between (including showing fall stats, education, fall risk check boxes)	The unit fall rate decreased from the first to third audits. Staff compliance improved for all audit criteria. Authors mention that real change can often take longer than expected.
Shuey 2014	USA	Quality Improvement	QI project on falls prevention bundle in oncology unit	Adults	Multicomponent intervention	Multicomponent nursing intervention	Falls with injury reduced; fall rates unchanged
Trummer 1996	USA	Quality Improvement	report on algorithm for falls prevention in confused patients	Confused patients	Multicomponent intervention	Algorithm for multicomponent assessment & intervention in patients with confusion: Side rails, call light, family involvement; bed alarm; restraints; sitter (possible interventions)	N/A

Weinberg 2011	USA	Quality Improvement	Implementation and evaluation of falls prevention intervention	All inpatient-days of persons aged 18 years and older, with an admission lasting at least one day, between April 2006 and March 2010,	Multicomponent intervention	The intervention included two phases (1) a review phase, in which existing fall prevention efforts were evaluated, and (2) the FPI (fall prevention initiative) implementation phase, in which systems were implemented to ensure fall risk assessments, fall incident investigations, identifying and confronting problem issues, planning and adherence to corrective action, and accountability for missed preventive opportunities.	The FPI was associated with a significant reduction in fall and fall-related injury rates. The results suggest that increasing commitment to continuous quality improvement through enhanced safety awareness and accountability contributed to the initiative's success and led to a change of normative behavior and a culture of safety
Morgan 2017	UK	Quasi-experimental (non-randomised)	This study designed and evaluated the use of a specific implementation strategy to deliver a nursing staff-led Intentional Rounding intervention to reduce inpatient falls.	Inpatients	Multicomponent intervention	Intentional rounding was instigated using a prespecified implementation strategy, which comprised of: (1) engagement and communication activities, (2) teamwork and systems improvement training, (3) support and coaching and (4) iterative Plan-Do-Check-Act cycles.	There was a 50% reduction in patient falls on the active ward v a minimal increase across the rest of the Trust (3 48%). Customised Intentional Rounding, designed by staff specifically for the context, appeared to be effective in reducing patient falls.
Schwendimann 2006	Switzerland	Quasi-experimental (non-randomised)	Evaluate effectiveness of nurse-led fall prevention program	Adult in-patients	Multicomponent intervention	Multicomponent: Fall risk assessment; protocol of nursing interventions (n=15) aimed at reducing falls; fall incident reporting system; Information & education of nursing team	Effective at preventing multiple falls but not first falls
Villafane 2015	Italy	Quasi-experimental (non-randomised)	the effectiveness of three different rehabilitative programs: group exercise, individual core stability or balance training intervention with a stabilometric platform to improve balance ability in elderly hospitalized patients	Thirty consecutive elderly patients with a physiatric indication to global motor rehabilitation known to have had at least one fall during the last 12 months	Multicomponent intervention	All participants received 28 treatment sessions scheduled on separate days, at least 24h apart, and at the same time of day, 5 days/week, for 3 weeks. Patients consecutively assigned to one of the following three groups: group exercise intervention, individual core stability or balance training with a stabilometric platform	Findings indicate that participation in an exercise program can improve balance and functional mobility, which might contribute toward the reductions of the falls of elderly hospitalized patients and the subsequent fall-related costs.

Haines 2004	Australia	RCT	To assess the effectiveness of a targeted, multiple intervention falls prevention programme in reducing falls and injuries related to falls in a subacute hospital.	Adult patients admitted to the rehabilitation and care of elderly hospital, referred from acute care, aged 38+	Multicomponent intervention	Intervention group received a targeted fall prevention programme in addition to usual care. Staff completed the Peter James Centre falls risk assessment tool to determine which interventions to use. Interventions included a falls risk alert card with information leaflet, an exercise programme, education programme and hip protectors.	Patients who received a targeted multiple intervention fall prevention programme, in addition to usual care, had 30% fewer falls and were less likely to experience more than one fall.
Haines 2007	Australia	RCT	To evaluate the clinical effectiveness and implementation of a falls prevention exercise programme for preventing falls in the subacute hospital setting	Older adults subacute care	Multicomponent intervention	Participants in this study were a subgroup of patients (n=173) participating in a larger randomized controlled trial (n=626) of a targeted, multiple-intervention falls prevention project. These 173 were distributed among control and intervention and provided with exercise. Additional exercise programme sessions were conducted three times per week, for 45 minutes per session. The content of these sessions was based on combining the therapeutic principles of tai chi, with functional movements (transferring from chair to chair, weight shifting, reaching, stepping) and activity visualization. A focus was also maintained on patient enjoyment during the exercise sessions	Intervention group participants in this subgroup analysis had a significantly lower incidence of falls than their control group counterparts (control: 16.0 falls/1000 participant-days, intervention: 8.2 falls/1000 participant-days, log-rank test: P=0.007). However few differences in secondary balance, strength and mobility outcomes were evident. This exercise programme provided in addition to usual care may assist in the prevention of falls in the subacute hospital setting.
Hardin 2013	USA	RCT	This study compared inpatient falls on medical-surgical units with and without Webcams and assessed the Morse Risk Assessment (MRA) for effectiveness in identifying fall risk	Adults in medical-surgical units	Multicomponent intervention	CareView is a system that consists of NurseView and Virtual Bed Rails. NurseView is a Webcam that is installed in the room that allows for continuous visualization of the patient at a central location where a touch screen nurse station is placed. Virtual Bed Rails allow the nurse to activate motion sensitive borders so that if the patient moves across the virtual border, an audible alarm occurs on the central control station	Consent rate was 20.7% for the intervention group. A significant difference between groups was found in fall rate per 1000 admissions, but no significant difference was found in fall rate per 1000 patient days. The Morse Risk Assessment was a significant predictor of risk.

Healey 2004	UK	RCT	To test the efficacy of a targeted risk factor reduction core care plan in reducing risk of falling while in hospital.	Elderly inpatients	Multicomponent intervention	The intervention consisted of a brief falls risk factor screen and related interventions in the form of a pre-printed care plan, including risk factors for falls that could be properly addressed in the hospital where the study took place. The reverse of this plan contained a brief summary of evidence, such as medication most likely to be implicated in falls, and local advice such as optical testing arrangements.	After introduction of the care plan there was a significant reduction in the relative risk of recorded falls on intervention wards but not on control wards. There was no significant reduction in the incidence of falls-related injuries.
Koh 2009	Singapore	RCT	To develop a multifaceted strategy using tailored interventions to implement a fall prevention programme, and to achieve a change in fall prevention practices and a reduction in fall incidence at an acute care hospital in Singapore.	Nurses & inpatients	Multicomponent intervention	Revision of hospital's fall prevention policy; Change champions; Educational sessions; Reminders & identification systems; Audit & feedback	Nurses' knowledge & use of falls risk assessment increased. However, no statistically significant reduction nin fall rate.
Martinez-Velilla 2018	Spain	RCT	To assess the effectiveness of a multicomponent exercise intervention on functional status of elderly patients	Acutely hospitalised patients aged 75+	Multicomponent intervention	Two daily supervised exercise sessions lasting 20minutes for 5-7 consecutive days. Exercises adapted from Vivifrail multicomponent programme and included: individualised resistance, balance and walking training. Control group: Usual care, including rehabilitation when needed.	No between-group difference in falls. Intervention group demonstrated improvements in functional & cognitive status, not control group. Adherence between 83% and 95% for evening and morning sessions.

Hayes 2004	UK	Review - Narrative	Review of various aspects of hospital fall prevention including; policy context, the evidence base, and ethical issues. A falls prevention program in one hospital is described.	N/A	Multicomponent intervention	Extensive number of interventions discussed	Potential for the development of nurses' roles in falls prevention in hospital. Opportunity for nurse-led research and practice developments.
Healey 2010	UK	Review - Narrative	This article outlines the range of interventions that can reduce the likelihood of falls and injury, and explains the value of the Patient Safety First.	N/A	Multicomponent intervention	Extensive number of interventions discussed	Nurses have a critical role to play in falls prevention, and the how to guide can help them work with their colleagues in supporting roles and from other professions to deliver a multifactorial approach from the board to the ward. The rewards of good falls prevention policy and practice are not only reduced harm from injury and fractures but increased communication and trust between patients, their relatives, and staff, and ultimately improved confidence, mobility and quality of life for the older person.
Hill 2014	Australia	Review - Narrative	Overview of falls and fall prevention in older adults	Older adults	Multicomponent intervention	Extensive number of interventions reviewed.	Fall risk assessments are not "one-size-fits-all" or the sole answer to fall prevention. When considering a fall risk assessment for use, facilities or staff must first evaluate the reliability and validity of the tool for use with their population. Once they select a tool to use, they should develop a comprehensive set of evidence-based interventions for each area in the fall risk assessment. Careful staff education planning and evaluation for periodic re-education are also integral to any successful fall prevention protocol. Coordinated effort involving all interdisciplinary team members is critical to the safety of older adults in all settings.

LeCuyer 2017	USA	Review - Narrative	To review the literature and make recommendations for falls prevention in ambulatory surgery setting	N/A	Multicomponent intervention	Extensive number of interventions discussed	Multicomponent fall prevention program developed, resulting in no falls for full fiscal year
Meissner 1988	USA	Review - Narrative	Narrative review on elderly falls prevention	N/A	Multicomponent intervention	Extensive number of interventions discussed	Falls prevention program should include reviews surrounding when falls occur, technology available (e.g. bed alert systems), identification of high-risk individuals, patient education
Moore 2015	UK	Review - Narrative	To review fan approach to fall reduction in bathrooms	N/A	Multicomponent intervention	Motion sensitive lighting, falls alarms, elevated toilets etc.	Approach has now been shared with other hospitals and she suggests it could be adapted to other institutional settings, such as nursing and care homes. With a little planning and relatively minor expenditure, life-changing falls can be avoided
Oliver 2010	UK	Review - Narrative	Overview of falls literature	N/A	Multicomponent intervention	Extensive number of interventions discussed	Best practice approach includes 4 key components: 1. Implementation of safer environment of care 2. Identification of specific modifiable risk factors 3. Implementation of interventions to target risk factors 4. Interventions to reduce risk of injury to those who do fall
Parsons 2015	USA	Review - Narrative	Review of Protocols to Prevent and Manage Patient Falls	N/A	Multicomponent intervention	Extensive number of interventions discussed	Health providers must have vigilant policies and health care protocols in place to promote patient safety, prevent patient falls, and decrease injuries for patient across the lifespan that are admitted to long-term care facilities and hospitals. Focusing on patient safety enhances quality care delivery and patient outcomes while addressing escalating health costs associated with patient falls.

Quigley 2007	USA	Review - Narrative	Narrative review providing examples of actual fall prevention programs and their approaches to measurement are showcased in this article	N/A	Multicomponent intervention	Extensive number of interventions discussed	Data analysis using only general fall rates lacks specificity needed to profile effectiveness of fall risk reduction programs and injury prevention methods. The exemplars of data management, analysis, and reporting for systematic analysis of patient, unit and organizational factors illustrated vital components of program evaluation needed for understanding the effectiveness of patient safety programs surrounding falls. These exemplars have results that are meaningful to patients, clinicians, administrators and policy makers. Falls can be prevented and severity of fall related injuries can be minimized.
Hempel 2013	USA	Review - Systematic	To systematically document the implementation, components, comparators, adherence, and effectiveness of published fall prevention approaches in U.S. acute care hospitals.	Hospitalized individuals	Multicomponent intervention	Extensive number of interventions included	Implementation strategies were sparsely documented (17% not at all) and included staff education, establishing committees, seeking leadership support, and occasionally continuous quality improvement techniques. Most interventions (81%) included multiple components (e.g., risk assessments (often not validated), visual risk alerts, patient education, care rounds, bed-exit alarms, and post fall evaluations). Better reporting is necessary to establish evidence eon how hospitals can successfully prevent falls.
Horov 2017	Czech Republic	Review - Systematic	To summarize the conclusions of empirical studies on the effectiveness of preventive programs established in hospitals over the last 5 years.	Majority older adults	Multicomponent intervention	Extensive number of interventions included	Education – for patients and staff – appears to be important for inclusion in multicomponent falls prevention interventions.

Kim 2015	Korea	Review - Systematic	To identify which nursing interventions are the most effective in fall prevention for hospitalized patients	Inpatients	Multicomponent intervention	Extensive number of interventions reviewed, classed as: education; environmental; exercise; risk assessment (single of combinations)	Most effective intervention education + environment, followed by education. Multifaceted interventions more effective than unifactorial.
Miake-Lye 2013	USA	Review - Systematic	Reassess the benefits and harms of fall prevention programs in acute care settings and to identify factors associated with successful implementation of these programs.	Inpatients	Multicomponent intervention	The review investigated: 1) Benefits and harms; 2) Implementation considerations and costs;	The evidence base indicates that inpatient multicomponent programs are effective at reducing falls and that consistent themes are associated with successful implementation. However, there is no strong evidence about which components are most important for success. The effects of context have not been well-studied; however, multicomponent interventions have been effective in hospitals that vary in size, location, and teaching status. The cost of implementing fall prevention programs has not been rigorously assessed but generally does not involve capital expenses or hiring new staff.
Oliver 2000	UK	Review - Systematic	Systematic review of published hospital fall prevention programs. Meta-analysis	Inpatients	Multicomponent intervention	Extensive number of interventions included	Main conclusions related to study design & nature of interventions. Little high-quality evidence currently
Ireland 2010	Canada	Text and Opinion	Description of how one hospital creatively used evidence, systems change, staff engagement, expert consultation, policy and protocols, to reduce annual fall rates by 20%.	falls prevention strategy on 60 clinical units	Multicomponent intervention	Strategy development involved: Systems support; Intervention development; falls working group; identifying a falls risk assessment tool; developing a screening tool; policy & protocol strategy; staff, patient & family education, communication & marketing; implementation & evaluation.	The development of a multifaceted, although basic, falls prevention strategy was effective in (1) engaging a wide range and number of clinical staff in education, (2) reducing fall rates by 20%, and (3) meeting corporate time lines and milestones in the complex environment of a Canadian, multisite, academic teaching hospital. The strategy was designed to meet organizational needs, while encouraging and supporting its adaptation to match patient population needs and the clinical realities of staff.

Kato 2009	Tokyo	Text and Opinion	To establish a methodology for preventing accidental falls.	N/A	Multicomponent intervention	Development of a model and prototype system for preventing falls, which uses data from the user and system to determine a falls prevention plan.	The prototype created suitable falls prevention plans in most cases. Needs to be tested in hospital setting with actual patients.
Katsulis 2016	USA	Text and Opinion	Developing a falls prevention program	Older adults	Multicomponent intervention	We examined the use of human factors techniques in the redesign of the existing paper fall prevention tool with the goal of increasing ease of use and decreasing inpatient falls	The inclusion of patients and clinical staff in the redesign of the existing tool was done to increase adoption of the tool and fall prevention best practices. The redesigned paper Fall T.I.P.S toolkit showcased a built in clinical decision support system and increased ease of use over the existing version
Kruger 2006	USA	Text and Opinion	Describe an original Patient Safety Platform Model and give a case example of how the model can be used in a falls-prevention programme.	N/A	Multicomponent intervention	Safety Platform Model proposed, with Patients at centre, visitors & staff overlapping, with physical environment & caregiver competence also included.	Authors suggest that the safety platform model can be used in a multitude of settings
Mashta 2010	UK	Text and Opinion	Commentary regarding falls prevention strategy	N/A	Multicomponent intervention	Identifying risk factors, close monitoring (monitor fluids, wearing non-slip socks, offering to assist to toilet etc.)	Training 42 ‘falls prevention champions’ from every clinical area who will be able to run workshops for their nursing staff themselves.
Morse 2002	Canada	Text and Opinion	This article reviews the rationale and principles of fall prevention and protection in a hospital-based program designed to reduce patient falls and fall related injuries.	N/A	Multicomponent intervention	Extensive number of interventions discussed	Understanding the principles of fall interventions and the role and appropriate use of fall protective and preventive interventions and of implementing a comprehensive program that targets interventions appropriately and effectively will meet the hospital’s goal of providing safe care efficiently and at minimal cost

Nicolas 2016	USA	Text and Opinion	Case study	Inpatients	Multicomponent intervention	Family sharing brochure on patient safety that includes a patient/family/nurse contract. Hourly rounding also used	Consistent downward trends in falls
Nnodim 2005	USA	Text and Opinion	Overview of falls prevention program.	N/A	Multicomponent intervention	Intervention included exercise prescription, focus on medications, environment modification, behaviour modification, assistive protective devices, footwear assessment, vision assessment vitamin D supplementation	A comprehensive fall evaluation (CFE) is proposed, particularly for use in recurrent fallers,
Putnam 2015	USA	Text and Opinion	Overview/ opinion on falls prevention	N/A	Multicomponent intervention	Suggest individualised approach and treat every patient as a falls risk ('No one walks alone' program'). Preventative measures include: call nurse for help on getting up, visual cues for healthcare staff (signs, symbols and wristbands. Involvement of frontline nurses in solution finding.	Individualised approach to falls prevention important
Tiessen 2010	Canada	Text and Opinion	Describe falls management & patient safety culture	Elderly	Multicomponent intervention	Falls management rather than falls prevention. Falls assessment & strategies related to decreasing physical deconditioning - encourage mobility & activity - falls tolerated - aim to reduce falls with injury	Reduced rate of falls with harm
Hamm 2016	UK	Review - Systematic	Conceptual framework and survey of the state of the art of technology-based fall prevention systems	N/A	Multicomponent interventions	To develop the conceptual framework and carry out a survey of the state of the art technology-based fall prevention systems	A number of research challenges emerge as a result of surveying the research literature, which include a need for: new systems that focus on overcoming extrinsic falls risk factors; systems that support the environmental risk assessment process; systems that enable patients and practitioners to develop more collaborative relationships and engage in shared decision making during falls risk assessment and prevention activities. Recommendations and future research directions are proposed to overcome each respective challenge.
Stoeckle 2019	USA	Quality improvement	Quality improvement project to identify and	Patients & staff in the emergency department	Multifactorial	In addition to universal fall prevention - staff education, door falls risk sign, patient family education, fall champion. (Provision of sign	Zero falls were recorder in the month immediately following intervention implementation, however there doesn't appear

			implement evidence based interventions to prevent falls and injuries in an emergency department.			and patient/family education was based on fall risk).	to have been a significant decrease in falls in the following months.
Tartu 2014	Australia	Audit	Implementation project to improve falls prevention practices	Not stated	Multifactorial intervention	Education of clinical staff in falls prevention; Risk assessment; Multifactorial falls prevention	Achieved improved adherence to criteria
DalMolin 2018	Italy	Before-after design	To explore the effect of “Primary Nursing” on nursing-sensitive patient outcomes, staff-related outcomes, and organization-related outcomes.	Adult patients (aged 18+) and nurses in the wards where the care plan was implemented	Multifactorial intervention	Implementation of a "Primary Nursing" strategy whereby one "primary” nurse is responsible for the nursing-care of certain patients throughout their entire hospital stay. Every patient was allocated a primary nurse; an individual nursing care plan was drawn up and where necessary an individualised discharge plan developed.	Fall percentage decreased from 2.4% to 1.9% following the implementation of a patient-focused care strategy, "Primary Nursing", however not significantly. There were positive outcomes for staff and organisation also.
Dykes 2017	USA	Before-after design	To describe the process used for pilot testing and promoting adoption and spread of Fall TIPS toolkit.	Piloted on staff/patients at two medical centres	Multifactorial intervention	Strategies to integrate the Fall TIPS Toolkit into practice were implemented including engaging stakeholders by leveraging existing shared governance structures, identifying unit champions, holding training sessions for all staff and implementing auditing to assess and provide feedback on protocol adherence and patient outcomes. Fall TIPS (Tailoring Interventions for Patient Safety) is a bedside poster aids clinical decision making by linking falls risk with evidence-based interventions.	Fall rates decreased in one hospital but slightly increased in the other (which had a low baseline fall rate) following implementation. Staff adherence to the protocol was over 82% and patients became more aware of their falls risk.
Eckstrom 2016	USA	Before-after design	To describe a project engaging an Interprofessional teaching team to support Interprofessional clinical teams to reduce falls risk in older adults using the American	Staff from ambulatory, long term care, hospital, and home health settings	Multifactorial intervention	Interprofessional clinical teams with representatives from medicine, nursing, pharmacy, and social work (and others) were given a 4 hour training workshop, developed using AGS/BGS guidelines and the Stopping Elderly Accidents, Deaths and Injuries (STEADI) Tool Kit, and "coaching" over 1 year for implementation. Education included evidence-based strategies including fall risk screening; assessment of gait, balance, orthostatics and other medical conditions; Vitamin D supplementation;	Implementing an Interprofessional education and fall prevention protocol had no significant effect on fall rates after 9-12 months, although they tended to reduce. Most clinical teams were effective in implementing all strategies except for Vitamin D supplementation.

