Preventing Falls in Older People: Impact of an Intervention to Reduce Environmental Hazards in the Home

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OBJECTIVES: To evaluate the impact of an intervention to reduce fall hazards in the homes of older people.

DESIGN: The intervention was administered to the 570 subjects in the experimental arm of a randomized controlled trial, with follow-up of subjects for 1 year.

SETTING: Community-based seniors living in Perth, Australia.

PARTICIPANTS: People age 70 and older.

INTERVENTION: Registered nurses delivered the intervention. It consisted of a home hazard assessment, an educational strategy on general fall hazard reduction and ways to reduce identified home hazards, and the free installation of safety devices: grab rails, nonslip stripping on steps, and double-sided tape for floor rugs and mats. All intervention subjects received the home hazard assessment, and 96% received the educational strategy. Grab rails were installed in 77% of homes, rugs were stabilized in 8%, and nonslip step stripping was installed in 36%.

MEASUREMENTS: Hazard prevalence was assessed at baseline in all homes and 11 months later in a random sample of 51 homes. Action taken in response to the intervention was assessed by a self-completed postal questionnaire completed 11 months after the intervention.

RESULTS: All homes had at least one fall hazard. The most prevalent were floor rugs and mats (mean of 14 per home), stepovers (Stepovers are structural changes to the height of the floor that were designed to be stepped over rather than stepped upon, for example, the lip of a shower or a bath side.)(mean of seven per home), steps (mean of four per home), and trailing cords (mean of two per home).

The intervention was associated with a small but significant reduction in four of the five most prevalent hazards. The mean number of unsafe rugs and mats was reduced by 1.57 per house (95% confidence interval (CI) = 0.91–2.24); the mean number of unsafe steps was reduced by 0.61 per house (95% CI = 0.28–0.94); the mean number of rooms with trailing cords was reduced by 0.43 per house (95% CI = 0.10–0.76); and the mean number of unsafe chairs was reduced by 0.10 per house (95% CI = 0.02–0.18).

Safety devices were installed in 81.9% of homes. Advice on modifying specific hazards identified on the home hazard assessment resulted in over 50% of subjects removing hazards of floor rugs and mats, trailing cords, and obstacles. The general education message prompted less activity to reduce these hazards than did the advice on identified hazards.

CONCLUSIONS: Fall hazards are ubiquitous in the homes of older people. The intervention resulted in a small reduction in the mean number of hazards per house, with many study subjects taking action but removing only a few hazards. The impact of the intervention in achieving self-reported action to reduce hazards was high. J Am Geriatr Soc 49:1442–1447, 2001.

Key words: falls; home hazards; seniors

Falls in senior citizens have many component causes. Some of these relate to the physical environment, some to the social environment, and others to the functional capacity of the individual.1,2

The relative contribution of home environmental hazards to the risk of falling remains uncertain. Prospective and cross-sectional studies indicate that approximately 50% of falls occur in and around fallers’ homes and that about 40% involve environmental hazards.3–7 Slipping and tripping hazards, such as stairs, objects on the ground, and chair legs are commonly implicated in the initiation of a fall.3,5,6 Studies estimating the effect of home environmental hazards on the relative risk of falling have reached varying conclusions, ranging from no association3,8 to a significant association between obstacles that interfere with daily life and nonsyncopal falls4 or the presence of hazards and falls in particular functional groups.9

Slipping and tripping hazards are ubiquitous in the homes of older people,3,8,10–12 and a number of intervention
studies and public health programs have used hazard reduction strategies alone or as part of a more comprehensive intervention to prevent falls. Of these studies, only that by Cumming et al. included an evaluation of subjects’ compliance with the recommendations for improving home safety following a hazard assessment.

Despite the lack of evidence of effectiveness, reducing the prevalence of home hazards remains an appealing intervention strategy, offering the potential of long-term benefit from a one-time, relatively inexpensive intervention. A number of current public health programs to prevent falls include low-cost home hazard reduction strategies as a component of the intervention; the effectiveness of this strategy requires evaluation.

