# Preventive interventions for pressure ulcers in long-term older people care facilities: A systematic review

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## Abstract

**Aims and objectives**. To explore the effectiveness of interventions aimed at pressure ulcer (PU) prevention in long-term older people care facilities (LOPC).

**Background**. Pressure ulcers cause suffering for patients and constitute a major financial burden. Although most PUs could be prevented, their number has remained high. To avoid unnecessary suffering and costs, PU prevention must be effective.

**Design**. A systematic review.

**Methods.** A systematic search was conducted in six electronic databases PubMed (MEDLINE), CINAHL, Web of Science Core Collection, Scopus, Cochrane Wounds Group Specialized Register and Cochrane Central Register of Controlled Trials. The inclusion criteria were 1) study published in 2005 – 2017, 2) intervention with pre- and post-tests, focusing on PU prevention, 3) implemented in LOPC-facilities, 4) persons >65 years as study population, and 5) outcomes reported as PU incidence or prevalence or healing time. The methodological quality of the studies was evaluated using the Joanna Briggs Institute's MAStARI critical appraisal checklist. The data were analyzed with narrative synthesis.

**Results.** The review included eighteen studies. The study designs were RCTs (n=10), comparable cohort or case-control studies (n=3), and descriptive or case series (n=5). PU incidence in LOPC facilities decreased by using computerized decision-making support systems, PU prevention programs, repositioning, or advanced cushions. PU prevalence decreased with PU prevention programs, by using advanced mattresses and overlays, or by adding protein and energy supplements to diet.

**Conclusions.** There are many ways to prevent PUs in LOPC facilities; no single effective way can be identified. One third of the preventive interventions in LOPC facilities were effective. However, systematic evidence from randomized trials on preventive interventions of PUs in LOPC settings is still lacking.

**Relevance to clinical practice.** The findings can be used in practice for selecting and in research for developing effective preventive interventions of PUs in LOPC facilities.

**Key words:** Aged Care, Evidence-Based Practice, Implementation, Intervention, Long-Term Care, Nursing Homes, Older People, Pressure Ulcer, Quality of Care, Systematic Review

## Introduction

Although most pressure ulcers (PUs), also called pressure injuries, could be prevented (Black *et al.* 2011) their number has remained high. The number of PUs is high worldwide. For example, in the US, the prevalence of PUs in long-term-care was 11.8% in 2009 (VanGilder *et al.* 2009) and in nursing homes, 5.1% in 2014 (CMC 2015). Corresponding rates are seen in Europe. For example, in Germany, the annual nosocomial PU prevalence rate was 13.7% but dropped to 6.4% after three years of annual point prevalence surveys in 60 nursing homes in 2001 — 2004 (Lahmann *et al.*2010). The institutions with ongoing development of PU prevention protocols had the lowest prevalence rates, 0 — 10.3%. (Wilburn *et al.* 2006, Lahmann *et al.*2010).

Pressure ulcerss cause suffering for patients (Eriksson *et al.* 2000) and decrease their quality of life (Moore *et al.* 2011). Furthermore, PUs cause a risk for secondary infection (Ayello & Lyder 2007) and have a significant association with mortality and convalescence status (Dhandapani *et al.* 2014). Care of PUs poses a major financial burden on society (Moore *et al.* 2011, Dealey *et al.* 2012). In the US, PUs were the most common medical error in 2008, with a total cost of USD 3.3 billion (Van Den Bos *et al.*2011). In the United Kingdom, the cost of treating a stage 1 PU in 2011 was £1,214, rising to £14,108 for a stage 4 PU (Dealey *et al.* 2012). Because the number of patients in long-term older people care facilities (LOPC) is also increasing internationally as a result of population aging, the work on the prevention of PUs must be evidence-based and of sufficient quality to inform and attain cost savings in PU treatment (Pieper 2012) and to prevent suffering for patients.

In clinical care, solutions for PU prevention have been sought. Several international and national guidelines regarding the prevention of PUs have been published. The European Pressure Ulcer Advisory Panel (EPUAP), the National Pressure Ulcer Advisory Panel in the US (NPUAP) and the Pan Pacific Pressure Injury Alliance (PPPIA) have published common international guidelines regarding the evidence-based recommendations for the prevention and treatment of PUs. Based on these guidelines, national recommendations also exist in many countries (NPUAP, EPUAP, & PPPIA, 2014). Despite the guidelines, the clinical practices in preventing of PUs vary widely (Ayello & Lyder 2007, Niederhauser *et al.* 2012) and the implementation of these guidelines is unclear. The implemented guidelines do not always correspond with international or national guidelines and are often based on expert opinion and low-level evidence (Wilburn *et al.* 2006, Jackson *et al.* 2016.)

Contextual features, such as the characteristics of older people or the constitution of nursing staff, are important in the success or failure of the implementation of an intervention. It is important to understand which interventions and implementation strategies for PU prevention are best suited to particular contexts (Soban *et al.* 2011, Niederhauser *et al.* 2012). By documenting these details, researchers of future studies will advance the understanding of the implementation of PU prevention programs (Soban *et al.* 2011.)

Preventive PU interventions targeting older people's care are needed. Previously, the emphasis in preventing PUs focused on acute care where preventive methods have been successfully identified (Schindler *et al.* 2013, Tayyib *et al.* 2015). In acute care, PUs can be prevented with the contiguous implementation of evidence-based interventions and system support aimed at helping nurses with changes in practice (Schindler *et al.* 2013). In addition, multiple interventions with several components have seemed to be effective (Schindler *et al.* 2013, Tayyib *et al.* 2015). The involvement of frontline staff members at all stages of complex intervention design and implementation is considered essential to ensure staff engagement. The EPUAP also includes the aspect of training and further education in the prevention of PUs. (Niederhauser *et al.* 2012.)

To promote high-quality care in LOPC facilities, it is important to review effective PU prevention in this context. Previous systematic reviews were usually carried out in various health care settings and mostly included interventions targeted at acute care settings (Reddy *et al.* 2006, Niederhauser *et al.* 2012). A review of the prevention of PUs conducted solely in LOPC facilities seems to be lacking. Reddy *et al.* (2006) performed a review in various health care settings in the years 1988 – 2005 including 49 RCTs conducted in acute care and 10 RCTs conducted in various LTC-settings. Seven of the ten interventions were conducted in LOPC- setting. Only two of the 10 interventions reduced the incidence of PUs, one published in 1994 (Conine *et al.*1994) and one in 2005 (Defloor *et al.* 2005). Both interventions were conducted in an LOPC setting. The study of Reddy and colleagues (2006) described well the preventive PU interventions in LTC-settings. To continue the investigation of this topic, we conducted a review of studies from the year 2005 to 2017, focusing on the LOPC- setting. In this review, we focused on PU incidence, PU prevalence and PU healing time outcomes.

**Aim**

The aim of this review was to explore the effectiveness of the preventive interventions of pressure ulcers (PUs) in long-term older people care facilities (LOPC). The research questions were as follows: a) What interventions have been conducted in long-term older people care facilities on

prevention of PUs? b) How effective are the interventions targeting the prevention of PUs? The ultimate goal is to promote high-quality care in LOPC by adding the understanding of effective preventive methods to reduce PUs in LOPC facilities.

## Methods

### Design

A systematic review was conducted. A systematic review is suitable when aiming to systematically search for, appraise and synthesize research evidence, using guidelines on the conduct of a review (Grant & Booth 2009). The systematic review was required for this topic because in order to promote high-quality care in LOPC facilities, it is important to systematically find, evaluate and analyse effective PU prevention interventions conducted previously in this context. PRISMA guidelines for systematic reviews and meta-analyses (Moher *et al.* 2009) were followed.

### Literature search

To identify articles for the review a literature search in six electronic databases (PubMed (MEDLINE), CINAHL, Web of Science Core Collection, Scopus, Cochrane Wounds Group Specialized Register and Cochrane Central Register of Controlled Trials) was conducted in February 2017 (Figure 1). The search was limited to articles published in English and within the timeframe 2005— 2017 to continue the investigation of an earlier review (Reddy *et al.* 2006) on this topic. The search terms were pressure ulcer, prevention and intervention study and their synonyms.

The search produced a total of 2,664 citations (PubMed (Medline, n=839), CINAHL (n=531), Web of Science (n=616), Scopus (n=487), Cochrane Wounds Group Specialized Register (n=29) and Cochrane Central Register of Controlled Trials (n=162)). After removing duplicates, 2,072 citations remained.

### Article inclusion criteria

The inclusion criteria for the studies were: 1) a study published between 2005 — 2017, 2) description of an intervention with pre- and post-tests, focusing on the prevention of PUs as primary or secondary outcome, 3) implemented in long-term older people care facilities, 4) persons over 65- as study population or subsample, and 5) clinical outcomes of the intervention reported as incidence or prevalence of PUs or as healing time. The outcomes PU incidence and PU prevalence were

chosen, because pressure ulcer rates are the most direct measure of the success in preventing PUs. The outcome healing time was chosen to measure the success in the secondary prevention. The measurement of certain outcomes may be a criterion for including studies in a review when the intervention is aimed at preventing a particular outcome (Higgins *et al.* 2011).

