Prevention of Fall-Related Injuries in Long-term Care
A Randomized Controlled Trial of Staff Education

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Background: Fall-related injuries, a major public health problem in long-term care, may be reduced by interventions that improve safety practices. Previous studies have shown that safety practice interventions can reduce falls; however, in long-term care these have relied heavily on external funding and staff. The aim of this study was to test whether a training program in safety practices for staff could reduce fall-related injuries in long-term care facilities.

Methods: A cluster randomization clinical trial with 112 qualifying facilities and 10,558 study residents 65 years or older and not bedridden. The intervention was an intensive 2-day safety training program with 12-month follow-up. The training program targeted living space and personal safety; wheelchairs, canes, and walkers; psychotropic medication use; and transferring and ambulation. The main outcome measure was serious fall-related injuries during the follow-up period.

Results: There was no difference in injury occurrence between the intervention and control facilities (adjusted rate ratio, 0.98; 95% confidence interval, 0.83-1.16). For residents with a prior fall in facilities with the best program compliance, there was a nonsignificant trend toward fewer injuries in the intervention group (adjusted rate ratio, 0.79; 95% confidence interval, 0.57-1.10).

Conclusion: More intensive interventions are required to prevent fall-related injuries in long-term care facilities.

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Fall-related injuries are a major public healthcare problem in long-term care. Of the estimated 1.7 million nursing home residents in the United States,1 approximately half fall annually,2,4 which is twice the rate for persons dwelling in the community.5,7 and 11% sustain a serious fall-related injury.3,4,8,9 The growing number of nursing home residents underscores the need to develop and implement preventive programs for this vulnerable population.

A promising approach to prevention of fall-related injuries is improvement of safety practices. Evidence from community and long-term care settings demonstrates that multifactorial interventions to improve poor safety practices can reduce the risk of falls.11 A randomized controlled trial of an academically based program for high-risk nursing home residents identified and sought to correct suboptimal practices for environmental and personal safety, wheelchair use, psychotropic medication use, and transferring and ambulation.12 Among nursing home residents, fall risk is thought to increase with host functional impairment,13,14 psychotropic medication use,14,15

METHODS

INTERVENTION
and environmental hazards. We focused on modifying medications and environmental factors because it is difficult to improve function sufficiently to prevent falls in frail nursing home residents and because institutional settings provide an opportunity to efficiently implement safety interventions. Our intervention targeted the following 4 specific safety domains: living space and personal safety, wheelchair, cane, and walker characteristics, psychotropic medication use, and transferring and ambulation. It sought to improve suboptimal practices for each of these domains through individual resident safety assessment and facility-wide programs to improve staff safety practices.

The cornerstone of the program was structured individual assessment and treatment. For living space and personal safety, the assessment sought to identify and correct potential problems with the resident’s bed, floor surfaces, clutter, lighting, accessibility of objects, and bathroom equipment. For wheelchairs, there was a detailed review of the fit, maintenance, brakes and other safety features, foot-and-leg rests, seat and back, forward motion protection, posture of the resident, and propelling and reaching. A routine wheelchair maintenance program also was suggested. For psychotropic medication use, the program recommended reevaluation of medication use and assessment of behavior, as well as changes in drug regimens when needed (with sample letters for contacting the prescribing physician and consulting pharmacist and model schedules for gradual dose reduction) and appropriate nonpharmacologic interventions. For transferring and ambulation, the assessment included direct observation of transferring (from a bed, wheelchair, lounge chair, and toilet) and ambulation or self-propelling in a wheelchair, inspection of equipment height and stability and footwear, and review of the quality of staff assistance with transferring and foot care. This evaluation provided the basis for instruction of staff and residents in safer transfer techniques (including managing unsafe behavior related to cognitive impairment) and potential recommendations for occupational and physical therapy, medical consultation, or routine staff assistance during transfers, repair, or modification of equipment (including wheelchair seating modifications).

