A multi-faceted tailored strategy to implement an electronic clinical decision support system for pressure ulcer prevention in nursing homes: A two-armed randomized controlled trial

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ABSTRACT

Background: Frail older people admitted to nursing homes are at risk of a range of adverse outcomes, including pressure ulcers. Clinical decision support systems are believed to have the potential to improve care and to change the behaviour of healthcare professionals.

Objectives: To determine whether a multi-faceted tailored strategy to implement an electronic clinical decision support system for pressure ulcer prevention improves adherence to recommendations for pressure ulcer prevention in nursing homes.

Design: Two-armed randomized controlled trial in a nursing home setting in Belgium. The trial consisted of a 16-week implementation intervention between February and June 2010, including one baseline, four intermediate, and one post-testing measurement. Primary outcome was the adherence to guideline-based care recommendations (in terms of allocating adequate pressure ulcer prevention in residents at risk). Secondary outcomes were the change in resident outcomes (pressure ulcer prevalence) and intermediate outcomes (knowledge and attitudes of healthcare professionals).

Setting: Random sample of 11 wards (6 experimental; 5 control) in a convenience sample of 4 nursing homes in Belgium.

Participants: In total, 464 nursing home residents and 118 healthcare professionals participated.

Methods: The experimental arm was involved in a multi-faceted tailored implementation intervention of a clinical decision support system, including interactive education, reminders, monitoring, feedback and leadership. The control arm received a hard-copy of the pressure ulcer prevention protocol, supported by standardized 30 min group lecture.

Results: Patients in the intervention arm were significantly more likely to receive fully adequate pressure ulcer prevention when seated in a chair \(F = 16.4, P = 0.003\). No significant improvement was observed on pressure ulcer prevalence and knowledge of the professionals. While baseline attitude scores were comparable between both groups [exp. 74.3% vs. contr. 74.5% \((P = 0.922)\)], the mean score after the intervention was 83.5% in the experimental group vs. 72.1% in the control group \(F = 15.12, P < 0.001\).

Conclusion: The intervention was only partially successful to improve the primary outcome. Attitudes improved significantly while the knowledge of the healthcare workers remained unsatisfactorily low. Further research should focus on the underlying reasons for these findings.

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What is already known about the topic?

- Non-adherence to pressure ulcer guidelines in clinical practice is reported recurrently.
- Clinical decision support systems may change behaviour of healthcare professionals.
- Strategies tailored at identified barriers and facilitators may enhance the effectiveness of guideline implementation.
- Studies on the effect of multi-faceted tailored strategies for the implementation of clinical decision support systems for pressure ulcer prevention are missing.

What this paper adds

- The proposed intervention was only partially successful to improve adherence to recommendations for pressure ulcer prevention in nursing homes.
- Attitudes of the professionals improved significantly as a result of the intervention; their knowledge remained unsatisfactorily low.
- Further research should focus on the underlying reasons for these findings.

1. Introduction

Frail older people admitted to nursing homes are at risk for a range of adverse outcomes, including pressure ulcers (Brown et al., 2001). Targeted care strategies can improve health outcomes for these patients. Pressure ulcers are key clinical quality indicators for the care in nursing homes (Comondore et al., 2009). Incidence studies report on figures between 6.2% and 8.8% in hospitalized geriatric patients (Baumgarten et al., 2003, 2006). Even higher incidence figures between 11.9% (Vap and Dunaye, 2000) and 23.2% (Baumgarten et al., 2004) are reported in nursing homes. Effective prevention consists of a set of strategies aimed at reducing the intensity and/or duration of pressure and shear on the tissue and the underlying body structures (Pressure Ulcer Advisory Panel & National Pressure Ulcer Advisory Panel, 2009). Prevention should be focused on patients at risk and should be provided on a continuous basis during the time that the patient is at risk (Pressure Ulcer Advisory Panel & National Pressure Ulcer Advisory Panel, 2009).

1.1. Clinical decision support systems for pressure ulcer prevention

Evidence-based prevention guidelines are developed by international authoritative organizations, such as the European Pressure Ulcer Advisory Panel (EPUAP), the National Pressure Ulcer Advisory Panel (NPUAP), the National Institute for Health and Clinical Excellence (NICE), the Scottish Intercollegiate Guidelines Network (SIGN), and the Agency for Healthcare Research and Quality (AHRQ). These guidelines include mainly recommendations which are often vague and limited focused on the context of practice. As a result, non-adherence to pressure ulcer guidelines is reported recurrently (Beeckman et al., 2011; Vanderwee et al., 2007, 2011). A 2002 cross-sectional, multi-centre study in European hospitals showed that only 10% of the patients at risk received fully adequate prevention (Vanderwee et al., 2007). Similar results were found in a 2008 cross-sectional study including 19,968 patients (admitted to 84 hospitals) in Belgium (Vanderwee et al., 2011). The latter found that only 10.8% of the patients at risk received fully adequate prevention in bed and when seated. Furthermore, 70% of the patients who were not at risk received some pressure ulcer prevention.

Kawamoto et al. (2005) concluded that clinical decision support systems are believed to have the potential to improve care and to change the behaviour of healthcare professionals. Such a clinical decision support system aims to assist healthcare professionals with decision making tasks. The systems are able to deliver clinical advice for patient care based on a number of items of patient and context specific data. Evaluation studies of clinical decision support systems have tended to focus on the assessment of system quality and clinical performance in laboratory settings (Varonen et al., 2008). Relatively few studies have used field trials to determine if these systems are likely to be used in routine clinical settings (Varonen et al., 2008).

