Characteristics and Effectiveness of Fall Prevention Programs in Nursing Homes: A Systematic Review and Meta-Analysis of Randomized Controlled Trials

Ellen Vlaeyen, MSN, a Joke Coussement, MSN, a,b Greet Leysens, MSN, a Elisa Van der Elst, MSN, a Kim Delbaere, MPT, PhD, c Dirk Cambier, MPT, PhD, d Kris Denbaerynck, MSN, PhD, e Stefan Goemaere, MD, f Arlette Wertelaers, MD, g Fabienne Dobbels, PhD, a Eddy Dejaeger, MD, PhD, b and Koen Milisen, MSN, PhD, a,b on behalf of the Center of Expertise for Fall and Fracture Prevention Flanders

OBJECTIVES: To determine characteristics and effectiveness of prevention programs on fall-related outcomes in a defined setting.

DESIGN: Systematic review and meta-analysis.

SETTING: A clearly described subgroup of nursing homes defined as residential facilities that provide 24-hour-a-day surveillance, personal care, and limited clinical care for persons who are typically elderly and infirm.

PARTICIPANTS: Nursing home residents (N = 22,915).

MEASUREMENTS: The primary outcomes were number of falls, fallers, and recurrent fallers.

RESULTS: Thirteen studies met the inclusion criteria. Six fall prevention programs were single (one intervention component provided to the residents), one was multiple (two or more intervention components not customized to individual fall risk), and six were multifactorial (two or more intervention components customized to each resident’s fall risk). Meta-analysis found significantly fewer recurrent fallers in the intervention groups (4 studies, relative risk (RR) = 0.79, 95% confidence interval (CI) = 0.65–0.97) but no significant effect of the intervention on fallers (6 studies, RR = 0.97, 95% CI = 0.84–1.11) or falls (10 studies, RR = 0.93, 95% CI = 0.76–1.13). Multifactorial interventions significantly reduced falls (4 studies, RR = 0.67, 95% CI = 0.55–0.82) and the number of recurrent fallers (4 studies, RR = 0.79, CI = 0.65–0.97), whereas single or multiple interventions did not. Training and education showed a significant harmful effect in the intervention groups on the number of falls (2 studies, RR = 1.29, 95% CI = 1.23–1.36).

CONCLUSION: This meta-analysis failed to reveal a significant effect of fall prevention interventions on falls or fallers but, for the first time, showed that fall prevention interventions significantly reduced the number of recurrent fallers by 21%. J Am Geriatr Soc 63:211–221, 2015.

Key words: accidental falls; prevention; multifactorial interventions; residential aged care facilities; meta-analysis

Nursing home residents have a high risk of falling. The average fall incidence is estimated to be 1.6 falls per bed per year, with almost half of residents falling more than once a year.1–3 Falls in nursing homes often lead to serious injuries, with for example, an estimated hip fracture incidence rate of 4% annually.3–5 Previous studies showed that, within 1 year after a fall-related hip fracture, 12% of residents incur a new fracture, and 31% die as a result.5,6 Apart from the physical burden, falls often have psychological consequences such as fear of falling and poor quality of life. Falls also have a significant economic burden.7,8

The Prevention of Falls Network Europe (ProFaNE) taxonomy divides fall prevention programs into three types: single programs, which include one intervention component...
provided to all residents (e.g., supervised exercises); multiple programs, which include two or more intervention components provided to all residents (e.g., supervised exercise and staff training); and multifactorial programs, which include two or more customized intervention components that target each resident’s fall risk profile. No conclusive evidence exists on the effectiveness of fall prevention programs in nursing homes, partly because of differing study approaches. For example, five of seven published reviews used a narrative approach, one of which reviewed only multifactorial interventions. Two recent systematic reviews used a meta-analytical method and reported no effect of any type of intervention, with the exception of one single intervention that showed improvement in number of falls and fallers after supplementing residents’ diets with vitamin D.

These reviews did not distinguish between fallers and recurrent fallers. This is a missed opportunity, given the high frequency of recurrent fallers and their influence on the total number of falls. Furthermore, previous reviews compared studies that used heterogeneous groups of residents from various care settings that had major differences in care intensity or used vague terminology to define the care settings (e.g., residential or nursing care facilities, nursing homes, care homes, and long-term care facilities). This could partly explain why evidence on effective fall prevention strategies in nursing homes is less conclusive than reviews specifically focusing on a more-clear-cut delineated population of community-dwelling elderly adults. The current review aimed to determine the characteristics and effectiveness of single, multiple, and multifactorial fall prevention programs on the number of falls, fallers, and recurrent fallers in older persons who permanently reside in a nursing home. A nursing home was defined as “a residential facility that provides 24-hour-a-day surveillance, personal care, and limited clinical care for persons who are typically elderly and infirm” and excluded post-hospital skilled nursing care, rehabilitation, and long-term care for younger people with illnesses, injuries, functional disabilities, or cognitive impairment.