Facility staff received program training during an intensive 2-day regional workshop. As a prerequisite for participation, intervention facilities had to appoint a team that included a nurse as the program coordinator, 1 to 2 certified nursing assistants (according to facility size), an occupational and physical therapy assistant, and an engineer. A study nurse (J.A.T.) and an occupational therapist (A.K.B.) who had participated in the previous intervention provided the program training using lectures and demonstrations, group discussions, and hands-on sessions. The director of nursing and facility administrator attended a morning session on the first day for an overview of the program and discussion of their roles. The nurse program coordinator was trained to select high-risk residents, perform assessments of psychotropic medication use and unsafe behavior, develop individual care plans designed to reduce falls, monitor staff performance, and conduct in-service training. The nursing assistants were trained to inspect the resident living space and equipment, the occupational and physical therapy assistant was trained to assess transferring and mobility and recommend wheelchair seating modifications, and the engineer was trained to inspect and repair wheelchairs. During the workshop, each facility received an 82-page manual, a video, additional materials for staff inservice training, and a complete set of materials for performing the study assessments and for tracking the implementation of the resulting treatment plan.

Two weeks after the meeting, we initiated a planned 12-month follow-up that included weekly telephone calls to the facility’s program coordinator for the first 3 to 4 months, followed by calls every 2 to 4 weeks, for a mean of 24 calls per long-term care facility. There were also 2 telephone calls to the facility’s occupational and physical therapy assistants. The objective of these telephone calls was to provide motivation, resolve implementation problems, and assist with planning resident assessment and treatment. During this follow-up, we also tracked facility noncompliance with program recommendations, which most frequently comprised failures to perform the program assessments, develop a treatment plan to correct problems identified in the assessments, or execute the treatment plan.

The program encouraged facilities to focus their limited resources on the highest-risk residents. Triaging was based on mandatory Minimum Data Set (MDS) assessments and did not impose an additional administrative burden. The living space assessment was recommended for all residents because it could be performed efficiently during a structured walk-through by the nursing assistants. Wheelchair, cane, and walker assessments by the facility engineer were recommended for all residents using this equipment. The psychotropic medication use and transferring and ambulation assessments, which required the most time, were recommended for residents who had fallen in the past 180 days, started a psychotropic medication, or had other new problems identified in the past 90 days that, according to the MDS assessment, indicated an elevated risk of falls (eg, wandering, dizziness, or trunk restraint).

STUDY FACILITIES AND BASELINE DATA

The study was conducted in 5 geographically contiguous regions of the state. Regional training meetings for intervention facilities were conducted between November 9, 1999, and June 27, 2000. The day after each meeting, or t0, was considered the first day of study follow-up. One year after t0, facilities randomized to the control group were invited to a similar regional meeting. Regional phasing of the study permitted us to assure the quality of the meetings by limiting their size. The study enrolled 112 facilities, which comprised 18 to 30 facilities per region. A study investigator (S.M. or J.A.T.) approached 186 potentially qualifying facilities (ie, having ≥50 beds, ≤1 serious violation on the most recent annual state inspection, and the director of nursing and facility administrator positions currently filled). Of these, 6 did not respond and 68 ultimately declined participation; these were similar to participating facilities in terms of size and number of violations on the annual state inspection. Facilities were not accepted until they had agreed to devote the resources needed for the study, identified staff to attend the training meeting, and submitted a current resident roster (including names, dates of birth, and identification numbers).

A team of nurses (including P.G.) not involved in the intervention program abstracted the mandatory MDS assessments for each resident on the roster. The MDS assessment closest to the time of the training conference was selected, as long as it was no more than 1 year before or 3 months after the training meeting. Variables collected included date of birth, sex height and weight, transferring and ambulation, history of falls, and psychotropic medication use. Long-term care facility records were used to verify residence in the facility on t0 and to obtain the discharge date, if any. If this information was unavailable, we used records of nursing home reimbursement from TennCare, which is Tennessee’s expanded Medicaid program (in which 70% of the residents in the present study were enrolled).

STUDY RESIDENTS

A total of 14,027 names were listed in the rosters submitted by the study facilities. Of these, we excluded 913 persons not veri...
ified to be in the facility on \( t_0 \), 1268 who were younger than 65 years (the younger residents were usually severely disabled), and 1286 who were bedridden (these have a low rate of fall-related injuries\(^4\) and were unlikely to benefit from the study procedures), leaving 10 558 study residents.