1.2. The implementation of evidence-based pressure ulcer prevention guidelines

The implementation of guidelines in clinical practice is complex. Implementation includes multiple strategies and variables which influence the adoption of evidence-based practices by individuals and organizations (Titler and Everett, 2001). Implementation aims to influence practitioners’ awareness, attitudes, knowledge, understanding and acceptance of a guideline (Grol and Grimshaw, 2003). Numerous models and conceptual frameworks for implementation are proposed in the literature: (1) the Stetler model (Stetler, 1994), (2) the Rogers’ Diffusion of Innovations model (Rogers, 2003; Sanson-Fisher, 2004), (3) The Iowa Model of Evidence-Based Practice to Promote Quality Care (Titler et al., 2001; Titler, 2007), (4) the Promoting Action on Research Implementation in Health Services (PARIHS) framework (Kitson et al., 1998; Rycroft-Malone et al., 2002), and (5) the model for effective implementation...
by Grol and Wensing (2005). An in-depth review of these models and frameworks is beyond the scope of this article. However, implementation studies must be guided by a conceptual model or framework to organize strategies being tested, and to elucidate the extraneous variables to be included.

For the current study, the model for effective implementation by Grol and Wensing (2005) was selected. The developers of this model put forward a clear stepwise approach to implementation and primarily recommend the justification of the implementation need to decrease the possible resistance of the target group. Therefore, an in-depth analysis of current practice, target group, and context is recommended as a first step in the process. Further steps include: (1) matching research findings and/or existing guidelines to the relevant practice, (2) describing the specific change outcomes, (3) selecting/developing implementation strategies, (4) developing and executing the implementation process, and (5) continuously evaluating and adapting the process.

The selection and/or development of the implementation strategies can focus on intrinsic motivation (such as attitude and knowledge) and extrinsic motivation (such as the team and the organization) (Bosch et al., 2011; Grol et al., 2006). Frequently used strategies oriented at intrinsic motivation are education, monitoring and feedback, and the use of reminders (van Achterberg et al., 2008). Interventions focusing on extrinsic motivation are the introduction of leadership and team-directed interventions (Hollemen et al., 2009). Multi-faceted strategies and strategies tailored to barriers and facilitators may enhance the effectiveness of guideline implementation (Grimshaw et al., 2004; NHS Centre for Reviews and Dissemination 1999; Rycroft-Malone et al., 2004). Unfortunately, there is little empirical evidence to support this approach (Baker et al., 2010; Francke et al., 2008). Furthermore, data on the effectiveness of combining such a multi-faceted tailored strategy with the use of a clinical decision support system for pressure ulcer prevention are missing.

2. Aims and objectives

The aim was to study whether a multi-faceted tailored strategy to implement an electronic clinical decision support system for pressure ulcer prevention improved adherence to recommendations for pressure ulcer prevention in nursing homes.

3. Operational definition: electronic clinical decision support system for pressure ulcer prevention

The electronic clinical decision support system was defined as a computer programme that generated a resident-tailored protocol for pressure ulcer prevention. Information to be entered into the system included (1) the availability of preventive materials (e.g. availability of alternating mattress, memory foam mattress, and foam wedge-shaped device to off-load the heels) and (2) resident characteristics. The set of resident characteristics was determined based on an extensive review of the literature and validated by two independent pressure ulcer experts (PhD level). The characteristics included the personal preferences of the resident (acceptance of the use of an alternating mattress), the presence of a pressure ulcer (sacrum, hip), and whether the resident returned in a supine position after being repositioned (see Table 1). An algorithm was developed to generate a resident-specific protocol based on the characteristics entered into the system. The protocol included recommendations with a focus on four main themes: (1) skin observation, (2) the use of support surfaces, (3) repositioning (frequency and postures), and (4) heel elevation. The name of the resident and the date of generating the protocol could be entered into the system and the protocol could be printed in a one page format. The final version of the protocol was named PrevPlan® and published online using Lectora Pro Suite® (Trivantis, Cincinnati, US) (http://www.decubitus.be/PrevPlan/, translation into English in progress).

Table 1
Entry of characteristics in the clinical decision support system (PrevPlan®).

<table>
<thead>
<tr>
<th>Prevention in bed</th>
<th>Prevention in chair</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Pressure ulcer risk (Braden &lt; 17/PU)</td>
<td>1. Pressure ulcer risk (Braden &lt; 17 and/or pressure ulcer)</td>
</tr>
<tr>
<td>2. Need/availability to use an alternating mattress</td>
<td>2. Availability of a pressure redistributing foam cushion/thick air cushion</td>
</tr>
<tr>
<td>3. Personal preferences of the resident</td>
<td>3. Availability of a chair that tilts back</td>
</tr>
<tr>
<td>4. Availability of a pressure redistributing foam mattress</td>
<td>4. Whether the resident has a risk of reclined/slouched position when seated in a chair</td>
</tr>
<tr>
<td>5. Presence of a Pressure ulcer (sacral, hip)</td>
<td></td>
</tr>
<tr>
<td>6. Whether the resident returned in a supine position after being repositioned</td>
<td></td>
</tr>
<tr>
<td>7. Availability of a pressure redistributing foam wedge-shaped device to off-load the heels</td>
<td></td>
</tr>
</tbody>
</table>

4. Methods

4.1. Design

The study is designed as a two-armed randomized controlled trial. Randomization at the level of the nursing ward was chosen to prevent contamination between intervention and control participants. Simple randomization was used to assign the wards to the experimental and the control groups (SPSS®, Inc., Chicago, IL, USA). Blinding of either residents or professionals was not possible due to the character of the intervention. The trial was performed between February and June 2010 and consisted of a 16-week implementation intervention with one baseline, four intermediate, and one post-testing measurement (see Fig. 1).

4.2. Participants

The study was performed in a random sample of 11 nursing home wards (6 experimental; 5 control) in a convenience sample of 4 nursing homes. The study participants included all nursing home residents and all healthcare professionals involved in pressure ulcer prevention (nurses, nursing assistants, physiotherapists, occupational therapists).