METHODS

The review protocol was registered on PROSPERO (CRD42011001687) and conducted in concordance with PRISMA guidelines.

Search Strategy

A systematic literature search was conducted in multiple databases (MEDLINE, EMBASE, Cochrane Central Register of Controlled Trials, PEDro, CINAHL, SportDiscus), restricting the search to articles published from database inception to September 2013. Depending on the selected database, Medical Subject Headings, a thesaurus, or free text was combined with the Boolean operators “AND/OR” to build a search strategy. Search terms were “accidental falls,” “falls,” “faller,” “aged,” “older,” “elderly,” “nursing homes,” “residential facilities,” “long-term care,” “institutionalization,” “residential*,” and “prevention and control.” Relevant studies were identified using three steps. First, two independent reviewers (EV, JC) conducted an initial study selection based on title and abstract. Second, three reviewers (EV, JC, KM) obtained and examined full-text copies of all articles meeting initial selection criteria. Disagreement was resolved through discussion with three additional reviewers (GL, EVdE, ED). Third, reference lists of articles meeting the inclusion criteria were screened for additional relevant papers.

Inclusion Criteria

Studies had to meet the following criteria.

Setting

The study had to be conducted in a nursing home, as defined previously; other kinds of residential care facilities were excluded. If the setting was in doubt, an attempt was made to contact the authors for clarification. When studies included nursing homes and other facilities (e.g., assisted living facilities), the study was included only when separate results for the nursing home population were available in the article.

Design

The study had to be an original or a priori secondary analysis of individual-level or cluster randomized controlled trials (RCT).

Objective

The intervention had to include single, multiple, or multifactorial fall prevention programs designed to prevent falls.

Outcomes

The study had to examine intervention effect on number of falls, fallers, or recurrent fallers. The term “faller” included all residents sustaining at least one fall during the intervention or follow-up period. In the same way, recurrent fallers were defined as residents sustaining two or more falls.

Duration

The duration from the start of the intervention (including follow-up) had to be 6 months or longer.

Language

Only publications in English, French, German, or Dutch were considered.

Risk of Bias Assessment

The methodological quality of each study was assessed using the Cochrane methodological quality assessment scheme (Table 1). One loss-to-follow-up criterion was added and evaluated according to the question: “Were the majority of participants still in the sample at the end of the study?” Majority was operationally defined as 80% or higher.
Table 1. Methodological Quality

<table>
<thead>
<tr>
<th>Study</th>
<th>Fall Incident Clarity Defined and Related to Staff</th>
<th>Inclusion and Exclusion Criteria Clearly Defined</th>
<th>Blinded Randomization</th>
<th>Treatment and Control Groups Comparable at Baseline</th>
<th>Identical Standard Care Programs for Both Groups</th>
<th>Blinded Treatment Providers</th>
<th>Blinded Outcome Assessors</th>
<th>Blinded Subjects</th>
<th>Identical Ascertainment of Outcomes</th>
<th>Intention-to-Treat Analysis</th>
<th>Loss to Follow-Up</th>
<th>Total Score (0–22)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Becker34b</td>
<td>1</td>
<td>2</td>
<td>2</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>2</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>Cox27</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>2</td>
<td>0</td>
<td>6</td>
</tr>
<tr>
<td>Dyer36</td>
<td>0</td>
<td>2</td>
<td>2</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>2</td>
<td>2</td>
<td>11</td>
</tr>
<tr>
<td>Kerse37</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>0</td>
<td>0</td>
<td>2</td>
<td>0</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>14</td>
</tr>
<tr>
<td>Lapane29</td>
<td>1</td>
<td>2</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>2</td>
<td>0</td>
<td>0</td>
<td>6</td>
</tr>
<tr>
<td>Law31</td>
<td>0</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>11</td>
</tr>
<tr>
<td>McMurdo38</td>
<td>1</td>
<td>2</td>
<td>1</td>
<td>2</td>
<td>0</td>
<td>0</td>
<td>2</td>
<td>0</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>12</td>
</tr>
<tr>
<td>Neyens39</td>
<td>0</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>10</td>
</tr>
<tr>
<td>Patterson30</td>
<td>0</td>
<td>2</td>
<td>2</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>2</td>
<td>1</td>
<td>0</td>
<td>9</td>
</tr>
<tr>
<td>Rapp31b</td>
<td>1</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>2</td>
<td>0</td>
<td>0</td>
<td>9</td>
</tr>
<tr>
<td>Ray40</td>
<td>1</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>0</td>
<td>0</td>
<td>2</td>
<td>0</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>13</td>
</tr>
<tr>
<td>Schnelle33</td>
<td>1</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>0</td>
<td>0</td>
<td>2</td>
<td>0</td>
<td>2</td>
<td>0</td>
<td>0</td>
<td>11</td>
</tr>
<tr>
<td>Schoenfelder32</td>
<td>1</td>
<td>2</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>2</td>
<td>0</td>
<td>2</td>
<td>8</td>
</tr>
<tr>
<td>Ward35</td>
<td>0</td>
<td>2</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>7</td>
</tr>
</tbody>
</table>

