CLINICAL INVESTIGATION

Home Visits by an Occupational Therapist for Assessment and Modification of Environmental Hazards: A Randomized Trial of Falls Prevention

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OBJECTIVE: To determine whether occupational therapist home visits targeted at environmental hazards reduce the risk of falls.

DESIGN: A randomized controlled trial.

SETTING: Private dwellings in the community in Sydney, Australia.

PARTICIPANTS: A total of 530 subjects (mean age 77 years), recruited primarily before discharge from selected hospital wards.

INTERVENTION: A home visit by an experienced occupational therapist, who assessed the home for environmental hazards and facilitated any necessary home modifications.

MEASUREMENTS: The primary study outcome was falls, ascertained over a 12-month follow-up period using a monthly falls calendar.

RESULTS: Thirty six percent of subjects in the intervention group had at least one fall during follow-up, compared with 45% of controls ($P = .050$). The intervention was effective only among subjects (n = 206) who reported having had one or more falls during the year before recruitment into the study; in this group, the relative risk of at least one fall during follow-up was 0.64 (95% confidence interval, 0.50–0.83). Similar results were obtained when falls data were analyzed using survival analysis techniques (proportional and multiplicative hazards models) and fall rates (mean number of falls per person per year). About 50% of the recommended home modifications were in place at a 12-month follow-up visit.

CONCLUSIONS: Home visits by occupational therapists can prevent falls among older people who are at increased risk of falling. However, the effect may not be caused by home modifications alone. Home visits by occupational therapists may also lead to changes in behavior that enable older people to live more safely in both the home and the external environment. J Am Geriatr Soc 47:1397–1402, 1999.

Key words: accidental falls; environment design; randomized controlled trial; occupational therapy; safety management

More than 30% of people aged 65 years and older fall at least once a year.[1] Many of these falls have serious consequences, such as hip fracture.[1–3] Even when no injury occurs, repeated falls can cause a loss of confidence that may eventually lead to permanent residence in an aged care facility.[4,5] There is now good evidence that many of the falls experienced by older people can be prevented by multifactorial intervention packages targeted at frail older people.[6,7] Unfortunately, the design of many falls prevention studies makes it impossible to determine the effectiveness of individual components of the multifactorial intervention packages. In particular, there have been no randomized trials of home modifications alone for prevention of falls.

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Home modifications to reduce environmental hazards are often included in lists of interventions for prevention of falls among older people, but their effectiveness is unproven. Indeed, observational epidemiological studies have tended to find only minor differences in environmental hazards between the homes of fallers and non-fallers,[1–3,8–12] leading some to conclude that modification of the home environment is unlikely to be useful for falls prevention.[3,13]

In this paper, we report the first randomized trial to evaluate the effectiveness of home modifications for prevention of falls among older people. An occupational therapist with experience in aged care assessed homes for environmental hazards and supervised the necessary home modifications.

METHODS

Subject Recruitment

Most subjects were recruited while inpatients in selected wards at Royal Prince Alfred Hospital (a major teaching

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hospital) or Balmain Hospital (a rehabilitation hospital): geriatric wards (n = 115), a respiratory ward (n = 131), a gastroenterology ward (n = 77), a general medical ward (n = 61), and an eye ward (n = 60). Wards were chosen if they had a high proportion of older patients and if ward staff were willing to assist in subject recruitment. Some subjects were recruited from outpatient clinics at the two study hospitals (n = 26) and from local day care centers for older people (n = 60).

Subjects were eligible for inclusion if they were aged 65 years or older and lived in the community (not a nursing home or hostel for the aged) in the geographically defined study area, the Central Sydney Area Health Service region in Sydney, Australia. An interpreter was used for people who spoke little English. People with cognitive impairment were included as long as they lived with someone who was able to give informed consent and who could report on falls during follow-up. Inpatients were excluded if a home visit by an occupational therapist was planned as part of their usual care.