4.3. Interventions

4.3.1. Experimental arm

The experimental arm was involved in a multi-faceted tailored implementation intervention to implement PrevPlan® in clinical practice. The intervention was based on the six-step model for effective implementation by Grol and Wensing (2005).

4.3.1.1. Step 1: analysis of current practice, target group, and context. A key nurse was appointed by the senior nurse to act as the contact person between the researcher and the healthcare professionals on the ward. All key nurses had a bachelor degree in nursing, had clinical experience in pressure ulcer prevention or wound care in general, had more than five years of clinical experience, and worked at least for two years on the ward. All senior nurses had a bachelor degree or a masters’ degree (n = 2) and followed postgraduate education in management skills. The senior nurse and key nurse received an introduction to the study aims and protocol and a training about pressure ulcer prevention.

The analysis of current practice, target group, and context started with a diagnostic interview with (1) the key nurse and (2) a selection of professionals involved in pressure ulcer prevention on the nursing ward. The average duration of the interviews was 43.6 min. During these interviews, information on the allocation of tasks, team competences, attitudes, practical barriers, and needs for education (content, methods, and organization) were gathered. Barriers for implementation were mainly generic and included: (1) lack of appropriate education; (2) lack of knowledge; (3) time limitations; (4) ease of use/accessibility of the current pressure ulcer protocol; and (5) lack of clarity about each one’s responsibilities. The diagnostic interview revealed in all wards that the development, format and layout of PrevPlan® had to receive substantial attention and involvement of a ward based consultation team.

4.3.1.2. Step 2: match of research findings and/or existing guidelines to practice. This step included the development of a ward based multi-disciplinary consultation team (including the key nurse, senior nurse, occupational therapist, physiotherapist, nurse assistant, and researcher). The consultation team made an inventory of existing guidelines and best practices. Recommendations were summarized and the feasibility of the recommendations in relation to the context was discussed within the team. The key nurse

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**Assessed for eligibility (4 nursing homes)**

**Randomized (11 wards in 4 nursing homes)**

**Experimental group**

(6 wards, 225 residents, 65 professionals)

- Electronic clinical decision support system
  
  + Multi-faceted tailored implementation (6 weeks)
    
    o (Interactive) education
    o Monitoring and feedback
    o Reminders
    o Leadership

**Control group**

(5 wards, 239 residents, 53 professionals)

- Pressure ulcer prevention protocol in hard copy format
- No implementation intervention

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acted as the chair of the consultation team. The number of meetings was different for each ward, ranging between 4 and 7. The average time of each meeting was 63.4 min.

The meetings resulted in a set of recommendations for pressure ulcer prevention to be reviewed by two independent pressure ulcer experts (PhD level). After validation, the recommendations were used to develop PrevPlan®.

Structural issues (availability of computers/printers) and considerations about computer literacy were discussed in the consultation team and with the management of the nursing home. PrevPlan® was pre-tested by future users and found to be user-friendly. The time to generate a resident-tailored protocol was approximately 3 min, which was considered to be acceptable.

4.3.1.3. Step 3: description of the specific change outcomes. Three outcomes were considered to assess the effectiveness of the implementation intervention: (1) behavioural change of the healthcare professionals involved in pressure ulcer prevention, (2) change in patient outcomes, and (3) intermediate outcomes.

Behavioural change was defined in terms of allocating adequate pressure ulcer prevention in residents at risk. Change in resident outcomes was defined as pressure ulcer prevalence (Category II–IV). Intermediate outcomes were defined as knowledge and attitudes of healthcare professionals. Behavioural change of the healthcare professionals was considered as the main outcome in this study.

4.3.1.4. Step 4: selection/development of the implementation strategies. During the final pre-implementation meeting, the implementation strategies were determined based on the previously identified barriers and facilitators: education, monitoring/feedback, reminders, and extrinsic motivating strategies (see Table 2). All activities were planned and organized resulting in an individual implementation plan for each ward.

Education included a theoretical training about pressure ulcer prevention, interactive and participatory small-group sessions, the distribution of a CD Rom, website links about pressure ulcer classification and differentiation between pressure ulcers and incontinence-associated dermatitis (IAD), and small group case discussions. Monitoring and feedback included providing advice about baseline assessment results (adequacy of pressure ulcer prevention, knowledge, attitude) and monthly feedback about the process measure (adequacy of pressure ulcer prevention) by distributing graphs on the ward. Posters, flyers, daily reminders during shift change and a file card with information about risk assessment, pressure ulcer classification, and IAD differentiation in each of the nurse’s uniform pocket were introduced as reminders.

Extrinsic motivating strategies included (1) a review of the quality of the material for pressure ulcer prevention, (2) advice on the acquisition of new material (mattresses, cushions, wedge-shaped devices to off-load the heels), and (3) support on the organization of the delivery of pressure ulcer preventive materials.