This report describes the design of an intervention to reduce fall hazards in the homes of 570 people age 70 and older living in the community and its impact on the prevalence of environmental hazards. It is the first rigorous evaluation of a home hazard modification strategy on the prevalence of hazards in the home. A separate paper reports the outcomes of this intervention when evaluated in a randomized controlled trial.

METHODS

The Intervention

There were three intervention strategies.

1. A home hazard assessment.
2. Specific advice on the removal or modification of up to three fall hazards identified in the assessment, plus general education on fall hazards and their removal and modification.
3. An invitation to have safety devices installed free of charge. These consisted of grab rails, nonslip stripping on steps and double-sided tape to stabilize floor rugs.

Trained registered nurses offered the intervention to all study subjects at a home visit conducted at the commencement of the study. The intervention was delivered after informed consent was obtained.

Home Hazard Assessment

The home hazard assessment counted the environmental hazards present in the home using a checklist designed for the purpose. A panel of occupational therapists vetted the instrument, which was designed to identify those fall hazards reported in published papers and existing checklists. Eleven hazards were included in the checklist. Definitions of hazards, based on physical characteristics, were created to provide observers with objective criteria for hazard recognition.

The checklist recorded the total number of steps and floor rugs in each room and the presence of safety devices, such as nonslip stripping on steps or rubber backing on mats. The presence or absence of the other nine hazards in each room in each house was recorded. The home hazard assessment was conducted in the presence of the household.

Before commencement of the intervention, the reliability with which hazards were recorded was evaluated by concurrent assessment of the hazards found in 93 rooms of six suburban homes by five (of the seven) research nurses. The kappa statistics for interrater agreement between multiple raters were calculated using the methods described by Fleiss and Holman et al. and the standard errors of the kappa were calculated according to Fleiss et al. Hazards that could be identified by counting or other objective measurement (e.g., steps, rugs, and mats) had higher kappa statistics, whereas hazards requiring more qualitative assessment (e.g., poor lighting, trailing cords) had relatively low kappa statistics (Table 1).

Advice and Education on Hazard Reduction

An educational pamphlet was designed to illustrate the role of home hazards in falls and to give information on their removal or modification. At the conclusion of the home hazard assessment, the research nurse discussed with the participant each hazard identified in the house, pointing out the potential of the hazard to cause falls and making suggestions as to how the hazard could be reduced. The nurse selected the three most conspicuous and remediable hazards and gave specific advice on their removal or modification. Because structural modifications are difficult and expensive, the nurses were directed to base the decision about choice of these hazards on their location (in a commonly-used area of the house) and ease of remediation. This advice was recorded on the pamphlet, which was left with the study participant.

Table 1. Hazards and Safety Features Recorded on the Checklist and the Interrater Agreement on Each Hazard and Safety Feature

<table>
<thead>
<tr>
<th>Hazard Recording</th>
<th>Hazard</th>
<th>Kappa ± SE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Numbers of each hazard counted</td>
<td>Steps</td>
<td>0.70 ± 0.07</td>
</tr>
<tr>
<td></td>
<td>Steps with nonslip stripping</td>
<td>0.70 ± 0.07</td>
</tr>
<tr>
<td></td>
<td>Rugs and mats</td>
<td>0.65 ± 0.06</td>
</tr>
<tr>
<td></td>
<td>Nonslip backing to rugs and mats</td>
<td>0.18 ± 0.05</td>
</tr>
<tr>
<td>Number of rooms with hazard present</td>
<td>Trailing cords</td>
<td>0.33 ± 0.06</td>
</tr>
<tr>
<td></td>
<td>Hazardous floor conditions</td>
<td>0.39 ± 0.11</td>
</tr>
<tr>
<td></td>
<td>Slippery floors</td>
<td>0.44 ± 0.05</td>
</tr>
<tr>
<td></td>
<td>Lighting deficient</td>
<td>0.23 ± 0.05</td>
</tr>
<tr>
<td></td>
<td>Obstacles</td>
<td>0.43 ± 0.07</td>
</tr>
<tr>
<td></td>
<td>Stepovers*</td>
<td>0.32 ± 0.06</td>
</tr>
<tr>
<td></td>
<td>Bathroom floor (when wet)†</td>
<td>1.00 ± —</td>
</tr>
<tr>
<td>Safety of specific furniture and fixtures</td>
<td>Bed height</td>
<td>1.00 ± 0.13</td>
</tr>
<tr>
<td></td>
<td>Seat height of favorite chair</td>
<td>0.40 ± 0.13</td>
</tr>
<tr>
<td></td>
<td>Toilet height</td>
<td>1.00 ± —</td>
</tr>
</tbody>
</table>