			Geriatrics Society/British Geriatrics Society (AGS/BGS) guidelines.			exercise (tai chi); environment assessment; eyewear and footwear recommendations; medication review and reduction. Clinician teams brainstormed a plan to implement their strategies.	
Gray-Miceli 2017	USA	Before-after design	To deliver an educational health care practice change intervention focused on fall prevention, the Falls Prevention Collaborative (FPC) to health care professionals in 38 acute care hospitals.	Hospital staff and patients	Multifactorial intervention	Varied interventions depending on the fall prevention team. All teams received team training, coaching and mentoring in fall prevention and were encouraged to develop a fall prevention strategy for their unit. Interventions developed included: falls risk assessment; staff education; instituted rounding; post fall assessment intervention; supervised toileting; responding to call lights, environmental; staff safety awareness; comprehensive.	Following a falls team training initiative the most common interventions devised were fall risk assessment, staff education, rounding and post fall assessment. These interventions resulted in a decrease in fall rates in all participating units.
Murphy 2008	USA	Before-after design	To describe and measure the impact of a multifaceted program developed to reduce the falls rate on an acute medical unit at an academic tertiary care center.	Inpatients in acute care	Multifactorial intervention	A new fall precautions policy was introduced. All patients were assessed for fall risk using the Hendrich II Fall Assessment, reassessed daily and those deemed at risk given fall precautions. These include: non-skid footwear; a clutter-free environment with a dry floor and minimal hazards; call bell within reach; optimal lighting; low bed (locked in position); fall risk stickers on charts, magnets on doors and colour wristbands; gait assessment and physiotherapy; personal alarms; falls tool boxes; staff education and re-education; hourly rounds.	Following the implementation of a fall prevention intervention there was a gradual decrease in fall numbers and the number of calls by patients using call bells significantly decreased. Staff reported that they were able to address several other potential issues during rounds. Patient satisfaction increased.
Rossy 1997	Canada	Before-after design	To develop and implement a fall prevention programme in a geriatric assessment unit, which easily identifies patients at high risk of falling, for	Geriatric patients	Multifactorial intervention	A fall risk questionnaire was implemented first in the unit then hospital wide (which assessed history of previous fall; altered thought process; mobility impairment; altered elimination; predisposing medications and perceptual/spatial disturbance); purple was used to identify patients at risk (dot on kadrex; sign above bed); plan of care specific for geriatrics (inc. routine toileting; lighting evaluation; mobility	The number of falls on the geriatric unit reduced in the first year after the implementation of a fall risk assessment tool and fall prevention programme, but increased slightly in the second and third years. Staff increased their use of the tool and an updated version has been implemented across the hospital.

			eventual hospital wide implementation.			aids); patient education leaflets; staff education sessions; continuous assessment of falls and injuries with results displayed on notice boards.	
Titler 2016	USA	Before-after design	Evaluate impact of implementing targeted risk factor fall prevention bundle	Nurses & adult patients	Multifactorial intervention	Targeted risk factor fall prevention bundle addressing: Mobility, elimination. Medications, cognition, risk of serious injury	Fall rates declined & use of intervention increased
Vieira 2013	Canada	Before-after design	To evaluate the effectiveness of an intervention programme to reduce falls among geriatric rehabilitation patients	Seventy-six matched pairs (n =152) of geriatric rehabilitation patients from one control and one intervention ward participated in the study, and 36 nursing staff surveys were completed	Multifactorial intervention	The intervention programme was developed based on interviews and systematic reviews. Educational materials were distributed to patients and families, and preventive measures were implemented: (1) risks and Vieira et al. 327 preventive measures to be integrated into a falls risk assessment and intervention tool; (2) preventive measures to be implemented on the ward; (3) changes to be made on the ward; and (4) topics for staff educational sessions and to be conveyed to patients and families.	intervention programme was effective in reducing falls among geriatric rehabilitation patients
Abdalla 2017	USA	Cohort study (Prospective)	Evaluate whether an ACE unit at a community-based teaching hospital decreased the risk of falls in patients over 65 years old compared to general and medical surgical units.	Aged 65+, admitted to ACE or general medical/surgical unit	Multifactorial intervention	Acute care of the elderly (ACE) unit includes specially trained nursing staff and senior-friendly amenities: special lighting, non-skid flooring, low beds, soothing sounds/low noise policies. Staff address seniors' specific needs regarding nutrition, proper sleep patterning, early delirium detection, skin integrity, and medication management. Early physical and occupational rehabilitation, patient-centred care & senior friendly environment. Falls risk assessment. Morse Fall Score (assessed on admission, every 8 hrs, after fall or change in medical status, after any transfers between units).	Patients in the ACE unit had a 73% decreased incidence of falls, after adjusting for potential confounders.

Brady 1993	USA	Cohort study (Prospective)	To describe the quality assurance efforts to reduce the incidence of geriatric falls in a 172-bed rehabilitation centre and present a falls prevention programme.	Elderly patients from a geriatric rehab unit	Multifactorial intervention	1. Brief 2 week intervention on 25 patients. Nurses rounded on patients 30mins prior to identified peak fall times, offering assistance with ambulating, toileting or fluids/food. 2. Multifactorial intervention based on patient's fall risk rating. Call bell within reach; lowering bed; lock wheels; assess cognitive, sensory and mobility deficits every shift; side rails; reinforcing patient calls for assistance; assisted toileting and mobility; coloured wristband; fall risk sign above bed and on door; patient leaflet.	Percentage of falls were reduced following a brief 2 week intervention that pre-empted the reasons for falling during peak fall times.
Brandis 1999	Australia	Cohort study (Prospective)	To present the 'Fall STOP' falls prevention programme, implemented to prevent falls in an acute care hospital.	Hospital patients, aged 65+	Multifactorial intervention	Falls management taskforce led by a nurse manager. Multifactorial intervention 'Fall STOP' including: coloured arm band, hip protectors, falls management plan decision tree, ward posters incorporating decision trees, staff education. Environment modifications.	The number of patient falls decreased in the 2 year period following implementation of the Falls STOP programme.
Capan 2007	USA	Cohort study (Prospective)	To describe the processes involved in implementing an inpatient falls prevention programme.	Hospital wide - patients	Multifactorial intervention	Fall risk assessment (7 risk factors) and prevention tool with suggested fall prevention interventions to choose from. These include: coloured wrist band, door sign, family/patient education, hip protector, assess for orthostatic hypotension, low bed, bed/chair alarm, physiotherapy/occupational therapy, self-release belt (restraint), assessment of and assistance with toileting, medication review.	Fall rates have continued to decrease since the implementation of the fall risk assessment and prevention tool.
Carroll 2009	USA	Cohort study (Prospective)	To minimize modifiable risk factors and identify patients at risk of falling in a hospital setting.	Hospital patients	Multifactorial intervention	A mixture of multicomponent and multifactorial interventions following a falls risk assessment. Interventions included: identification of person at risk (door sign, armband, star on assignment board and not on computer), monitoring (hourly rounding, frequent ambulation, encouragement to call for help, frequent toileting), physical environment (call light within reach, bed/chair alarms, low beds, minimising clutter), patient specific interventions (avoidance of bladder catheters, double sided slippers, removal of unnecessary intravenous lines, activity apron for dementia patients, avoid sedatives, back rub and warm milk at bedtime). Intervention implemented following educational sessions	Fall rates have been fluctuating since the beginning of the project, with a significant decrease in the 3 months after implementation. Authors highlight the need to remain vigilant and reassess frequently to maintain fall prevention.

						for staff regarding the fall prevention programme.	
Cohen 1991	USA	Cohort study (Prospective)	To reduce fall numbers among neuroscience patients with the use of a fall prevention programme and to increase awareness.	Hospital patients	Multifactorial intervention	Fall risk assessment to identify patients, implementation of prevention techniques and re-evaluation of patients for continued or new risk factors. Fall prevention techniques include: fall precaution sign on door and bed, kardex flagged, patient/family education, orientation to environment, instruction on call for help, ensuring a clutter free safe environment, assistance with toileting on hourly rounds, providing opportunities for mobility under strict supervision, call bell and personal articles in reach, side rails up at all times, night light, mediation review, low bed. Interventions for patients with altered mental status included chest or limb restraint use, a high visibility room. Staff education.	Following implementation of the fall prevention programme the fall rates reduced and continue to be lower. Authors suggest that increasing staff awareness through education had a positive outcome.
Dellasega 2001	USA	Cohort study (Prospective)	To use a consultative model geriatric assessment team (GAT) to identify specific patient problems amendable to intervention, rather than diagnoses and evaluate the outcomes of tailored interventions.	Patients aged 70+ admitted to hospital for treatment of an acute medical condition	Multifactorial intervention	Geriatric Assessment Team (GAT), consisting of a master's-prepared geriatric clinical nurse specialist, pharmacist, nutritionist, social worker and primary physician, each performed a comprehensive assessment with patients, identifying discipline specific problems and approaches to address them. Team met to discuss interventions (including, for fall prevention: nursing measures, bed check, physical therapy evaluation, orthostatic blood pressure, assistive devices).	Although it is unclear from the results, the authors state that there was an improvement in the problem codes including fall risk, for patients receiving the intervention.
Dyer 2008	Canada	Cohort study (Prospective)	To develop an effective falls prevention programme and a falls risk assessment specific for adult amputee patients.	Patients and staff in the amputee rehabilitation ward	Multifactorial intervention	A revised Falls Assessment Tool including clear process to customise a prompt intervention plan for those at risk of falling; multidisciplinary review following a fall and plan for future prevention; falls data reviewed regularly and intervention effectiveness monitored; education for nursing staff on falls specific to amputees.	Following 3 month of intervention implementation there was a 5% decrease in the incidence of falls. Nursing staff reported positively on the usefulness and effectiveness of the tools.

Dykes 2009	USA	Cohort study (Prospective)	To describe the Fall TIPS Toolkit and to report on strategies used to drive adoption of the Toolkit in four acute care hospitals.	Acute care hospitals, staff	Multifactorial intervention	Fall TIPS is a web-based application which aims to establish evidence based linkages between routine nursing fall risk assessment, and structured communication and tailored interventions to prevent patient falls in acute care hospitals. Fall risk assessment performed online and the system suggests evidence-based interventions individualised to the patient specific risk factors which the nurse can edit and add to. Generates a bed poster, a plan of care and an educational handout for patients and family members. A toolkit for spreading the use of Fall TIPS was employed.	There was an improvement in the mean number of fall risk assessments completed using the toolkit following the intervention as well as other adoption measures. No fall related data.
Foley 2014	USA	Cohort study (Prospective)	A pilot study to determine whether interdisciplinary recommendations provided by the Acute Care for Elders (ACE) team were effective in preventing falls.	Patients aged 65+	Multifactorial intervention	The Acute Care for Elders (ACE) team evaluates patients using an interdisciplinary approach and gives recommendations for fall prevention as part of the geriatric syndromes evaluation. Interventions include medication changes, increase mobility, and consideration of cognitive deficits.	There were no falls recorded during the month of data collection, with patients being assessed by an interdisciplinary team.
Galbraith 2011	Ireland	Cohort study (Prospective)	To examine the impact of a multidisciplinary Falls-Prevention Program (FPP) on the incidence of inpatient falls and fall-related injuries in an orthopaedic hospital during a 6-year period, and perform a cost analysis.	All patients admitted to hospital within a 5 year period and for 1 year post-intervention	Multifactorial intervention	A multidisciplinary taskforce established to develop and implement a FPP. The intervention involved fall risk assessment on admission (Falls Risk Assessment Scale for the Elderly, FRASE); at risk patients placed close to nursing stations; staff education and training (role outlines, patient transfer, mobility device and adequate footwear provision; frequent toileting ward modifications (nonslip mats, hand rails, better lighting); information leaflets on wards; risk alert signs; assistance to ambulate; gait and balance physiotherapy; commodes and urinals; family/patient education; 2 monthly review of FPP.	There was a 30.6% reduction in the relative risk of falls from the year before to year after the tailored FPP was implemented in an orthopaedic patient population. There was a reduction in the cost of care as a result of falls in the post-intervention years.

Goljar 2016	Slovenia	Cohort study (Prospective)	To evaluate the effectiveness of a fall prevention programme, based on a fall risk assessment, for stroke rehabilitation patients.	Patients admitted to the stroke rehabilitation ward during the study period (Sept 1st 2010-Sept 30th 2011)	Multifactorial intervention	A stroke patient specific fall risk assessment (Assessment Sheet for Fall Prediction in Stroke Inpatients (ASFPSI)) was performed on admission and high risk patients identified. In addition to general fall prevention activities the following interventions were introduced for high risk patients: discrete risk ID; physician agreed safety restraints and psychologist assistance when explaining the need for these; balance training; emphasis on sit/stand training; speech therapists assistance during explanation of fall risk to patients with impaired communication; staff - family consultations; accompanied transfer to therapy locations; hourly rounding; patient close to nurses station; alerting visitors to fall prevention measures.	There was no association between falling and the ASFPSI fall risk assessment score. Completing fall risk assessments together with targeted fall prevention measures resulted in a decrease in the yearly fall incidence which remained stable in the 3 years following the intervention.
Gowdy 2003	USA	Cohort study (Prospective)	To discuss a fall prevention program that entails comprehensive fall risk assessment, root cause analysis of falls, and proactive Failure Mode and Effects Analysis (FMEA) of the fall prevention process.	Patients in the geriatric psychiatric ward	Multifactorial intervention	Interdisciplinary Fall Team; development of a Fall Risk Assessment tool; staff education (in-services, posters, meetings, educational fair); fall risk assessment tool used to stratify patients into risk groups so appropriate interventions were applied. High risk group interventions include: fall risk on pink ID bracelet and door sign and communicated to team/family/patient; fall education brochure; encourage family participation in safety; frequent toileting; avoid clutter; call bell and phone in reach; door open; night light; top 2 side rails up; accompanied to commode or toilet; non-slip socks/shoes; medication review; physiotherapy; diversion activities; walking aids; in wheelchair at desk or hall for observation; sitter volunteer; soft restraint belt. Further interventions: assistive walking devices; convex mirrors for easy hallway monitoring from nursing station; motion detectors at bedside; bed-exit alarms; staff education specific to high risk population.	43% reduction in fall rate following the implementation of a Falls Team and fall prevention interventions specific to a high risk fall group in the geriatric psychiatric ward. Authors suggest to concentrate on high risk group first and if successful to implement wider. They also conclude that a culture change takes time and requires administrative support.
Gutierrez 2008	USA	Cohort study (Prospective)	To describe a project designed to evaluate obstacles to the implementation of a research-based fall	Nursing staff and patients on the Definitive Observation Unit (DOU) (cardiac and high acuity	Multifactorial intervention	Fall champion teams rounded, educated and trained staff on fall prevention strategies, including rounding; toileting; family presence; appropriate lighting and removing trip hazards. Increased staffing of 2 RN's and 1 technical partner for 6 patients.	Following the implementation of fall champions and a supported educational oversight, fall rates reduced from 4.87 to 3.59 and further to 1.37. The authors strongly recommend the use of champions to implement and drive a fall prevention project.