4.3.1.5. Step 5: development and execution of the implementation process. The duration of the implementation phase was 16 weeks (120 days). In each intervention ward, the team of healthcare professionals received an interactive training in the use of the clinical decision support system. The key nurses instructed their teams about the tailored

<p>| Table 2 |
| Tailored-implementation: overview of intrinsic-motivation and extrinsic-motivation oriented strategies. |</p>
<table>
<thead>
<tr>
<th>Intrinsic-motivation oriented strategies</th>
<th>Intensity and duration</th>
</tr>
</thead>
<tbody>
<tr>
<td>Education</td>
<td></td>
</tr>
</tbody>
</table>
- Theoretical training about PU prevention for each key nurse  
- Interactive and participatory small-group sessions at ward level  
- CD Rom on PU classification and differentiation between PU and IAD*  
- Case discussions  
- Website links | 
- Week 1  
- Weeks 1–8  
- Throughout the study  
- Weeks 1–8  
- Throughout the study |
| Monitoring and feedback | 
- Feedback on baseline assessment results (adequacy of PU prevention, knowledge, attitude) by distributing graphs on the ward  
- Monthly feedback on the process measure (adequacy of PU prevention) by distributing graphs on the ward | 
- Week 2  
- Weeks 1, 3, 6, 9, 13, 16 |
| Reminders | 
- Posters and flyers on the ward  
- Daily reminder during shift change  
- File card with information about risk assessment, PU classification, and IAD differentiation in each of the nurse’s uniform pocket | 
- Distribution at week 1  
- Daily during handover  
- Introduction during week 1 |
| Extrinsic-motivation oriented strategies | Preparatory activities |
| - Introduction of the key nurse role (definitions of roles and responsibilities)  
- Inventory and feedback on the quality and availability of the material used for the prevention of PUs on the nursing ward  
- Support on the acquisition of new material (mattresses, cushions, wedge-shaped devices to off-load the heels)  
- Support on the organization of the delivery of PU preventive materials (mattresses, cushions, wedge-shaped devices to off-load the heels) | 
- Analysis of current practice, target group, and context |

* Incontinence-associated dermatitis.
implementation procedure. The validated pressure ulcer classification education tools were used to provide the interactive education (Beeckman et al., 2008, 2010a,b,c). All educational activities were levelled to the scope of practice for the nurses, nursing assistants, physiotherapists, and occupational therapists. Most of the education activities were organized at the start of the implementation (between weeks 1 and 8) because of practical reasons indicated by the participating wards. Each session lasted between 40 min and 125 min. An average of 5.4 educational sessions was provided on each ward. The attendance rate varied and ranged between 34% and 73% of the staff available that moment.

4.3.1.6. Step 6: continuous evaluation and adaptation of the implementation. The multi-disciplinary consultation team had monthly meetings during the study to discuss the progress and intermediate results of the study. The progression reports and intermediate results were communicated to the ward staff and management of the nursing home and appropriate alterations to the intervention were discussed and implemented.

4.3.2. Control arm

In the control arm, the senior nurse received the introduction to the study aims and protocol. No key nurse was appointed. In each control ward (n = 5), a standard pressure ulcer prevention protocol (hard-copy) was developed based on the 2009 NPUAP/EPUAP international prevention guidelines and evaluated by two pressure ulcer experts. The standard protocol was presented by the senior nurse in a standardized 30 min group lecture (attended by all members of nursing staff). No further implementation strategies were used.

4.4. Procedure

Baseline data (day 1) were collected in February 2010. Data on (1) general nursing home and ward characteristics, (2) risk assessment, skin observation, pressure ulcer prevention in each resident, and (3) knowledge/attitudes of healthcare professionals about pressure ulcer prevention were collected by the researcher using validated instruments (see Section 4.7). At four pre-defined moments during the study (day 21, day 42, day 63, day 91), the ward nurse (1) assessed pressure ulcer risk, (2) observed the skin, and (3) collected data about applied prevention in all residents. A final assessment was performed on day 120. The knowledge and the attitudes of the healthcare professionals were re-assessed in both groups after 16 weeks of implementation (day 120).

Inter-observer reliability checks on risk assessment and skin observation were performed between the researcher and the nurses by means of Cohen’s kappa (κ). In each experimental ward, the researcher and the key nurse had contact twice a week about the study progress. In each control ward, the senior nurse and the researcher had contact once every two weeks. Because of the specific nature of this study, the researcher could not be blinded to unit assignment to control or experimental conditions.

4.5. Sample size

Clustering took place at ward level to prevent possible cross-contamination of the study groups. The desired number of wards needed to provide sufficient cluster-level data for subsequent analyses but, at the same time, had to be manageable in terms of implementation and data collection.

The sample size was determined based on the primary outcome (residents receiving fully adequate prevention), with a two-sided alpha of 0.05 and 80% power. At baseline, the proportion of residents receiving fully adequate prevention was expected to be 10% (based on Vanderwee et al., 2007). An improvement of 20% was expected to be found in the experimental arm (with no effect in the control arm). The sample size was calculated using an online tool for cluster sample size determination (http://www.ssisweb.org/trial_protocol_tool/Collected%20files/SOURCE/Checklist/Stats/SampleSize.html).

Assuming an intra-cluster correlation (ICC) of 0.01 (van Gaal et al., 2009) and an average cluster size of 35, a total of at least 10 wards and 248 residents (5 nursing wards and 124 residents per arm) was required.

4.6. Ethical approval

The ethical review board of Ghent University Hospital (Belgium) and each of the participating nursing homes approved the study (B/67020097196). Permission to contact the residents for the study was obtained from attending physicians; no eligible residents were excluded because of a physician’s refusal. Written consent was obtained from residents who were conscious and communicative. Proxy consent was obtained for other residents. For the healthcare professionals, a completed questionnaire was taken as consent to participate.

4.7. Instruments

4.7.1. General characteristics of the nursing home and ward

A data collection sheet was designed to collect data on nursing home and ward characteristics: number of residents, number of staff, availability of preventive material (bed and chair), and actual pressure ulcer management.

4.7.2. Risk assessment, skin observation, and prevention

The validated EPUAP minimum-dataset and uniform procedure were used to collect data on risk assessment, skin observation, prevention (materials and repositioning frequency in bed/chair), and general resident data (Vanderwee et al., 2007). Skin observation consisted of details on pressure ulcer category and location, and incontinence-associated dermatitis (IAD). Pressure ulcers were categorized according to the 2009 EPUAP/NPUAP classification system (European Pressure Ulcer Advisory Panel & National Pressure Ulcer Advisory Panel, 2009).