All subjects (or their carers) gave written informed consent, and the trial was approved by the Ethics Review Committee of the Central Sydney Area Health Service.

Baseline Interview

Baseline data were collected by the study research assistants (EO, CW) before randomization, using an interviewer-administered questionnaire at the site of recruitment. Data collected at baseline included sociodemographic details, a brief medical history, current medications, history of falls in the past 12 months, and activities of daily living (using the Spector-Katz Index[14] and Smith's modification of the Rosow-Breslau Health Scale[15]). Subjects were also asked about areas of their home they considered hazardous.

After completing the baseline interview, subjects were given a set of follow-up falls calendars, which they were asked to return by mail at the end of each month (see below).

Randomization

Allocation to intervention (n = 264) or control groups (n = 266) was done using a randomized consent design and occurred only after subjects had returned their first follow-up falls calendar. At the end of each week, a list of names of people who had returned their first calendar was given to an investigator (RGC) who was not involved in recruitment. Stratified (sex, recruitment site, one or more versus zero falls in the past year), block randomization (blocks of 4) was done with a random numbers table. The names of subjects randomized to the intervention group were given to the study occupational therapist (GF).

The study occupational therapist wrote to subjects allocated to the intervention group and then telephoned them to arrange a convenient time for a home visit. Most home visits were conducted within 3 weeks of randomization. Thirty-three percent (n = 86) of the intervention subjects were not visited by the occupational therapist, mainly because they refused the visit (n = 70) or because they had died (n = 11).

Intervention

The study occupational therapist had 2 years' experience in a local community aged care service before joining the study team. She conducted her routine occupational therapy home assessment for the study, except that a standardized home assessment form was used to record hazards.[16] The home visit usually took about 1 hour to complete. At the end of the visit, a list of the specific recommended home modifications for that home was given to subjects to keep. The study occupational therapist supervised the completion of any recommended home modifications, including further home visits if needed. About 2 weeks after her visit, the occupational therapist telephoned all subjects who needed home modifications to check that the modifications had been made and to encourage compliance with recommendations. Modifications were funded through the usual sources available to older people who are clients of occupational therapists employed by the Central Sydney Area Health Service.

The most commonly recommended home modifications were removal of floor mats and use of non-slip mats for the bath (see Table 1). A substantial number of people were given advice on safer footwear and on changing how they did things around the home. Only 28 subjects (16%) were felt not to need home modifications or advice regarding footwear or behavior. Five or more recommendations were made for 31 subjects (17%).

Follow-up

Falls during follow-up were ascertained with a set of monthly falls calendars, which subjects were asked to fill in each day and return by mail to the study center at the end of each month (postage paid by the study). Subjects were asked to write an F on the calendar if they had a fall on that day and N if they did not fall. Subjects who had not returned a calendar within 10 days of the end of the month were telephoned and asked about falls in the previous month. If one or more falls were reported, a telephone-administered questionnaire was used to elicit details of each fall, including where the fall had occurred, whether there was any injury, and whether they had seen a doctor as a result of the fall.

Subjects provided data about falls for approximately 12 months from randomization (n = 388) or until they died (n = 86), moved into a nursing home or aged-care hostel (n = 31), or they asked to withdraw from the study (n = 25), whichever came first. Data on falls from calendars or telephone calls were collected for 97% of the person-months of follow-up.

Table 1. Home Modifications Recommended by Study Occupational Therapist and Compliance with Recommendations at 12-Month Follow-up Home Visit

Recommended Modification	No. of Homes (n = 178)	Compliance at 12 Months*
Remove mats/rugs	85 (48%)	49%
Change footwear	43 (24%)	54%
Use non-slip bathmat	38 (21%)	75%
Change behavior†	26 (15%)	60%
Use light at night	23 (13%)	58%
Add rail to external stairs	22 (12%)	19%
Move electrical cords	21 (12%)	67%

*The denominator includes only those homes with the particular hazard where there was a 12-month follow-up home visit.