Scores: 0 = not meeting the criterion, mentioned but unclear, or not mentioned; 1 = partially meeting the criterion; 2 = completely meeting the criterion.

*Were the majority (≥80%) of participants still in the sample at the end of the study? Loss-to-follow-up was defined as participants who died, became terminally ill, or moved out of the nursing home during the study or follow-up period.

*bSame intervention described in both articles.
Five reviewers (EV, JC, KD, ED, KM) independently scored methodological quality on a scale ranging from 0 to 2, depending on whether the criterion was not fulfilled or not mentioned (0), partially met (1), or completely met (2). The total score ranged between 0 and 22, with higher scores indicating better quality. Disagreement was resolved through discussion and consensus.

Data Synthesis and Analysis
Data were synthesized to collate and summarize individual study results. One reviewer (EV) collected data on characteristics and effectiveness of the fall prevention programs. Two reviewers (GL, EV & E) independently confirmed the accuracy of the data synthesis. The ProFaNE taxonomy for fall prevention interventions was used to classify and describe the intervention programs.9 The programs were categorized according to the ProFaNE taxonomy: intervention type (single, multiple, or multifactorial) and intervention component (e.g., exercise, medication).9 Effectiveness was classified according to outcome. For number of falls, the relative risk of falls per resident years was calculated (ratio of proportion of (recurrent) fallers in intervention group to corresponding proportion in control group). For number of fallers and recurrent fallers, the relative risk was calculated (ratio of proportion of (recurrent) fallers in intervention group to number of falls per resident year in the control group). For number of fallers and recurrent fallers, the relative risk was calculated (ratio of proportion of (recurrent) fallers in intervention group to corresponding proportion in control group).

Effect size pooling was followed by regression analyses using a random effects approach.22 Publication bias was checked using the trim and fill method, which alerts for publication bias if more than three studies on the funnel plot are estimated to be concealed (assuming $\beta > 0.80$ and $\alpha = 0.05$).23,24 Heterogeneity of variance tests were used to examine whether between-study variability was significantly different from 0 using weighted error sum of squares Q.25 Calculated P parameters reflected the proportion of between-study variability to total variability.26

An a priori subgroup analysis was conducted according to ProFaNE intervention type (single, multiple, multifactorial) and to determine any possible effects the intervention might have had on residents with dementia. For the latter analysis, dementia was converted into a categorical variable, based on the methodology that Oliver and colleagues used.16 Studies were categorized into three groups ranging from 1 to 3 according to the prevalence of dementia, with 1 being assigned to studies with less than 40% prevalence, 2 being assigned to studies with a prevalence between 40% to 69%, and 3 being assigned to studies with 70% or more of residents with dementia being included in the study. Studies with an unspecified number of participants with dementia were excluded from the subgroup analysis. Regression analyses were conducted to determine whether dementia prevalence predicted effect size in this subgroup analysis.

RESULTS

Selected Studies
Figure 1 summarizes the results of the different steps for identifying appropriate articles for review.19,20 Fourteen articles, describing 13 studies, met the inclusion criteria.27-40 Two studies34,35 were combined as one study in the meta-analysis because they reported data on the same cohort of individuals.