An algorithm was used to assess the adequacy of the prevention when lying in bed, and when seated in a chair. This algorithm was based on a pilot study by Vanderwee et al. (2007) and included the combination of (1) the use of
a pressure redistributing surface (mattress or cushion), (2) the frequency of repositioning, and (3) offloading of the heels in residents at risk for pressure ulcers (Vanderwee et al., 2007). Prevention was defined as fully adequate if all preventive measures were applied. Prevention was defined as partly adequate if not all required preventive measures were applied. Prevention was defined as not adequate if no prevention was applied.

4.7.3. Knowledge and attitudes of healthcare professionals about pressure ulcer prevention
A validated pressure ulcer Knowledge Assessment Tool was used to assess the knowledge of the healthcare professionals towards pressure ulcer prevention (Beeckman et al., 2010a,b,c). The instrument included 26 items and reflects six domains: (1) aetiology and development; (2) classification and observation; (3) nutrition; (4) risk assessment; (5) reduction of the magnitude of pressure and shearing; (6) reduction of the duration of pressure and shearing. The psychometrically validated Attitude towards Pressure Ulcer tool (APuP) was used to study the attitudes of the healthcare professionals towards pressure ulcer prevention (Beeckman et al., 2010a,b,c). The instrument included 13 items covering five domains: (1) personal competency to prevent pressure ulcers; (2) priority of pressure ulcer prevention; (3) impact of pressure ulcers; (4) responsibility in pressure ulcer prevention; (5) confidence in the effectiveness of prevention.

4.8. Statistical analysis
Descriptive data are presented in frequencies (percentages) and means (standard deviation). Chi square test, Fisher’s exact test, and independent sample t-tests were performed to test for differences in scores between groups.

To evaluate the effectiveness of the intervention, a repeated measures analysis of variance (ANOVA) was performed at ward level. The primary outcome measures were the ward level proportion of residents at risk receiving fully adequate prevention measures and the ward level proportion of residents at risk receiving no adequate prevention measures respectively. Time (day 1, day 21, day 42, day 63, day 91, and day 120) was entered as the within-subjects factor. Group (intervention vs. control group) was entered as between-subjects factor. The time x group interaction effect was considered to evaluate the intervention effect. The intervention effect on pressure ulcer prevalence was assessed with a similar repeated measures ANOVA using the ward level proportion of residents having pressure ulcers Category I–IV and pressure ulcers Category II–IV as secondary outcome measures.

The effectiveness of the intervention on the knowledge and attitudes of healthcare professionals was evaluated by means of a linear mixed model with the healthcare professionals being grouped within wards. The null model including no predictor variables indicated an intra-class correlation coefficient of 4.23% for attitude and 5.90% for knowledge. Next, an individual-level random intercept model was applied with group (intervention vs. control group) and time (pretest vs. posttest) as factors and the time x group interaction effect representing the intervention effect. All analyses were performed using SPSS Statistics 19® software. A value of P < 0.05 was considered statistically significant.

5. Results
5.1. Baseline characteristics
In total, 464 residents (exp. wards = 239, contr. wards = 225) were included in the study. The mean age of the participating residents was 84.5 years in the experimental group and 84.9 years in the control group (t = 0.72, df = 462, P = 0.47). In total, 118 healthcare professionals (exp. wards = 65, contr. wards = 53) participated in the study. No significant differences emerged between the intervention and control wards. The characteristics of all participants are shown in Table 3. Interobserver reliability concerning risk assessment was

Table 3
Baseline characteristics of the residents and healthcare professionals.

<table>
<thead>
<tr>
<th></th>
<th>Experimental % (n)</th>
<th>Control % (n)</th>
<th>χ² df</th>
<th>P²</th>
</tr>
</thead>
<tbody>
<tr>
<td>Residents</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Gender</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Male</td>
<td>24.0 (54)</td>
<td>17.2 (41)</td>
<td>3.35</td>
<td>0.07</td>
</tr>
<tr>
<td>Female</td>
<td>76.0 (171)</td>
<td>82.8 (198)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Incontinence</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Urine</td>
<td>68.9 (155)</td>
<td>64.9 (155)</td>
<td>0.85</td>
<td>0.36</td>
</tr>
<tr>
<td>Feces</td>
<td>48.4 (109)</td>
<td>38.9 (93)</td>
<td>4.30</td>
<td>0.04</td>
</tr>
<tr>
<td>Weight</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>&lt;55 kg</td>
<td>46.5 (101)</td>
<td>48.8 (102)</td>
<td>1.67</td>
<td>0.44</td>
</tr>
<tr>
<td>55–94 kg</td>
<td>24.0 (52)</td>
<td>22.0 (46)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>&gt;94 kg</td>
<td>17.5 (38)</td>
<td>20.1 (42)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Medication</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tranquilizer</td>
<td>63.6 (143)</td>
<td>66.9 (160)</td>
<td>0.59</td>
<td>0.44</td>
</tr>
<tr>
<td>Corticosteroid</td>
<td>4.0 (9)</td>
<td>2.9 (7)</td>
<td>0.40</td>
<td>0.53</td>
</tr>
<tr>
<td>Pressure ulcer riskc</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>At risk</td>
<td>25.8 (58)</td>
<td>26.4 (63)</td>
<td>0.02</td>
<td>0.89</td>
</tr>
<tr>
<td>Healthcare professionals</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Male</td>
<td>10.8 (7)</td>
<td>1.9 (1)</td>
<td>3.65</td>
<td>0.06</td>
</tr>
<tr>
<td>Female</td>
<td>89.2 (58)</td>
<td>98.1 (52)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Age</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>&lt;25 years</td>
<td>15.4 (10)</td>
<td>17.0 (9)</td>
<td>0.75</td>
<td>0.86</td>
</tr>
<tr>
<td>25–34 years</td>
<td>26.2 (17)</td>
<td>28.3 (15)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>35–50 years</td>
<td>46.2 (30)</td>
<td>47.2 (25)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>&gt;50 years</td>
<td>12.3 (8)</td>
<td>7.5 (4)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Function</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ward nurse</td>
<td>21.5 (14)</td>
<td>22.6 (12)</td>
<td>1.3</td>
<td>0.73</td>
</tr>
<tr>
<td>Senior nurse</td>
<td>6.2 (4)</td>
<td>5.7 (3)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tissue viability</td>
<td>0.0 (0)</td>
<td>1.9 (1)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Other</td>
<td>72.3 (47)</td>
<td>69.8 (37)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Education level</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Nurse assistant</td>
<td>43.1 (28)</td>
<td>49.1 (26)</td>
<td>0.91</td>
<td>0.82</td>
</tr>
<tr>
<td>Diploma nurse</td>
<td>21.5 (14)</td>
<td>18.9 (10)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bachelor nurse</td>
<td>10.8 (7)</td>
<td>13.2 (7)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Other</td>
<td>24.6 (16)</td>
<td>18.9 (10)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Experience</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>&lt;5 years</td>
<td>18.5 (12)</td>
<td>28.3 (15)</td>
<td>3.12</td>
<td>0.37</td>
</tr>
<tr>
<td>5–10 years</td>
<td>27.7 (18)</td>
<td>18.9 (10)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>11–20 years</td>
<td>27.7 (18)</td>
<td>20.8 (11)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>&gt;20 years</td>
<td>26.2 (17)</td>
<td>32.1 (17)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