* Stepovers are structural changes to the height of the floor that were designed to be stepped over rather than stepped upon, for example, the lip of a shower or a bath side.
† All bathroom floors were hazardous when wet.
SE = standard error.
The advice for the modification of each type of hazard was:

- **Steps**: Install nonslip stripping on steps located indoors and at entrances to the house, if not carpeted. Install grab rails at steps leading into the house.
- **Rugs and mats**: Remove if possible, or use double-sided tape to stick the edges of the rug or mat to the floor.
- **Trailing cords**: Remove.
- **Hazardous floor conditions**: Repair.
- **Slippery floors**: Install grab rails in the bathroom and toilet.
- **Lighting deficient**: Identify and repair nonfunctional lights. Install a night-light.
- **Obstacles**: Move out of walkways.
- **Stepovers (changes in the floor height, designed to be stepped over)**: None.
- **Bed height**: None.
- **Chair height**: Raise or lower the height of the seat of the chair to allow the subject to sit upright with feet flat on the ground and knees bent at an angle of 90°.
- **Toilet**: Install grab rails.

The pamphlet also provided the basis for a more general discussion on home hazards and their removal plus suggestions on behaviors to reduce the risk of falls. Additional recommendations for behavior change and hazard removal made to subjects were to:

- **wear properly fitted shoes with good grip and low heels**;
- **avoid storage that was too high or too low by moving contents of storage to waist level**; and
- **sit when dressing and undressing, particularly for putting on and removing socks and pantyhose**.

**Safety Devices**

Safety devices were offered to all subjects at no cost. They were grab rails (maximum of three per house), nonslip stripping for noncarpeted internal steps (unlimited amount), and double-sided tape to fix rugs and mats to the floor (unlimited amount). All safety devices were installed by a skilled tradesperson within 2 weeks of the home visit. Grab rails were installed according to the Australian Standard (AS142).

**Evaluation Methods**

The impact of the intervention on home hazards and high-risk fall behaviors was measured in the 11th month of follow-up. Participants’ responses to the educational advice on hazard removal and avoidance of high-risk behaviors was assessed by a postal questionnaire; the change in the prevalence of home hazards was measured by repeating the home hazard assessment in the homes of a random sample of 51 study subjects.

Because this intervention study formed one arm of a randomized controlled trial, the extent to which members of the control group changed their home hazards and behaviors as a result of participating in the study was also evaluated.

**Postal Questionnaire**

Eleven months after the intervention was administered, a postal questionnaire was sent to each of the 527 subjects remaining in the study. The questionnaire asked the subject to describe the actions taken in response to the specific advice on removing up to three home hazards and the changes to hazards and behaviors resulting from the general advice offered in the pamphlet. The questionnaire was adjusted to match the specific advice given to each study subject. All questionnaires were returned and less than 10% of data was missing.

At the same time, members of the control group (n = 1,091), who had received no home hazard assessment and no intervention, were sent a postal questionnaire asking them to document changes to home hazards and hazardous behaviors made since their commencement in the study.

**Home Hazard Reassessment**

Subjects for the home hazard reassessment were selected by random lottery from a sampling frame formed by subjects recruited in the same month the year before and resident in post codes close to the General Post Office. Recruitment occurred by telephone, with three attempts made over 3 days to contact each subject. When contact was made, permission to conduct a second home hazard assessment was sought. If telephone contact was not made, if there was no suitable time for the visit, or if the person refused the visit, the next person on the list was selected. The date and time of the home visit were confirmed by letter.

Telephone contact was attempted with 73 subjects and was successfully established with 64 subjects. Of these, 56 (87.5%) agreed to a second home assessment and eight refused because they were too busy (n = 3), going away (n = 3), or not interested (n = 2). The first 51 subjects of the 56 recruited received a second home assessment.