**RANDOMIZATION**

Randomization was designed to balance the number of facilities within each region. The SAS (version 8; SAS Institute Inc, Cary, NC) random uniform variate generator was used to generate a balanced block schedule (block size of 2) for each region, with a separate schedule for the remaining facility in regions with an odd number of participating long-term care facilities (block size of 4). To preserve blinding, random assignments were revealed for 2 facilities at a time, with one always being an intervention facility and the other being a control facility. The study administrator kept randomization assignments in sealed envelopes in a locked drawer; these were revealed in a meeting that included the study administrator, a senior study investigator (S.M.), and the database manager (K.H.).

**FOLLOW-UP AND STUDY END POINT**

Each study resident was followed up from \( t_0 \) through the earliest of these dates, \( t_0 + 364 \) (the end of the planned follow-up), death, discharge to home or to another long-term care facility, discharge to a hospital for more than 30 days, or occurrence of the study end point. We sought to verify presence in the facility at the end of the study or the date of discharge from review of on-site or electronic facility records, computerized hospital discharge records, computerized death certificates, or TennCare files. Otherwise, we assumed that the resident was in the long-term care facility through the end of the study, which provided the most conservative assessment of study effect.

The study end point was a fall-related injury leading to hospital admission or an emergency department or physician visit. We did not include fall-related provider encounters when there was not an actual injury. Experience (unpublished data) shows that nursing homes vary markedly in their use of external medical care for diagnostic evaluation after a fall, and in theory this could be affected by the intervention program.

The primary source of data for end point ascertainment was the Tennessee hospital discharge data set, which includes discharges from all state hospitals and emergency department visits. We supplemented this with data from the outpatient and inpatient files of TennCare because these files had more complete data on outpatient physician visits. Previous studies\(^2,33\) have shown that the use of medical care encounters to detect serious, treated injuries has good sensitivity and specificity.

Injuries were defined as fractures or soft tissue injuries. Fracture identification was based on a previously published algorithm.\(^30\) Because 90% of nonvertebral fractures in the study age group are caused by falls,\(^31\) we included these in the analysis unless an E code indicated another cause or there was evidence of a pathologic fracture. Soft tissue injuries were defined as wounds, sprains or strains, dislocation, or intracranial, internal, or crushing injuries. These were identified from inpatient admissions and emergency department or physician visits with a primary diagnosis of an injury. We also required an E code indicating a fall, because as many as 40% of soft tissue injuries in this age group have other causes.\(^31\) For wounds and sprains or strains, we further required a procedure indicating treatment (eg, suturing of a wound) to avoid inclusion of less serious injuries that in some long-term care facilities might not receive external medical care. For fractures and soft tissue injuries, the presumed date of occurrence was that of the first associated medical encounter.

**STATISTICAL ANALYSIS**

A Cox proportional hazards regression model was used to compare time to first injury occurrence in intervention and control residents.\(^32\) Marginal models were used, a standard technique for cluster randomization clinical trials that uses the individual resident as the unit of analysis but accounts for correlation within clusters.\(^33\) There was neither visual nor statistical evidence of departures from the Cox proportional hazards assumption.\(^34\) Marginal linear and logistic regression models, with generalized estimating equations using the independence working covariance matrix to account for clustering by long-term care facility, were fitted to compare baseline facility characteristics.\(^35\)

One planned subgroup analysis was performed. The intervention program focused the most attention on residents who met the MDS requirements for high risk. The best surrogate for this in the available data was the occurrence of a fall in the 180 days preceding \( t_0 \). Residents with such a prior fall who were in the intervention facilities were further classified according to approximate median facility compliance with the program recommendations (ie, \(<66%\) or \(>66%\)).

Given the approximate 4000 person-years of follow-up in each group and an injury incidence rate of 100 cases per 1000 residents per year, the study had power (\(\alpha = .05\) and \(1 - \beta = .80\)) to detect a 20% or greater reduction in injuries.\(^36\) All calculations were performed with SAS. All \(P\) values are 2-sided. The program was approved by the Vanderbilt University committee for the protection of human subjects.