Risk of Bias Assessment
Overall quality scores ranged from 6 to 14 (Table 1). The definition of a fall was reported in eight studies,29,32-35,37,38,40 but in only one study was the definition clearly explained to the staff collecting and reporting the data.47 Inclusion and exclusion criteria were clearly defined in all but two studies.27,28 None of the included studies had identical standard care programs for both intervention and control groups, neither did they employ treatment blinding for the treatment providers or participants. Outcome assessors were blinded in four studies.31,33,37,38 Eight studies used intention-to-treat analysis.28,31,34,36-40 The majority of participants were still in the sample at the end of the study in three studies.32,34,36

Study Characteristics
Seven studies were conducted in Europe,27,30,31,34-36,38,39 four of which were in the United Kingdom.27,31,34,36,38 Four were conducted in the United States,28,32,33,34 and two in Australia/Oceania (Table 2). Follow-up ranged from 6 to 17 months. Two studies were categorized as being individual RCTs,32,33 and 12 were cluster RCTs.27-31,34-40 With regard to ProFaNE intervention type, there were six single,27-32 one multiple,33 and six multifactorial34-40 fall prevention programs (Table 3). The included articles had 22,915 residents, with an overall mean age range of 82 to 88.

Overall Effects on Number of Falls, Fallers, and Recurrent Fallers
The number of falls was reported in 12 studies (Table 4).27-36,38,39 In nine studies, the intervention and control groups did not differ significantly in number of falls.27-35,36,38 Two multifactorial studies34,39 showed a significant decrease in falls of 36% and 45%, respectively, over a 12-month period for the intervention groups. An a priori secondary subgroup analysis35 of one study34 showed that the effect was only significant in cognitively impaired residents (relative risk (RR) = 0.49, 95% confidence interval (CI) = 0.35–0.69) and not in cognitively intact residents (hazard rate (HR) = 0.91, 95% CI = 0.68–1.22). Pooled data from 10 studies showed no effect on number of falls (RR = 0.93, 95% CI = 0.76–1.13; $P = 0.89\%$, $P < .001$).27-31,33,34,36,38,39

Seven studies assessed the number of fallers as an outcome measure,31,33-38 of which two multifactorial studies showed significantly fewer fallers in the intervention group than in the control group. These two studies reported 25%34 and 30%35 fewer fallers, although the pooled risk estimates failed to demonstrate a beneficial effect of the intervention on number of fallers (RR = 0.97, 95% CI = 0.84–1.11; $P = 47.9\%$, $P = 0.9\%$).31,33,34,36-38

The number of recurrent fallers was assessed in four multifactorial studies.34,36,38,40 One study34 described a
significant 44% reduction in the number of recurrent fallers for the intervention group. In another study, the mean proportion of recurrent fallers was 19% lower in the intervention facilities than in the control facilities. The pooled estimate showed significantly fewer recurrent fallers in the intervention groups than in the control groups (RR = 0.79, 95% CI = 0.65–0.97; I² = 6.3%, P = .36).34,36,38,40 Because only four of 13 included studies assessed recurrent fallers as an outcome measure, an additional sensitivity analysis was performed for the three studies that also reported on the outcomes “falls” and “fallers” (the other study reported only recurrent fallers) to determine whether the results for those two outcomes were concordant with the outcome for “recurrent fallers.” Pooled data showed a significant effect of intervention on number of falls (RR = 1.29, 95% CI = 1.23–1.36; F = 0%, P = .49).27,28

The trim-and-fill analysis did not reveal any publication bias for the above analyses.23

Characteristics and Effects of Different Types of Interventions

Single Interventions

Two studies examined the effect of staff training and education that focused on dissemination of information on falls prevention, fall risk assessment and potential modifications of risk factors, and postfall management review.28 Pooled risk estimates showed that the intervention groups had significantly more falls than the control group (RR = 1.29, 95% CI = 1.23–1.36; F = 0%, P = .49).27,28 Two other studies evaluated medication interventions.29,30 One used health information technology to analyze medication use in order to identify residents with

Figure 1. Flow diagram of study selection. RCT = randomized controlled trial.
a high risk of falling. Consultant pharmacists then reviewed medication and discussed their findings with the nursing staff. Nurse assistants observed and reported symptoms of medication side effects. In contrast, another study evaluated whether trained pharmacists who reviewed clinical and prescribing information and then consulted with general practitioners improved prescribing behavior. This study used an algorithm to evaluate the appropriateness of the residents’ prescribed psychoactive medications. The pooled risk estimate of 1.20 (95% CI = 0.89–1.61; I² = 63.0%, P = .10) indicated a nonsignificant effect but with a trend toward more falls in the intervention groups.29,30

Another study reported results from a vitamin D supplement intervention. Every 3 months, residents were offered 2.5 mg of ergocalciferol for a median 10 months. Another study examined a supervised ankle strengthening and walking program in which the duration, distance, and gait speed were progressively increased according to the capabilities of each participant. Neither of these two studies led to a significant reduction in the number of falls or fallers.