**Retrieval of the studies for the review**

The retrieval process was conducted in two phases. First, 2,072 titles and abstracts were examined against the inclusion criteria. Two researchers (SM-T-R & MS) worked independently on this. To achieve consensus, the researchers discussed their selections and decided together which abstracts would be examined at full-text level. In this phase, a total of 2,007 abstracts were excluded because their content was not pressure ulcer prevention, they lacked an intervention, they were carried out in other settings than long-term older people care facilities, or included people who were too young. The remaining 65 studies were included in the full-text investigation.

Second, the full texts of the 65 studies were investigated independently against the inclusion and exclusion criteria. At this phase, 47 articles were excluded for the following reasons: participants' age was less than 65 years or not reported (n=21), other setting than LOPC (n=8), missing intervention or pre-/post-test (n=5), duplicate or same research (n=5), other outcome than PU prevalence/ incidence/ healing time (n=4), reviews, included published studies (n=3) that were too old, or not in English (n=1). The final inclusion and exclusion was confirmed within the research team. Based on this, 18 articles were included in the review.

**Article quality assessment**

The methodological quality of the studies was evaluated by using the MAStARI critical appraisal checklist of the Joanna Briggs Institute for three study designs (JBI 2014). The quality of the 18 selected studies was assessed independently by two reviewers (S.M-T-R, M.S). There were 10 questions to guide the appraisal of RCTs and nine questions to guide the appraisal of the cohort with control or case-controlled studies and descriptive or case series. The quality appraisal was quantified by using scores of 0 or 1 per question. One point was given if the answer to the question was 'yes' and zero points if otherwise. The quality scores of the 18 studies varied from five to eight. (Table 1.)

**Data analysis**

First, the data from the articles was extracted and tabulated. The following characteristics of the studies were collected: authors, year of publication, study design, LOPC- setting, country, sample, participants and length of follow-up (Table 2).

Second, information on the intervention was extracted. Content and dosing of the intervention, supporting structures, fidelity of treatment, outcomes of PU incidence, PU prevalence or PU healing time, assessment, assessor and instrument were tabulated (Table 3). The interventions were categorized based on the similarity of the content of the interventions. Using inductive analysis, six categories were formulated: support surfaces, repositioning, computerized support in PU decision-making, PU-prevention bundle or programs, wound care support team and nutrition.

The data of the interventions were analyzed by narrative synthesis according to Popay *et al.* (2006). The data would have been analyzed by meta-analysis if sufficient homogeneity between studies had been present. Narrative synthesis was used because meta-analysis could not be conducted. Meta-analysis cannot be conducted if there are different care methods with different comparators (Higgins *et al*. 2011), as was the case here. First, a preliminary synthesis of findings was developed by searching for common and differing components (codes), and then by grouping the related components together into the themes intervention, supportive structure and fidelity of treatment (Table 4). Following this, the components in the categories were explored. (Popay *et al.* 2006).

Third, the clinical effectiveness of the interventions was estimated by investigating the outcomes: PU incidence, PU prevalence or PU healing time. (Table 3). The evidence related to clinical effectiveness was categorized dichotomously. Interventions where PU incidence, PU prevalence or PU healing time was reported to reduce more in the intervention group than in the comparison group or was reduced between pre-post measurements were labeled “yes”. Interventions with the opposite outcomes were labeled “no” with the note: “negative effect”, while interventions with no difference between the groups were labeled “no”. (Popay *et al.* 2006.) Moreover, the results with a reported p-value under 0.05 were considered effective interventions and were reported with “yes” in the column named “significantly reduced”.

## Results

### General description of the studies

A total of 18 studies were included in this review (Table 2). The study designs were RCT (n=10), comparable cohort or case-control study (n=3) and descriptive or case series (n=5). The majority of the studies (n=13) were published between 2010 and 2015. The studies were conducted in LOPC settings: nursing homes (n=11), LTC (long-term care) facilities (n=5), nursing and rehabilitation centers (n=1) and a nursing facility (n=1) in the USA (n=4), the Netherlands (n=3), Canada (n=2), and – in the United Kingdom, Ireland, USA/Canada, Italy, Belgium, Norway, China (Hong Kong), France, (n=1) in each country. The country was not reported in one study. The sample size varied from 21 to 94,789. The age of the participants in the studies varied from 60 to 100 years and the reported mean age ranged from 73.2 to 92.5 years. The length of follow-up ranged from three weeks to ten years. The instruments used in the studies were the EPUAP scale for PUs (n=14, NPUAP, EPUAP, PPPIA 2014), The Stirling PU grading system (n=1, Reid and Morrison 1994), standardized evidence-based assessment (n=1) or unclear (n=1).

### Interventions conducted in long-term older people care facilities targeting the prevention of PUs

A variety of interventions targeting the prevention of PUs was used (Table 3). The most common intervention was support surfaces (mattresses, overlays and cushions, n=6), followed by repositioning (n=3), computerized support in decision-making in PU prevention (n=3), PU prevention bundle or program (n=3), wound care support teams (n=2), and nutrition (n=1). The types of interventions may be either single, consisting of one component, or complex, including several components (Richards *et al.* 2015). The studies reported in this review included both single and complex interventions. The interventions consisted of different components and also factors of support structures for promoting the implementation of the intervention and treatment of fidelity to define the degree to which the implementation followed the planned intervention (Table 4). Education was the most often used support structure of the interventions. The fidelity of treatment varied. Next, the interventions are described, namely support surfaces, repositioning, computerized support in decision making of PUs, PU -prevention bundle or programs, wound care support team and nutrition, with support structures and treatment fidelity.

Support surfaces were used as an intervention in six studies: different mattresses and overlays were used in four, cushions in one, and both in one study. In most studies, an advanced intervention

mattress, overlay or cushion was compared with a standard mattress, overlay or cushion (Brienza *et al.*2010, van Leen *et al.* 2011, van Leen *et al.* 2013, Ricci *et al.* 2013, Table 3). In the study of Hampton *et al.* (2005), both mattresses and cushions were used. Van Leen *et al.* (2014) used an intervention where a standard visco-elastic mattress was replaced by more advanced support surfaces (a visco-elastic mattress with a static air overlay or a low air-loss system) using step-by-step approach. As supporting structure of the interventions, a copy of the EPUAP-NPUAP guidelines was provided to the staff in the units (Ricci *et al.* 2013), nursing staff were given training and coaching (van Leen *et al.* 2014), or each participating resident was given a new, properly fitted wheelchair and cushions which were checked weekly by seating specialists (Brienza *et al.*2010). The fidelity of treatment was not reported in these studies.

Repositioning was used in three studies (Vanderwee *et al.* 2006, Moore *et al*. 2011, Bergstrom *et al*. 2014), all investigating different patient turning schedules and positions. Repositioning using back and 30 degrees or 90 degrees tilt was used as intervention in all studies (Vanderwee *et al.* 2006, Moore *et al.* 2011). The patient turning schedules varied from 2 to 6 hours. In one study, the repositioning also included heels offloaded from the bed (Moore *et al.* 2011). In all these interventions, the supportive structure was education. The contents of the education sessions varied and included education on how to carry out the intervention or topics related to the prevention of PUs (Vanderwee *et al.* 2006, Moore *et al.* 2011, Bergstrom *et al*. 2014). The fidelity of treatment in the interventions was ensured by comparing the observed positions of patients with the reported turns (Moore *et al*. 2011, Bergstrom *et al*. 2014) or by visits in the wards at unexpected times by the researcher or study nurse (Moore *et al*. 2011, Vanderwee *et al.* 2006).

Computerized support in decision-making in PU prevention was used in three studies, either as a direct guide for care or as a component of decision-making in care planning (Fossum *et al*. 2011, Shannon *et al.* 2012, Olsho *et al*.2014). Guided by decision algorithms and based on the resident's physiological factors stored in a database, the computer program chose skin care products, absorbent briefs and mattresses for the residents (Shannon *et al.* 2012), or, based on the results of the Risk Assessment Pressure Scale (RAPS) and the Mini Nutritional Assessment (MNA) scale, the computerized decision support service (CDSS) system presented evidence-based interventions for care planning (Fossum *et al*. 2011). In addition, based on weekly reports from electronic nursing documentation of residents' changing PU risk factors, such as nutritional status, incontinence and recent PU history, the work-flow was redesigned biweekly and the processes were improved using certain components. (Olsho *et al.*2014.) In all these interventions, one supporting structure was education. The timing and duration of the education sessions varied, including the topics of PU

prevention, PU treatment and training on device use (Fossum *et al.* 2011, Shannon *et al.* 2012). In addition to education, mentoring, researcher's visits to the units or telephone calls (Fossum *et al.* 2011, Shannon *et al.* 2012, Olsho *et al*.2014) were used as supporting structures. The fidelity of treatment was ensured by keeping a daily record of actions of care and assessments by nursing staff and by monitoring of activities by an external team. (Shannon *et al.* 2012.)