a Chi-square.

b Statistical significance.

c Braden < 17 and/or pressure ulcer (Category I–IV).
\( \kappa = 0.83 \) (95% CI, 0.62–0.90) and \( 0.89 \) (95% CI, 0.79–0.97) for skin observation.

5.2. Behavioural change of the professionals

An overview of the effects of the intervention on the main outcome is presented in Fig. 2. In the experimental group, a significantly overall positive effect was found on the allocation of fully adequate prevention when seated in a chair (exp. wards: 60.0% vs. contr. wards: 13.2%, \( F = 16.4, P = 0.003 \)) (see Table 4). Additional analyses showed that the proportion of residents receiving no prevention was significantly lower in the experimental wards compared to the control wards (both in bed and when seated) (see Table 4).

**Table 4**

Overview of the effectiveness of the intervention on the adequacy of pressure ulcer prevention in residents at risk.

<table>
<thead>
<tr>
<th>Primary outcome</th>
<th>Group</th>
<th>Timea</th>
<th>1 (n/N)</th>
<th>2 (n/N)</th>
<th>3 (n/N)</th>
<th>4 (n/N)</th>
<th>5 (n/N)</th>
<th>6 (n/N)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fully adequate prevention</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bed</td>
<td>E(^c)</td>
<td>8.6 (5/58)</td>
<td>23.0(^b) (14/61)</td>
<td>11.5(^b) (7/61)</td>
<td>1.8 (1/55)</td>
<td>3.2 (2/63)</td>
<td>4.6 (3/65)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>C(^d)</td>
<td>9.5 (6/63)</td>
<td>9.0(^b) (6/67)</td>
<td>0(^b) (0/65)</td>
<td>6.3 (4/64)</td>
<td>4.9 (3/61)</td>
<td>1.5 (1/68)</td>
<td></td>
</tr>
<tr>
<td>Chair</td>
<td>E(^c)</td>
<td>17.2 (10/58)</td>
<td>55.7(^b) (34/61)</td>
<td>63.9(^b) (39/61)</td>
<td>67.3(^b) (37/55)</td>
<td>68.3(^b) (43/63)</td>
<td>60.0(^b) (39/65)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>C(^d)</td>
<td>15.9 (10/63)</td>
<td>16.4(^b) (11/67)</td>
<td>10.8(^b) (7/65)</td>
<td>14.1(^b) (9/64)</td>
<td>14.8(^b) (9/61)</td>
<td>13.2(^b) (9/68)</td>
<td></td>
</tr>
<tr>
<td>No prevention</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bed</td>
<td>E(^c)</td>
<td>34.5(^b) (20/58)</td>
<td>4.9(^b) (3/61)</td>
<td>1.6(^b) (1/61)</td>
<td>0 (0/55)</td>
<td>0(^b) (0/63)</td>
<td>10.8(^b) (7/65)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>C(^d)</td>
<td>15.9 (10/63)</td>
<td>20.9(^b) (14/67)</td>
<td>27.7 (18/65)</td>
<td>29.7 (19/64)</td>
<td>29.5(^b) (18/61)</td>
<td>30.9(^b) (21/68)</td>
<td></td>
</tr>
<tr>
<td>Chair</td>
<td>E(^c)</td>
<td>44.8(^b) (26/58)</td>
<td>6.6(^b) (4/61)</td>
<td>4.9(^b) (3/61)</td>
<td>0(^b) (0/55)</td>
<td>6.3(^b) (4/63)</td>
<td>15.4(^b) (10/65)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>C(^d)</td>
<td>57.1 (36/63)</td>
<td>52.2(^b) (35/67)</td>
<td>50.8(^b) (33/65)</td>
<td>51.6(^b) (33/64)</td>
<td>52.5(^b) (32/61)</td>
<td>55.9(^b) (38/68)</td>
<td></td>
</tr>
</tbody>
</table>

---

\(^a\) Significant differences based on \( \chi^2 \) or Fisher’s exact test.

\(^b\) 1 = day 1, 2 = day 21, 3 = day 42, 4 = day 63, 5 = day 91, 6 = day 120.