**RESULTS**

Fifty-six facilities each were randomized to the control and intervention groups, with 5626 and 4932 study residents, respectively (Table 1). The control group was larger because the 2 largest facilities in the study were randomized to this group. Therefore, facilities in the control group had a larger mean number of beds and more study residents. Control facilities also had more violations on the most recent annual state inspection.

Residents of control and intervention facilities had similar baseline characteristics (Table 1). The mean follow-up was 283 days, 77% were female, and the mean age was 84 years. Residents were at high risk of fall-related injuries; their mean body mass index was 23 (calculated as weight in kilograms divided by the square of height in meters), 36% had had a fall in the past 180 days, 61% used psychotropic medications, more than 80% required assistance with walking or transferring, and 60% used (at least occasionally) wheelchairs. Residents of intervention facilities had slightly lower body mass index (\(P = .05\)) and were more likely to use canes or walkers (\(P = .002\)). For the intervention facilities, 52% of residents were in facilities that complied with fewer than two thirds of the study program recommendations (26% complied with \(\leq33%\) of recommendations, 26% complied with 34%–66%, and 48% complied with \(>66%\)).

There were 838 first injuries during 8172 person-years of follow-up, or 103 per 1000 person-years of residence (Table 2). Of these, 270 were fractures of the hip or distal femur (33 per 1000 person-years of residence), 240 were...
other fractures (28 per 1000 person-years of residence), and 328 were nonfracture injuries (40 per 1000 person-years of residence), most commonly wounds (252 injuries [31 per 1000 person-years of residence]). These rates are comparable to those reported in other settings.4,37,38

There was no difference in the occurrence of injuries between the intervention and control facilities (Figure). In the intervention facilities, there were 106.0 injuries per 1000 person-years of follow-up; in the control facilities, there were 99.5 injuries (Table 2). The rate ratio, adjusted for baseline differences between the facilities, was 0.98 (95% confidence interval, 0.83-1.16; \( P = .84 \)). Similar findings were present for each type of injury.

There was no evidence that the program effect differed according to whether residents had or had not fallen in the 180 days before baseline (adjusted rate ratios, 0.91 [95% confidence interval, 0.72-1.14], and 1.06 [95% confidence interval, 0.86-1.32], respectively) (Table 3). For residents with a prior fall, there was a trend toward lower injury rates in the intervention facilities that had increased compliance with program recommendations (adjusted rate ratio, 0.79 [95% confidence interval, 0.57-1.10]); however, this was not statistically significant (\( P = .17 \)).

**Figure.** Cumulative incidence of all fall-related injuries.

The negative finding of the present study is puzzling in the context of other work demonstrating that multifactorial interventions can prevent falls.11,39 Indeed, it was previously reported that the safety program on which the present intervention was based prevented falls in nursing home residents.12 However, there are several key differences that may explain this discrepancy.

Although the end point for past studies has been falls, we studied serious fall-related injuries in this investigation. In frail residents receiving long-term care, it is possible that moderate reductions in the risk of falls do not lead to equivalent reductions in the risk of injuries. A previous intervention reported a 19% reduction in the proportion of recurrent fallers.12 If this reduction in the risk of falls does not reduce injuries to a similar degree, the present study would have had insufficient power to detect an intervention effect.

The present study included all long-term care residents who were not bedridden, whereas the previous in-

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**Table 1. Characteristics of the Study Groups**