**Multiple Interventions**

In the only multiple intervention study, intervention group residents received incontinence care and a low-intensity, functionally oriented exercise program. No significant decrease in number of falls or fallers was detected as a result of the intervention.

**Multifactorial Interventions**

One study used a customized intervention, with all intervention components targeted to the individual risk profile of each resident. Five studies examined partially customized interventions (general components given to all residents, some components targeted to individual risk profile of the resident). The studies’ interventions focused on exercise, medication, orthostatic hypotension, environment, hip protectors, vision, feet and footwear, and goal setting, reminders, and feedback. In all but one study, a multidisciplinary team implemented the intervention program.

For the multifactorial interventions reviewed, the pooled risk estimates showed a significant beneficial effect of the intervention for number of falls (RR = 0.67, 95% CI = 0.50–0.89; P = 0.63%, P = .36) and recurrent fallers (RR = 0.79, 95% CI = 0.65–0.97; P = 0.63%, P = .36) but not for number of fallers (RR = 0.83, 95% CI = 0.68–1.01; P = 0.29).

### Table 2. Characteristics of Included Articles

<table>
<thead>
<tr>
<th>Study</th>
<th>Design</th>
<th>Setting</th>
<th>Nursing Homes, n</th>
<th>Residents, n</th>
<th>Age, Mean ± Standard Deviation</th>
<th>Female, n (%)</th>
<th>Duration of Study Period, Months</th>
</tr>
</thead>
<tbody>
<tr>
<td>Becker34</td>
<td>CRCT</td>
<td>Germany</td>
<td>6</td>
<td>509</td>
<td>509</td>
<td>64.3</td>
<td></td>
</tr>
<tr>
<td>Cox27</td>
<td>CRCT</td>
<td>United Kingdom</td>
<td>209</td>
<td>3,476</td>
<td>2,753</td>
<td>69.7</td>
<td></td>
</tr>
<tr>
<td>Dyer36</td>
<td>CRCT</td>
<td>United Kingdom</td>
<td>20</td>
<td>102</td>
<td>94</td>
<td>74.5</td>
<td></td>
</tr>
<tr>
<td>Kerse27</td>
<td>CRCT</td>
<td>New Zealand</td>
<td>41</td>
<td>330</td>
<td>352</td>
<td>80</td>
<td></td>
</tr>
<tr>
<td>Lapane29</td>
<td>CRCT</td>
<td>United States</td>
<td>25</td>
<td>1,769</td>
<td>1,552</td>
<td>85</td>
<td></td>
</tr>
<tr>
<td>Law31</td>
<td>CRCT</td>
<td>United Kingdom</td>
<td>118</td>
<td>1,762</td>
<td>1,955</td>
<td>85</td>
<td></td>
</tr>
<tr>
<td>McMurdo38</td>
<td>CRCT</td>
<td>United Kingdom</td>
<td>9</td>
<td>77</td>
<td>56</td>
<td>85</td>
<td></td>
</tr>
<tr>
<td>Neyens39</td>
<td>CRCT</td>
<td>The Netherlands</td>
<td>12</td>
<td>249</td>
<td>269</td>
<td>85</td>
<td></td>
</tr>
<tr>
<td>Patterson30</td>
<td>CRCT</td>
<td>Northern Ireland</td>
<td>22</td>
<td>173</td>
<td>161</td>
<td>85</td>
<td></td>
</tr>
<tr>
<td>Rapp35</td>
<td>CRCT</td>
<td>Germany</td>
<td>6</td>
<td>365</td>
<td>360</td>
<td>85</td>
<td></td>
</tr>
<tr>
<td>Ray40</td>
<td>CRCT</td>
<td>United States</td>
<td>14</td>
<td>221</td>
<td>261</td>
<td>85</td>
<td></td>
</tr>
<tr>
<td>Schnelle33</td>
<td>RCT</td>
<td>United States</td>
<td>4</td>
<td>92</td>
<td>92</td>
<td>85</td>
<td></td>
</tr>
<tr>
<td>Schoenfelder32</td>
<td>RCT</td>
<td>United States</td>
<td>2</td>
<td>9</td>
<td>7</td>
<td>85</td>
<td></td>
</tr>
<tr>
<td>Ward28</td>
<td>CRCT</td>
<td>Australia</td>
<td>88</td>
<td>2,802</td>
<td>2,589</td>
<td>85</td>
<td></td>
</tr>
</tbody>
</table>

*aDuration from start of the intervention to and including follow-up period.
*bSame intervention described in both articles. Rapp et al.35 is a secondary analysis of the study performed by Becker et al.34
*cMean.
*dMedian.