†Change behavior means advice to perform specific everyday tasks in a safer manner.

Twelve-month follow-up interviews were done for 377 of the 388 subjects still living in the community (341 were interviewed in their own home and 36 were interviewed by telephone). The interviewer-administered follow-up interview included many of the same questions as the baseline interview. Follow-up interviews were blind to group allocation. After completing the interview, the research assistant opened a sealed envelope that contained either a blank piece of paper (control group) or a photocopy of the occupational therapist's original home modification recommendations (intervention group). The research assistant then checked whether the recommended modifications had been completed (see Table 1).

To assess the frequency of non-study occupational therapist home visits during follow-up, lists of names of study subjects were sent to coordinators of local community aged care services, who identified 21 intervention subjects and 19 control subjects as having been seen by one of their service's occupational therapists.

Statistical Analysis

It was estimated that about 700 subjects would be needed for the study to have 80% power (alpha = 5%) to detect a 25% reduction (from 50% to 37.5%) in the percentage of people who had at least one fall during follow-up (assuming 25% 'losses' spread evenly across the year of follow-up). For logistic reasons, 530 subjects were actually recruited.

As specified in the study protocol, the primary analysis compared the proportions of people in the intervention and control groups who had at least one fall during follow-up. Survival analyses were also conducted: a Cox proportional hazards model with time to first fall as the dependent variable and the Andersen-Gill extension of the Cox model, which permits inclusion of multiple falls per person.[17] Only the first five falls for any individual were included in the Andersen-Gill models. Finally, the mean number of falls per person per year in each group was compared using the negative binomial distribution to estimate 95% confidence intervals (CI) around differences in fall rates.[18]

No sub-group analyses were specified in the study protocol, but before commencing any data analysis it was decided to conduct separate analyses for those with and without a history of falls in the 12 months before recruitment into the study. No other sub-group analyses were performed.

A P value of .05 or less was considered statistically significant. Analyses were conducted using SAS statistical software (version 6.12). All analyses were by intention-to-treat.

RESULTS

A total of 530 people were randomized. Figure 1 shows the trial profile. The mean age of subjects in the intervention group was 76.4 years (SD: 7.1 years) and the mean age of the control group was 77.2 years (SD: 7.4 years). There were no important differences between intervention and control