The research nurse reassessed the home using a home hazard checklist on which the rooms in the house, as identified in the original assessment, were marked. After completion of the assessment, the research nurse compared the second checklist with the original checklist. Any discrepancies were checked by reexamination of the room and any apparent changes were confirmed with the householder. One research nurse who had been involved in the delivery of the intervention at the start of the study conducted the second assessment.

The 95% confidence interval for the change in hazards in the houses was calculated using the difference in paired means.

**RESULTS**

**Study Subjects**

The 370 intervention subjects lived in 452 homes. The style of housing ranged from purpose-built units for older people to large multistory family homes. The number of rooms per house ranged from 7 to 24. Eleven months after the intervention was administered, 527 subjects from 417 homes remained in the study.

**Safety Devices Installed and Remaining**

One or more safety devices were installed in 370 homes (81.9%). Grab rails were more readily accepted than either nonslip stripping for steps or double-sided tape for floor rugs, with 346 homes (76.5%) having one or more
grab strips were installed in 166 homes (36.7%) and rug stabilization in 34 homes (7.5%).

Responses to the postal questionnaire indicated that most safety devices that had been installed were still in place; 77.2% of homes had grab rails, 33.8% had step stripping, and 6.9% had rug stabilization. Grab rails had been removed from two homes, rug stabilization from three homes, and step stripping from six homes.

Change in the Prevalence of Home Hazards
The initial assessment of 452 homes found floor rugs and steps to be the most prevalent hazards (Table 2). Every house had one or more floor rugs, with an average of 14 per house and a maximum of 41. There was non-slip backing on only 18% of floor rugs, giving an average of 11.6 unsafe rugs per house. The number of steps in each house ranged from zero to 34, with an average of four per house. Non-slip stripping was pre-existent on only 12.9% of steps, giving an average of 3.9 unsafe steps per house.

Stepovers and slippery floors were the most common and diffusely distributed hazard. Stepovers were present in an average of seven rooms per house, slippery floors in six rooms per house, and poor lighting in two rooms per house. Of these hazards that were generally only present once per house, the height of the favorite chair was too low for 66% of subjects, the bed was too low for 12%, and the bathroom floor was slippery when wet in 100% of homes.

Home hazard reassessment showed that there had been a significant reduction in four of the five most prevalent hazards (Table 3). The use of non-slip tape on steps significantly reduced the mean number of hazardous steps per house by 0.61 (95% confidence interval (CI) = 0.28–0.94), and there was a minimal change in the number of rooms per house, the mean reduction being 0.43 (95% CI = 0.10–0.76), and the number of chairs with seats too high for the user, the mean reduction being 0.10 (95% CI = 0.02–0.18).

There was a small nonsignificant increase in the mean number of rooms per house with obstacles that could be tripped over.

There was no change in the prevalence of other hazards such as poor lighting or unsafe flooring, which were much more difficult to modify or remove.

Actions to Remove or Modify Specific Hazards
Advice to remove or modify specific fall hazards was given to 548 people (96% of the intervention subjects) from 432 homes. Participants’ actions arising from this advice were assessed by the postal questionnaire.

Specific advice to modify three fall hazards identified in the home hazard assessment most frequently related to the removal or stabilization of floor rugs and mats and the removal of obstacles and trailing cords. Over half of subjects given this advice reported that they had acted on it (Table 4). Advice to change the height of the seat of the subject’s favorite chair, when identified as hazardous, was given to 60 subjects and acted on by 28%. Advice on four hazards and hazardous behaviors was common to both specific hazards and the educational pamphlet. In each instance, a lower proportion of subjects reported acting in response to the general advice in the pamphlet than in response to the specific advice.

Control group members reported less action to remove hazards than did members of the intervention group, with 15.8% reducing fall hazards and 74.4% taking more care to avoid falls. The proportion of the intervention group taking action to remove or modify common household hazards and behaviors was significantly higher than the proportion of the control group, with the exception of wearing safer shoes, for which there was no significant difference.