CRCT = cluster randomized controlled trial; RCT = randomized controlled trial; NA = not available.
Table 3. Components of the Intervention Studies According to the Prevention of Falls Network Europe Taxonomy

<table>
<thead>
<tr>
<th>Study</th>
<th>Component</th>
<th>Type</th>
<th>Frequency</th>
<th>Duration</th>
<th>Medication</th>
<th>Environmental</th>
<th>Knowledge</th>
<th>Other</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Single intervention</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cox$^{27}$</td>
<td>Social: Staff training</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Written materials, videos, lectures</td>
</tr>
<tr>
<td>Lapane$^{29}$</td>
<td>Informatics tool to analyze and review medication use</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lau$^{31}$</td>
<td>Vitamin D</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Patterson$^{30}$</td>
<td>Assessment of medication needs Algorithms detection of inappropriate psychoactive medication Recommendations to nursing staff, resident/caregiver General practitioner consultation</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Schoenfelder$^{32}$</td>
<td>Strength and resistance General physical activity</td>
<td>Group</td>
<td>3x/week, 3 months</td>
<td>20 minutes</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ward$^{68}$</td>
<td>Social: Staff training</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Multiple intervention</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Schnelle$^{33}$</td>
<td>Strength and resistance General physical activity</td>
<td>Individual</td>
<td>5x/week, 8 months</td>
<td>NA</td>
<td></td>
<td></td>
<td>Management of urinary incontinence Fluid or nutrition therapy</td>
<td></td>
</tr>
<tr>
<td><strong>Multifactorial intervention</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Becker$^{34}$, Rapp$^{35}$</td>
<td>Gait, balance, and functional training Strength and resistance General physical activity</td>
<td>Group</td>
<td>2x/week</td>
<td>75 minutes</td>
<td></td>
<td>Furnishings and adaptations: environment assessment Body-worn aids for personal care and protection: hip protectors Aids for personal mobility: proper use and maintenance of walking aids Social: staff training and support, feedback</td>
<td>Written materials, videos, lectures Resident education</td>
<td></td>
</tr>
</tbody>
</table>

(Continued)
<table>
<thead>
<tr>
<th>Study</th>
<th>Exercise</th>
<th>Component</th>
<th>Type</th>
<th>Frequency</th>
<th>Duration</th>
<th>Medication</th>
<th>Environmental</th>
<th>Knowledge</th>
<th>Other</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dyer</td>
<td>Gait, balance, and functional training</td>
<td>Group, Individual</td>
<td></td>
<td>3x/week, 3 months</td>
<td>40 minutes</td>
<td>Medication review</td>
<td>Furnishings and adaptations</td>
<td>Written materials, videos, lectures</td>
<td>Orthostatic hypotension: advice on correction of orthostatic hypotension Optometry: optician referral</td>
</tr>
<tr>
<td>Kerse</td>
<td>Gait, balance, and functional training</td>
<td>Individual</td>
<td></td>
<td>Daily or more</td>
<td></td>
<td>Medication review</td>
<td></td>
<td>Social: staff training</td>
<td></td>
</tr>
<tr>
<td>McMurdo</td>
<td>Gait, balance, and functional training</td>
<td>Group, Individual</td>
<td></td>
<td>2x/week, 6 months</td>
<td>30 minutes</td>
<td>Medication review</td>
<td>Furnishings and adaptations</td>
<td>Orthostatic hypotension: advice on correction of orthostatic hypotension Optometry: optician referral</td>
<td></td>
</tr>
<tr>
<td>Neyens</td>
<td>Individual</td>
<td>Individual</td>
<td>NA</td>
<td>NA</td>
<td></td>
<td>Medication review and monitoring medication intake</td>
<td>Furnishings and adaptations: environment assessment  Aids for personal mobility: (re)assessing need and proper use of assistive and protective aids Social: staff training and feedback</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*Same intervention described in both articles.
NA = not available.
The results of the regression analysis performed at the meta level to examine effectiveness of falls prevention programs in residents with dementia were not anticipated. There were fewer fallers in intervention groups that had a greater prevalence of dementia. This outcome contradicts a previous review, but because studies in which the number of residents with dementia was unknown were excluded, the number of studies included in the current review was limited, which might explain the contrary results. Although the analyses showed no effect on the number of fallers, it has been argued that using falls as an outcome has potential benefits over using fallers, because each fall entails an injury risk. Therefore, an effective intervention on number of falls has clinical, public health, and economic relevance. The latter reasoning also justifies focusing on recurrent fallers as an important outcome, as in the current review.