			prevention protocol in hospital patients, and an attempt to remove the obstacles and improve outcomes.	medical surgical patients).			
Apold 2012	USA	Cohort study Retrospective	Present the outcomes of a large scale fall an injury reduction programme and summarise lessons learnt.	Minnesota hospitals (state-wide implementation)	Multifactorial intervention	Implement SAFE from FALLS programme in hospitals following an intense 1 day learning session. Programme is a 'road map' which includes practice and implementation recommendations. S = SAFE teams (e.g., interdisciplinary team, physician champion); A = Access to information (e.g., sharing data with team members, physicians, and administration). F = Fall risk screening, A = Assessment of risk factors, L = Linked interventions, L = Learn from events, & S = Safe environment	Number of reported falls decreased with the use of the SAFE from FALLS programme. Authors recommend using a smaller number of targeted tools; minimise burden of a risk tool to maximise prevention implementation time; collaboration with colleagues and ongoing learning/enhancing.
Barry 2001	Ireland	Cohort study Retrospective	Develop and implement a fall prevention strategy for elderly patients and to improve safety awareness among patients and staff.	Older patients; average age 81 years; varying levels of dependency	Multifactorial intervention	Staff education. Environmental changes including: handrails in corridors; handrails, grab rails and arm rests in bathrooms; no polishing of floors; suitable chairs with armrests; removal of obstructive furniture; rubber outdoor tiling on patios. Environmental changes tailored to patients e.g. Commodes without wheels, braces fitted to men's trousers. Emergency call bells maintained. Fall risk factors were addressed individually including vision, medication, and mobility. Hip protector pads provided to high risk patients.	Overall, falls reduced following the intervention. Recommend that environmental risk factors be monitored regularly and corrected when needed.
Rabadi 2008	USA	Cohort study Retrospective	To define the fall incidence rate in patients on an acute stroke rehabilitation unit who routinely undergo fall prevention measures.	Adult stroke patients	Multifactorial intervention	All patients received wheelchair lap belts and bed rails and neuropsychiatric drugs were used sparingly. Incontinent patients had a 2-hour timed toileting schedule. Patients considered as high-fall risk (based on their fall history in the referring hospital, observed impulsive behaviour, and poor understanding of their abilities and impairments) were also given the following interventions: bed/chair alarms; enclosed beds; rooms close to nursing station.	A retrospective review of patient records showed that 117 (15.5%) of 754 patients fell when fall prevention strategies were in place. Those that fell had more cognitive, visual, physical, postural instability and proprioceptive impairments, and lower admission ambulation speed. Particularly having cognitive impairment and slower ambulation was predictive of falling.
Røyset 2019	Norway	Observational	To assess the effectiveness of	Inpatients aged 65+	Multifactorial intervention	Patients screened for risk factors. All patients received medication review and	There were no significant differences between intervention and control on the rate of fallers,

			a fall prevention intervention in reducing rate of fallers, improving perceived patient safety culture and patient experienced safety.			information about the room and surrounding environment. Individually tailored interventions included: locking wheels, items within reach, low low beds, lighting adjustments, remove clutter, assisted out of bed, footwear, physical training, medication review, treatment of conditions, nutrition. Control: did not participate in safety campaign but continued routine preventative measures.	patient safety culture, or patient-perceived safety.
Dempsey 2004	Australia	Other	To perform a practice review of a Falls Prevention Programme in an acute care hospital, 5 years after implementation to determine the sustainability of the effect.	NA	Multifactorial intervention	Re-assessment of fall prevention strategy following a period of 5 years. Original intervention involved: risk assessment tool (injury risk assessment form); choice of interventions matching individual risk factors; graphic alerting of 'at risk patients'; patient and staff education.	Rise in fall rates in the 5 years after initial programme implementation that exceeded the pre-implementation fall rate. Nurse compliance appeared to be one of the main contributors. The authors recommend that the approach to fall prevention should be one that fosters patient care and increases nursing satisfaction, in the hope of sustaining fall reduction rates.
Goldsmith 2009	USA	Other	To test performance usability of a web-based Fall Prevention Tool Kit (FPTK) to identify errors and/or problems with the system that may negatively impact current acute care workflows.	Clinical nurses using the toolkit	Multifactorial intervention	Evaluation of a web-based Fall Prevention Tool Kit (FPTK), which takes into account an individual's fall risk and provides decision support that creates a tailored evidence-based plan of care for use across acute care settings.	Nurses provided useful and positive information for the application developers to improve the systems acceptance for future end users.
Semin-Goossens 2003	Netherlands	Other	To implement an evidence-based nursing guidelines to achieve reduction in fall incidence	Adult in-patients	Multifactorial intervention	Nursing guideline incorporating risk assessment; fall reporting; nursing interventions (informing patient & relatives; environmental; restraints where necessary; extra observation rounds	Implementation of Guideline did not result in reduction in falls

Belita 2013	Canada	Quality Improvement	Describe the process used to design, develop and implement a change initiative that specifically focused on cardiac-related falls and injuries.	Cardiology patients	Multifactorial intervention	Falls risk assessment AND targeted interventions. Specialised 'Assessment and Intervention Falls Guide' for older inpatients with arrhythmia and syncopal episodes - screens for fall risk using 'trigger' questions. Interventions include: cardiology specific initial nursing interventions; fall interventions including low-low bed, belongings within reach, call bell within reach, mobility aids, clear pathway and clean dry surface; ongoing medical assessments; additional interventions including close supervision, up with supervision, consulting physiotherapist/occupational therapist for mobility, patient/family education; and medication treatment strategies.	Found useful by nurses and provided a new way to assess patients' risk for falls taking into account specific cardiac problems which may increase falls risk in this population.
Fonda 2006	Australia	Quality Improvement	To determine whether the rate of falls and associated serious injuries in a hospital aged care setting can be reduced with a multistrategy prevention approach.	Patients from acute care of the elderly, geriatric evaluation and management and restorative care wards	Multifactorial intervention	A multifactorial intervention was implemented including the following areas: bedside falls (toileting review, fitted bed sheets, bedside mats, extended call bell chord, non-slip chair mats, low beds, bed alarms, bed poles for easy self-transfer); increasing surveillance (falls information for family, volunteer programme, early feeding of dependent patients, wristbands, bed chart); reducing night falls (glow in the dark commodes and toilet signs, night sensor light); education (fall prevention folder on ward, compliance audits, staff brochures, falls risk assessment and alter sticker, promote team ownership of falls, protocol for post-fall review, fall reporting at meetings); general environment (review footwear, reduce clutter, bathroom door magnets, non-slip bathroom flooring, alter floor cleaning, appropriate seat height).	Following the implementation of a multifactorial intervention, there was a 19% decrease in falls over a 3 year period. Staff compliance increased as well as staff satisfaction.
Trepanier 2014	USA	Quality Improvement	Evaluate effectiveness of multifactorial falls prevention intervention	Adult patients	Multifactorial intervention	Policy & procedures with minimum set of standards	Significant reduction in falls
Spano-Szekely 2019	USA	Quality improvement	To improve the current fall prevention programme and reduce falls.	Medical/surgical inpatients	Multifactorial intervention	All patients receive universal precautions and depending on patients risk category individualised interventions were implemented (Including: injury assessment, medication review, mobility assessment and mobility equipment, communication of fall risk, bed/chair alarms, hourly rounding).	54% reduction in falls & 72% reduction in sitter usage, resulting in annual savings of $84000 following the implementation of the intervention including video monitoring.

						Staff education included. Video monitoring added later	
Kinn 2001	UK	Quasi-experimental (non-randomised)	A risk-assessment tool and care plan were developed and evaluated prospectively	Elderly inpatients	Multifactorial intervention	Risk assessment + modified falls prevention intervention including: orientate to environment, ensure area is hazard-free, assess patients for use of cot sides, and place bed in area for close supervision. Use of an alarm system was omitted.	Staff found risk-assessment tool & care plan easy to complete; however little documentation about whether appropriate interventions carried out. Multidisciplinary group set up because of project to look at fall management.
Trombetti 2013	Switzerland	Quasi-experimental (non-randomised)	Evaluate effect of multifactorial fall-and-fracture risk assessment & management programme applied in geriatric hospital setting	Geriatric inpatients	Multifactorial intervention	Multifactorial fall-and-fracture risk assessment & management: Multidisciplinary comprehensive assessment & individually tailored intervention (individual & group physiotherapy & occupational therapy)	Effective compared to usual care
Vassallo 2004	UK	Quasi-experimental (non-randomised)	To determine whether a change in practice to introduce a multidisciplinary fall-prevention program can reduce falls and injury in nonacute patients in a rehabilitation hospital	825 consecutive patients to 3 wards	Multifactorial intervention	The patients' fall-risk status was assessed using the Downton Score. Current practice was maintained on the two control wards (n=550). On the experimental ward(n=275),a fall prevention program was introduced. A mulidisciplinary team (physician, nurse, occupational therapist, social worker, and physiotherapist) met weekly specifically to discuss patients' fall risk and formulate a targeted plan. Patients at risk were identified using wristbands; risk factors were corrected or environmental changes made to enhance safety.	This study shows that falls might be reduced in a multidisciplinary fall-prevention program, but the results are not definitive because of the borderline significance achieved and the variable length of stay. More research on fall prevention in hospital is required, particularly as to what interventions, if any, are effective at reducing falls in this group of patients

Aizen 2015	Israel	RCT	To evaluate the effectiveness of a targeted individualized falls prevention program in reducing the rate of falls in a geriatric rehabilitation hospital.	Patients aged 65+ consecutively admitted to geriatric rehabilitation ward	Multifactorial intervention	Weekly falls risk assessment (tool) & individual management (medical, behavioural, cognitive and environmental modifications) based on falls risk level. Mild risk: medical interventions, environmental modifications, toilets and shower-room adjustment, mobility care, bed and wheelchair adjustment, behavioural and cognitive treatment and patient and family guidance. Moderate risk: +supervised mobility assistance. High risk: +placed in visible location on ward, permanent supervision, hip protection, multidisciplinary discussion on fall prevention	No differences in fall rates between groups
Ang 2011	Singapore	RCT	To evaluate the effectiveness of a targeted multiple intervention in reducing fall number in patients identified as high falls risk by the Hendrich II Falls Risk Model.	Patients newly admitted to medical wards, age ≥21 years, score of ≥5 on Hendrich II Fall Risk Model	Multifactorial intervention	In addition to usual care, intervention group (patients identified as high risk on the Hendrich II Falls Risk Model) received a risk appropriate targeted multiple intervention, including an educational session (≤30 minutes) on their specific intervention.	Using targeted multiple interventions in addition to usual care reduced the number of falls, relative risk of falls and risk of falls compared to usual care in an acute care hospital.
Barker 2016	Australia	RCT	To evaluate the effect of the 6-PACK programme on falls and fall injuries in acute wards using a randomised controlled trial.	Patients admitted to 24 acute wards	Multifactorial intervention	The 6-PACK programme involved using a falls risk tool and targeted individualised intervention of one or more of six interventions: falls alert sign; supervision in the bathroom; low-low beds; walking aid within reach; toileting regimes; bed/chair alarm.	Fall rates were higher (7.46) in the intervention wards than control wards (7.03) during the trial period but not significantly different.
Cumming 2008	Australia	RCT	To determine the efficacy of a targeted multifactorial falls prevention programme in elderly care wards with relatively short lengths of stay.	Patients from elderly care wards	Multifactorial intervention	Targeted multifactorial intervention, delivered by nurse and physiotherapist, that included a falls risk assessment, staff and patient education, drug review, modification of bedside and ward environments, walking aids, an exercise programme (balance and functional), eyewear, increased supervision and sock alarms for selected patients.	There were no differences in fall rates between intervention and control elderly care wards following a targeted multifactorial intervention for fall prevention. Authors suggest that innovative approaches are needed as well as a whole system approach to prevention strategies.

Dykes 2010	USA	RCT	To investigate whether a fall prevention toolkit (FPTK) using health information technology (HIT) decreases patient falls in hospitals.	Staff and patients from 4 urban US hospitals	Multifactorial intervention	Fall prevention toolkit software used information from a fall risk assessment (Morse Fall Scale, MFS), filled out by nurses, to create a tailored set of fall prevention interventions specific to the patients' risk. The toolkit produced a bed poster, patient education handouts and plans of care.	Using a fall prevention tool kit (FPTK) resulted in a lower rate of hospital falls compared to usual care. Authors report that the tool was particularly useful in patients over 65. Adherence to protocol outcomes measured above 81%.
Stenvall 2006	Sweden	RCT	Effectiveness of postoperative multidisciplinary programme on falls & fall-related injuries after femoral neck fracture	Patients with femoral neck fracture aged over 70	Multifactorial intervention	Multi component intervention including: ward layout; staffing; staff education; teamwork; individual care planning; prevention & treatment of complications; nutrition; rehabilitation	Multidisciplinary, multifactorial intervention resulted in fewer falls & fewer injuries
Van Gaal 2011	Netherlands	RCT	To test the effect of a comprehensive patient safety programme on incidence of 3 adverse events & preventative care given to patients at risk of pressure ulcers, UTI or falls in hospital and nursing homes	Nurses within ward, patients (aged 18 or over and staying on ward for at least 5 days)	Multifactorial intervention	10 hospital wards randomised to interventional or usual care. Baseline data recorded then 3 months intervention with patient safety program (initial education to nurses inc CD ROM and information to patients; case discussions; digital computerised registration and feedback) via multifaceted implementation strategy	showed implementing multiple guidelines is possible but more research is required
Van Gaal 2011	Netherlands	RCT	To test if effects on the main outcome (incidence of adverse events) coincided with favourable effects on preventive care	patients (aged 18 or over and staying on ward for at least 5 days)	Multifactorial intervention	10 hospital wards randomised to interventional or usual care. Process of change was assessed with process indicators: % of patients at risk who received preventive care according to guidelines	Findings in contrast to previous work. More research into the effectiveness of this patient safety program

Blake 2013	New Zeland	Text and Opinion	Overview and opinion of the 'Open for better care' campaign	N/A	Multifactorial intervention	Paper discusses the 'Open for better care' campaign. Uses 'Ask, Assess, Act' to prevent falls by first using screening questions, then assessing the patients falls risk together with patient/family input and determining interventions. Mentions individualised interventions, intentional grounding, call bell nearby, personal belongings nearby, familiarisation with new environments, bed/chair height appropriate, mobility equipment within reach, clear pathways, good light, locked wheels on furniture, wheelchairs, toilet chairs and hoists, prompt cleaning of spills.	Recommends that risk factors and interventions be well matched/linked in an individualised care plan.
Boothe 2010	USA	Text and Opinion	Describe how a fall scene investigation (FSI) as a performance improvement strategy to prevent falls enhances patient safety and quality of care.	Hospital patients	Multifactorial intervention	Fall scene investigation (FSI) approach - analyse each fall (with the aid of a documentation tool) and implement new initiatives to avoid future falls.	Using the FSI approach has resulted in the nursing staff beginning to take a proactive rather than reactive approach to fall prevention. 11% reduction in falls that year.
Dean 2012	UK	Text and Opinion	To discuss the FallSafe project aimed at reducing falls in inpatients settings.	Aimed at hospital patients	Multifactorial intervention	Care bundles gradually implemented in practice, consisting of: a basic care bundle (ask about falls history and fear of falling, check if footwear is safe, call bell in reach and able to use, clear communication of mobility status, personal items in reach, walking aids are in reach, check for new night sedation, cognitive screen if aged over 70 years. check use/not use of bedrails, no trip or slip hazards) and second-level bundle (Delirium screen, medication review, UTI test, continence assessment/toilet, offering routine, supine and standing blood pressure, manual pulse for arrhythmias, review for medical causes and osteoporosis, physiotherapy and occupational therapy review, eyesight basic screen, depression screen, bed in optimal position (observable bay or nearer a toilet)).	The author reports that following implementation of the FallSafe project there was an average 25% decrease in falls across the participating wards, as reported by the Health Foundation. High staff turnover and number of temporary staff was highlighted as a challenge in the project.

Pond 2017	USA	Text and Opinion	Opinion on falls prevention program and case study	Inpatients	Multifactorial intervention	Use of the Morse scale, individual care plans, and post-fall debriefings.	Decrease in the number of falls and a reduction in the severity of injury when falls do occur. Authors suggest that an all-staff approach to quality care inspires greater buy-in and participation, which fosters best-practice outcomes.
Sweeting 1994	UK	Text and Opinion	Description of strategy for falls prevention in elderly patients	All staff & elderly patients	Multifactorial intervention	Fall risk assessment; Coloured wristbands; Staff training; Resource packs on wards; Patient & visitor leaflets	Decreased number of falls
Swift 2014	UK	Text and Opinion	Overview of NICE guidelines	N/A	Multifactorial intervention	Do not use fall risk prediction tools - consider older patients to be at risk; Do use multifactorial falls assessment & interventions that are tailored to individual needs	Individually tailored multifactorial risk assessment & intervention recommended for preventing in-patient falls
Avanecean 2017	USA	Review - Systematic	To evaluate the effectiveness of patient-centred interventions on falls in the acute care setting.	Included all adults admitted to medical or surgical acute care units for any condition or illness	Multifactorial interventions	Review focused on RCT studies of patient-centred intervention strategies to reduce falls (compared to usual care)	Of the five identified studies, three studies showed significant reduction in fall rates; and involved personalised care plans and patient centred education based on their assessed fall risk.
Kitson 2014	Australia	Audit	To perform a clinical audit to assess current compliance with identified best practice falls prevention strategies and implement strategies to reduce falls rate.	Hospital patients admitted for general medicine or general surgery	N/A	Four phases of auditing took place. Audit criteria included completion of fall risk assessments, reassessment, staff and patient education, implementation of targeted interventions.	There was improvement in compliance with audit criteria from the first to last phase of audit.
Bemis-Dougherty 2008	USA	Other	Educational series aimed at presenting issues relating to patient falls in the inpatient setting.	Aimed at older inpatients	N/A	Discussed several interventions: patient & family education, staff education, individualised interventions, bed/chair alarms, hip protectors, patient risk identification (colour bands), exercise, restraints/bedrail.	A multifactorial and multifaceted intervention is recommended. Physiotherapists' role is highlighted as being important for fall prevention.
Mitchell 2018	Australia	Other	To map the resource allocation across a partnership of large health services, to	Health service staff	N/A	Cross-sectional survey of fall prevention activities and associated costs in hospitals from six health services in Australia. Cost of illness approach used and data collected at semi-structured interviews (asking the amount of time spent on each fall prevention activity and how frequently).	Physiotherapy treatments had the highest proportion of spending in fall prevention (18%) with continuous observers or sitters being second (14%). The total estimated cost over six health services was $46,478,014 a year. Authors conclude that hospitals are spending money on strategies that have little evidence of

			understand the amount and variability of resource allocation to various falls prevention activities.			Interventions included physiotherapy; continuous observers; fall assessment by non-nurses; fall prevention alarms; nursing risk screening; patient education; moving patients to higher visibility area; occupational therapy for fall prevention (written in order of cost allocation).	effectiveness and they should consider targeting interventions with stronger evidence base.
Carroll 2010	USA	Qualitative study	To explore patients' experience of a fall and discuss ways of preventing falls in acute care hospitals.	Hospital patients within 48hrs of falling	N/A	Patients who fell were interviewed (semi-structured), within 48hrs post fall, regarding their fall experience, injury, being informed or not about their fall risk, and their thoughts on fall prevention methods.	The need to toilet coupled with loss of balance and unexpected weakness were the main reasons for falling. Patients identified that they wanted to be more involved in their fall prevention strategy. Authors highlight need for nurses to clarify that patients are not 'bothering' them when they call for help.
Dykes 2009	USA	Qualitative study	Record views of nurses and assistants as to why patients in acute care hospitals fall.	Nursing and assistance staff from different hospital settings but in the same hospital system.	N/A	Focus group interviews were performed to gain opinions on fall prevention.	Authors summarise nurses and assistant views and insight on fall prevention with some future recommendations for practice.
Lee 2013	Australia	Qualitative study	To describe the sources of falls prevention information provided to older adults during and after hospitalization, identify and explore reasons why discussion about falls prevention may not take place	Older adults + caregivers	N/A	Extensive number of interventions discussed	Findings showed provision of falls prevention information was dependent on setting of the ward and which health professionals the older adult encountered during and after hospitalization. Great potential to improve consistency of falls prevention information provision to older adults during hospitalization and in preparation for discharge.
Lim 2018	Singapore	Qualitative study	To explore the experiences of patients who had fallen in hospital and their perspectives towards fall prevention in the acute care setting.	Adult inpatients	N/A	N/A	Patients downplayed their risks of falling. Patients were reluctant to call for help, which was influenced by perceptions of nurses being busy or unapproachable. Many did not remember the fall prevention advice given. Therefore, it is important to constantly remind the patients of their fall risk, reorientate them to the fall prevention measures, and reassure them that the nurses are there to help.