\(^c\) Experimental group.

\(^d\) Control group.

---

5.3. Resident outcomes and intermediate outcomes

Results of the resident outcomes and intermediate outcomes are shown in Tables 5 and 6. A significantly lower pressure ulcer prevalence (Category I–IV) could be observed in the experimental group compared to the control group at the end of the study. In contrast, no difference was found between the groups when only Category II–IV pressure ulcers were considered.

No difference was found between the knowledge of the healthcare professionals in the groups during the post-test ($F = 1.98, P = 0.16$). In contrast, a significant difference in the attitudes of the healthcare professionals was found between the groups ($F = 15.12, P < 0.001$). While baseline attitude scores were comparable between both groups during the pre-test [exp. 74.3% vs. contr. 74.5% ($t = 0.11, df = 116, P = 0.92$)], the mean score after the intervention was 83.5% in the experimental group vs. 72.1% in the control group.

6. Discussion

The aim of this clinical trial was to evaluate whether a ward based multi-faceted tailored implementation strategy could improve the adherence to guideline-based care recommendations in a nursing home setting. The intervention can only be considered partially successful. Positive effects were found on the allocation of pressure ulcer prevention in residents at risk when seated in a chair and on the attitudes of the healthcare professionals. However, no effect was found in patients at risk when lying in bed and on the knowledge of the healthcare professionals. A trend towards a positive effect on pressure ulcer prevalence (Category I–IV) was observed.

### Table 5

Overview of the effectiveness of the intervention on pressure ulcer prevalence (I–IV) and (II–IV).

<table>
<thead>
<tr>
<th>Secondary outcome</th>
<th>Group</th>
<th>Time</th>
<th>1 % (n/N)</th>
<th>2 % (n/N)</th>
<th>3 % (n/N)</th>
<th>4 % (n/N)</th>
<th>5 % (n/N)</th>
<th>6 % (n/N)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pressure ulcers (I–IV)</td>
<td>E&lt;sup&gt;c&lt;/sup&gt;</td>
<td>15.1 (34/225)</td>
<td>8.9&lt;sup&gt;b&lt;/sup&gt; (20/225)</td>
<td>5.8&lt;sup&gt;b&lt;/sup&gt; (13/225)</td>
<td>1.8&lt;sup&gt;b&lt;/sup&gt; (4/225)</td>
<td>4.4&lt;sup&gt;b&lt;/sup&gt; (10/225)</td>
<td>7.1&lt;sup&gt;b&lt;/sup&gt; (16/225)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>C&lt;sup&gt;d&lt;/sup&gt;</td>
<td>16.3 (39/239)</td>
<td>17.2&lt;sup&gt;b&lt;/sup&gt; (41/239)</td>
<td>12.6&lt;sup&gt;b&lt;/sup&gt; (30/239)</td>
<td>13.4&lt;sup&gt;b&lt;/sup&gt; (32/239)</td>
<td>12.1&lt;sup&gt;b&lt;/sup&gt; (29/239)</td>
<td>14.6&lt;sup&gt;b&lt;/sup&gt; (35/239)</td>
<td></td>
</tr>
<tr>
<td>Pressure ulcers (II–IV)</td>
<td>E&lt;sup&gt;c&lt;/sup&gt;</td>
<td>6.2 (14/225)</td>
<td>3.6 (8/225)</td>
<td>1.8 (4/225)</td>
<td>0.9&lt;sup&gt;b&lt;/sup&gt; (2/225)</td>
<td>1.3 (3/225)</td>
<td>1.8 (4/225)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>C&lt;sup&gt;d&lt;/sup&gt;</td>
<td>7.1 (17/239)</td>
<td>4.6 (11/239)</td>
<td>3.3 (8/239)</td>
<td>6.3&lt;sup&gt;b&lt;/sup&gt; (15/239)</td>
<td>2.9 (7/239)</td>
<td>2.1 (5/239)</td>
<td></td>
</tr>
</tbody>
</table>

* Significant differences based on $\chi^2$ or Fisher's exact test.
<sup>b</sup> 1 = day 1, 2 = day 21, 3 = day 42, 4 = day 63, 5 = day 91, 6 = day 120.
<sup>c</sup> Experimental group.
<sup>d</sup> Control group.

### Table 6

Overview of the effectiveness of the intervention on knowledge and attitudes of healthcare professionals.

<table>
<thead>
<tr>
<th>Group</th>
<th>Pre-test</th>
<th>Post-test</th>
<th>Time Group</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>n</td>
<td>% (SD)&lt;sup&gt;a&lt;/sup&gt;</td>
<td>n</td>
</tr>
<tr>
<td>Knowledge</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>E&lt;sup&gt;b&lt;/sup&gt;</td>
<td>65</td>
<td>42.9 (15.1)</td>
<td>50</td>
</tr>
<tr>
<td>C&lt;sup&gt;c&lt;/sup&gt;</td>
<td>53</td>
<td>39.4 (11.7)</td>
<td>38</td>
</tr>
<tr>
<td>Attitude</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>E&lt;sup&gt;b&lt;/sup&gt;</td>
<td>65</td>
<td>74.3 (10.8)</td>
<td>50</td>
</tr>
<tr>
<td>C&lt;sup&gt;c&lt;/sup&gt;</td>
<td>53</td>
<td>74.5 (9.5)</td>
<td>38</td>
</tr>
</tbody>
</table>

<sup>a</sup> Standard deviation.
<sup>b</sup> Experimental group.
<sup>c</sup> Control group.

information about the availability of material aimed to cover this issue. If no specific material was available for a resident (in bed and/or armchair), the protocol indicated to increase the frequency of repositioning. This recommendation is in line with the 2009 international pressure ulcer prevention guideline. EPUAP/NPUAP recommends that “the frequency of repositioning will be influenced by variables concerning the individual and the support surface in use. An individual should be repositioned with greater frequency on a non-pressure redistributing mattress than on a viscoelastic foam mattress. The repositioning frequency should depend on the pressure-redistributing qualities of the support surface”. Even if appropriate materials were lacking, effective prevention could be provided (however being more labour and time-intensive).