PU prevention bundle or program was used in three studies. The bundle of Keen and colleagues (2014) included the elements surface and skin inspection, keep moving, incontinence and nutrition. After a one-hour educational session to the staff, the bundle chart was completed for residents at high or very high risk of PUs, and based on the result, the assessing nurse planned the frequency of care for each resident. Kwong and colleagues (2011) used the PU prevention program consisting of two components: 1) A focused training course including a two-hour lecture and four hours of skills training for non-licensed care providers (NLCPs) and nurses, and 2) A prevention protocol that included PU prevention care tasks and indicated each task to be performed at a specific time. The lecture consisted of topics of PU prevention and evidence-based preventive interventions. The four-hour skills trainings included topics of PU prevention and/or PU assessment and protocol compliance. Tippett (2009) used the "Wound Program" with an interdisciplinary team, intensive training and evidence-based PU prevention protocols. Initial and follow-up training was given by a physician consultant or a director of nursing and nursing supervisors. Training included the use of the Braden scale, PU assessment, treatment and prevention, and the use of support surfaces. Additionally, annual training provided by physician consultant was mandatory for all staff, and in-service training for staff was also routinely provided. Protocols for prevention were shared in training classes. The PU prevention protocols (plan of care) of 19 interventions (Table 3) were part of routine shift reporting and charting. They were based on the Braden scale risk assessment and followed the Agency for Health Care Policy and Research (AHCPR) guidelines. All residents received five interventions (from 1 to 5). Residents at higher risk received further interventions, up to 19. In these interventions the supporting structures were information of the content of the bundle concept and NPUAP/EPUAP guidelines and knowledge tests about PU prevention (Keen *et al*. 2014). Fidelity of treatment was monitored twice a week by two visiting RNAs (Kwong *et al.* 2011).

A wound care support team was used in two studies. These teams educated nursing staff weekly at bedside, observing and counseling the nurses on the prevention and treatment of PUs (Nobrega *et al.* 2009), or worked biweekly as a remote support team for a skin and wound care expertise nurse who visited and educated nursing staff weekly at bedside and in group sessions (Stern *et al.* 2014).

The wound care support team consisted of the hospital-based expert multi-disciplinary wound care team (Stern *et al.* 2014) or a geriatrician and a clinical nurse specialist (Nobrega *et al.* 2009). The fidelity of treatment was not reported in these studies.

Nutrition as an intervention was used in one study (Pouyssegur *et al.* 2015). In nursing homes a six-week diet was used, where in addition to a standard institutional diet, eight cookies containing 11.5 g protein and 244 kcal were served every day.

**Effectiveness of the interventions in the prevention of pressure ulcers**

The effectiveness of the interventions varied. The majority (n=6) of the effective interventions were significantly effective in decreasing the incidence or prevalence of PUs and one intervention decreased both of them, whereas none of interventions improved the length of healing time (Table 3). Next, the effectiveness of interventions: support surfaces, repositioning, computerized support in decision-making in PU prevention, PU prevention bundle or program and nutrition is described.

Support surfaces decreased the incidence and prevalence of PUs. In the RCT study of Brienza and colleagues (2010), an air, viscous fluid and foam cushion or gel and foam cushion decreased significantly the incidence of PUs near the ischial tuberocities. Eight (6.7%) participants in the control group and one (0.9%) in the intervention group developed PUs (p=0.04). The prevalence of PUs was reduced significantly by the 3-step prevention strategy (van Leen *et al.* 2014) in a nursing home where a standard visco-elastic mattress was replaced by a static air overlay if signs of PU developed, after which repositioning was initiated. If signs of PUs still persisted, the resident's mattress was replaced by a low air-loss system. The results of the national nursing home sector showed a linear reduction of the prevalence of stage 2 – 4 PUs from 8.7% to 3.7% in 2011. After the introduction of 3-step model in 2005, the PU prevalence dropped to 0.5% within 1 year. This level was maintained at a rate of between 1.2% – 2.6% (category 2 – 4) during the rest of the study period (p= <0.001–0.002). (van Leen *et al.* 2014.) The prevalence of PUs was also reduced by changing 21 nursing home residents' standard mattresses into visco-elastic foam mattresses and visco-elastic cushions (Hampton *et al.* 2005). There was 82.5% decrease of PUs prevalence. However, in the study of Hampton and colleagues (2005) the significance of the results was not reported.

Repositioning using 30 degrees tilt (left side, back, right side, back) every three hours during the night, combined with the heels offloaded from the bed, reduced the incidence of PUs significantly.

The incidence of PUs was 11% in the control group and 3% in the experimental group (incidence rate ratio 0.27, 95% CI 0.08–0.93, p = 0.038, ICC 0.001). (Moore *et al.* 2011.)

Computerized support in decision-making in PU prevention reduced significantly the incidence of PUs (Shannon *et al*. 2012) when the computer program chose the skin care products and absorbent briefs for incontinent residents and selected mattresses based on the risk of PU or having a PU. In the study of Shannon and colleagues (2012) the incidence of PUs was 36% in the control group and 12% in the experimental group. There was a significant difference in the incidence of PUs between the experimental and control group (x2 = 10.770, p = .001). A 67% reduction in the incidence of PUs was reported. In addition, health information technology was used in nursing homes to compile weekly reports to identify residents' PU risk factors that were likely to change. When nursing staff's workflow was redesigned and processes were improved with guidance, the use of these weekly reports was associated with statistically significant reductions in PU incidence (IRR = 0.409, p< 0.035). Baseline PU incidence was 4.6%. (Olsho *et al.* 2014).

Pressure ulcer prevention bundle or program was significantly effective in reducing PU incidence and prevalence. A wound program including prevention protocols (Tippett 2009) and a focused training course for NLCPs and nurses (Kwong *et al.* 2011) reduced the incidence and prevalence of PUs. Tippett (2009) reported that average pre-initiative PU incidence was 5.19% and post-initiative PU incidence was 0.73%, a reduction of 86%, with an incidence of 0.06% in the program's fourth year, a reduction of 99% (p = <0.0001). Kwong and colleagues (2011) reported a decrease in PU incidence from 2.5% to 0.8% and in PU prevalence from 9% to 2.5 % after completion of the program. However, they did not report the statistical significance of the results.

Nutritional intervention reduced the PU prevalence significantly (Pouyssegur *et al.* 2015). Within-group analysis showed a significant reduction in PU prevalence in the intervention group (from 23.9% to 8.0%; p=0.001), but not in the control group (from15.3% to 6.9%, p= 0.11). Subgroup analysis confirmed the positive impact of cookie supplementation alone on PU reduction (p= 0.031).

## Discussion

This review explored the effectiveness of preventive interventions of PUs in LOPC facilities. The effective interventions to reduce the incidence of PUs in LOPC facilities were computerized decision-making support systems in PU prevention (n=2 studies, Shannon *et al*. 2012, Olsho *et al.* 2014, 6161 residents), PU prevention programs (n=1 study, Tippett 2009, monthly census during

six years 137 residents), repositioning using 30 degrees tilt every three hours during the night and heels offloaded from the bed (n= 1 study, Moore *et al.* 2011, 197 residents) or the use of more advanced cushions in wheelchairs (n= 1 study, Brienza *et al.* 2010, 180 residents) (Table 3).

The prevalence of PUs was reduced effectively by using PU prevention programs (n=1 study, Tippett 2009, monthly census during six years 137 residents), by changing into more advanced mattresses (n=1 study, van Leen *et al.* 2014, 91857 residents) or by adding protein and energy supplements to diet (n=1 study, Pouyssegur *et al.* 2015, 154 residents). In this review we did not find any studies reporting effective interventions that would improve the healing time of PUs. Most studies did not report the healing times of PUs with the various interventions used, and one study (Stern *et al.* 2014) reported non-significant healing time of PUs. In the results section of this review we provided information on the existing preventive interventions of PUs in the LOPC setting.

There were a variety of interventions in this review targeting the prevention of PUs in LOPC facilities. The interventions were conducted at primary level, secondary level or both of these levels of prevention. The primary prevention was done before the occurrence of any PU while secondary prevention was conducted after a resident had developed a PU, to prevent worsening and to promote healing of the PU by eliminating or reducing the risk factors. Our results support previous findings (Reddy *et al.* 2006) where support surfaces were the most common intervention. However, other methods for preventing PUs were noted in our review that were not included in previous reviews, such as interventions with computerized support in decision-making in PU prevention, PU prevention bundle or program and wound care support teams were developed. In the review of Reddy *et al.* (2006) the types of interventions in LTC settings were mostly single, including one component. This review provided evidence that complex interventions were also developed for the prevention of PUs in LOPC settings. Both complex and single interventions were effective. This gives the possibility to choose and implement suitable interventions, depending on the resources and context of the facility.

Education of the nursing staff was the most often reported supporting structure to promote the implementation of the interventions. However, we found that the way of reporting the supportive structures was not coherent. These findings are similar to Jackson *et al*. (2016), arguing that the implementation of preventive guidelines of PUs is unclear. There are international and national guidelines for the prevention of PUs (NPUAP, EPUAP, PPPIA 2014, Hotus 2015) on which to base planning of interventions, but there is a clear need for consistent guidelines for the implementation of interventions in LOPC facilities.