Salem 2015	Saudi Arabia	Qualitative study	To explore the medical and public opinion about the Jana's Bed Belt for high risk fall patients	medical staff and public participants from local hospitals and universities	N/A	No intervention applied. Study participants were questioned on their opinions regarding the use of a Jana's Bed Belt for patients/individuals at high risk of falling in long-term stay and wards in hospitals to prevent falls. A short 3 question yes/no questionnaire was used.	Most of the participants gave the opinion that they would be willing to use the belt (78%) and did not see it as a restraint (81%) and almost all medical staff (97%) would recommend it for their patients.
Demontiero 2014	Australia	Review - Narrative	To review evidence relating to postoperative prevention of falls in older adults with fragility fractures.	Aimed at hospital patients	N/A	Extensive number of technologies reviewed & discussed in relation to post-operative falls prevention.	Authors conclude that falls risk assessment should be common practice in the pre and post-operative periods and suggest areas of focus for interventions targeting secondary fracture prevention.
Healey 2012	UK	Review - Narrative	To discuss organizational culture & processes that can increase the effectiveness of falls prevention. To present learning from quality improvement projects.	N/A	N/A	Extensive number of interventions discussed	Commitment to improve falls prevention is often high in frontline staff, who are motivated by repeatedly observing the harm and distress falls cause to patients and their relatives. However, without central support systems in place to deliver evidence-based policy, protocols, training, expertise, equipment and support, their efforts are unlikely to be effective. Effective falls prevention cannot be delivered by any single professional group working in isolation, but requires genuine multidisciplinary collaboration to develop local policy and practice.
Hendrich 1988	USA	Review - Narrative	Review of falls prevention and overview of one unit-based fall prevention plan	Not specified	N/A	High-risk fall protocol plan consisting of: Identification of at-risk patients; use of restraints; education of patients, families & staff; development of nursing standards	Nurses can have a major role to play in decreasing cost and improving quality of care in healthcare facilities.
MacCulloch 2007	USA	Review - Narrative	Review of fall prevention and management literature	N/A	N/A	Extensive number of interventions discussed	To make progress toward fall and injury prevention across settings, health care organizations, consumer groups, legislators and other stakeholders must collaborate on local, regional and national levels to identify potential interventions to reduce falls. Evidence that fall risk assessment and comprehensive, multidimensional fall prevention programs are effective in reducing falls and injuries already exists, and effective prevention programs are likely to result in lower total health

							care costs. An aggressive public policy agenda to reduce the number of injurious falls should be pursued, given the high human cost of falls and hip fractures.
MacIntosh 2007	UK	Review - Narrative	Review of risk factors, risk assessment tools & falls management	N/A	N/A	Extensive number of interventions discussed	Need for UK-wide guidelines to be developed and implemented
Malik 2012	USA	Review - Narrative	Focus on older adults with mental health problems.	Older adults with mental health problems	N/A	Extensive number of interventions discussed	When mental health problems are coupled with decreased or limited mobility, patients are at high risk for falls. Initiating fall prevention measures is a collaborative effort. Elements to be considered: risk assessment, vitamin/calcium supplementation, hourly rounding, technology inclusion
McNamara 2011	USA	Review - Narrative	Narrative review on reducing falls in surgical wards	N/A	N/A	Extensive number of interventions discussed	A true culture of safety requires members of an organization to be willing to remain current on evidence-based practices and research, promote learning, and help colleagues create a responsible, accountable environment that encourages everyone to freely report errors without fear of negative consequences. A just safety culture helps ensure safety for patients and caregivers
Nelson 2004	USA	Review - Narrative	To describe new technologies that are designed to help prevent adverse events in the functional domain of mobility	N/A	N/A	Extensive number of interventions discussed	Technology offers the potential to eliminate or mitigate preventable adverse events that interfere with treatment, delay rehabilitation, potentiate impairment, and compromise patient safety.

Quigley 2013	USA	Review - Narrative	To showcase the components of a patient safety culture and the integration of these components with fall prevention.	N/A	N/A	Extensive number of interventions discussed	Measurement systems utilized for performance remains at the aggregate level, not affording precise evaluation of program changes and measurement. The authors assert that measurement must change by setting up program evaluation that examines organizational, unit, and patient level data. A model is proposed.
Quigley 2016	USA	Review - Narrative	To apply level of evidence rating scales to identify the best practice interventions to prevent falls on rehabilitation units.	Inpatients in rehabilitation settings	N/A	A review of interventions for fall prevention including the following: fall risk screening; sitters; bed/chair alarms; signage for falls risk; floor mats; hip protectors.	Authors highlight the difference between risk screening and patient assessment and the need for both to be performed. Using only evidence-based practice is encouraged. There is little evidence for sitters reducing fall risk but they can prevent harm if present. The linking of bed/chair alarms to fall risk is questioned. Signage of fall risk does not appear to differentiate care. Floor mats and hip protectors are identified as low cost and low risk methods of protecting patients from injury.
Rutledge 1998	USA	Review - Narrative	To synthesize scientifically based assessments and recommendations on fall risk assessment and fall prevention in healthcare facilities and discuss implementation strategies from specific research-based practice innovations.	Not specified	N/A	No intervention applied. Detailed descriptions and reliability/validity of the following fall risk assessment tools are presented: Morse Fall Scale (MFS); Schmid Fall Risk Assessment Tool (RAT); Hendrich Fall Risk Model (HFRM); Downton Fall Risk Index. The following interventions are discussed: risk ID bracelets; post-fall assessment; fall risk assessment with implementation of nursing care protocols; alarm devices; hip protection; rest stop (chair mid-way between walk from bed to toilet); toileting rounds; area redesign. Different strategies for implementation and safety culture change are also discussed.	Authors highlight the benefit of using standardised evidence-based falls risk tools and proper training to improve their effectiveness. Identifying patients at risk of falling and collecting good quality data for continual assessment of falls/injury rates are noted as important to any fall prevention programme. Targeted interventions tailored to the patient group (and their underlying causes for falls) and clinical setting are encouraged.
Spoelstra 2012	USA	Review - Narrative	Review of fall prevention interventions	Adults	N/A	Extensive number of interventions discussed	Multifactorial interventions most effective. Effective studies included some or all of: Developing safety culture; fall-risk assessment; multifactorial interventions; post fall follow-up & QI; integration with electronic records

Khosravi 2016	Australia	Review - Systematic	Effectiveness of technologies applied to assist seniors – including sensors for falls risk	Older adults	N/A	Sensor technology to alert patients & caregivers about falls & other behaviours indicating falls risk	Reduction in falls rate & cost saving compared to sitters.
Matarese 2014	Italy	Review - Systematic	To identify the most accurate fall risk screening tool(s) for older inpatients (65 years of age and over) at risk of falling in acute care settings.	Adult inpatients aged 65+	N/A	Reviewed falls risk assessment tools, including the following: St. Thomas Risk Assessment Tool in Falling elderly inpatients (STRATIFY); Hendrich Fall Risk Model; Conley Scale.	There was no strong evidence for the use of one risk screening tool over another in older patients and no tool was specifically designed for older patients. STRATIFY and Hendrik II-FRM were used most commonly, however both had inadequate predictive accuracy. The authors suggest that risk-screening tools should be designed with the specific population and setting in mind and used in conjunction with clinical assessment.
Oliver 2007	UK	Review - Systematic	To evaluate the evidence for strategies to prevent falls or fractures in residential care and hospitals and to investigate the effect of dementia and cognitive impairment.	Inpatients (hospital & care homes)	N/A	Multiple interventions including risk assessment; risk factor assessment; care planning; medical/diagnostic approaches; changes in the physical environment; education; medication review, hip protectors; removal of physical restraints; exercise.	There was evidence for modest reductions in rates of falls in hospital patients with multifaceted interventions, however the evidence for single interventions was insufficient. The potential effect of dementia was difficult to measure as very few studies reported on this, although it is highly prevalent in participants.
Rimland 2016	Italy	Review - Systematic	To systematically examine reviews and meta-analyses evaluating non-pharmacological interventions to prevent falls in older adults in the community, care facilities and hospitals.	Review includes older adults in the community, care facilities and hospitals.	N/A	No intervention applied. This study is part of the ONTOP (Optimal Evidence-Based Non-drug Therapies in Older People) project, a work-package of a European Union funded FP7 research project named SENATOR (Software ENgine for the Assessment & Optimization of drug and non-drug Therapy in Older peRsons). An overwiew of systematic reviews, including at least one comparative study, was performe. The following interventions were reported: exercise (gait, balance, functional training, strength/resistance training, flexibility, 3D (Tai Chi), general physical activity, endurance or other), surgery, management of urinary incontinence, fluid or nutrition therapy,	Multifactorial interventions appeared to be the most commonly effective interventions, including reducing falls in hopsitals. Exercise was the most frequently reported intervention, either in combination with others or alone, and was very effective in community and had some positive results in hospital. Enviromental modifications only worked in higher risk patients. Management of urinary incontinence might have some effect of fall numbers in hospital.

						psychological, environment/assistive technology (inc. low beds, walking aids, hip protectors, identification bracelets, vision assessment/correction, bed alarms and footwear), social environment (staff training), knowledge and other.	
Zhao 2019	USA	Text & Opinion	To provide clinical implications and recommendations for adult inpatient fall and injurious fall prevention through a brief review of factors associated with falls and injurious falls and current fall prevention practices in acute care hospitals.	N/A	N/A	Discusses a variety of interventions from the following categories: environmental, educational, communicational, nursing process, fall risk assessment.	Complicated phenomenon. Recommends the following: Multicomponent prevention and valid assessment under strong leadership. Frontline staff should be involved in the development & implementation of interventions. Staff education & appropriate staffing are vital. .
Gustafson 2007	USA	Text and Opinion	To give advice on performing a fall risk assessment and providing interventions for adult patients at risk of falls.	NA (advice for adult patient)	N/A	The following options are listed: fall risk ID (eg. wristband); physical and occupational therapy; speech consult; medical review; low bed; call bell within reach and reminders about call bell use; room lighting optimal; sitter; bed alarm; frequent rounding; nonslip footwear; adaptive equipment (mobility aids, hip protectors, a bedside commode, cushioned floor pads.); rooms free from clutter; supervision of high risk patients in bathroom and treatment areas.	Recommendations are given with regards to performing a risk assessment and potential interventions. Furthermore, nursing staff are encouraged to take a proactive approach to fall prevention and advice is given on how to accomplish that.

Lloyd 2011	USA	Text and Opinion	To demonstrate how evidence can be used to build a multi-intervention fall-prevention program	N/A	N/A	Extensive number of interventions discussed	The evidence in the literature indicates that programs tailored to the needs of patient population have more impact on fall incidence than general programs, this holds especially true for high-risk units. Staff awareness and ongoing education regarding falls appear to facilitate the most change. However, because falls are best addressed through a multifactorial approach, physical environment and physical status cannot be overlooked. Interventions must be created that encompass all facets of care and ways must be sought to overcome barriers to implementation
Rimland 2017	Italy	Text and Opinion	To develop clinical recommendations for non-pharmacological interventions to prevent falls in older adults based on published evidence gathered in a systematic overview of reviews.	NA (studies involved older adults)	N/A	To provide recommendations a clinical question was formulated by an expert group for each single component intervention identified from a previous overview review. A summary of findings was created and the expert panel commented on these and recommendation was considered.	45 clinical questions and responses were formulated; 8 of which were presented here as they had strong recommendations and moderate-quality evidence. The authors recommend the use of multifactorial interventions (exercise, medication review, management of urinary incontinence, fluid or nutritional therapy, environment/assistive technology, social environment, knowledge and ophthalmology referral) to reduce falls in older adults (aged 65+) in hospital.
Ross 2012	USA	Text and Opinion	An overview article of falls incidence, prevalence and impact in a rehabilitation setting which also identifies key factors for assessing falls risk and potential strategies to reduce risks.	Aimed at patients in rehabilitation facilities	N/A	No intervention applied. Authors comment on the following interventions: assessment for risk of falling from physical examination and assessing medical history; pre-bedtime toileting; patient/family education; multidisciplinary rounds; activities in common areas; medication review for high-fall risk medications; blood pressure and HR check; environmental modifications (low bed with brakes; night light; clean up spills; remove clutter; call bell, glasses, dentures within reach); adequate staffing for highest fall risk; anti-slip socks/footwear; single physician in charge of prescribing medication in patient record; limit restraint use; bed/chair alarms; visual cues; treating orthostatic hypotension; hip protectors; exercise and ADL training; assistive devices.	Authors discuss risk factors specific to patients in rehabilitation facilities and suggest a variety of interventions which can be implemented. No specific conclusions.

Emory 2011	USA	Before-after design	To examine the feasibility of implementing a daily exercise programme with addition of line dancing in an adult general psychiatric inpatient setting and potential impact on fall rates.	Patients admitted to the hospital during the 6 months prior to and during the project	Other	40 minutes of line dancing was introduced to the already existing daily 'varied exercise programme' in the unit.	The introduction of line dancing to a daily exercise programme had a reduced percentage of patients falling, although the fall rate was not significantly different. Authors suggest their sample size was too small to detect an effect. The programme was accessed by 68% of patients with the only barriers to participation being other medical appointments or religious beliefs.
Haumschild 2003	USA	Before-after design	To compare the number of patient falls in elderly patients before and after pharmaceutical interventions; identify cost saving as a result of fall reduction; and to determine whether specific medication classes are related to falls in the elderly.	Adult patients aged 65+ with one of the following diagnoses: orthopaedic, respiratory, neurology, infection, cardiovascular.	Other	Pharmaceutical intervention developed using the American Society of Consultant Pharmacists' MDS-Med Guide. Full medication review by pharmacist (including any medications causing adverse effects or clinical condition listed in a table for review by pharmacist, nurse and physician). Recommendations for dosage, reduction and frequency and precautions for drug administration given to nurses and immediately implemented.	A complete pharmaceutical review of medications resulted in a 47% reduction in falls (30 falls down to 16). This reduction would equate to a saving of $308,000 per year or $25,667 a month on fall related costs. Reductions in cardiovascular drugs, analgesics and psychoactive medication resulted in reductions in falls.
Murphy 2015	USA	Before-after design	To determine the effectiveness of the Falls Roundtable intervention as a standalone performance-improvement tool for reducing the rate of falls in an urban academic trauma center emergency department.	Patients from an emergency department	Other	The Falls Roundtable intervention involves an interprofessional weekly meeting to review all patient falls having occurred that week. The type and nature of falls were classified and where deemed preventable further intervention recommendations were made.	The introduction of an interdisciplinary falls roundtable intervention did not significantly affect the number or rate of falls, although a decreasing trend was present. Authors highlight the differences between emergency departments and other units in relation to fall prevention and barriers to fall prevention which could be addressed.

Nuckols 2017	USA	Before-after design	To evaluate the clinical effectiveness and incremental net cost of a fall prevention intervention that involved hourly rounding by registered nurses at 2 hospitals.	Adult inpatients	Other	Hourly rounding by nurses, involving regular individualised patient assessments and responding to any new findings. Nurses used the '5P' method (assessing pain, personal needs, patient's position, preventing falls and placement of items within reach). Additionally, training in thinking critically about falls risk, via videos of scenarios. Nursing unit directors oversaw implementation of rounding via morning huddles.	The introduction of hourly nursing rounds was associated with a significant decline in fall rate in one hospital but a non-significant decline in the other. Nurses at both hospitals spent less time on fall-related activities after as compared with before the intervention which equated to substantial cost savings.
Knight 2010	USA	Cohort (prospective)	Quality improvement initiative for falls in nonelderly psychiatric patients	Adults	Other	Medication review & enhanced monitoring of patients	Falls risk awareness among staff increased. Tachycardia may be a risk factor in psychiatric patients – further study required
Bhandari 2010	Canada	Cohort study (Prospective)	Development of a symbiotic simulation decision support system for use in preventing patient falls in hospitals.	Elderly patients in small rural hospital	Other	Decision support system that takes into account many factors including falls, staffing, time of day and nurses speed/ability of response to patient call, to help make decisions about staffing levels, patient positioning in relation to nurses stations and general falls management approach to reduce falls.	Fall rates remain consistently lower than published rates after the hospital successfully implemented a falls management approach.
Browne 2014	Ireland	Cohort study (Prospective)	To implement a falls prevention programme focused on medication review by a pharmacist in an acute hospital and to evaluate the scope to dose reduce, discontinue or switch falls risk medicines to safer alternatives.	Patients from general medical and from care of the elderly wards, with a STRATIFY score of two or more	Other	Medication review with a clinical pharmacist focused on fall prevention, specifically to minimise use of medicines associated with falls.	Identifying medicines associated with falls was straightforward however switching to safer alternatives proved challenging. Authors suggest scope for further research.
Grenier-Sennelier 2002	France	Cohort study (Prospective)	To evaluate the effects of continuous quality improvement on	Hospital staff and patients	Other	A continuous quality improvement project was performed, first performing an assessment of falls in the hospital and then taking a multidisciplinary approach to developing and implementing fall prevention	Authors make recommendations for extending an existing continuous quality improvement strategy for designing and implementing a fall prevention programme.

			fall prevention strategies in hospital.			recommendations (which are not detailed in the paper).	
Lee 2016	Korea	Cohort study (Prospective)	To develop and validate an automated fall risk assessment system (Auto-FallRAS) to assess fall risks based on electronic medical records	In patients	Other	Auto-FallRAS was developed using 4211 fall-related clinical data extracted from electronic medical records	Auto-FallRAS results were better than were the nurses' predictions
Potter 2016	USA	Cohort study (Prospective)	To assess the ability of a depth-sensor system to capture inpatient fall events within patient hospital rooms.	Inpatients	Other	Sensor	A total of 16 falls involving 13 patients were recorded by depth sensors. Nurses had less than two minutes from the time a patient began to exit a bed to the time a fall occurred. Patients expressed few complaints with depth sensors installed in rooms
Potter 2017	USA	Cohort study (Prospective)	Combined depth and bed sensor system designed to assign patient fall probability, detect patient bed exits, and subsequently prevent falls was evaluated.	Inpatients	Other	Kinect depth sensor computes fall risk probability, sends text alerts when patient exits bed, captures actual falls & sends text alerts to staff when falls occur. Computes timed up & go score each time patient walks. Hydraulic bed sensor placed under mattress.	Statistically significant reduction in fall rate. Sensor technology is a viable fall prevention option.
Van Der 2006	netherlands	Cohort study (Prospective)	Renewed effort to implement a nursing falls prevention guideline previously developed in 1993 which had a poor uptake in hospital	All nurses on both wards	Other	Re-introduction of nursing falls prevention guideline. Barriers to implementation identified and steps to resolve them implemented. Implementation of guideline then evaluated	Implementation of falls prevention guidelines requires an implementation strategy but may still not result in guaranteed success.