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Control (n = 56)</th>
<th>Intervention (n = 56)</th>
<th>P Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Facilities†</td>
<td>(n = 56)</td>
<td>(n = 56)</td>
<td></td>
</tr>
<tr>
<td>Beds per facility</td>
<td>150.7</td>
<td>124.3</td>
<td>.06</td>
</tr>
<tr>
<td>Residents in facilities with ≥200 beds, %</td>
<td>12.5</td>
<td>8.9</td>
<td>.48</td>
</tr>
<tr>
<td>Study residents per facility</td>
<td>100.5</td>
<td>88.1</td>
<td>.27</td>
</tr>
<tr>
<td>Violations on the annual state inspection</td>
<td>5.3</td>
<td>3.7</td>
<td>.04</td>
</tr>
<tr>
<td>Residents‡</td>
<td>(n = 5626)</td>
<td>(n = 4932)</td>
<td></td>
</tr>
<tr>
<td>Enrolled in TennCare</td>
<td>78.0</td>
<td>73.0</td>
<td>.23</td>
</tr>
<tr>
<td>Study follow-up, mean, d</td>
<td>281.6</td>
<td>283.6</td>
<td>.50</td>
</tr>
<tr>
<td>Female gender</td>
<td>76.4</td>
<td>77.4</td>
<td>.60</td>
</tr>
<tr>
<td>Age, mean, y</td>
<td>83.4</td>
<td>83.8</td>
<td>.21</td>
</tr>
<tr>
<td>Body mass index, mean§</td>
<td>23.6</td>
<td>23.2</td>
<td>.05</td>
</tr>
<tr>
<td>Fall in the past 180 d</td>
<td>34.9</td>
<td>36.2</td>
<td>.58</td>
</tr>
<tr>
<td>Psychotropic medication use</td>
<td>59.8</td>
<td>61.5</td>
<td>.41</td>
</tr>
<tr>
<td>Walks with assistance</td>
<td>83.2</td>
<td>82.1</td>
<td>.65</td>
</tr>
<tr>
<td>Transfers with assistance</td>
<td>81.5</td>
<td>81.5</td>
<td>&gt;.99</td>
</tr>
<tr>
<td>Cane or walker use</td>
<td>23.6</td>
<td>30.3</td>
<td>.002</td>
</tr>
<tr>
<td>Wheelchair use</td>
<td>61.0</td>
<td>58.7</td>
<td>.43</td>
</tr>
</tbody>
</table>

*Data were missing for the following characteristics: violations on the annual state inspection (192 facilities), gender (22 residents), body mass index (214 residents), fall in the past 180 days (88 residents), psychotropic medication use (88 residents), walks with assistance (642 residents), transfers with assistance (657 residents), cane or walker use (88 residents), and wheelchair use (88 residents). All characteristics were obtained at study baseline except for days of follow-up.
†Data are given as mean numbers unless otherwise indicated.
‡Data are given as percentages unless otherwise indicated.
§Calculated as weight in kilograms divided by the square of height in meters.

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**Table 2. Occurrence of Injuries**

<table>
<thead>
<tr>
<th>Variable</th>
<th>Control</th>
<th>Intervention</th>
<th>Unadjusted</th>
<th>Adjusted</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>No.</td>
<td>Rate†</td>
<td>No.</td>
<td>Rate†</td>
</tr>
<tr>
<td>Total Injuries</td>
<td>432</td>
<td>99.5</td>
<td>406</td>
<td>106.0</td>
</tr>
<tr>
<td>Hip fractures</td>
<td>143</td>
<td>33.0</td>
<td>127</td>
<td>33.2</td>
</tr>
<tr>
<td>Other fractures</td>
<td>125</td>
<td>28.8</td>
<td>115</td>
<td>30.0</td>
</tr>
<tr>
<td>Soft tissue injuries</td>
<td>164</td>
<td>37.8</td>
<td>164</td>
<td>42.8</td>
</tr>
</tbody>
</table>

*Unadjusted rate ratios, 95% confidence intervals (CI), and \( P \) values were estimated from the Cox proportional hazards regression models using only the intervention term. Adjusted rate ratios were adjusted for facility number of beds and violations on the annual state inspection and for resident enrollment in TennCare, gender, age, body mass index, fall in the past 180 days, psychotropic medication use, walks with assistance, transfers with assistance, cane or walker use, and wheelchair use.
†Per 1000 person-years of follow-up.
The frequent occurrence of serious fall-related injuries in long-term care facilities continues to be an important public health problem. There is good evidence that improving safety practices can reduce falls and subsequent injuries. However, devising an effective program for improving these practices that is feasible in the current long-term care environment is challenging.

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