The results of this review are similar to previous systematic reviews concerning mattresses in various settings (Reddy *et al*. 2006), where more advanced static support surfaces were associated with lower incidences for PUs compared with standard hospital mattresses. The results also support previous results in various settings suggesting that the use of nutritional supplements may be useful in the prevention of PUs (Horn *et al.* 2004). However, whereas previously the composition of the best nutrients was unclear (Reddy *et al*. 2006) or differed based on individual characteristics (NPUAP, EPUAP, PPPIA 2014), in our review, one study (Pouyssegur *et al.* 2015) reported that in the LOPC setting the use of the same amount of supplement was generally effective (Pouyssegur *et al.* 2015). Ideal repositioning frequency or degrees in reducing PUs was not identified in an earlier systematic review (Reddy *et al.* 2006) in various settings. Instead, in our review, one study (Moore *et al.* 2011) reported that the position of 30 degree tilt with the turning frequency every three hours at night to be effective in LOPC-facilities. Optimal repositioning is important because it reduces pressure over vulnerable areas of the body (NPUAP, EPUAP, PPPIA 2014).

The findings of our review are in line with the viewpoint of Dykes *et al.* (2013) that for PU prevention, health information technology tools can be part of a complex intervention. The nursing record system has been regarded (Dykes *et al*. 2013) as a system which can be integrated within the clinical workflow of practicing nurses. In addition, Dykes *et al.* (2013) considered that it is not possible to build nursing knowledge from practice without data related to what nurses do to prevent adverse outcomes such as PUs.

Care facilities have increasingly bundled together best practices of PU prevention and implemented them in-house as extensive programs. An earlier review in various settings showed, that multifaceted, multidisciplinary programs were effective in preventing PUs, but the level of evidence was weak. (Niederhauser *et al*. 2012.) In our review, a significantly effective PU prevention bundle or program in prospective 6-year evaluation and a clinically effective PU prevention bundle or program in a quasi-experimental pretest-posttest study in LOPC setting were found. Bundled best practices are relatively inexpensive to establish, but to provide strong evidence of their effect, RCT studies are needed. For successful implementation of the bundles, it is also important to collect evidence as to which bundles of best practices of PU prevention are best suited to the context of older people's care (Soban *et al.* 2011, Niederhauser *et al.* 2012).

Evidence-based, targeted interventions of PU prevention in the context of LOPC are needed. In addition, technology could be emphasized, as its role is likely to grow in this area. New health care technology should be tested, such as pressure sensors in mattresses that produced online data of

long-lasting pressure with increased PU risk in certain skin areas. Furthermore, clothing, sheets and wheelchairs should be fitted with sensors that sound of alarm when there is pressure in the same area over an extended period. The context of LOPC differs from acute care as it involves frail, older people who live in these facilities on a long-term or permanent basis and nursing staff of whom a major proportion are licensed practical nurses or non-licensed care providers. There are characteristics related to the residents themselves, their treatment and the facility that are associated with greater likelihood of developing a PU. These characteristics include higher severity of illness, history of recent PU, weight loss, eating difficulties, use of catheters and use of positioning devices (Horn *et al*. 2004). Older patients with PU had the characteristics advanced age, low cognitive and consciousness function, low risk points of PU, Parkinson's disease, chronic diseases, low nutritional status and more antibiotics (Jaul *et al*.2013). All these characteristics are typical of residents in the context of LOPC facilities and affect interventions and their implementation. However, in the future it would also be important to develop interventions collaboration with older people themselves so that they could be actively involved in preventing PUs, depending on their resources.

The results of this review are useful at different levels of care in LOPC. They are important for clinical practice to define the evidence-based practice in PU prevention, to clarify the practices and to make them consistent in the LOPC setting. Healthcare leaders can also utilize the results to compare and choose effective interventions of PU prevention in LOPC facilities aimed at developing the quality of care. Moreover, the findings of this review can be utilized in education, in planning of health care education programs, continuing education and in-service training in LOPC facilities. At the moment, information of evidence-based PU prevention exists, but it is not used. Also, Kielo *et al.* (2017) stated that nursing students' knowledge in the prevention of wounds is poor. This review may serve as a source when educating nursing students to search for information on evidence-based practices in wound prevention. Finally, this review is important for research because it provides an over-view of the evidence of existing preventive interventions of PUs in LOPC setting.

**Strengths and limitations**

The strengths of this review were the following: First, the search to identify the studies was conducted with informatics specialists from the library. Second, the six electronic databases used in this review cover comprehensively the topic of pressure ulcer research and more widely the topic of health sciences. Third, the variety of the search terms pressure ulcer, prevention and intervention study and their synonyms gave a large number of citations on the topic, indicating that the search

targeted the topic widely. Fourth, a systematic study selection process involving three phases by two independently working researchers was conducted to minimize subjective selection bias. All these aspects strengthened the quality of this review.

There are some limitations in this review: English language, subjectivity in the synthesis process and heterogeneity of the interventions. Languages other than English were excluded, which may have led to publication bias. By including also non-English literature this review, it could have provided a more comprehensive overview of the evidence. We are aware of this deficiency. However, the review was based on several databases and involved articles from several journals and different cultures, including non-English speaking countries which increases the coverage of the review. The included studies were analyzed with narrative synthesis. According to Popay *et al.* (2006), robustness of the synthesis is achieved by reflecting on the synthesis process. The synthesis in this review was made in the manner that Grant *et al.* (2009) described as being typically used in systematic reviews, "narratively with tabular accompaniment" (Grant *et al.* 2009). The categories and components of the interventions were chosen by the researcher; this is to some extent subjective and may increase the bias. However, it was done after careful reading of the included studies which minimized the risk of bias. At some points the heterogeneity of the interventions made it difficult to synthetize the evidence: there were differences in study designs, samples, participants and follow-up times of the interventions. This heterogeneity of the studies weakened the evidence of the synthesis. The studies were not analyzed with meta-analyses. Meta-analysis cannot be conducted if there are different care methods with different comparators (Higgins *et al.* 2011) as in this review. This may have weakened the synthesis of the available evidence.

The methodological quality of the studies was assessed by using the JBI MASTARI criteria. The strength of the studies is the use of same instrument, the scale of EPUAP of the PUs stage 1— 4, in several studies (Table 3). On the other hand, the quality of some studies was quite poor on other points (Table 1), limiting the generalizability of the results of this review. However, to obtain an extensive understanding of the topic and to identify various interventions we included all the assessed studies in the review. Based on methodological analysis, there was particularly a lack of well-designed RCTs. There were also some methodological points which may have weakened the quality of this review. First, in RCTs, blinding of the participants or assessors was lacking. Blinding would decrease the bias after randomization (Altman *et al.* 2001). However, blinding is often irrelevant when studying interventions with multiple components (Karanicolas *et al.* 2010). Second, in the descriptive or case series studies, a comparison group was lacking. Third, in the results of four RCTs the confidence interval was not reported and the authors of the included studies were not

contacted to provide missing data; as a result the degree of certainty of the findings in those studies was unclear. Fourth, some interventions were reported as clinically effective, but no statistical significance of the results was included in the study. However, as these studies were clinically effective, a more powered sample size could show them to be statistically significant as well.

In the articles, the scientific robustness of the studies was evaluated by the authors themselves. Most of the reported limitations involved sample sizes or sampling (Hampton *et al.* 2005, Vanderwee *et al.* 2006, Brienza *et al.* 2010, Kwong *et al.* 2011, Moore *et al.* 2011, Shannon *et al.* 2012, van Leen *et al.* 2013, Olsho *et al.* 2014, Bergstrom *et al.* 2014, Pouyssegur *et al.* 2015). Impossibility of blinding (Vanderwee *et al.* 2005) or partial randomization (Pouyssegur *et al.* 2015) was also reported. In addition, there were limitations of data collection, when tissue viability nurse was not available (Keen *et al.* 2014), when the patients went to other facilities and came back (de Nobrega *et al.* 2009), or when self-reported PU outcome data were collected by participating nursing homes (Olsho *et al.* 2014). Wide confidence intervals (Moore *et al.* 2011), scoring of PUs (Pouyssegur *et al.* 2015) or lack of information of prevention strategies in comparison groups (van Leen *et al.* 2013) were also reported. Moreover, the possibility of "carry over" -effect between interventions (van Leen *et al.* 2013) or Hawthorne effect (Hampton *et al.* 2005, Brienza *et al.* 2010, Kwong *et al.* 2011) was reported.

Evidence of effective preventive interventions of PUs conducted in LOPC settings was found. One third of the interventions were effective. However, more systematic accumulation of information is still needed because of variety of interventions. In addition, there is a lack of systematic evidence obtained with randomized trials in this area.

## Conclusions

There are many ways to prevent PUs in LOPC facilities; however, no single, most effective way can be identified from the evidence available to date. The effective interventions to reduce the incidence of PUs in LOPC facilities were computerized decision-making support systems in PU prevention, PU prevention programs, repositioning using 30 degrees tilt every three hours during the night and heels offloaded from the bed, or the use of more advanced cushions in wheelchairs. The prevalence of PUs was reduced effectively by using PU prevention programs, by changing into more advanced mattresses, or by adding protein and energy supplements to diet. Evidence of effective preventive interventions of PUs in LOPC settings was found. However, there is still a lack of systematic evidence obtained with randomized trials in this area.

## Relevance to clinical practice

In the results of this review we provided information of existing preventive interventions of PUs in the LOPC setting. We also provided information of some new kind of effective interventions of PU prevention in this area. The results of this review are important for clinical practice to define the evidence-based practice in PU prevention, to clarify the practices and to make them coherent in the LOPC setting. The leaders in healthcare can utilize these results in work aimed at the development of the quality of care to compare and choose effective interventions for PU prevention in LOPC facilities.