Lindsay 2004	Australia	Cohort study Retrospective	To evaluate the ability of the Timed Up and Go Test to predict those older people who will fall whilst admitted to an acute hospital.	Inpatients	Other	Timed Up and Go Test	The Timed Up and Go Test, used in isolation, was unable to identify those patients who were likely to fall. However the co-morbidity of incontinence was identified as a falls risk factor
Spritzer 2015	USA	Cohort study Retrospective	Retrospective evaluation of fall prevention measures	All patients	Other	Multiple interventions evaluated	Trend to reduced fall rate with rounding, patient education, bed alarms, 2-person assistance for high risk patients & immediate post fall team review but no single intervention more effective than other. Ceiling lift system for out-of-bed use reduced falls to zero (15-months)
Van Leeuwen 2001	Australia	Cohort study Retrospective	Determine factors associated with falls from bed, in order to identify 'at risk' patient groups and circumstances conducive to such falls.	patients	Other	Retrospective review of patient incident forms	There was a patient death resulting from a fall from bed over elevated bedrails was considered to be of particular clinical significance. Thus the role of bedrails as protective or safety devices was challenged and an urgent re-evaluation of current practices recommended.
Tzeng 2015	USA	Descriptive	Assess the feasibility of an innovative fall prevention, *I engaging*, to engage participants in their own falls prevention care during hospital stays	Five in-patients - from 1 adult subacute stroke rehabilitation inpatient care unit of a rehabilitation hospital.	Other	*i Engaging* is a Web-based software application for use on any type of PC, Apple computer device, or smartphone at the bedside to engage patients to take an active role in fall prevention during hospitalization. Helps patients understand factors contributing to falls and helps them make decisions to decrease their fall risk	Well perceived by adults 65 years of age or older and health care providers as being easy to use, effective, and practical

Spetz 2015	USA	Economic evaluation	Assess cost-savings associated with implementing nursing approaches to preventing falls	Adult in-patients	Other	Sitters; bed exit monitors; multidisciplinary integrated programme; patient education	Falls prevention programmes can reduce treatment costs but in many scenarios costs greater than potential cost savings. Falls prevention programmes need to be carefully targeted to highest risk patients
Majumder 2013	USA	Emerging technology development	Smartphone-based fall prevention system that can alert the user about their abnormal walking pattern.	N/A	Other	Phone based sensor	Our system uses a gait analysis approach that couples cycle detection with feature extraction to detect gait abnormality. Potentially useful for community-dwelling – possibly ambulatory care.
Masuda 2002	Japan	Emerging technology development	Description of a monitoring system,that includes a step sensor, a wandering alarm and floor lighting.	N/A	Other	Sensors	The system was operated without any trouble. Wandering in each subject was detected 30 times in total. In any detection, wandering is successfully alarmed to the caregiver and treat properly.
Rantz 2014	USA	Emerging technology development	To test the implementation of a fall detection and “rewind” privacy protecting technique using the Microsoft® Kinect™ to not only detect but prevent falls from occurring in hospitalized patients.	Adult inpatients	Other	Kinect depth camera in patient rooms, logging data continuously	During pilot study, falls were detected at acceptable false positive rate, supporting ongoing deployment of Kinect sensors for fall detection.
Takanokura 2016	Japan	Emerging technology development	Development of MEMS system (micro-electro-mechanical-system) for falls detection & prevention that could be applied in hospital setting	Healthy young males	Other	Microcomputer & sensing devices; Force resistance sensors on bed & passive infra-red sensors under bed & in front of door (	Could be used in hospital setting - more research required

Carroll 2012	USA	Historically controlled trial	To evaluate the effectiveness of an electronic fall prevention toolkit for promoting documentation of fall risk status and fall prevention interventions.	Adult inpatients	Other	Reviewed records from intervention hospitals which received the Fall TIPS (Translating Interventions for Patient Safety) prevention toolkit. This uses the Morse Fall Scale (MFS) and provides fall prevention decision support, communication at the point of care and nursing documentation. Control group had usual care.	Fall TIPS system facilitated better documentation of a fall prevention plan of care.
Teh 2018	Australia	Mixed methods	To evaluate clinicians' perspectives, before and after clinical implementation (i.e. trial) of a handheld health information technology tool for falls risk assessment and prevention in hospital.	Staff on geriatric & acute medical units	Other	Handheld health information technology (HIT) tool, incorporating an iPad device and automatically generated visual cues for bedside display. Staff education on tool use.	Staff willing to use the tool.
Williams 2014	USA	Mixed Methods	To increase our understanding of falls by identifying factors associated with falls, with and without harm.	Patients in Academic medical centres entered into database after fall	Other	Multiple technologies: bed in low position (68%), patient education (60%), fall alerts in place (47%), toileting schedule (33%), bed exit alarm (18%), medication modified (5%), and chair exit alarm (3%).	Large analysis of patient falls provides useful information on fall risks and gaps in fall risk assessments and prevention practices
Xu 2015	Singapore	Mixed Methods	A systematic review of falls risk assessment tools then a care bundle for fall prevention in a tertiary psychiatric hospital would be implemented,		Other	SR previously reported (Xu CQ, Tan XN, Loh HS, Yip WT, Tan JM, Premarani K, et al. Effectiveness of interventions for the assessment and prevention of falls in adult psychiatric patients: A systematic review. JBI Library Syst Rev 2011;9:387-403.). universal falls prevention suggested from results of SR = falls risk assessment, orientation of patient to surroundings, provision of safe environment, non-skid footwear, patient and family education on falls prevention, medication review, flagging system for patients at risk of fall	Results of SR previously reported informing content for falls prevention package
Shever 2008	USA	Observational	Determine the cost of	Over 60's	Other	Nursing surveillance	$191 more for high surveillance - might be supported if evidence of clinical benefit

			surveillance for older hospitalized patients at risk of falling				
Dowding 2012	USA	Other	To examine the impact of KP HealthConnect, an electronic health record system, implementation on nursing care process and outcome measures in hospitals in South California.	Kaiser Permanente associated hospitals in the North and South California region	Other	An electronic health record (HER) system called KP HealthConnect was implemented across 29 hospitals. The system includes computerized physician order entry; computerized decision support; communication and documentation of all inpatient and outpatient laboratory, pharmacy, and clinical care activities. A secure patient portal allows member to view parts of their record and securely email service providers, order repeat prescriptions and book appointments.	No changes in fall rates at hospitals following the implementation of an electronic health record system KP HealthConnect. Completion of risk assessment for falls did not change although documentation of falls improved. Identify need for further research on this.
Hubscher 2011	Germany	Other	To investigate the relative slip resistance of commercially available non-slip socks during gait.	Twenty-four healthy subjects	Other	Assess slip resistance of non-slip socks	Non-slip socks improved slip-resistance during gait when compared to conventional socks and slippers. Future investigations should verify the present findings in hospital populations prone to slip-related falls
Hurley 2009	USA	Other	To describe the development and validation of a set of icons to be used to translate and communicate falls risk status, and tailored interventions to prevent falls.	Health professionals and assistants (mostly nurses)	Other	As part of the larger Fall TIPS (Tailoring Interventions for Patient Safety) initiative a set of 17 icons, representing fall risks and interventions, were developed and assessed by endpoint users (professionals and assistants, mostly nurses).Risk areas taken from the Morse Fall Scale	Set of icons developed for communicating alerts that can be understood by all stakeholders.
McCabe 2011	USA	Other	To examine the perceptions regarding physical restraint use among registered nurses and nursing assistants.	Nurses and nursing assistants	Other	Restraints	Nurses and assistants had an overall neutral perception regarding restraints. Both RNs and NAs identified treatment interference as the most important reason for restraining a patient and substituting of restraints for staff as the least important reason.

Morello 2017	Australia	Other	This study examined implementation fidelity of the 6-PACK program during a large multi-site RCT.	Inpatients	Other	Adherence indicators were: 1) falls-risk tool completion; and for patients classified as high-risk, provision of 2) a 'Falls alert' sign; and 3) at least one additional 6-PACK intervention. Organizational support indicators were: 1) Provision of resources (executive sponsorship, site clinical leaders and equipment); 2) implementation activities (modification of patient care plans; training; implementation tailoring; audits, reminders and feedback; and provision of data); and 3) program acceptability. Data were collected from daily bedside observation, medical records, resource utilization diaries and nurse surveys.	Implementation fidelity variable across wards, but overall acceptable during RCT.
Nawaz 2015	Italy	Other	To evaluate health care professionals user experience of a fall risk assessment tool.	Healthcare staff	Other	Development of computer algorithm.	Suggested that tool should be simplified and integrated with patients records better
Shever 2011	USA	Other	To describe nursing practices around fall prevention as percived by nurse managers	Nurse managers	Other	Extensive number of interventions discussed	Interventions used (most common first): bed alarms; Rounds; Sitters; Relocation of patients closer to nurses' station; Sign identifying fall risk; Low bed; Wrist band; Siderails down; Physical restraint; Increased monitoring/surveillance; Call-light within reach; Non-skid slippers; Referral to pharmacy; Referral to physical therapy; Personal items within reach; Ambulation
Stubbs 2015	UK	Other	Conduct umbrella review of meta-analyses on falls prevention interventions in hospitals & long-term care facilities	Older adults, aged 60+	Other	Extensive number of interventions discussed	Only 2/10 meta-analyses were on hospital settings. Evidence that multifactorial interventions reduce falls in hospital setting. Need for further research.
Tucker 2012	USA	Other	feasibility of structured nursing round interventions for falls prevention	Adults undergoing orthopaedic surgery	Other	Structured Nursing Rounds	Variable fidelity of intervention & barriers ot implementation
Tzeng 2014	USA	Other	Describe / *engaging* falls	N/A	Other	Web-based software application to use at the bedside to engage patients in their own	Free web-based application available (see paper). Needs to be tested in clinical trials.

			prevention intervention – early prototype version			falls prevention. Included features: (i) falls risk assessment, (ii) patient-selected interventions to address each risk factor, (iii) individualized falls prevention plan, which can be printed	
Vassallo 2005	UK	Other	to explore attitudes to restraint and what are acceptable fall prevention measures in hospital	100 patients/relatives and 100 care professionals	Other	Structured questionnaire among patients, relatives and health care professionals. The questionnaire was developed in association with the Dorset Research and Development Support Unit. Psychometric principals were used. Each question involved an attitudinal statement followed by a 5-point Likert scale to assess the degree of agreement with the statement. Strong disagreement scored 1 point while strong agreement scored 5. A number of questions were stated with reversed meaning and scoring was reversed. Strong disagreement was placed on the left to counteract ordinal bias	Identified a wide range of opinion about measures currently defined as restraint, and how acceptable they are. Measures strongly thought of as restraint, such as direct binding or tranquilliser use, were considered unacceptable. Conversely, measures not widely thought of as restraint such as observation beds, ID bracelets or bed or chair alarms were acceptable. There were also a number of measures, such as furniture changes or nursing patients on the floor, where such an observation was not clear. Significant differences in opinions between patients/relatives and care professionals have been identified in the perception of restraint.
Gallinagh 2001	Ireland	Qualitative study	To explore the perceptions of relatives whose family had side rails used during their care in an older person ward.	Family (sibling, spouse/partner or off-spring) of patients in elderly care ward who were provided with side rails.	Other	Families' perceptions of the use of side rails (cot sides and bed rails). Simplified version of the Family interview guide used to gain perceptions.	There were mixed perceptions towards side rail use. Most comments were relating to their perceived safety and usefulness rather than real past events. Some negativity was expressed in terms of freedom and comfort and suggestions made.
Horan 2014	Ireland	Qualitative study	A pilot of Alert Charts was performed to identify potential fallers and improve communication within the multi-disciplinary team, families and patients.	Elderly patients	Other	Alert Charts, giving a clear instruction of the level of assistance required for transfers and mobility of individual patients, were piloted (unclear where they were placed).	Alert Charts that display individual patients' requirement for transfer and mobility assistance was found to be easy to use and an excellent form of communication by staff. Suggestions for improvement were made and new charts are being trialled on other units.
Shuman 2016	USA	Qualitative study	explore patients' perceptions of falls prevention interventions	in-patients aged 60+	Other	Extensive number of interventions discussed	Healthcare providers need to more fully engage patients & families in understanding fall prevention strategies
Tzeng 2011	USA	Qualitative study	feasibility of providing folding commode chair in patient bathrooms for preventing falls	Hospital staff	Other	Equipment - folding commode chair	Folding chair useful/feasible & appropriate as part of multifactorial falls prevention intervention

Tzeng 2012	USA	Qualitative study	Explore nursing staff's perceptions of usefulness of bed-height alert system	registered nurses & patient care assistants	Other	bed height alert system	Nursing staff were aware of the need to keep bed at lowest height for preventing falls
Silkworth 2016	USA	Quality Improvement	Enhance patient & family participation in fall prevention	In-patients	Other	Video for patients & families	Fall rate reduced by 29.4% but confounding factors present - hospital on Magnet journey & other fall prevention interventions implemented at same time
Padula 2011	USA	Quasi-experimental (non-randomised)	To examine the impact of lower extremity strengthening exercises and mobility on fall rates and fall rates with injury.	Inpatients.	Other	The physical therapy department collaborated to develop an exercise “menu” targeted at lower extremity strengthening. A series of easy, moderate, and difficult lower extremity exercises were identified, with 4 exercises in each series. On the 2 control units, all patients received the existing standard of care, which included the GENESIS mobility protocol, without the lower extremity strengthening exercises.	Possible benefit of lower extremity exercises combined with mobility demonstrated. Further work required.
Burleigh 2007	UK	RCT	To determine whether Vitamin D supplementation is effective in reducing fall number in older hospital inpatients.	Patients admitted to general assessment and rehabilitation in the acute geriatric unit. Aged 65+	Other	Supplementation with 800 iu cholecalciferol (Vitamin D) and 1,200 mg of calcium carbonate once daily	Supplementation with Vitamin D and Calcium did not result in a decrease in falls. Authors suggest this may be due to the short treatment period and insufficient participant numbers.
deMorton 2007	Australia	RCT	To examine the effects of additional exercise on hospital and patient outcomes for acutely-hospitalised older medical patients.	Patients aged 65+, with a general medical condition, admitted to acute care hospital	Other	In addition to usual care, intervention group received exercise individually tailored by a physiotherapist, lasting 20-30 minutes, twice a day throughout their hospital stay. Exercise targeted upper limb, lower limb and trunk.	No significant differences between the number of falls in control and intervention groups following an exercise intervention. Authors suggest that the inclusion of more physiotherapy care as standard in many hospitals may have precluded the effect associated with additional exercise.
Donald 2000	UK	RCT	To compare two flooring types and two modes of physiotherapy in avoiding falls.	All patients admitted for rehabilitation were targeted	Other	Flooring (carpet v vinyl) and physiotherapy (conventional physiotherapy or additional exercise). A hospital-duty carpet (Flotex 200) was compared to latex vinyl floor tiling. Conventional physiotherapy, involving once	More patients fell in the carpeted group than in vinyl, favouring vinyl as being more protective against falls. Those receiving strength exercises in addition to usual physiotherapy were less likely to fall but not significantly.

						to twice daily treatment with functional therapy (e.g. transfers, walking exercises, dynamic balance) tailored to the patients was compared with specific strengthening exercises (3x10 lifts using hip flexors and ankle dorsiflexors at personal maximum weight twice daily) in addition conventional physiotherapy.	
Mayo 1994	USA	RCT	To determine whether an identification bracelet is effective in preventing falls among high-risk patients who are undergoing in-patient physical rehabilitation.	Inpatients in rehabilitation setting	Other	Identification bracelet	More falls occurred in intervention group, suggesting that the identification system was of no benefit in preventing falls among high-risk persons.
Bradley 2011	USA	Review - Narrative	To discuss falls risk, falls risk assessment and interventions to prevent falls.	N/A	Other	Discusses the following: exercise, Vitamin D supplementation, withdrawal of psychotropic medications, expedited first cataract surgery, medication review and reduction, management of orthostasis; environmental adaptation, rails, restraints, fall alert bracelets, and bed alarms.	Recommend the use of multifactorial risk assessment and interventions.
Cozart 2009	USA	Review - Narrative	To evaluate, summarise and synthesis literature on the incidence of falls and the effectiveness of preventative strategies for hospitalised elderly.	Hospitalised elderly patients	Other	Environmental changes (low-position beds, hipsters, bed/chair sensors/alarms, enclosure beds, fall T-shirts, motion detectors, video cameras, lighted grab rails, recessed flooring, non-skid shower mats, non-skid floorings and waxes, strip lighting similar to movie theatres or jet planes, bevelled edged floor mats, nonslip bathroom and shower mats, along with conventional fall-prevention modalities such as room/bedside poster, chart fall alert sticker, fall-alert bracelet, non-skid double-sided socks, non-exit side rails (raised for support), exit side rail up for support and foot rail down at all times, movable hand rail (Hemi-walker within reach), bed trapeze, and grab rails.	Authors suggest that the cost of "fall-proofing" a room is more cost effective compared to the cost of a fall.