Overall, advice that was specific to identified hazards prompted a greater level of action than did the general fall

Table 2. Prevalence of Fall Hazards in the Homes of Subjects Before Intervention

<table>
<thead>
<tr>
<th>Hazards</th>
<th>n</th>
<th>%</th>
<th>Average number per house</th>
</tr>
</thead>
<tbody>
<tr>
<td>Enumerable hazards</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>All steps</td>
<td>2,008</td>
<td>79.4 of houses</td>
<td>4.44</td>
</tr>
<tr>
<td>All rugs/mats</td>
<td>6,430</td>
<td>100 of houses</td>
<td>14.23</td>
</tr>
<tr>
<td>Rooms with hazards</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cords</td>
<td>742</td>
<td>9.0 of all rooms</td>
<td>1.64</td>
</tr>
<tr>
<td>Floor conditions unsafe</td>
<td>202</td>
<td>2.5 of all rooms</td>
<td>0.45</td>
</tr>
<tr>
<td>Slippery floors (dry)</td>
<td>2,797</td>
<td>34.5 of all rooms</td>
<td>6.19</td>
</tr>
<tr>
<td>Lighting deficient</td>
<td>937</td>
<td>11.6 of all rooms</td>
<td>2.07</td>
</tr>
<tr>
<td>Obstacles</td>
<td>448</td>
<td>5.5 of all rooms</td>
<td>0.99</td>
</tr>
<tr>
<td>Stepovers*</td>
<td>3,129</td>
<td>38.6 of all rooms</td>
<td>6.92</td>
</tr>
<tr>
<td>Bathroom floor slippery when wet</td>
<td>551</td>
<td>96.7 of all rooms</td>
<td>1.22</td>
</tr>
<tr>
<td>Safety of specific furniture and fixtures</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bed height</td>
<td>66</td>
<td>11.6 of subjects</td>
<td>0.15</td>
</tr>
<tr>
<td>Chair safety</td>
<td>378</td>
<td>66.3 of subjects</td>
<td>0.84</td>
</tr>
<tr>
<td>Toilet height</td>
<td>40</td>
<td>7.0 of subjects</td>
<td>0.09</td>
</tr>
</tbody>
</table>

* Stepovers are structural changes to the height of the floor that were designed to be stepped over rather than stepped upon, for example, the lip of a shower or a bath side.
prevention advice contained in the pamphlet, and actions that were easy for subjects to take, such as removal of obstacles, were more frequently followed than were structural changes of a more permanent nature, such as raising or lowering the height of a chair seat or modifying slippery floors.

DISCUSSION

This study is the first to measure the impact of an intervention to reduce the prevalence of environmental hazards in the homes of older people. Although the removal and modification of home hazards is a popular fall prevention strategy, the effectiveness of this type of intervention had not been objectively assessed.

The intervention was well accepted by the study participants. The home hazard assessment was conducted on all homes, advice was accepted by 96% of participants, the installation of safety devices was accepted by 83%, and action was taken to reduce hazards and hazardous behaviors by up to 88% of subjects. Every house had at least one fall hazard, with floor rugs and mats being the most prevalent, followed by stepovers, slippery floors, steps, poor lighting, and trailing cords.

The intervention was associated with a modest but significant reduction in four of the most prevalent hazards in the home, resulting in reductions in unsafe steps by 16%, unsafe floor rugs and mats by 14%, rooms with trailing cords by 26%, and unsafe chairs by 12%. A large proportion of subjects reported acting to reduce hazards identified by the home assessment and hazards described in the educational pamphlet. Over 50% reported acting to remove rugs and mats, trailing cords, and obstacles noted on the hazard assessment, and about 40% acted to remove rugs and mats and obstacles in response to the general advice.

The level of compliance with the recommendations to change identified hazards was similar to that reported by Cumming et al.\textsuperscript{21} In both studies, simple and inexpensive changes, such as the removal of rugs and mats, gained around 50% compliance, whereas more complex and expensive changes, such as the installation of rails to external steps or changing the height of chairs, had much lower levels of compliance.

The discrepancy between the high proportion of seniors who reported acting to reduce hazards and hazardous behaviors and the small reduction in the mean number of hazards per house implies that many subjects took some action, but did not apply this consistently to all similar hazards present in their home.