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## What does this paper contribute to the wider global clinical community?

*Summary box:*

1 The prevention of pressure ulcers (PUs) must be effective in long-term older people care (LOPC) facilities to avoid the unnecessary suffering and costs they cause. In this review we provide information on the effectiveness of interventions aimed at PU prevention in LOPC facilities.

2 The effective interventions to reduce the incidence of PUs in LOPC facilities were computerized decision-making support systems in PU prevention, PU prevention programs, repositioning using 30 degrees tilt every three hours during the night and heels offloaded from the bed or the use of more advanced cushions in wheelchairs. The prevalence of PUs was reduced effectively by using PU prevention programs, by changing into more advanced mattresses, or by adding protein and energy supplements to diet.

3 Evidence was found of effective preventive interventions targeting PUs in LOPC settings. One third of the preventive interventions of PUs conducted in LOPC facilities were effective. However, more systematic accumulation of information is still needed because of the variety of the Interventions. Furthermore, systematic evidence, obtained from randomized trials is still lacking.

**Table 1** Appraisal of the methodological quality of the studies (n = 18) (MAStARI critical appraisal checklist of Joanna Briggs Institute 2014)

Appraisal of Randomized controlled trials (n = 10)

| | Is the assignment to treatment groups truly random? | Are participants blinded to treatment allocation? | Is allocation to treatment groups concealed from the allocator? | Are the outcomes of people who withdrew described and included in the analysis? | Are those assessing the outcomes blind to the treatment allocation? | Are the control and treatment groups comparable at entry? | Are groups treated identically other than for the named intervention? | Are outcomes measured in the same way for all groups? | Are outcomes measured in a reliable way? | Is appropriate statistical analysis used? | Total quality scores |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Bergstrom et al 2014 | Y | N | Y | N | Y | Y | Y | Y | Y† | Y | 8/10 |
| Brienza *et al.* 2010 | Y | N | N | N | Y | Y | Y | Y | Y† | Y | 7/10 |
| van Leen *et al.* 2011 | Y | N | N | Y | N | N | Y | Y | Y | N | 5/10 |
| van Leen *et al.* 2013 | Y | N | N | N | n/a | Y | Y | Y | Y | Y | 6/10 |
| Moore *et al.* 2011 | Y | N | Y | N | Y | Y | Y | Y | Y | Y | 8/10 |
| Pouyssegur *et al.* 2015 | Y | N | N | N | N | Y | Y | Y | Y† | Y | 6/10 |
| Ricci *et al.* 2013 | Y | N | Y | n/a | ? | Y | Y | Y | N | Y | 6/10 |
| Shannon *et al.* 2012 | Y | N | N | N | N | Y | Y | Y | Y† | Y | 6/10 |
| Stern *et al.* 2014 | Y | N | Y | N | Y | Y | Y | Y | Y | Y | 8/10 |
| Vanderwee *et al.* 2006 | Y | N | N | n/a | N | Y | Y | Y | Y | Y | 6/10 |

Appraisal of cohort with control / case-controlled studies (n = 3)

| | Is the sample representative of patients in the population as a whole? | Are the patients at a similar point in the course of their condition / illness? | Has bias been minimized in relation to selection of cases and controls? | Are confounding factors identified and strategies to deal with them stated? | Are outcomes assessed using objective criteria? | Is follow-up carried over a sufficient time-period? | Are the outcomes of people who withdrew described and included in the analysis? | Are outcomes measured a reliable way? | Is appropriate statistical analysis used? | Total quality scores |
|---|---|---|---|---|---|---|---|---|---|---|
| Fossum *et al.* 2011 | Y | Y | N | N | Y | Y | N | Y | Y | 6/9 |
| van Leen *et al.*2014 | Y | Y | Y | Y | Y | Y | n/a | Y | Y | 8/9 |
| Olsho *et al.* 2014 | Y | N | N | Y | Y | Y | Y | Y | Y | 7/9 |

Appraisal of descriptive / case-series (n = 5)

| | Is the study based on a random or pseudo-random sample? | Are the criteria for inclusion in the sample clearly defined? | Are confounding factors identified and strategies to deal with them stated? | Are outcomes assessed using objective criteria? | If comparisons are being made, is there sufficient description of groups? | Is follow-up carried over a sufficient time- | Are the outcomes of people who withdrew described and included in the analysis? | Are outcomes measured in a reliable way? | Is appropriate statistical analysis used? | Total quality scores |
|---|---|---|---|---|---|---|---|---|---|---|
| Hampton *et al* .2005 | N | Y | Y | Y | n/a | Y | N | Y | Y | 6/9 |
| Keen *et al.* 2014 | N | Y | N | Y | n/a | Y | Y | Y | N | 5/9 |
| Kwong *et al.* 2011 | Y | Y | Y | Y | n/a | Y | Y | Y | Y | 8/9 |
| Nobrega *et al.* 2009 | N | Y | Y | Y | n/a | Y | n/a | Y | Y | 6/9 |
| Tippett 2009 | N | N | Y | Y | n/a | Y | n/a | Y | Y | 5/9 |

(† Accepted if three of four: baseline data, percentage of changes and P value was reported but not confidence interval)

**Table 2** Characteristics of the studies

| Author & year of publication | Design<br>LOPC-Setting<br>Country | Sample<br>Participants (completed)<br>Intervention group (completed) /<br>control or comparison group (completed) | Length of follow-up |
|---|---|---|---|
| Support surfaces (Mattresses, overlays and cushions) (n=6) | | | |
| van Leen<br>*et al.* (2011) | RCT<br>Nursing home (n=1)<br>Netherland | 83 (74)<br>42 (37) / 41 (37)<br>patients with Norton score 5 – 12, no PU in previous 6 months | 6 months |
| van Leen<br>*et al.* (2013) | RCT<br>Nursing home (n=1)<br>Netherland | 42 (39)<br>20 (19 ) / 21 (19 )<br>patients with Braden score 6 – 19, no PU | 12 months |
| Ricci<br>*et al.* (2013) | RCT<br>LTC units (n=2)<br>Italy | 50 (50)<br>25 (25) / 25 (25)<br>patients with Braden score 8 – 14 or Norton scale 6 – 12, no PU or PU stage 1 | 4 weeks |
| van Leen<br>*et al.* (2014) | An explorative longitudinal study<br>Nursing homes<br>Netherland | Years 2002 – 2004: 114 –172/ 4,600 – 7,321,<br>Years 2005 – 2011: 179 – 303/ 8,337 – 14,852<br>patients with Braden scale =< 20 | 10 years / 7years |
| Hampton<br>*et al.*(2005) | Prospective longitudinal study<br>Nursing home (n=1) | 21 (13) / -<br>patients with PU stage 0 – 2 (Stirling) | 6 months |
| Brienza<br>*et al.* (2010) | RCT<br>Nursing homes (n=12)<br>USA | 232 (180), 113 (86) / 119 (94)<br>residents, using wheelchairs 6 or more hours/day with Braden<br>scores <=18 (combine activity and mobility score <=5), no PU | 6 months or until PU, discharge from the facility, withdrawal from the study, or death. |
| Repositioning (n=3) | | | |
| Bergstrom<br>*et al.* (2014) | RCT<br>LTC facilities(n=27)<br>USA and Canada | 967 (942)<br>residents with Braden scores 13 – 14 or 10 – 12, no PU | 3 weeks |
| Moore<br>*et al.* (2011) | RCT<br>LTC of the older person hospital (n=12)<br>Republic of Ireland | 213 (197)<br>99 (88) / 114 (109)<br>older persons, at risk of PU development (Braden activity and mobility components) | 4 weeks |
| Vanderwee<br>*et al.* (2006) | RCT<br>Older care nursing homes(n=16)<br>Belgium | 235 (235)<br>122 (122) / 113 (113)<br>patients with stage 1 PU. | 5 weeks |

Table 2 (continued)

| | | | |
|---|---|---|---|
| Computerized decision support systems (n=3) | | | |
| Shannon *et al.* (2012) | RCT<br>Nursing and rehabilitation centers(n=2)<br>USA | 133 (133)<br>83 (83) / 50 (50)<br>patients at risk of PUs, the historical control including 270 residents from the same facilities. | 6 months or until discharge, death or PU,<br>A 6-month retrospective review of facility-acquired PU incidence rates before the study |
| Fossum *et al.* (2011) | Quasi-experimental study<br>Nursing homes (n=15)<br>Norway | 2007 Baseline 491,<br>Intervention group1: 167, Intervention group 2: 172, control group 152 residents,<br>2009: 480,<br>Intervention group1: 200, Intervention group2 :158/ control group 122 residents | 8 months |
| Olsho *et al.* (2014) | An interrupted time series design<br>Nursing homes(n=25)<br>USA | 6,161,<br>3,463 / 2,698<br>residents | 12 months after full implementation |
| PU prevention bundle or program (n=3) | | | |
| Keen *et al.* (2014) | Descriptive study<br>One unit in care home | The first audit: 28 residents / -,<br>The second audit: 30 residents / - | The second audit almost a year after the program had been implemented |
| Kwong *et al.* (2011) | A quasi-experimental pretest posttest study<br>Nursing home (n=1)<br>China (Hong Kong) | 122 – 124 residents | 12 weeks |
| Tippett (2009) | A prospective 6-year evaluation<br>Nursing facility (n=1)<br>USA | The average monthly nursing home census during the study was 137<br>(range from 120 to 145) | 2 years before the implementation of the wound program<br>and +4 years post-implementation |
| Wound care support team (n=2) | | | |
| Stern *et al.* (2014) | RCT<br>(pragmatic cluster randomized stepped wedge trial)<br>LTC facilities (n=12)<br>Canada | 181/ 127<br>101 (71) / 80 (56)<br>residents with PU stage 2 or more | 4 –14 months per facility: The control period 3–12 months,<br>P1: 3months,<br>P2: 1–11 months<br>PUs were followed until healed, or until the end of the study period. |
| Nobrega *et al.* (2009) | A retrospective study<br>Five units in one geriatric LTC facility<br>Canada | 2003: 112 residents,<br>2005: 127 residents | Data derived from the database over two 12-weeks periods:<br>2003 and 2005 |
| Nutrition (n=1) | | | |
| Pouyssegur *et al.* (2015) | RCT<br>Nursing homes (n=7)<br>France | 175 (154)<br>88 (82) / 87(72)<br>residents | 6 weeks |