Hignett 2010	UK	Review - Narrative	Narrative exploration of interventions for inpatient falls among the elderly with respect to the design of technology (equipment and furniture) and buildings.	N/A	Other	Multiple interventions reviewed. Including broad areas of communication (with staff/patient, call bells, signs, huddles, labels), monitoring (alarms, sitters, rounding, supervision etc), modify patient (medication, training, protection vision etc)	There are many examples of initiatives to improve communication and monitoring (systems design) and modify the patient (intrinsic factors), but there are fewer examples of building and technology design initiatives. This offers an exciting challenge to explore and design for the functional needs of this growing elderly frail and/or confused population.
Bunn 2014	UK	Review - Systematic	A systematic review to evaluate the effectiveness of fall prevention interventions for older people with mental health problems being cared for across all settings.	Older people with mental health conditions	Other	Patient assessment, non-pharmacological management plan, staff education, minimising restraint use, communication, behavioural strategies and education, written and video based intervention materials and 1-to-1 follow-up with a physiotherapist, joined up assessments by OT and dietician	Single interventions were not effective in reducing fall incidence in older people with cognitive impairment. One multifactorial intervention was identified and found a reduction in falls in people with dementia.
Cameron 2012	Australia	Review - Systematic	A systematic review to assess the effectiveness of interventions designed to reduce falls by older people in case facilities and hospitals; specifically RCTs	Older individuals (average age 65)	Other	Hospital single interventions included: exercise; medication interventions (Vitamin D and calcium supplementation); furnishing adaptations (carpeted floors, low-low beds); communication aids (colour high risk ID bracelet, bed exit alarms); staff training; service model changes (computer based fall prevention toolkit, behavioural advisory service); education. Hospital multifactorial interventions.	In relation to hospital patients, providing physiotherapy in subacute wards, patient education on falls risk and risk reduction strategies and multifactorial interventions can reduce the risk of falling.
Hartung 2017	Canada	Review - Systematic	Review the literature on the effectiveness of non-slip socks to determine if there is sufficient evidence to support their use in the prevention of	Older adults	Other	Non-slip socks as an intervention for falls prevention	The results suggested that there is inconclusive evident to support the use of non-slip socks to prevent falls among hospitalized older adults. Non-slip socks do not possess the properties of adequate footwear and have the potential to spread infection. The patient's personal footwear from home is the safest footwear option while admitted into hospital.

			falls among hospitalized older adults.				
Kosse 2013	Netherlands	Review - Systematic	Review of senor systems that prevent falls in geriatric patients	Geriatric patients	Other	Sensors	The evidence is inconsistent whether the current sensor systems can prevent falls and fall-related injuries in institutionalized elderly. Further research should focus more comprehensively on user requirements and effective ways using intelligent alarms
Lapierre 2018	Canada	Review - Systematic	Scoping review: To examine the extent and the diversity of current technologies for fall detection in older adults.	N/A	Other	Extensive number of fall detection technologies dicussed	Ten types of technologies were identified ranging from wearable to ambient sensors. Their Technology Readiness Level was low. Outcomes were typically evaluated on technological basis and in controlled environments. Few were evaluated in home settings or care units with older adults. Acceptability, implementation cost and barriers were seldom addressed. Conclusions: Further research should focus on increasing Technology Readiness Levels of fall detection technologies by testing them in real-life settings with older adults

Marques 2017	Portugal	Review - Systematic	To identify the effectiveness of the use of bedrails in preventing falls among hospitalized older adults when compared with no use of bedrails or any type of physical restraints.	Adults 65+	Other	Bedrails	There is no scientific evidence comparing the use of bedrails in preventing falls among hospitalized older adults to no use of bedrails or any type of physical restraints.
Stern 2009	Australia	Review - Systematic	Determine how effective interventions that are designed to reduce the incidence of falls in older adult patients in acute-care hospitals, when compared with standard practice or no intervention.	Older adult patients (65+) in acute-care hospitals.	Other	Extensive number of interventions included	Following may be effective: Multidisciplinary multifactorial intervention (falls risk alert card, exercise programme, education programme & use of hip protectors); 1-1 patient education package; Targeted risk factor reduction intervention
Xu 2012	Singapore	Review - Systematic	to identify the best available evidence for the effectiveness of nursing fall risk assessment tools, interventions to reduce incidence of falls, and common risk factors of adult psychiatric patients who fall	Adults (19 to 64 years) diagnosed with mental illness	Other	Evaluation of nursing fall risk assessment tools in adult psychiatric settings, and interventions, which minimised fall risk or fall rates	Evidence with regards to the effectiveness of fall risk assessment tools and prevention strategies was inconclusive. certain risk factors were found to be more commonly associated with falls in adult psychiatric patients (Level III Evidence

Bock 2017	USA	Text and Opinion	Discusses the use of sitters in hospitals and other interventions that can be used in place, commenting on effectiveness.	NA	Other	Discuss sitters; interventions related to physical care environment (unit layout, room design, room clutter, footwear, ambulatory assist devices, chair alarms, and commodes), care process (toileting needs) and safety culture; intentional rounding; decision algorithm guiding; team approach and individual needs assessment; post-fall review sessions, staff/patient education.	Suggest that the use of sitters in hospitals can be greatly reduced but only by using evidence based and individualised fall prevention approaches which take into account the patient's environment as well as patient care plans. Highlight the importance of post fall reviews as a learning experience essential for maintaining improvement of fall prevention.
Chaabane 2007	UK	Text and Opinion	To discuss issues relating to falls prevention in older adults with dementia and strategies for prevention.	Aimed at hospital patients	Other	Discusses risk assessment including balance, mobility, physical presentation, sleep patterns, falls history, medication, comprehension and co-operation, use of aids/physical interventions, diagnosis. Interventions discussed include changes to environment (quick clean-up of spills, cordoning off wet areas, avoid bed rail use and instead have better night time supervision, noise reduction), ward design (use of primary colours, daylight, low and higher level spot lighting, shock absorbing floors and floor coverings, non-slip flooring, eye level age-appropriate signs, central observation nursing stations, visual aids and adequate provision and use of space), patient supervision, medication review, recreational social or educational activities, exercise and post-fall review.	Identifies importance of risk assessment and discusses interventions aimed at dementia patients, specifically considering cognitive functioning.
Tung 2014	USA	Text and Opinion	Overview of falls assessment & prevention	Any	Other	Multilple technologies reviewed including: Universal precautions (low beds, non-slip footwear, familiarise patients with surroundings); Multicomponent interventions; Single component interventions (medication management) most evidence); restraints; Patient education	
Hakenson 2014	USA	Review - Narrative	Review of a study on Preventing Falls Among Psychiatric Patients	Psychiatric Patients	Risk assessment	Review of study using Edmondson Psychiatric Fall Risk Scale.	The electronic tool provides the patient care team with a view of the entire unit's risk for falls. By using the tool during the safety huddle, teamwork around fall prevention improved
Coussement 2008	Belgium	Review - Systematic	To determine characteristics & effectiveness of hospital fall	Any hospital setting	Single, Multicomponent & Multifactorial interventions	Vitamin D; Alarm bracelet; Bed alarm; Flooring; Multicomponent & Multifactorial interventions	No conclusive evidence on effectiveness. Further research required.

			prevention programs				
Giles 2006	Australia	Before-after design	To evaluate a fall prevention strategy which introduced volunteers to 'sit' with patients identified as being at high risk of falling.	Volunteers from the community	Sitters	Patients identified as high falls risk were placed in a four bed 'safety bay' where trained volunteer companions (sitters) were placed to closely observe them. Volunteers provided social interaction, diversional and engaging activities; alerted staff when patients were at risk of falling and generally complemented the roles of paid staff. A multidisciplinary team, including volunteer coordinators, developed clear guidelines and role outline for the volunteer companion role.	There was a slight increase in the rate of falls after volunteer companions were introduced, however no falls occurred on the volunteers watch. There was an overall positive response from family, staff and volunteers regarding satisfaction and their role in fall prevention. The volunteers donated a total of $56,866 Australian dollars over the implementation period.
Donoghue 2005	Australia	Cohort study (Prospective)	To determine whether introducing a companion-observer (CO) intervention in high-risk in-patients on an acute aged care ward would reduce the rate of falls.	High risk patients from the acute aged care ward	Sitters	High risk patients allocated trained volunteer sitters (companion-observers) in their room who reassured patients and engaged them in conversation, played cards, read aloud, played music, helped with meals, aided with getting personal belongings and used call bell if patients attempted to move to ambulate without assistance. Each volunteer stayed for approximately 2 hours.	Following the introduction of companion-observers (or sitters) there was a decrease in the falls rate equating to a 44% reduction in risk. Feedback from families of patients was positive.
Boswell 2001	USA	Cohort study Retrospective	Analyse the costs and benefits of a patient-sitter programme in relation to falls and patient satisfaction.	Adult inpatients from medical and surgical units	Sitters	Sitters placed in patients' rooms	Falls marginally increased. Authors conclude that the sitter programme is still important but must be used in conjunction with other fall interventions for when sitter have to step away.
Votruba 2016	USA	Descriptive	to evaluate the effectiveness of remote video monitoring with a dedicated telesitter in order to reduce falls, as well as to reduce patient companion usage in the inpatient adult population	All adult patients admitted to one of the three study units during the intervention stage were eligible to be selected for video monitoring	Sitters	A dedicated telesitter was added to the central monitoring unit (CMU) 24/7 to ob serve up to 12 patients at high risk for falls in three adult inpatient units as an alternative to using a patient companion. The telesitter workstation was located in the CMU, at a workstation adjacent to the hospital’s two current cardiac monitor technicians (CMTs). 92 non-recording cameras were mounted in the ceilings of all inpatient rooms of three inpatient units, infrared lighting was installed for better night vision, as well as speakers and microphones to allow for two-way	demonstrated that not only is video monitoring a safe intervention, it is more effective than patient companions alone in decreasing falls by expanding the number of patients who are directly observed 24/7.

						communications between the patient and telesitter.	
Wood 2018	UK	Review - Systematic	Explore the breadth and scope of literature on one to one specialling, sitters and similar types of care in acute secondary care settings.		Sitters	Review questions:1)How is specialling/one to one care defined? 2) What activities does that care involve? 3) What are the decision-making processes used when deploying staff for one to one care? 4) Which types of patients are being cared for and what are their needs? 5) Who is providing the care? 6) What are the costs of one to one care? 7) How are the costs taken into account when deciding whether or not to use this type of care? 8) What are the alternatives to delivering one to one care?	Wide variation in what specialling and one to one care entails, which can in turn lead to the provision of poor quality care. A reduction in this variation and improved quality care might be achieved through the development of guidelines, training and standardized decision-making tools
Thomas 2017	USA	Before-after design	Evaluate effectiveness for remote telemonitroing	Adult in-patients	Stationary fall detection device	Remote telemonitoring - Cameras, open channel to speak with patient, alarm to notify staff. I staff member can monitor 15 cameras	Telemonitoring reduced fall rate
Balaguera 2017	USA	Cohort study (Prospective)	To conduct a technology evaluation, including feasibility, usability, and user experience, of a medical sensor-based Intranet of things (IoT) system in facilitating nursing response to bed exits in an acute care hospital.	Patients over 18 years old with high fall risk (Morse fall score ≥45) from a surgical ward	Stationary fall detection device	SensableCare System. Sensor pad placed on the bed to monitor patient's upper body movement; when system recognises attempts to exit the bed nurses are alerted via a mobile device and a message is played on a bedside monitor to the patient to remind them to wait for the nurse before exiting.	No falls were reported during the study period from patients using the system. Focus groups reported the system to be easy to use and effective.
Cournan 2016	USA	Cohort study (prospective)	Compare falls rates before & after implementation of video	Adults with brain injury	Stationary fall detection device	10 ceiling-fixed cameras & 5 portable cameras + video monitoring room with technician. Technician can speak to patients over system & alert staff.	Annual falls reduced from 97 to 65 following introduction of the system. Staff & families reported satisfaction.

			monitoring system				
Diduszyn 2008	USA	Cohort study (Prospective)	To describe the hospital's experience using the Posey Sitter II wireless nurse call fall monitor to reduce falls among elderly inpatients.	Adult hospital patients and nurses	Stationary fall detection device	A bed alarm system (Posey Sitter II, consisting of alarm unit, mattress pad sensor, wireless transmitter, beeper carried by nurse) was used on patients at high risk of falls, which alerted the nurse if a patient tried to sit up but also played a recorded message to the patient (such as "please stay in bed").	18% reduction in fall number following the use of the bed alarm system, compared to 1 year earlier. The majority of nurses thought the device helped to prevent falls.
Kido 2009	Tokyo	Cohort study (Prospective)	Evaluating a thermal imaging sensor to differentiate between normal toilet room activity and simulated falling activity	Healthy males, simulation environment	Stationary fall detection device	Thermal imaging camera	The results showed that the thermal imaging sensor could detect various falls in the toilet room with a discriminant ratio of 97.8%. Also, while the room temperature needs to be 31°C or less, falls can be judged in less than one second, and the subject's privacy can be protected.
Wong 2014	Australia	Cohort study (Prospective)	To evaluate the effectiveness of an electronic sensor bed/chair-exit alarm system on fall incidence and fall-related injury rates in a subacute hospital ward for patients with cognitive impairment.	Patients admitted to the subacute ward over a 6-month period	Stationary fall detection device	The electronic sensor alarm system (Proximate Fall Prevention System, Assistive Technologies Pty Ltd, Wynard, Tasmania, Australia) uses electronic sensors to detect when the patient moves beyond a threshold distance from the sensor mat, at which time an alert is sent to a hand held pager via the nurse call system. Two types of sensor mats were used: the bed sensor mat (1050 × 350 mm) and the chair sensor mat (280×220 mm). Usual care also given to participants	The electronic alarm system was found to be a feasible, effective, and acceptable fall prevention strategy for patients with cognitive impairment
Jeffers 2013	USA	Cohort study Retrospective	Evaluation of centralized video monitoring program	Inpatients in acute care facility	Stationary fall detection device	Centralized video monitoring program used in Denver hospitals	Implementing the CVM program required tight connections and collaboration with a multidisciplinary team of individuals. Actual program performance exceeded the initial projected benefits. The CVM program supports the high level of vigilance required by nursing staff to ensure patient safety and quality.

Sand-Jecklin 2019	USA	Descriptive	To evaluate the video monitoring process at a large teaching hospital; including staff, technician, patient/family perspectives on patient monitoring.	Medical & surgical inpatient settings	Stationary fall detection device	Video-monitoring only	Video monitoring was seen as being effective in fall prevention by most staff and patients/family
Yamanaka 2009	Japan	Descriptive	to increase the detection capability of this system (Neural network), we adopt a face extractive method into the proposed system to execute more detail extraction of the objective person's image from the background	Not stated	Stationary fall detection device	neural network with sensors	Low success of system in clinical setting
Yonezawa 2005	Japan	Descriptive	presents development of new system for hospital and home use	Not stated	Stationary fall detection device	Intelligent bed care system which employs three almost-undetectable stainless steel tape and wire electrodes installed directly under the bedsheet. The microcomputer detects whether the patient is in bed, is trying to get out of bed, is out of bed, is in bed and inactive, or is leaking infusion fluid, blood, or urine. The microcomputer alerts the nursing station via the nurse call system,	Authors concluded that the developed system does not require any special electrical or magnetic fields or body-mounted sensors and offers a very effective method for protecting patients from accidental injury.
Kittipanya-Ngam 2012	Singapore	Diagnostic test accuracy	In this project, an algorithm with camera images from a hospital is used to detect falls	Inpatients	Stationary fall detection device	Camera system which triggers alarms, including fall detection alarm	Privacy issues raised by staff. Initial performance of system encouraging Further testing required

Knight 2008	USA	Diagnostic test accuracy	Describe & test accuracy of GRiT (Gesture Recognition Interactive Technology) Chair Alarms	NA	Stationary fall detection device	Array of capacitive proximity sensors and pressure sensors to create a map of the patient's sitting position, which is then processed using gesture recognition algorithms to determine when a patient is attempting to stand and to alarm the care providers.	Authors concluded that the system can be seamlessly integrated into existing hospital WiFi networks to send notifications and approximate patient location through existing nurse call systems.
Aud 2010	USA	Emerging technology development	To describe the development of a prototype Smart Carpet, for detecting a fall and signalling for help.	Aimed at older adults and dementia patients	Stationary fall detection device	Smart Carpet with imbedded pressure sensors connected to a computer. The Smart Carpet can detect walking/standing and aims to identify falls in order to send a signal for assistance.	The Smart Carpet correctly identified steps most of the time and was able to detect varying pressures and walking characteristics. Further work required before application in practice.
Banerjee 2014	USA	Emerging technology development	To reduce false fall alerts from a patient activity recognition system to be used in hospital	Hospital patients	Stationary fall detection device	Microsoft Kinect sensor mounted near the hospital bed used depth-imagery to detect activity and used an algorithm to detect falls.	False fall alerts were still generated. Need for further work is identified.
Bauer 2017	USA	Emerging technology development	To reduce the risk of falls for patients by developing a 3D camera-based system (Ocuvera) for monitoring patients at risk of falling without requiring human supervision.	Patients	Stationary fall detection device	Video-based monitoring system (including Microsoft Kinect) that can predict behaviour which can lead to a fall from the bed and sound an alarm to warn staff.	Good system sensitivity (95%) Needs tested in hospital setting
Belshaw 2011	Canada	Emerging technology development	To describe a camera-based system that detects a fall, outline the algorithms used and present empirical validation of effectiveness.	Aimed at older adults but piloted by 'able-bodied' volunteers	Stationary fall detection device	Camera-based Personal Emergency Response System (PERS) device was piloted. A single camera with a wide range lens was mounted on the ceiling in three office rooms and over 3 weeks volunteers simulated fall postures on the floor. The system identifies a fall using machine learning techniques on the silhouette and lighting features detected. A fall alarm is activated if a fall is detected.	During training the system resulted in a true positive rate of 92% and false positive rate of 5% on a test set of falls. However in tests of 33 fall sequences 115 false events were identified. Authors identify the need for further system development.