Several deficiencies of the evaluation strategy warrant consideration: the variable kappa values for the recognition of some hazards, the limited size of the sample for reassessment of hazard prevalence, and the lack of hazard prevalence data for the control group. The difficulty of achieving high interrater reliability in hazard identification

<table>
<thead>
<tr>
<th>Table 3. Change in the Prevalence of Home Hazards and Hazardous Rooms on Home Hazard Reassessment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hazards</td>
</tr>
<tr>
<td>Hazards that were reduced in the retest sample</td>
</tr>
<tr>
<td>All steps</td>
</tr>
<tr>
<td>Unsafe steps</td>
</tr>
<tr>
<td>All rugs/mats per house</td>
</tr>
<tr>
<td>Unsafe rugs/mats per house</td>
</tr>
<tr>
<td>Rooms with trailing cords</td>
</tr>
<tr>
<td>Rooms with an unsafe favorite chair</td>
</tr>
<tr>
<td>Hazards that were increased in the retest sample</td>
</tr>
</tbody>
</table>

| CI = confidence interval. |

<table>
<thead>
<tr>
<th>Table 4. Hazard Reduction Actions Reported by Subjects in Response to the Intervention</th>
</tr>
</thead>
<tbody>
<tr>
<td>Action</td>
</tr>
<tr>
<td>Action n Given Advice</td>
</tr>
<tr>
<td>Remove rugs and mats</td>
</tr>
<tr>
<td>Remove trailing cords</td>
</tr>
<tr>
<td>Change height of chair</td>
</tr>
<tr>
<td>Remove obstacles</td>
</tr>
<tr>
<td>Use chair for balance while dressing</td>
</tr>
<tr>
<td>Avoid unsafe climbing</td>
</tr>
<tr>
<td>Improve unsafe flooring</td>
</tr>
<tr>
<td>Change shoes</td>
</tr>
</tbody>
</table>

Note: The educational pamphlet containing general advice on hazard avoidance was given to 548 participants (96% of intervention group members).
has been recognized by others and was seen in this study, despite the careful definition of hazards and the comprehensive training of research nurses. For those hazards defined by measurable physical criteria, for example steps and rugs, the kappa values were high. Hazards defined by less objective criteria had lower kappa values, ranging from 0.23 for poor lighting to 0.44 for slippery floors. Although this would have caused errors in the preintervention assessment of hazard prevalence, the reassessment of hazards in 51 homes was not subject to this variability because of the tightly structured methodology and use of a single observer. The postintervention measurement of hazards was confined to a subsample of homes, rather than all homes that remained in the study. This curtailed the measurement of the change in prevalence of less common hazards. However, because these less common hazards were mainly structural, little change was expected.

The prevalence of hazards in control homes was not measured, because the identification of home hazards was felt to be an intervention in itself, which would raise awareness and possibly lead to an increase in the safety of control homes. The random allocation of subjects to the intervention or control group, as described in the accompanying paper, would be expected to give equal hazard prevalence in both study groups.

The effectiveness of interventions in reducing fall hazards in the home is a function of choosing those hazards most commonly involved in falls and providing intervention strategies that significantly reduce the prevalence of hazards or their potential to cause falls. The choice of hazards included in this intervention was determined by published case series and cohort studies of falls in older people. However, there was no scientific information to determine the criteria that define potential hazards. For example, there was no lighting standard for the domestic environment and no Australian standard for a domestic nonslip bathroom tile. The lack of a scientific basis for hazard identification and the lack of standardized hazard assessment instruments retards research progress and has prompted a call by other researchers for a consistent approach.

Similar uncertainty applies to the choice of intervention strategies. Although removal of the hazard is the optimum solution, existing structural hazards cannot be readily removed and must be modified. The effectiveness of safety devices to reduce the fall risk associated with these hazards has not been ascertained.

The effect of the intervention on the rate of falls in older people was tested subsequently in a randomized controlled trial. The outcome of this trial will provide information on the effectiveness of this particular intervention and will guide public health programs in their choice of fall prevention strategies.

ACKNOWLEDGMENTS

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REFERENCES