**Table 3** Content and effectiveness of the interventions

| Author & year of publication | Intervention | Dosing | Supporting structures | Fidelity of treatment | Outcomes † Assessment Assessor | Instrument | PU Incidence reduced | PU Prevalence reduced | PU Healing time reduced | Significantly reduced $ |
|---|---|---|---|---|---|---|---|---|---|---|
| Support surfaces (Mattresses, overlays and cushions) (n=6) | | | | | | | | | | |
| van Leen *et al.* (2011) | 1. A standard cold foam mattress with a static air overlay (intervention).<br>2. A standard cold foam mattress (control).<br>No repositioning before development of a grade 2 PU. | Six months while patient in bed. | NR | NR | Development of grade 2, 3, and 4 PUs at the heel or in the sacral /hip region.<br>A weekly inspection of the skin.<br>Assessor an independent nurse. | PU-classification scale of EPUAP stage 2 – 4 | Yes | | | No |
| van Leen *et al.* (2013) | 1.A static air overlay mattress placed on top of viscoelastic foam mattress (intervention).<br>2.A visco-elastic foam mattress (control).<br>All patients: No repositioning at night before development of a grade 1 PU. | Six months while patient in bed. | NR | NR | Development of grade 2 – 4 PUs<br>A weekly inspection of the skin.<br>Assessor unclear.<br>The data was collected by one researcher. | PU-classification scale of EPUAP stage 2 – 4 | Yes | | | No |
| Ricci *et al.* (2013) | Three dimensional mattress overlay (intervention) or viscoelastic mattress overlay (control) placed on top of a standard foam mattress.<br>All patients were repositioning every 2 hours, alternating lateral | 28 days while patient in bed. | Investigators from both units had 4 meetings: During the first two meetings were established the guidelines for prevention and treatment. The other two meetings were discussed the study design and case report | NR | PU incidence.<br>PUs was assessed on the day of the screening and days 7, 14, 21 and 28.<br>Assessor unclear. | PU-classification scale of EPUAP stage 1 – 4 | No | | | ? |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | (30 degrees) and supine position. Protocols were based on the EPUAP-NPUAP guidelines. | | forms. A copy of guidelines in Italian language was given to all actors in the units. | | | | | |
| van Leen *et al.*(2014) | 2002 A visco-elastic foam mattress (standard) received by all patients. 2005-2011 the PU protocol of 3 steps (intervention): 1) A visco-elastic mattress,2) If develop category1 PU a static air overlay 3) If still developed a PU repositioning every 3–4 hours. If still developed a PU a low air-loss system. | 10 years / 7years While patient in bed. 2.3 % received alternating mattresses and 13 % received static air mattresses. | In 2005 the nursing staff was trained and afterwards coached 3 months by a specialist wound nurse. | NR | PU prevalence. Assessment in "daily PU care". The annual national PU prevalence measurements 2002 – 2011, using a standardized questionnaire. Assessor unclear. | PU-classification scale of EPUAP stage 1 – 4 | Yes | Yes |
| Hampton *et al.*(2005) | 1.A pressure reducing visco-elastic foam mattress (intervention) 2.Standard mattress. Education was not supplied to the nurses or care assistants in the nursing home as any increase in knowledge may have affected to the study. | 6 months while patient in bed. | NR | NR | PU incidence. The skin was assessed the day one and in weeks 2,3,4 and 8, then monthly for 6 months. Assessor a qualified nurse; also nursing home reported in "daily care" detected skin changes. PUs was photographed weekly. | Stirling PU grading system (Reid and Morrison 1994). | Yes | ? |
| Brienza *et al.* (2010) | 1.An air, viscous fluid and foam, or gel and foam cushion in wheelchair (intervention). 2. 7.6-cm crosscut foam cushion in wheelchair. Each participant received a new, properly fitted wheelchair. | 6 or more hours per day, while using a wheelchair. | Wheelchairs and cushions were checked weekly by the seating specialist aided by occupational therapy students. | The research staff monitored actual daily sitting time by periodically sampling. | PU incidence near ischial tuberosities, Secondary analysis on combined IT ulcers and ulcers of the sacrum and coccyx. Weekly skin | PU-classification scale of EPUAP stage 2 – 4 or unstageable | Yes<br>Yes | Yes<br>No |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Treatment began with a seating assessment by the research team's seating specialist; an occupational therapist trained in seating and mobility. | | | | assessments. Assessor a research nurse, trained in detecting and staging PUs. | | | |

## Repositioning (n=3)

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Bergstrom *et al.* (2014) | Turning schedules 2-, 3-, or 4-hour intervals on high density foam mattresses<br>Documentation by certified nursing assistants (CNAs) and personal support workers (PSWs) at each repositioning episode: position, skin condition, briefs status and incontinence care. | 2-, 3-, or 4-hour intervals | By the study team in facility in 2 to 3 days: A study coordinator, recruiters, assessors, and record managers got individual training days. Licensed nurse supervisors were trained to observe and document position, record adverse events, and document skin care if a PU developed. CNAs and PSWs were trained to carry out the intervention. Training was completed in 1-hour required in service education classes. | Supervisors observed and recorded participants' positions hourly. Supervisor-observed positions were compared with CNA- and PSW-reported turns. Documentation from CNAs and PSWs were also evaluated of mean length of time patients spent in one position and monthly for percentage of on-time repositioning in bed. | PU on the coccyx or sacrum, greater trochanter or heels. Assessors licensed nurse supervisors, trained in the same way. | PU-classification scale of EPUAP stage 1 – 4 | No | No |
| Moore *et al.* (2011) | 1. Repositioning using 30 degrees tilt (left side, back, right side, back) every three hours during the night, heels offloaded from the bed (intervention).<br>2. Repositioning every six hours at night, using 90 degrees lateral rotation.<br>The clinical staff recorded each repositioning episode on a data collection sheet. | Every three hours | Education, before beginning the study for both groups: explanation of the purpose of the study, the data collection sheets and the PU–grading system. In addition, for the intervention group: the repositioning DVD and the demonstrated repositioning technique of the 30 degree tilt. | Fidelity of treatment: The researcher visited the wards at random times. A staff member from Nursing Administration and from each ward was also monitored compliance with repositioning and data collection. | PU incidence that occurred during the 28 days of the study. Assessment by staff at each turning episode, and if noted changes the skin then by the assigned key staff member, the clinical nurse manager and the researcher. | PU-classification scale of EPUAP stage 1 – 4 | Yes | Yes |
| Vanderwee | 1. Repositioning alternately 2 | 5 weeks while | Before the start of the study, all | On each ward study nurse | PU incidence. | PU- | Yes | No |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| *et al.* (2006) | hours in the lateral position 30 degrees and 4 hours in the supine position on a 7 cm visco-elastic foam overlay mattress (intervention)<br>2. Repositioning on the same mattress, the same turning scheme, but every 4 hours<br>The heels of patients in both groups were elevated from the mattress by cushion.<br>The nurse noted every repositioning on turning schedule at the bedside. | patient in bed. | nurses followed a training session of PU classification (PUCLAS). | was responsible for follow-up of adherence to the protocol. Weekly, an unexpected moment the research and study nurse monitored on wards the accuracy of the followed protocol. | The occurrence of PUs was assessed daily during the morning shift by nursing staff and weekly by the researcher and the study nurse independently of each other off a randomly selected sample of the patients. | classification scale of EPUAP stage 1 – 4 | | |
| Computerized decision support systems (n=3) | | | | | | | | |
| Shannon *et al.*(2012) | PU prevention program (PUPP): Guided by decision algorithms, -based on the resident's physiological factors, PU risk or having a PU, stored in the Minimum Data Set (MDS), the computer program chose to residents' skin care products, absorbent briefs and mattresses. | | PU prevention education was given for nurses by a nurse certified in the PUPP at the beginning and by trained senior nursing staff repeatedly at the end of the study. | The fidelity of treatment was ensured by keeping in each shift and a daily record of actions of care and assessments by nursing staff and by monitoring of activities by an external quality management team. | Reduction in the incidence of nosocomial PUs. Staff of the facilities completed weekly the electronical patient skin records. PU incidence was determined weekly and monthly from the records. | PU-classification scale of NPUAP stage 1 – 4 | Yes | Yes |
| Fossum *et al.* (2011) | A computerized decision support systems (CDSS), integrated into the electronic healthcare record, based on Risk Assessment Pressure Scale (RAPS) and the Mini Nutritional Assessment (MNA) scale. Based on the results from these, the CDSS presented | NR | Two 45-min educations for registered nurses (RNs) and nursing aides (NAs) offered twice with the same content. The education included information on PU and malnutrition risk assessment, prevention and treatment of PUs and | NR | PU prevalence. Assessors: trained RNs and NAs. | PU-classification scale of EPUAP stage 1 – 4 | No‡ | No |