Danielsen 2016	Norway	Emerging technology development	To present an experimental approach for recognising bedside events, and prevent patient falls, using a ceiling mounted longwave infrared array combined with an ultrasonice sensor device.	Aimed at hospital patients	Stationary fall detection device	Ceiling-mounted infrared sensors and ultrasonic processing device placed above the hospital bed. System can register when a person moves from lying to sitting and attempting to get out of bed.	The ceiling-mounted infrared sensor and ultrasonic sensor system correctly identified 113 out of 130 position change events and the sensitivity and accuracy figures suggest this to be a promising emerging technology for fall detection.
Enayati 2014	USA	Emerging technology development	To implement a web based application with the ability to review depth videos of hospital rooms to investigate the chain of events leading to a fall.	Aimed at nurses in hospitals	Stationary fall detection device	A web-based user interface was developed to aid nurses in post-fall analysis and potential causes by providing an easy to use interface for reviewing depth video footage from patients' hospital rooms. Nurses simply chose a time and date of interest and available footage is displayed.	The new web based interface allowed easier search and review of depth video footage for analysis of patient falls.
Haider 2017	Canada	Emerging technology development	To apply radio frequency radars to developing a device-free, non-invasive fall detection system.	Aimed at adults in hospital or care settings	Stationary fall detection device	A low-cost UWB radar, working on radio frequency, was mounted on a wall in the test room, a person's motion was monitored and fall motion detected.	This pilot demonstrated the ability of a wall mounted UWB radio frequency radar to detect a fall. Further work is planned to enable the system to send an alert to the caregivers that a fall has occurred.
Hanada 2015	Japan	Emerging technology development	Description of development of sleep activity and urine bio-sensor monitoring system.	8 Healthy nursing students	Stationary fall detection device	"Nezou" sleep activity monitoring system (sensor bar) + "Yuririn USH-052" urine bio-sensor	Demonstrated the possibility of predicting the need to urinate and monitoring movement in bed using the 2 sensor-based systems. Needs to be tested in real-life settings with older people.
Hilbe 2010	Austria	Emerging technology development	The aim of this work is to present the research and development process of the integrated, universally	N/A	Stationary fall detection device	BUCINATOR – bed exit alarm system using air-filled tubes attached to top of side rails.	After experimental testing, BUCINATOR shows great potential to be a reliable bed-exit alarm system. In general, bed-exit alarm systems with extended features could play a major role in ambient assisted living technologies. Needs to be tested in hospital setting.

			applicable BUCINATOR bed-exit-alarm system				
Jeon 2017	Korea	Emerging technology development	To describe the development and testing of a non-wearable bedside fall detection device.	Healthy subjects	Stationary fall detection device	An ambient-based fall detection system based on a pressure sensing triboelectric nanogenerator (TENG) array, essentially a large mat with several integrated sensors that is placed on the floor at bedside, was tested on healthy volunteers. Volunteers performed activities of daily living (including getting in/out of bed) and falls in various directions.	The system showed very high classification accuracy (95.75%). Suggestions for further development are made. Needs tested in hospital setting.
Kwolek 2014	Poland	Emerging technology development	Design & implementation of a low-cost system for reliable fall	Healthy adults	Stationary fall detection device Wearable detection device	A system with a wearable accelerometer and a stationary depth (Kinect) camera. Depth video records when the accelerometer detects fast motion (indicative of a fall)	The system performed above 80% on all measures of accuracy, precision, sensitivity, specificity. Sunlight appeared to hamper the system's efficiency and so authors suggest it is most suitable for indoor use.
Kwolek 2015	Poland	Emerging technology development	Propose a new architecture for a low cost and reliable fall detection system	Healthy adults	Stationary fall detection device Wearable detection device	As above (Kwolek 2014)	A 24/7 fall detection system is proposed, which scored above 83% on all measures of accuracy, precision, sensitivity, specificity. Authors note that placing the accelerometer on other locations (eg chest or back) did not noticeably reduce the detection performance.
Lee 2005	Canada	Emerging technology development	Develop & test sensor-based falls detection system	Adults 20-40 years old	Stationary fall detection device	Intelligent emergency response system consisting of (i) sensing; (ii) situation assessment; (iii) response planning & execution. Ceiling-mounted digital camera.	True positive 77%, True negative 95%. Limitations: Only tracks one person at a time and equipment (e.g. mobility aids) are not distinguished from person.
Mazurek 2018	Poland	Emerging technology development	To propose a methodology for acquisition and pre-processing of measurement data from infrared depth sensors, used in fall detection, and several approaches to classify the data.	Healthy adults	Stationary fall detection device	Two wall-mounted infrared Kinect cameras with an inertial measurement unit were used to detect falls.	A system with two wall mounted depth video cameras and inertial sensor showed good sensitivity (93.9-97.7%). Authors suggest that their study significantly contributes towards improvement in the reliability of unobtrusive monitoring systems. Needs tested in hospital patients

Mecocci 2016	Italy	Emerging technology development	To propose a framework for monitoring hospitalised patients, including fall detection, using environmentally mounted depth imaging sensors.	Healthy adults	Stationary fall detection device	A Microsoft Kinect infrared depth camera was mounted at a side-view position and inertial data of participants was acquired by wearable sensors.	A system using infrared depth imaging sensors was tested and correctly identified 52/55 non-occluded standing falls and 15/20 occluded standing falls, while falling out of bed was not reported. Future work will look at falls out of the bed.
Rialle 1999	France	Emerging technology development	Aims not explicit but describes a study on a multi-agent model in a context of cognitive science modeling for a smart room.	Unclear who the person was.	Stationary fall detection device	Set up smart room and tested physical variables (sensors) and semiotic variables (e.g. nurses, room differences that aid interpretation of the physical variables) on one person over 'several' nights. Physical elements included a camera, targets and sensors all configured to provide information within a smart room.	The day following the agitated night the patient fell. This could be correlated with the agitated night recorded actimetry. In daily clinical use of the system, such information could have allowed nurses to suspect an increased risk of fall, and reinforce patient care. Authors make technical comments on their sensors and other approaches to falls research.
Satoh 2006	Japan	Emerging technology development	To evaluate effectiveness of Kinect camera system for detecting awakening behaviour	Healthy volunteers	Stationary fall detection device	Infrared camera system for human behaviour classification	System ready for in-the-field testing
Shim 2011	Korea	Emerging technology development	Description of develoment of fall detection system using webcameras	Test subjects (experimental conditions)	Stationary fall detection device	Web cameras attached to hospital beds	Fall detection rate 93% & false rate 9%; future work proposed including improvements to algorithm & hardwrae and use of infrared cameras
Staranowicz 2015	USA	Emerging technology development	Develop easy-to-use calibration system for falls detection system using multiple Kinect-like cameras	Not reported	Stationary fall detection device	Use of Kinect-type cameras	Calibration method accurate and easy to use - future research required
Su 2017	Taiwan	Emerging technology development	Simulation of four kinds of neural networks (e.g., the MLP, RBF, SVM, and Deep Neural Network) were adopted and	Not stated - 7 subjects	Stationary fall detection device	Kinect depth camera & neural network based fall detection algorithm	98% accuracy of algorithm - could be used in a smart hospital - further research required using realistic data

			compared for fall detection using six scenarios.				
Takeda 2013	Japan	Emerging technology development	Describe use of Kinect camera to detect behaviour that might lead to falls in hospital-like setting	Not stated	Stationary fall detection device	Kinect camera	System accurate both in light and dark. Further research in the filed required
Tyrer 2016	USA	Emerging technology development	Evaluate use of low-cost processor to detect falls from smart-carpet	healthy volunteers	Stationary fall detection device	Smart-carpet	Achieved 87% accuracy; further work indicated
Sahota 2014	UK	RCT	Study reports the results of a large, pragmatic, parallel arm, randomised controlled trial f bed and bedside chair sensors using radio-pagers to reduce in-patient bedside falls in acute, general medical, elderly care wards in a UK hospital.	All patients admitted to one of the three acute general medical elderly care wards	Stationary fall detection device	Participants in the intervention group had a bed and bedside chair pressure sensor linked up to a radio-pager for the duration of their stay in the elderly care ward. An alarm would be triggered if patients left the bed or chair and the sensor was without pressure for 5s, sending the patients location to the nurse aide or nurse via the pager. Control group had usual care with no sensors.	The number of falls and falls rate were not significantly different when using bed and chair alarms with a pager system compared to usual care. The cost per patient was higher in the intervention group. The authors suggest that nurses may not answer a call quickly enough to prevent falls.
Shorr 2012	USA	RCT	Effectiveness of bed alarms at preventing falls	Inpatients in general medical, surgical & specialty unity	Stationary fall detection device	Bed alarms	Increased alarm use in intervention units compared to control but no difference in fall-related outcomes
Tideiksaar 1993	USA	RCT	Evaluate bed alarm system	Elderly	Stationary fall detection device	Pressure sensitive pad placed on top of mattress under bed sheet	No statistically significant difference in number of falls

Koh 2015	Singapore	Review - Systematic	Review of bed exit alarms in psycho-geriatric settings	Psychogeriatric inpatients	Stationary fall detection device	Bed exit alarms	Evidence inconclusive due to study designs. Authors conclude that the use of bed exit alarms are useful but should not compromise staff vigilance in any way
Garman 2005	USA	Other	To examine the evidence on fall prevention strategies related to older people's views and experiences raised in McInnes and Askie's review to assist nurses in informing their practice related to patient teaching and prevention following discharge.	Elderly patients	Multiple technologies	Risk assessment tools; increased socialisation; gait and strength training; reinforcement of safety practices for all staff; non-skid footwear; wristband and poster to ID fall risk; frequent toileting; larger doors; handrails in hallways; non-glare flooring; varying colours of walls and floors to aid visual and perceptual impairment; night light; creative education; patients can call nurses directly on their work mobiles.	A discussion of potential interventions is given. Assessing patients' reluctance for change/compliance and involving patients in the fall prevention programme were recommended.
Coussement 2009	Belgium	Other - survey	To present findings relating to fall prevention practices in Belgian hospitals.	Staff (geriatricians and head nurses) from Belgian hospitals with a geriatric department	Multiple technologies	Fall risk screening (Tinetti test, Timed Up and Go test, St Thomas's Risk Assessment Tool in Falling Elderly Inpatients (STRATIFY)); multidisciplinary fall meetings; restraints (fixed tray table, bedrails, belts, geriatric chairs, ankle or wristbands, restraint vests);patient interventions (information, mobility/balance, medication, shoe assessment, hip protector, education, occupational therapy); infrastructure (anti-skid floor, balustrades, lighting, low low beds, chairs or benches in hallways, room close to nurses station).	Although most hospitals recorded falls many of them did not use the information to help improve their prevention strategies. Few hospitals used a standard fall assessment plan (for after a fall). Almost all hospitals used physical restraints. Authors advise against "settling" for current practices and recommend regular update of practice.
Gray 2013	USA	Qualitative study	To perform a falls focus group with one hospital's stroke survivor and	Stroke survivors	Multiple technologies	Focus group discussed stroke survivors experiences with falls, reviewed fall prevention strategies and discussed any suggestions from patients and caregivers.	Patients and caregivers suggested that best practice would be to have sitters in patient rooms, or otherwise to use bed alarms. Following the introduction of bed alarms on

			caregiver support group with the aim of reviewing fall prevention strategies.			Intervention introduced bed alarms for all stroke patients and low beds.	admission and low beds there was a 50% reduction in stoke patient falls.
Haggqvist 2012	Sweden	Qualitative study	To describe licensed practical nurse experiences of predicting and preventing further falls when working with patients who had experienced a fall-related fracture.	Licenced practical nurses	Multiple technologies	Study looked at nurses 'experiences' of prevention and detection. Focus groups and interviews	Patient safety practices were more structured and prominent at the rehabilitation ward. The authors highlight the importance of expectations from leadership for performing fall risk prevention practices and having a clear structure to fall prevention strategies.
Amador 2007	USA	Review - Narrative	Review the literature on aging related changes predisposing older adults to falls; risk factors associated with hospital falls; and the consequences, management, and prevention of falls for older adults after surgery.	N/A	Multiple technologies	No intervention employed. Reviews interventions from the literature.	Recommend frequent falls risk assessment together with multifactorial prevention. Avoid bed rest, inactivity and restraints
Clyburn 2011	USA	Review - Narrative	A review comparing falls in community and in hospitals and comparing interventions.	Aimed at hospital and community	Multiple technologies	Multiple interventions discussed, including: medical interventions (delirium prevention, nutrition, medication review, vision/eye care) and physical interventions (bed rails, electronic bed, electronic bed sensors/alarms, bed height toilet seat height, footwear, flooring, identification bracelets, bed trapeze, grab rails, room and floor illumination, scheduled toileting, access to call light, bedside commode, unobstructed environment, exercise and balance training.	The authors conclude that although many of these interventions are effective they are not evidence based (but rather designed using expert opinion or statistical trends) and further investigation is needed.

Flanders 2009	USA	Review - Narrative	A review of current evidence about falls in intensive care, including the link between falls, early mobility and safe patient handling.	Hospital patients	Multiple technologies	Authors discuss general fall reduction efforts, including: risk assessment; ensuring the patient is routinely oriented to the environment; call light is within ready reach; maintaining beds in the lowest possible position; providing adequate lighting; non-skid footwear; assistive devices. Also discuss safety strategies in specific cases of patients as well as workplace safety for critical care staff.	Authors conclude that evidence of effective fall prevention strategies is minimal and emphasise the importance of monitoring falls and effectiveness of prevention strategies as well as publishing research.
Anderson 2012	UK	Review - Systematic	To assess the effectiveness of interventions designed to prevent patient injuries and falls from their beds.	Studies on adult patients from nursing care facilities or rehabilitation units	Multiple technologies	Reviewed studies including the following interventions: low height beds, bed exit alarms.	The reviewed studies found no significant change in fall number following implementation of low beds or bed exit alarms. Authors conclude that evidence for the effectiveness of these interventions remains unclear. And suggest improvements for future studies
Cameron 2018	Australia	Review - Systematic	To assess the effectiveness of interventions designed to reduce the incidence of falls in older people in care facilities and hospitals.	Older people (most 65+)in residential or nursing care facilities, or hospitals	Multiple technologies	RCT's were reviewed and the following interventions are discussed: exercise; medication review; Vitamin D supplementation; additional physiotherapy; environment/assistive technology (furniture adaptations, bed exit alarms, ID bracelet); service model change; knowledge interventions; multifactorial interventions.	Multifactorial interventions in hospital and Vitamin D supplementation in care facilities may reduce the rate of falls. The evidence regarding exercise, additional physiotherapy and bed sensor alarms is unclear.
Choi 2011	USA	Review - Systematic	A systematic review to assess the effectiveness and characteristics of fall prevention interventions implemented in hospitals.	Hospital patients	Multiple technologies	Three main characteristics identified 1) the physical environment, 2) the care process and culture and 3) technology-related interventions. Others include carpeted flooring, bedrail reduction, nightlight, regular toileting, medication review and modification, identification bracelets, Vitamin D and calcium supplementation, exercise, patient education, volunteer companions, bed alarm, unit and patient room design, flooring.	Authors conclude that multi-systemic interventions which take into account environment related interventions can be more efficient.
Cumbler 2013	USA	Review - Systematic	A systematic review of patient fall-risk stratification methods and fall prevention interventions.	Hospital patients	Multiple technologies	Risk stratification tools (St Thomas's Risk Assessment Tool in Falling Elderly Inpatients (STRATIFY), the Morse Fall Scale (MFS), and the Hendrich Fall Risk Model (HFRM)); staff and patient education; displaying patient fall risk (wristband, poster); exercise; safety while ambulating (assistive devices, footwear, eye wear); medication use (calcium, Vitamin D);	Authors conclude that there is no consensus on risk stratification tools and more research is required. They were not able to identify one intervention type that was most efficient

						toileting; sock alarm; carpet flooring; bed-chair alarms.	
Dibardino 2012	USA	Review - Systematic	To examine the available data evaluating multidisciplinary fall prevention strategies in the acute inpatient setting.	Studies involving acute care hospital inpatients	Multiple technologies	Multidisciplinary fall preventions reviewed. These included: fall risk assessment; mobility assessment and assistance; mobility aid; medication modification; education; fall risk sign/warning in chart; bedside interventions (bed alarm, bed rails, bed location/position); toileting schedule; exercise programme; frequent bed checks; documented fall prevention plan; ward modifications to patient rooms and bathrooms; hip protectors; sitter; reassessment of fallers.	Multidisciplinary fall prevention strategies had a statistically significant impact resulting in reduced fall rates, with a combined OR of 0.9. However, the authors question the clinical relevance of these reductions and whether they are cost-effective.
Evans 1998	Australia	Review - Systematic	A systematic review to present the best available information for the effectiveness of interventions designed to reduce the incidence of falls in patients during hospitalisation.	Review included adult patients in acute care hospitals or similar	Multiple technologies	Pressure alarms; identification bracelets; multifactorial interventions; learning from evaluation of patient fall data; fall risk assessment; education; risk of falling diagnosis given; environmental issues (reducing clutter, nightlights at bedside and toilet, stabilising beds and furniture, vertical grab bars near toilets); elimination (frequent toileting, placing near toilets, sitting down to toilet, review laxatives and diuretics); mobility (non-skid footwear, physiotherapy, rise slowly, aided walking, reinforcing activity limits to patients/family, assisted transfer, frequent walking with patients), mental state (sitters and support, low beds), bedrest (breaks on, half bedrails, possessions within reach), medications, wheelchair issues.	The review concluded that the most common approach for fall prevention was the use of multifactorial interventions based individual risk factors, although evidence for their effectiveness is contradicting. No one risk assessment tool could be recommended and those created by institutions were no less accurate than generic tools.
Evans 1999	Australia	Review - Systematic	To summarise the best available evidence on the effectiveness of interventions designed to reduce the incidence of patient falls in hospitals.	Adult patients	Multiple technologies	Evidence for the following is presented: bed alarm, ambulatory alarms (ambularms attached to the patient's leg and are triggered if the leg is shifted from the horizontal position to a dependent angle of 45); fall alarms; patient identification bracelets; falls risk ID; individually tailored multifactorial interventions based on fall risk.	Overall the methodological quality of studies was found to be poor and there appeared to be little evidence of the effective interventions. Bed alarms and identification bracelets did not reduce falls while multifactorial interventions had contradictory results.

Giles 2015	Australia	Review - Systematic	To describe the process used to determine what constitutes best practice in the area of fall prevention in acute care settings and the development of audit criteria for use in acute hospital settings.	Patients aged over 18 years in acute hospital settings	Multiple technologies	A systematic review was performed to inform development of audit criteria for fall prevention in acute hospital settings. The complex domains were identified that required attention in fall prevention: the physical environment, hospital culture and care processes, and the use of technology. Fall risk assessment tools and post fall assessment tools also important.	Eight audit criteria were developed as a result of a systematic review of systematic reviews of fall prevention literature.
Christy 2017	USA	Text and Opinion	To examine falls in older adults and discuss nursing interventions that can be implemented to prevent falls.	N/A	Multiple technologies	Multiple interventions reported, including: bed brakes always locked, remove clutter, keep floors dry, bed in lowest position, personal items in reach, bedside commodes, assisted toileting, transfer devices, call light within reach, sitter, targeted interventions, cognitive, continence, and orthostatic hypotension assessments and medication reviews, non-skid socks, assessing patient/family fear of falling (education on how to decrease this), walking aids,	Standard interventions such as socks and low beds can be effective but should be used together with individually targeted interventions.
Graham 2012	USA	Text and Opinion	To discuss importance of fall prevention, present strategies for managing inpatient falls and to describe the role of fall prevention committees in the hospital setting.	N/A	Multiple technologies	The following are discussed: falls risk assessment; medication management and review; environmental aids (signage, removal of environmental hazards, bathroom grab bars, shower chairs/benches, nonslip flooring); fall alarms (worn and stationary); developing technologies (video monitoring), multidisciplinary fall prevention teams.	Authors conclude that well researched interventions include medication review, fall alarms, and environmental aids, while further research is needed in other areas, particularly emerging technologies. The importance of a multidisciplinary team to bring about change is highlighted.