6.2. Effect on pressure ulcer prevalence

No overall significant effect was found on pressure ulcer prevalence (Category II–IV). This may be explained by the fact that the trial was powered on the main outcome measure (allocation of adequate pressure ulcer prevention), and not on pressure ulcer prevalence. However, clinically meaningful (but non-statistically significant) differences were found between the pressure ulcer prevalence figures in the experimental and the control arm. This trend may be confirmed by a longer follow-up trial in an appropriately powered study for this outcome.

6.3. Effect on knowledge and attitudes of the healthcare professionals

Although knowledge scores improved somewhat, they remained unsatisfactory low. A first explanation might be that most of the education activities were organized at the early start of the implementation phase. This might be the reason why no significant difference was found between the knowledge of the healthcare professionals in both groups at the end of the implementation phase. Possibly, knowledge did significantly improve in the experimental group straight after the education, but did not remain adequate over time. To assure that knowledge is retained, repetition and practice are necessary. Therefore, education should be organized continuously, presented regularly, and updated frequently (Beeckman et al., 2008). A second explanation might be the complexity of the knowledge questionnaire. A large proportion of the healthcare professionals had no nursing education background but were nurse assistants. Since the questionnaire was specifically developed for nurses, the questionnaire might have been too complex, resulting in remaining low scores on the instrument. A third explanation might be the nature of the knowledge questionnaire itself. All questions were rather theory focused, while most of the educational activities were more practical oriented (case discussions, repositioning exercises, wound classification using photographs).

The attitudes towards pressure ulcer prevention of the healthcare professionals in the experimental ward did improve significantly compared to the control ward. The use of interactive education, such as participatory small-group sessions and case discussions, may have caused this significant improvement (Grol and Grimshaw, 2003; Jenkins and Fallowfield, 2002; Pittet et al., 2000; Wensing et al., 2010). A second explanation may be linked with the role of the key nurse. The key nurse was appointed by the senior nurse and had to have sufficient knowledge of the project, status, a positive/enthusiastic approach, and good communication skills. The key nurse acted formally as the leader during protocol development and encouraged team members to attend and to participate actively in the meetings. After a theoretical and practical training, the key nurse instructed the ward professionals in the use of the clinical decision support system and encouraged them to use the tool actively in daily care. It is reasonable to assume that the key nurse was seen as a “clinical champion”, a persuasive leader being the force for change. This role has been widely promoted despite being empirically under-developed in health services literature (Soo et al., 2009).

Subsequent research should focus on the identification of the specific features of the champion role and expand the discussion about the introduction of champion roles for pressure ulcer practice change.

6.4. Recommendations for future research

Substantial challenges were experienced during the implementation intervention. A qualitative approach (using interviews, group discussions and observations) would possibly have led to a more in-depth understanding about why no more significant positive results were found for the primary outcome (application of fully adequate prevention in patients at risk). These insights could have provided the opportunity to further refine and improve the current implementation intervention. Unfortunately, time and budgetary limitations did not allow to organize this as part of the trial. This could be subject for future research.

Many residents in nursing homes are at risk for the development of often preventable adverse events (e.g. pressure ulcers, urinary tract infections, falls, adverse drug events, and events related to medical procedures) (Thomas and Brennan, 2000). Guidelines for the prevention of many types of adverse events are available. The large number of guidelines competing for attention makes it difficult to keep track of all of them. This requires that healthcare organizations translate each of the guideline to their own target group, and create and tailor implementation strategies, which is a time-consuming process (Hakkennes and Dodd, 2008). Further research should focus on the effectiveness of strategies to implement multiple guidelines simultaneously. Furthermore, still to be explored in implementation research is the issue as the long-term consequences of reshaping pressure ulcer prevention at ward level. As limited evidence exists about strategies to establish long-term effects of implementation, research in this field is strongly recommended.

7. Limitations

There are several limitations to note in the actual study, however. A first limitation is the possible impact of a
Hawthorne-effect in the control group. Lahmann et al. (2010) found that the participation in pressure ulcer surveys led to lower pressure ulcer incidence rates, an increased use of guidelines/risk assessment scales and to increased use of preventive measures and devices. Because of this effect, the results in the control group might be even too positive. A second consideration is the fact that fewer healthcare professionals participated during the assessments in the post-implementation phase. It is reasonable to assume that these professionals were less motivated due to the additional workload. Possibly, those who had a more profound affinity with pressure ulcer prevention were more likely to respond. This may have resulted in a selection bias. A final consideration affects the organization of the educational activities. A clear planning was developed together with the consultation team to organize all activities on the ward. Unfortunately, not all healthcare workers were able to attend these activities. This may be the reason for the limited effect of the intervention on the knowledge scores.

8. Conclusions

This clinical trial demonstrated that the intervention was only partially successful to improve the primary outcomes. Attitudes improved significantly while the knowledge of the healthcare workers remained unsatisfactorily low. Further research should focus on the underlying reasons for these findings. Evidence gathered from a qualitative study may indicate alterations and further improvements to the actual implementation strategy. The high prevalence and morbidity of pressure ulcers in nursing home residents underline the need to design and test implementation strategies to improve the outcomes in these vulnerable individuals.

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Conflict of interest

None.

Funding

None.

Ethical approval

The ethical review board of Ghent University Hospital (Belgium) and each of the participating nursing homes approved the study.

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