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| | evidence-based interventions to support care planning. | | malnutrition, and assessment of stages I to IV PUs. A lectures, exercises and discussions were used. The CDSS was introduced in a three days special educational program. An information system specialist provided training and support in using the CDSS. The CDSS users received instructions in the use and a telephone number they could call if they had questions. In the beginning and end of the data collection, one of the researchers visited units. | | | | | |
| Olsho *et al.* (2014) | The integrated reports + process improvements = "On-Time components".<br>Weekly gathered reports from documentations of resident PU risk factors that are likely to change, such as nutritional status, incontinence and recent PU history. Biweekly redesigned work flow and improve processes to integrate reports into day-to-day practices with facilitators. Facilitators guided nursing home implementation teams to select appropriate components for implementation (Four different components: nutrition, weight, priority and trigger). | Biweekly | Use off staff educators and certified nurse assistant (CNA) mentors.<br>After full implementation of the components, following 12 months the facilitators called monthly to nursing homes implementation teams | NR | PU incidence.<br>The number of PUs, developed in-house was collected each month. Assessor unknown. Self-reports from nursing home were collected by CNAs. | PU-classification scale of EPUAP stage 1 – 4 and unstageable | Yes | Yes |

## PU prevention bundle or program (n=3)

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Keen *et al.* (2014) | A one hour introduce the concept of the SKIN bundle (Surface/ skin inspection, Keep moving, Incontinence, Nutrition) to staff. A Skin bundle chart was then completed for residents at high or very high risk of PUs. The assessing nurse on each shift planned the frequency of SKIN bundle care for each resident.<br>Documentation used in the SKIN bundle implementation:<br>S — SURFACE (Functioning properly Heel protection effective)<br>S — SKIN INSPECTION (Sacral/perineal area red/sore Heels red/sore) Other bony prominences red/sore Names of any other red/sore areas)<br>K — KEEP MOVING: Repositioned to lie on back/ Repositioned with right 30-degree tilt/ Repositioned with left 30-degree tilt/ If sitting, has been stood or hoisted/ Other position name: (or patient mobile)<br>I — INCONTINENCE (If fully continent, record NA and proceed to N)/ Pad changed /Perineum cleansed (soap and /water) /Perineum cleansed (cleanser) / Barrier cream on intact skin / Barrier film on broken skin | Each shift | The education designed and given by the tissue viability nurse included information of the SKIN bundle concept and NPUAP/EPUAP (2009) guidelines.<br>Before and after education staff's knowledge of PU prevention was tested. The test consisted of 10 questions from the EPUAP/NPUAP (2009) guidelines: definition, PU classification, risk factors, repositioning, skin care, nutrition, support equipment and education of healthcare staff. | NR | PU occurrence.<br>Assessors: Tissue viability link nurse and tissue viability nurse. | PU-classification scale of EPUAP stage 1 – 4 and unstageable | No‡ | ? |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | N — NUTRITION Oral fluids/food taken /Supplements taken<br>Time/date next SKIN bundle care due, Staff/carer /patient signature | | | | | | | | |
| Kwong *et al.* (2011) | A PU prevention program for nursing homes includes two components: A focused training course for non-licensed care providers (NLCPs) and nurses to prepare them to implement a PU prevention protocol and a prevention protocol designed to guide them systematically in their decision-making processes and actions.<br>The prevention protocol included PU risk assessment, PU and skin assessments, evidence-based interventions and referrals to dieticians, physiotherapists and occupational therapists. The protocol outlines PU prevention care tasks and indicates each task to be performed by NLCPs or nurses at a specific time. | Each care task | The research team, experienced nurses, delivered a two-hour lecture and four hours of skills training sessions to the NLCPs and nurses. The lecture consisted topics of PU etiology and assessment, PU risk factors, PU risk and skin assessment and evidence-based preventive interventions. The four-hour skills training included turning, positioning, lifting, transfer, use of pressure relieving devices, skin assessment and protocol compliance for NLCPs and PU risk and PU assessment and protocol compliance for nurses. | Fidelity of treatment was monitored twice a week by two visiting RNAs. | PU prevalence and incidence.<br>Assessors: two research assistant (RA) nurses. | Unknown:<br>The prevalence form and incidence form was used to document stage of the PUs. | Yes | Yes | ? |
| Tippett (2009) | Wound program including interdisciplinary team, intensive training and use of evidence-based protocols. Prevention protocols (plan of care) of 19 interventions based on Braden scale risk assessment following Agency of Health Care Policy and Research | Part of the routine shift reporting and charting. | All staff was trained initially by the physician consultant; follow-up training was conducted by the director of nursing (DON) and nursing supervisors. The physician consultant conducted yearly mandatory follow-up training sessions for all staff. | NR | PU incidence of all stages nosocomial PUs.<br>Assessment every month.<br>Assessor the same nurse except the last year when the nurse | PU-classification scale of NPUAP stage 1 - 4 | Yes | Yes | Yes |

| | | |
|---|---|---|
| (AHCPR) guidelines. All residents receive interventions from 1 to 5, residents at higher risk receive further interventions, up to 19. Prevention protocols: Minimal risk – Braden Score 15 – 18; 1) Manage pressure (frequent turning, maximal remobilization, reduce pressure on heels), friction and share, 2) Pressure-reduction support surface, 3) Manage moisture, 4) Assist with peri-care hygiene as indicated per activities of daily living (ADL) needs and 5) Observe for ADL decline that could contribute to skin breakdown and notify MD if needed, 6) Systematically inspect skin at last once/day for signs and symptoms decreased skin integrity, with attention to bony prominences. Document results of inspection weekly, 7) Maintain good hydration, 8) Encourage adequate nutritional intake daily. Moderate risk – Braden Score 13 – 14; 9) Manage pressure, friction and share (assist with mobility in bed/chair, as needed to alleviate prolonged pressure, turning schedule, use pressure relieving devices as needed, pressure-reduction support surface, maximal remobilization, pressure reduction | Additionally, in-service training was provided routinely. Protocols for prevention were shared in training classes. | in charge of assessment who was trained in the same manner did it. |

| | | | | | | | | | |
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| | of heels), 10) Manage nutrition (supplement as needed, consult dietary 11 )Labs per orders, 12) Notify MD for problems as needed, 13) Apply treatments per orders. High risk – Braden Score 10 – 12: 14) Manage pressure (reposition as needed), 15) Manage friction and share (use trapeze when indicated, use lift sheet to move patient, protect elbows and heels if being exposed to friction, 16) Request lab orders as appropriate, 17) Dietary consult if not already obtained, 18) Evaluate need for additional pressure reduction/relieving as appropriate, 19) Consult Wound Team/ Wound Physician.<br>The interdisciplinary team included a physician, the wound coordinator, nurse supervisors from each floor, a director of nursing (DON), a physical therapist (PT), a Minimum Data Set (MDS) nurse, an activities therapist, a nutritionist, a product supply clerk, one nurse aide and a social worker. | | | | | | | | |
| <u>Wound care support team (n=2)</u> | | | | | | | | | |
| Stern *et al.* (2014) | Phase 1: An advance practice nurses (APNs) expertized in skin and wound care visited to educate staff on the prevention and | Phase 1: once a week, during three months | | NR | Secondary outcome healing time, PU incidence and prevalence. | PU-classification scale of EPUAP | No | No | No | No |

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| | treatment of PUs, supported with a hospital based expert wound care team via e-mail, telephone, or video link. The APNs educated staff case based at the bedside and structured group sessions created to meet the needs of facility.<br>Phase 2 Remote support of the facility wound care lead by APNs via e-mail and telephone.<br>Research assistants visited each facility every two weeks to obtain digital photos of PUs. Research assistants also administered surveys of utility (EQ5D and pain (VAS-Pain) every 2 weeks. The EQ5D was also measured by proxy.<br>Interviews and observations was done with characteristics that may influence PU healing rates. | Phase 2: Biweekly, during 1–11 months | | | Assessors wound care lead. | stage 1 – 4 | | |
| Nobrega *et al.* (2009) | Pressure ulcer team (geriatrician and a clinical nurse specialist), with a focus in prevention and management of PUs, discussed weekly at the bedside with the primary care nurse the ulcer management techniques being used, noted how the patient was being cared for (e.g. positioning) and made recommendations and observed how the nursing staff did the dressings | Weekly | NR | NR | Prevalence of PUs.<br>A retrospective assessment from the Minimum Data Set (MDS) conducted over two 12-week periods 2003 and 2005.<br>The assessor inter-disciplinary team members. | Instrument: "standardized evidence-based assessment" | Yes | No |