Nursing home residents are often physically frail and cognitively impaired. Considering the multifactorial nature of a fall, it is therefore not surprising that single interventions failed to show a beneficial effect on fall-related outcomes. The current results suggest that, in the specific care setting considered, single interventions could even be harmful, although these results should be interpreted with caution, considering the small number of studies, some of which had poor methodological quality. An a priori subgroup analysis showed that customized, multifactorial interventions reduced falls. A multidisciplinary team provided these multifactorial interventions in all studies, but team composition and frequency of assessment were not reported. Furthermore, the small number of studies did not allow additional moderator analyses to be conducted to evaluate which components of the multifactorial intervention programs or combinations thereof were most effective.

DISCUSSION

This study is unique, because it used a meta-analytical approach of the effectiveness of fall prevention interventions, focusing on a clearly defined setting. In previous studies, effectiveness remained unclear, partly because of differences in definitions of what constitutes a nursing home. The current study examined not only effectiveness of interventions in terms of number of falls and fallers, but also whether interventions reduced the number of recurrent fallers. Although the overall meta-analysis failed to show an effect on number of falls and fallers, it showed a significant 21% reduction of number of recurrent fallers in intervention programs. An a priori subgroup analysis of intervention type showed that multifactorial interventions had a significant effect on number of falls (33%) and recurrent fallers (21%).

Analysis of Intervention Effect Size When Considering Dementia Status

Regression of effect sizes for the number of fallers onto the studies’ prevalence-of-dementia category (see Data Synthesis and Analysis section in Methods) showed that the intervention had protective effects in studies with a greater proportion of residents with dementia. Each one-point increase in dementia prevalence category corresponded to a RR that was only 0.76 of its former size (analysis not considering dementia prevalence; 95% CI: 0.58–0.99, P = .04; P² = 0.31, P² = 22). No significant associations with dementia prevalence score were found for number of falls (RR = 0.95, 95% CI: 0.72–1.25, P = .72; P = 0, P = .39) or number of recurrent fallers (RR = 1.42, 95% CI: 0.49–4.11, P = .51; P = 0, P = .45).

DISCUSSION

This study is unique, because it used a meta-analytical approach of the effectiveness of fall prevention interventions, focusing on a clearly defined setting. In previous studies, effectiveness remained unclear, partly because of differences in definitions of what constitutes a nursing home. The current study examined not only effectiveness of interventions in terms of number of falls and fallers, but also whether interventions reduced the number of recurrent fallers. Although the overall meta-analysis failed to show an effect on number of falls and fallers, it showed a significant 21% reduction of number of recurrent fallers in intervention programs. An a priori subgroup analysis of intervention type showed that multifactorial interventions had a significant effect on number of falls (33%) and recurrent fallers (21%).

Although the analyses showed no effect on the number of fallers, it has been argued that using falls as an outcome has potential benefits over using fallers, because each fall entails an injury risk. Therefore, an effective intervention on number of falls has clinical, public health, and economic relevance. The latter reasoning also justifies focusing on recurrent fallers as an important outcome, as in the current review.

Nursing home residents are often physically frail and cognitively impaired. Considering the multifactorial nature of a fall, it is therefore not surprising that single interventions failed to show a beneficial effect on fall-related outcomes. The current results suggest that, in the specific care setting considered, single interventions could even be harmful, although these results should be interpreted with caution, considering the small number of studies, some of which had poor methodological quality. An a priori subgroup analysis showed that customized, multifactorial interventions reduced falls. A multidisciplinary team provided these multifactorial interventions in all studies, but team composition and frequency of assessment were not reported. Furthermore, the small number of studies did not allow additional moderator analyses to be conducted to evaluate which components of the multifactorial intervention programs or combinations thereof were most effective.

The results of the regression analysis performed at the meta level to examine effectiveness of falls prevention programs in residents with dementia were not anticipated. There were fewer fallers in intervention groups that had a greater prevalence of dementia. This outcome contradicts a previous review, but because studies in which the number of residents with dementia was unknown were excluded, the number of studies included in the current review was limited, which might explain the contradictory
finding. In addition, the lack of objective measurement of dementia in the included studies prevents firm conclusions from being drawn.