Hain 2012	USA	Text and Opinion	To discuss the best available evidence of fall prevention strategies, which can be used to support evidence-based projects to reduce falls.	Aimed at older adults undergoing in-center haemodialysis	Multiple technologies	The following are discussed: screening and assessment (focused fall history, physical examination, medication review, cognitive status, functional assessment, environmental assessment); exercise and physical therapy; medical management and medication review; management of chronic illness and acute problems; environmental modification; patient/family/staff education; Interprofessional approach; addressing vision impairment; appropriate footwear; podiatrist referral; environmental interventions (lighting, grab rails, tractable floor mats, in-ground weighing scales, clutter).	Authors conclude that the evidence supports the use of a multicomponent interprofessional fall prevention programme to address modifiable risk factors and reduce falls.
Bloch 2011	France	Cohort study (Prospective)	To evaluate the effectiveness and acceptability of a fall detection system Vigi'Fall in elderly subjects.	Patients aged 75+, geriatrics ward, at risk of falling	Wearable detection device	Patients wore the Vigi'Fall accelerometer device and were placed in rooms with infrared sensors. When a fall was detected a signal was sent to a nurse.	Authors suggest that the system is promising for patient fall detection but more work needs to be done to improve sensitivity in real life scenarios to avoid false alarms.
Kangas 2015	Finland	Cohort study (Prospective)	To evaluate the long-term fall detection sensitivity and false alarm rate of a fall detection prototype in real-life use.	Older adults	Wearable detection device	An accelerometery-based sensor system with an implemented fall detection algorithm.	The fall detection system detected 12 out of 15 real-life falls, having a sensitivity of 80.0%, with a false alarm rate of 0.049 alarms per usage hour with the implemented real-time system. With minor modification of data analysis the false alarm rate was reduced to 0.025 false alarms per hour, equating to 1 false fall alarm per 40 usage hours.
Visvanathan 2012	Australia	Descriptive	Describe a falls management framework based on a novel movement sensor–alarm intervention as a strategy to reduce falls risk in acute care, especially in clinical settings where patients may have cognitive impairment.	N/A	Wearable detection device	Described a proposed falls management framework developed for acute hospitals in terms of falls prevention using an AmbIGeM environment. real-time monitoring device is low cost, battery free, wearable and therefore smaller wireless sensing technologies, based on passive Radio Frequency Identification (RFID) technology, continuously without any maintenance. The system is customizable to individual patients and automatically determines the level of monitoring and care required for each patient based on the expert knowledge of physicians and clinicians. Unsupervised classification of high risk falls activities are used to facilitate an immediate	Described a proposed falls management framework developed for acute hospitals in terms of falls prevention using an AmbIGeM environment. next stage of the project is a pilot clinical trial

						response from caregivers by alerting them of the high risk activity, the particular patient, and their location	
Wickramasinghe 2015	Australia	Descriptive	feasibility of passive computational RFID sensors for ambulatory monitoring	Not stated	Wearable detection device	Investigate the feasibility of recognizing activities from a single passive body-worn CRFID sensor attached over clothing and develop an innovative framework capable of partitioning sparse data streams at approximate activity boundaries in real-time and an approach for recognizing transfers out of bed or chair that overcomes the sparsity and noise in sensor observations	Successfully demonstrated the use of body-worn passive CRFID sensors for ambulatory monitoring in the context of movement sensor alarm system
Vilas-Boas 2013	Portugal	Diagnostic test accuracy	To develop a software tool, for the MovinSense® device, which, using a single tri-axial accelerometer attached to the patients' chest would send feedback to the healthcare staff when the patient has fallen or is getting out of his/her bed and he/she is walking.	Healthy volunteers	Wearable detection device	The small transmitter is attached to the patients' chest with an adhesive, it has a single inertial sensor, and transmits this information to the MovinSense receiver®, through ZigBee, for processing and recording by the MovinSense® software. For fall detection, after positioning the MovinSense® each subject was asked to lay in a bed or couch and then roll and fall to the floor. Each subject was asked to fall to the floor at least twice. The rolling movement performance was not controlled. Average and standard deviation of the height of the falls studied was 48.03±11.19 cm (max = 75 cm, min = 40 cm).	analysis suggest that the developed algorithms are capable of detecting either bed falls or walking motion (at least five steps, from self-selected to high speeds) with a sensor located on the patients' chest and with high rate of good detections

Adame 2018	Spain	Emerging technology development	To describe RFID (Radio Frequency Identification & WSNs (Wireless Sensor Networks) in tracking patients.	Nursing, surgery & rehabilitation departments of a Barcelona Hospital.	Wearable detection device	A wristband was worn that allows tracking and location of patients with an integrated fall alarm. Tested on patients over 2-days.	Patient tracking was reported to be successful. Healthcare staff found the technology useful and easy to use and that it allowed them time to concentrate on other tasks. Need for future work identified.
Baig 2016	New Zealand	Emerging technology development	Develop a robust falls risk assessment system to predict and prevent falls and related long-term disability in hospitals; compare with adopted Morse Falls Scale.	General application testing but aimed at older adults in hospital.	Wearable detection device	Wearable detection device together with other input. Falls risk assessment model using motion data (accelerometer device attached to patient's arm), vital signs (medical devices), falls history, medication information, weighted parameters input into a falls prediction algorithm. Identification of abnormal or unstable motion data. Accuracy of fall identification was tested.	The model accurately identified all forward falls and over 85% of backward, left and right side falls. Achieved 75% accuracy, 88% sensitivity and 83% predictability against Morse Fall Scale.
Caporusso 2009	Italy	Emerging technology development	To introduce the 'Fallalarm', a system for remote management of a person's risk of falling and fall prevention, and demonstrate its applicability in clinical and home settings.	Piloted on hospital and community patients.	Wearable detection device	Fallalarm consists of a wearable device fitted to the wrist and waist. It contains an activity monitor (acceleration sensor) and a system which monitors and assesses activity to continually assess risk of falling; providing continual feedback to the patient regarding their level of risk. It also detects and reports any occurring falls.	There were no falls reported over the short 10hr test period. Patients were more accepting of the wrist worn device.
Chan 2014	France	Emerging technology development	To present a wireless mobility monitoring system and report on pilot trials in an Alzheimer's unit to determine mobility behaviour of patients.	Aimed at hospital patients and community	Wearable detection device	Wearable and stationary fall detection device. The wireless Zigbee tag (connected to a wireless network linked to a PC) was worn by participants to monitor their location and movements in relation infrared (IR) presence multisensor monitoring system set up in their room and on the ward.	Estimated accuracy of 80% for activity detection by the system.
Chou 2013	Taiwan	Emerging technology development	To design a real-time accelerometer based lying-to-	Aimed at hospital and community	Wearable detection device	Accelerometer attached to the chest that senses when a patient is moving from lying to sitting (using a tilt sensing technology). An alarm is triggered when a patient's tilt	The system was successful in sensing when the tilt angle changed from lying to sitting and sending out alerts. Needs to be tested on patients.

			sit sensing system to detect patients at risk of falling.			angle suggest that they are sitting up (potentially to get up).	
Dong 2005	Japan	Emerging technology development	To propose a wearable monitoring system which measures body movements of bedridden patients.	Aimed at elderly patients but piloted on volunteer	Wearable detection device	A wearable wireless sensor placed on the chest of a volunteer tracked acceleration and alerted the master computer if 'risky' movements potentially leading to a fall or if fall were detected. The volunteer lay on the bed, rolled over, woke up and walked around the bed.	A system monitoring movement of bedridden elderly patients was proposed and tested on a volunteer. The authors suggest this system can be expanded to track multiple patients.
Ferrari 2012	USA	Emerging technology development	To determine if a motion detection system, the 5S-MDS, was clinically feasible for hospitalised older adult patients.	Adults aged 65+ admitted to hospital	Wearable detection device	Patients wore wrist, ankle and chest sensors over a period of 4 hours in their hospital room while performing a series of prescribed movements. The wireless sensors transmitted information on patient movement which was displayed as an avatar on screen	The system was accurate in monitoring movement without time delay. Following wear of the sensors the skin integrity was maintained and on average the acceptance of the sensors was high (score of 4.77 out of 5).
Gibson 2016	UK	Emerging technology development	To present and evaluate an accelerometer-based multiple classifier fall detection and diagnostic system implemented on a single wearable Shimmer device for remote health monitoring.	Aimed at hospital and community	Wearable detection device	A wireless accelerometer device (Shimmer) was worn on the chest, which transmits 3D acceleration data to a base station receiver and can raise an alarm to a hospital or designated carer if a patient has fallen.	The system showed high accuracy and discrimination of fall events.
Gravina 2017	Italy	Emerging technology development	To propose Activity as a Service (Activity-aaService), a fully-fledged cyber–physical framework to support community, on-line and off-line	Older adults	Wearable detection device	A system that has a smart fall detection capability. An Android smartphone and one accelerometer placed in a trouser pocket or on the belt. Three levels of alarm (green, yellow and red) are available depending on fall severity and how quickly the patient recovers to standing. Details of the fall are posted on Facebook for predefined persons or carers to see and depending on the severity predefined services are alerted.	The system scored over 83% for specificity, sensitivity and precision for fall detection. Further development work is ongoing.

			human activity recognition and monitoring in mobility.			Piloted on emulated falls and everyday activities.	
Han 2016	Japan	Emerging technology development	To describe the development of a sensor network for falls detection	N/A	Wearable detection device	Four principles are proposed as fundamental criteria for designing a sensor network for elder-oriented fall detection and prediction. According to these criteria, a bidirectional electromyographic sensor network model is experimentally constructed, and qualitative analysis is conducted to explain that this solution performs more realistically and rationally.	A simple call/reply communication mechanism was imported, and the EMG data was shown to contribute to a more precise detection and prediction result.
Hidaya 2013	India	Emerging technology development	Describe data collection, monitoring and understanding physiological status of patients through a wireless approach for patient health care management.	Not specified	Wearable detection device	A wearable patient monitoring system was developed and piloted which detects body temperature, heart rate, ECG and falls (impact detected by an accelerometer); wirelessly transmits data to a computer.	Device has potential – further work required.
Jähne-Raden 2019	Germany	Emerging technology development	Overview & initial evaluation of INBED sensor system for falls prevention	Healthy adults	Wearable detection device	Thigh-worn, bed-exit detection system	System reliable & suitable for testing in clinical settings
Leake 2014	UK	Emerging technology development	To examine whether the reliability of fall detectors might be improved by using photoplethysmography.	Healthy adults	Wearable detection device	A photoplethysmographic sensor was worn on the outside of the wrist to measure and track pulse rate and blood volume changes. Data was recorder over 5 minutes in 10 different poses including variations of sitting, lying and standing with different arm positioning.	Further work required

Nho 2016	Korea	Emerging technology development	Introduces a low-cost, easily learnable and reliable wearable fall detection system for patients in the hospital setting.	Healthy adults	Wearable detection device	Wristband sensor (fitted with an accelerometer, hear rate sensor to detect heart rate variability, and microprocessor), compared to a waist sensor (fitted with accelerometer only), both of which were sewn into clothes.	The fall detection performance of the accelerometer and heart rate sensors is superior when used together. Although the waist worn sensor had better performance the others were close and deemed to be less intrusive. Authors suggest this is a low-cost option for fall detection. Needs to be tested in hospital patients.
Nyan 2008	Singapore	Emerging technology development	Implementation and trial results of a wearable pre-impact fall detection prototype, using inertial sensors to detect faint falls	Healthy adults	Wearable detection device	A fall detection system consisting of sensors on the thigh and waist and a data processing unit. The sensors include a 3D accelerometer and 2D gyroscope.	100% specificity (no false alarms) and 95.2% sensitivity (40/42 falls detected). Authors report that this system had the longest "lead time" so far, with 700ms, which could allow protective mechanisms such as hip air bags to deploy and soften the fall. Needs tested in hospital patients.
Olivares 2011	Spain	Emerging technology development	To present the development of Wagyromag (Wireless Accelerometer, GYROscope and MAGnetometer) a wireless Inertial Measurement Unit (IMU) composed of a triaxial accelerometer, gyroscope and magnetometer, which can be used for fall detection.	NA	Wearable detection device	A wearable fall detection device is described, consisting of a 3D accelerometer, 2 gyroscopes, magneto-resistive sensor (to track persons position) and temperature sensor, together with a processing unit. The device can be worn on the knee, wrist, waist or other body parts.	This paper presents the development of a wearable fall detection device and proposes several functions for its use, including fall detection.
Palmerini 2015	Italy	Emerging technology development	To present a novel feature for fall detection based on the wavelet-analysis of the impact phase.	Older adults	Wearable detection device	Presents a novel wavelet-based approach to fall detection, using a dataset of real-world falls	The wavelet-based feature outperformed previous approaches, with a sensitivity of 90%. However, there was a high false alarm rate and authors make suggestions for further improvements.

Rakhecha 2013	USA	Emerging technology development	The wearable wrist watch is programmable and has an in-built accelerometer sensor and microcontroller circuitry.	N/A	Wearable detection device	Fall detection device consisting of wrist watch & wireless sensor network	Algorithm was 81% efficient with watch on the wrist. However, if placed on waist or trunk of the patient, the efficiency increases to 89%. Consumes very little power and has an option of setting the watch in idle mode to save power. Needs tested in hospital patients.
Ranasinghe 2012	Australia	Emerging technology development	Describe development & evaluation of RFID-based system & algorithms	Heathy adults	Wearable detection device	Wireless identification & sensing platforms (WISPs); RFID readers & antennae; Patient monitoring software	94-100% accuracy achieved in pilot trial.
Ranasinghe 2014	Australia	Emerging technology development	Wearable sensor enabled RFID tag that is battery free, low cost, lightweight, maintenance free and can be worn continuously for automatic and unsupervised remote monitoring.	N/A	Wearable detection device	Wearable sensor enabled RFID tag that is battery free, low cost, lightweight, maintenance free and can be worn continuously for automatic and unsupervised remote monitoring of activities of frail patients at acute hospitals or residents in residential care. Sternum-worn & mattress sensors tested.	Successful pilot trial reported. Sternum method most accurate for detecting bed exit. Needs tested in hospital patients.
Rawashdeh 2012	USA	Emerging technology development	Developing a motion monitoring system to reduce the number of accidental falls among patients at acute risk, while preserving their privacy.	Elderly inpatients	Wearable detection device	The prototypical system includes five accelerometer-based wireless sensors that are placed on the wrists, ankles, and chest of a patient. The system senses the movements and postures of the patient and transmits the information wirelessly to a remote base station. The received motion information is processed in real-time and used to animate a 3D avatar that figuratively represents the movements of the patient. The 3D avatar is intended to give care staff early warning of patient wakefulness, agitation, and of patients attempt to arise from the bed without assistance, while preserving the privacy of the patients.	Prototype has undergone preliminary testing successfully on several elderly patients

Razjouyan 2017	USA	Emerging technology development	Feasibility of wearable technology to consciously monitor physical activity, sleep postures, and heart rate variability as potential markers of fall risk in the acute care setting	Inpatients form haematology/ oncology unit	Wearable detection device	The sensor was attached to participants' chests using standard ECG electrodes. The device is capable of recording several biological parameters, including ECG (250 Hz), respiratory rate (25 Hz), body temperature (1 Hz), and three-dimensional acceleration (100 Hz).	The current proof-of-concept study demonstrated feasibility of using a wearable technology for monitoring of physical activity and physiological parameters in an acute care setting and during entire length of stay. In addition, it demonstrated the proof-of-concept of using wearable technology to identify high fall risk in patients via monitoring day and night physical activities & heart rate variability.
Rescio 2018	Italy	Emerging technology development	To develop a low computational cost expert system for real time and automatic fall risk detection using electromyography (EMG).	Piloted on young healthy volunteers	Wearable detection device	A wearable surface EMG-based unbalance detection system was developed and piloted. The system consists of 4 wearable EMG sensors placed on the lower limbs (Gastrocnemius and Tibialis anterior muscles) and connected wirelessly to a USB receiver at a PC. A database of ADL and fall events was used to develop a fall prediction algorithm.	An EMG-based wearable fall detection system was piloted to increase the time between the inception of a fall and impact on the ground. The system had a longer time before impact (770ms) compared with inertial systems (200-700ms). However specificity (89.5%) and sensitivity (91.3%) were lower, so the authors suggest further work is needed.
Schwarzmeier 2014	Germany	Emerging technology development	Describes passive activity monitoring system using energy efficient, small & lightweight active UHF RFID sensor tag, infrastructure of multiple RFID readers & reader antennas, as well as server software (backend)	N/A	Wearable detection device	Lightweight accelerometer worn on clothing	N/A
Selvabala 2012	India	Emerging technology development	Description of wireless sensor network for elderly peop[le	Not stated	Wearable detection device	2 sensors - tri-axis accelerometer & PIR sensor	99% accuracy in detecting falls - need for real-world data

ShinmotoTorres 2016	Australia	Emerging technology development	Evaluation of battery less sensor-based chair & bed exit recognition approach	healthy over 65's	Wearable detection device	Flexible wearable wireless identification & sensing platform device: passive RFID tag with accelerometer & microcontroller	Promising preliminary results. Further work indicated on sensors (type & placement) and in target population (older in-patients)
ShinmotoTorres 2017	Australia	Emerging technology development	description & evaluation of classification algorithm for recognizing chair & bed-exits using accelerometer & RFID	healthy over 65's and geriatric patients	Wearable detection device	Flexible wearable wireless identification & sensing platform device: passive RFID tag with accelerometer & microcontroller	Novel hierarchical classification model presented that performs well against other models in healthy adults and patients. Need fro further work on effectiveness of system
Yacchirema 2018	Spain	Emerging technology development	An innovative IoT-based system for detecting falls of elderly people in indoor environments, which takes advantages of low-power wireless sensor networks, smart devices, big data and cloud computing.	3 healthy volunteers aged 40-60 underwent simulated falls	Wearable detection device	A 3D axis accelerometer embedded into a 6LowPAN wearable device is used to collect data from elderly people in real-time. Fall detection system architecture consists of four main components: A wearable device, a wireless communication network, a Smart IoT gateway and Cloud services. Each component plays an important role in the detection of falls.	high success rates shown with device and modelling
Wickramasinghe 2017	Australia	Mixed Methods	investigate the use of a batteryless radio-frequency identification (RFID) tag response to analyze bed-egress movements	participants had to be 65 years or older, living at home, able to consent to the study and mobilize independently	Wearable detection device	Monitoring framework that combines a novel sequence learning algorithm suitable for sparse accelerometer and RFID data. The framework is capable of generating a bed-egress alarm in real time. Based on a wearable embodiment of a triaxial accelerometer integrated in a passive RFID platform, which is loosely attached over a garment at the sternum level	The promising results indicate the efficacy of our batteryless bed-egress monitoring framework.

Wolf 2013	Germany	Other	to reduce the number of falls on geriatric wards.	all patients on a geriatric ward who had been classified as having an elevated risk of falling upon admission	Wearable detection device	bed exit alarm	the system that was built to detect attempts of patients to leav e the bed works as expected. It detects attempts r eliably and generates few false positive alarms. It was well accepted by patients and nurses, and multiple sensors worked flawlessly for more t han 1 year during the clinical trial. On the other hand, while none of the patients fell while wearing the sensor, there w ere not enough falls during the trial to statistically prove that the system is abl e to prevent falls.
Budinger 2003	USA	Review - Narrative	To review technologies for monitoring physiological parameters, including for fall detection.	Aimed at hospital patients	Wearable detection device	Several fall detection systems reviewed	Wireless telemetry will make monitoring more efficient and more reliable and in some cases bring improved health care at a major reduction in cost.
Schwickert 2013	Germany	Review - Systematic	Assemble, extract & critically discuss published information on studies in the field of falls & body-worn sensors	Varied - mostly healthy young populations	Wearable detection device	Body-worn sensors including accelerometers, gyroscopes, pressure sensors, switches & magnetometers	Limited methodological agreement in sensor-based fall detection studies using body-worn sensors. Need for standardisation of methodology for measuring & reporting falls. Lack of studies on real-world falls; mostly on young, healthy adults simulating falls
Noury 2007	France	Text and Opinion	To present a short review of fall detection research, discuss the physics of a fall and mean of detection, and propose a common evaluation framework for fall detection systems.	NA	Wearable detection device	Extensive number of interventions are discussed.	Small size sensors are more wearable; device maintenance interval not too short (reach 1 or 2 years); device activation should be automatic; communication capability enhances alert system.