Nutrition (n=1)

| | | | | | | | | |
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| Pouyssegur *et al.* (2015) | In addition of standard diet, residents ate eight protein-cookies with 11.5 g protein and 244 kcal daily.<br>The study was designed with five visits. There was first an initial period of 4 weeks to observe weight evolution, with medical data collected from patients' medical files. After this, participants in the Intervention group received cookies for 6 weeks. After the end of cookies consumption there was a follow-up period in both groups with two visits 1 and 3 months. | Daily | NR | NR | Secondary outcome episodes of PUs.<br>PUs recorded at baseline (w−4), and (w0, w6, w10 and w18).<br>Assessor unclear. | The instrument: unclear. | Yes | Yes |

(† NR Not reported)

**Table 4** Components of the interventions, supporting structure and fidelity of treatment

| INTERVENTION† | COMPONENTS‡ | van Leen *et al.* (2011) | van Leen *et al.* (2013) | Ricci *et al.* (2013) | van Leen *et al.* (2014) | Hampton *et al.* (2005) | Brienza *et al.* (2010) | Bergstrom *et al* (2014) | Moore *et al.* (2011) | Vanderwee *et al.* (2006) | Shannon *et al.* (2012) | Fossum *et al.* (2011) | Olsho *et al.* (2014) | Keen *et al.* (2014) | Kwong *et al.* (2011) | Tippett (2009) | Stern *et al.* (2014) | Nobrega *et al.* 2009 | Pouyssegur *et al.*(2015) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Support surfaces | | X | X | X | X | X | X | | | | | | | | | | | | |
| (n=6) | Mattress | | | | x | x | | | | | | | | | | | | | |
| | Overlay | x | x | x | x | | | | | | | | | | | | | | |
| | Cushion | | | | | x | x | | | | | | | | | | | | |
| Repositioning (n=3) | | | | | | | | X | X | X | | | | | | | | | |
| | Turning schedule | | | | | | | x | x | x | | | | | | | | | |
| | Degrees of tilt | | | | | | | | x | x | | | | | | | | | |
| | Heels | | | | | | | | x | | | | | | | | | | |
| Computerized | | | | | | | | | | | X | X | X | | | | | | |
| decision-making | Algorithms for selection of | | | | | | | | | | x | | | | | | | | |
| support system (n=3) | skin care products | | | | | | | | | | | | | | | | | | |
| | Algorithms for selection of | | | | | | | | | | x | | | | | | | | |
| | absorbent briefs | | | | | | | | | | | | | | | | | | |
| | Algorithms for selection of | | | | | | | | | | x | | | | | | | | |
| | mattresses | | | | | | | | | | | | | | | | | | |
| | Computer presented | | | | | | | | | | | x | | | | | | | |
| | evidence-based interventions | | | | | | | | | | | | | | | | | | |

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|---|---|---|---|---|---|
| | based on risk assessment of PUs | | | | |
| | The integrated electronic reports of PU risk factors that are likely to change + process improvements = "On-Time components" | x | | | |
| PU prevention bundle or program (n=3) | | | X | X | X |
| | Support surface/ pressure relieving devices | | x | x | x |
| | Heel protection / elbow protection | | x | | x |
| | Repositioning | | x | x | x |
| | PU risk assessment | | | x | |
| | Skin assessment | | x | x | x |
| | Skin care | | x | | x |
| | Documentation results of skin assessment | | | | x |
| | Incontinence Pad changed /Perineum cleansed | | x | | x |
| | Nutrition /hydration | | x | | x |
| | Consultation to dieticians | | | x | x |
| | Consultations to physiotherapists and occupational therapists | | | x | |

| | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Consultations to Wound Team/ Wound Physician | | | | | | | | | | | | x | | | | |
| | Evidence-based interventions by the European PU Prevention Panel (2010) | | | | | | | | | | | x | | | | | |
| | Labs per orders | | | | | | | | | | | | x | | | | |
| Wound care support team (n=2) | | | | | | | | | | | | | | X | X | | |
| | Bedside support | | | | | | | | | | | | | x | x | | |
| | Remote support | | | | | | | | | | | | | x | | | |
| Nutrition (n=1) | | | | | | | | | | | | | | | | X | |
| | Energy and protein supplement | | | | | | | | | | | | | | | x | |
| SUPPORTING STRUCTURE (including to or supporting the intervention) | Education (Lectures, exercises, discussions, DVDs) | x | x | | x | x | x | x | x | x | x | x | x | x | x | | |
| | Mentoring, coaching | | | | | | | | | x | | | | | | | |
| | Material | x | | | | | | | x | | | | | | | | |
| | Researcher's visits, phone number/ phone calls, e- mail, videolink | | | | | | | | x | x | | | | x | | | |
| | Use of technical specialists | | | x | | | | | x | | | | | | | | |
| FIDELITY OF TREATMENT | Recording or noting each turning schedule, action of care and or assessments by clinical staff | | | x | x | x | x | x | | | x | | | | | | |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| | Comparing reported and observed positions | x | x | | | | |
| | The researcher's visits at planned or random times | | x | x | | | x |
| | Administration or ward was monitored compliance with repositioning and data collection | | x | x | x | | |

(† X intervention, ‡ x component)

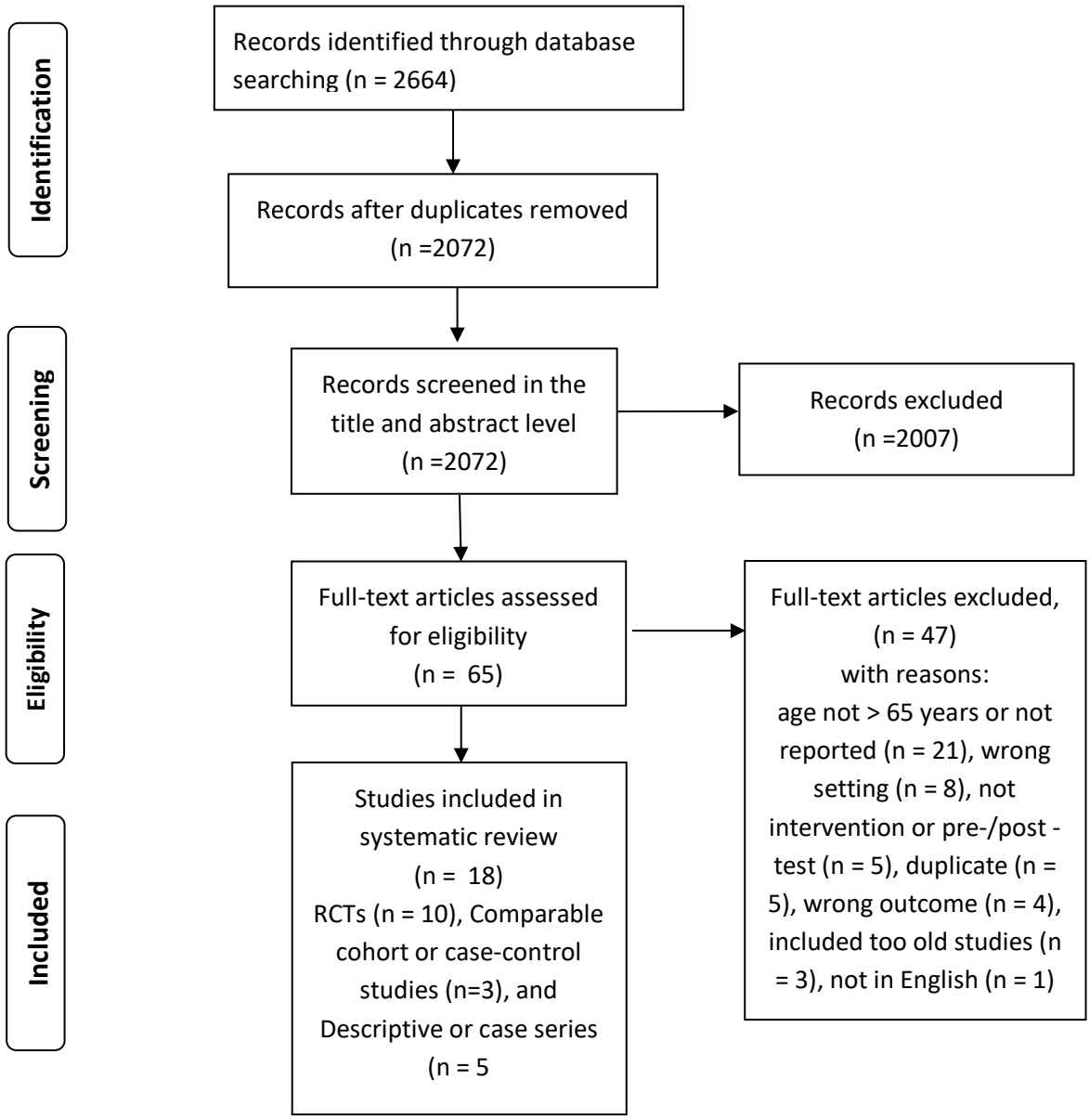


Figure 1. Retrieval of the studies (PRISMA)