Some methodological aspects deserve further attention. First, inherent to this type of research, high loss to follow-up caused by death or sudden illness and difficulty maintaining blinding of participants or treatment providers results in poor overall methodological quality of the included studies. Second, although this review is the first to suggest that it is possible to reduce the number of recurrent fallers in nursing homes, only four studies were eligible for this analysis. One might wonder whether this significant finding is not the result of multiple testing, but the subsequent sensitivity analysis results for falls and fallers are concordant with the effect size for recurrent fallers, which suggests that some unique features of those studies and not random chance might have influenced the effect on recurrent fallers. More specifically, all included studies used a customized, multifactorial approach conducted by multidisciplinary teams; included an environmental assessment and adaptation component; and had a minimum follow-up of 12 months, as recommended in ProFaNE. This approach was also found to be more effective in a priori subgroup analyses, although more research is needed to confirm these findings and to better understand which components are responsible for this significant reduction in recurrent fallers.

Third, despite verifying with the authors of the original articles that their research setting met, or failed to meet, the “nursing home” definition, this definition is not as refined and explicit as it could be. For example, it could be interpreted in different ways. For example, what is the meaning of “limited care”? This further points toward an overall lack of a robust conceptual definition of what constitutes a nursing home.

Fourth, fall-related outcomes were often inconsistently reported, and vague definitions were sometimes used. More specifically, fall definitions were often extended with one or more specifications, such as “regardless/whatever the cause,” “whether or not an injury resulted,” or “the potential for injury exists.” The same problem arose for recurrent fallers. Definitions varied from specifying more than one fall to more than three falls within the last year. The adoption of a more-uniform and universally accepted operational definition of fall incidents or recurrent fallers (e.g., 9, 41) will undoubtedly facilitate the interpretation of newly conducted studies and meta-analyses.

Finally, previous research shows that fall prevention programs require a minimum follow-up of 12 months to ensure that a sufficient number of falls occurred for analysis so that delayed, long-term effects of the intervention program can be detected. Some of the included studies had a shorter follow-up time, which could have hampered the likelihood of detecting a positive effect on outcome.

In terms of clinical implications, the results of this systematic review suggest that nursing homes should try to implement multidisciplinary, customized, multifactorial interventions to reduce falls in their residents. Such an intervention requires a large amount of time and effort but is necessary if nursing homes want to invest in fall prevention, especially because simple, single interventions have no effect or even can be harmful. For this reason, further research is needed on the type of fall prevention interventions being used in nursing homes. Furthermore, implementation research is needed to determine potential barriers to implementation of evidence-based multifactorial interventions and to evaluate how nursing homes can be supported in implementing more-effective, but more-complex and time-consuming, multifactorial fall prevention interventions. This will aid in avoiding implementing trivial and potentially dangerous single interventions. In addition, future intervention studies should include a more-detailed description of each of the intervention components to allow faster implementation and permit comparison of intervention effectiveness of studies.

In conclusion, multifactorial fall prevention programs can reduce the number of falls and recurrent fallers in residential facilities that provide 24-hour-a-day surveillance, personal care, and limited clinical care for persons who are typically elderly and infirm, whereas single interventions, such as education, may be harmful.

ACKNOWLEDGMENTS

The authors would like to thank all the members of the workgroup “Residential Care Facilities” of the Flanders Center of Expertise for Fall and Fracture Prevention. In particular, we acknowledge Prof. Dr. Steven Boonen (deceased) for his valuable contribution to the study.

Conflict of Interest: This study was funded by the Flemish Ministry of Welfare, Public Health and Family, Belgium, and the Universiteit Derde Leeftijd Leuven vzw. The editor in chief has reviewed the conflict of interest checklist provided by the authors and has determined that the authors have no financial or any other kind of personal conflicts with this paper.

Author Contributions: All authors participated in the design of the study. Data collection: Vlaeyen, Coussement, Leysens, Van der Elst. Methodological quality assessment: Vlaeyen, Coussement, Delbaere, Dejaeger, Milisen. Data interpretation and analysis: Vlaeyen, Coussement, Leysens, Van der Elst, Dobbels, Dejaeger, Milisen. Meta-analysis: Denhaerynck. Verification of calculations: Vlaeyen, Milisen. Drafting the manuscript: Vlaeyen. Critical revision of manuscript, revisions, approval of final manuscript: All authors. Supervision: Milisen.

Sponsor’s Role: Neither the Ministry nor the Universiteit Derde Leeftijd Leuven vzw played a role in the elaboration of this review.

REFERENCES