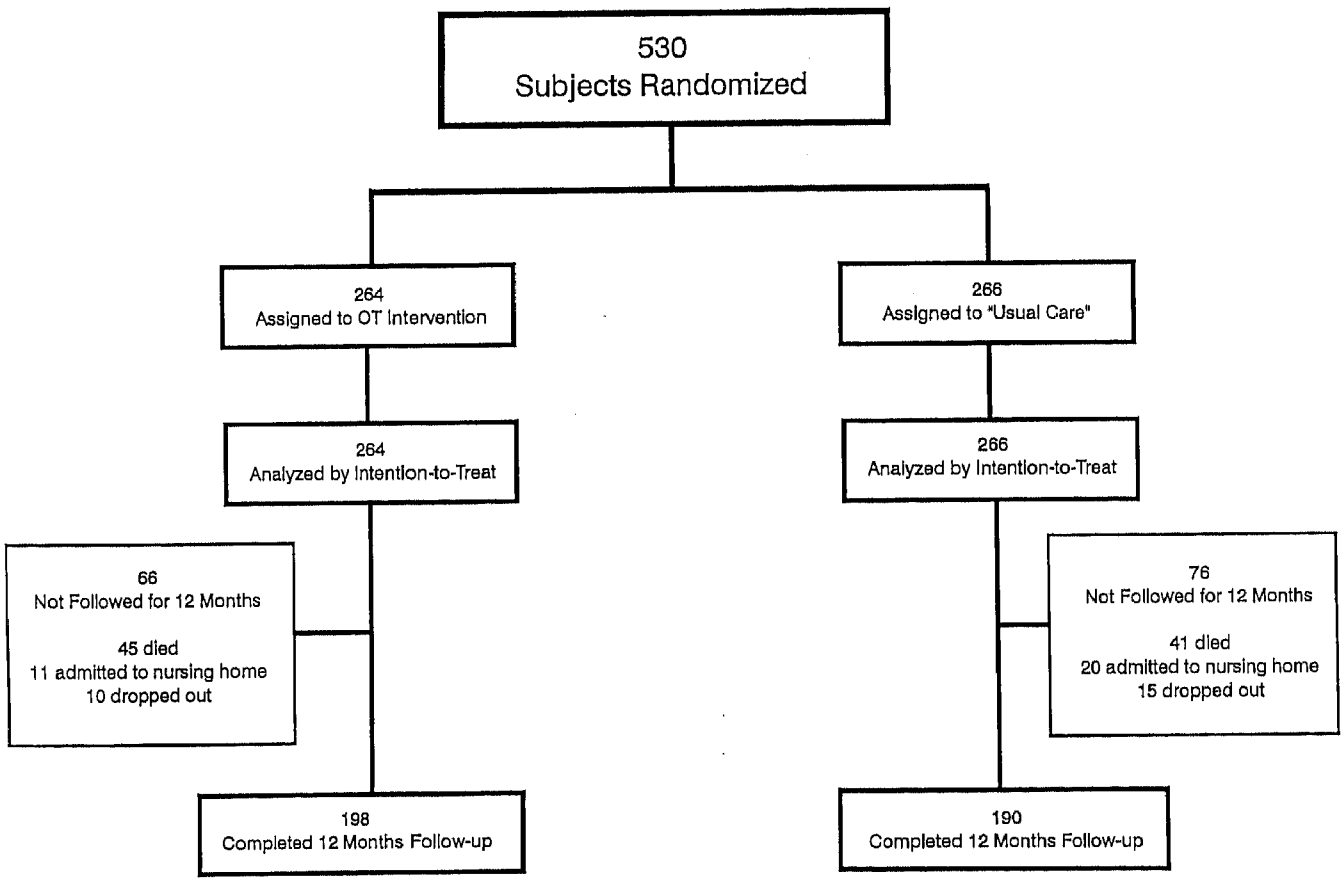

Figure 1. Trial profile.

Table 2. Baseline Characteristics of Study Subjects, According to Study Group

Characteristic	Intervention Group (n = 264)	Control Group (n = 266)
Age group		
65–69 years	50 (19%)	45 (17%)
70–79 years	123 (47%)	120 (45%)
80–89 years	84 (32%)	88 (33%)
≥90 years	7 (3%)	13 (5%)
Female sex	149 (56%)	154 (58%)
Falls in past year		
0	161 (61%)	163 (61%)
1	62 (23%)	54 (20%)
2	20 (8%)	23 (9%)
≥3	21 (8%)	26 (10%)
Afraid of falling	76 (29%)	82 (31%)
0 days in bed due to illness in past 2 weeks*	228 (86%)	222 (83%)
History of stroke	37 (14%)	47 (18%)
History of fractured hip	22 (8%)	13 (5%)
Self-reported poor vision	105 (40%)	85 (32%)
Use of sleeping tablets	64 (24%)	75 (28%)
Use of medicine for nerves, anxiety, or depression	25 (9%)	26 (10%)
Uses a walking aid	97 (37%)	98 (37%)
Need help to perform ≥ 1 self-care ADL†	36 (14%)	35 (13%)
Need help to:		
Do heavy work at home	170 (64%)	169 (64%)
Walk half a mile	133 (50%)	137 (52%)
Walk up stairs	114 (43%)	106 (40%)
No. of self-reported home hazards		
0	204 (77%)	202 (76%)
1	47 (18%)	48 (18%)
2	9 (3%)	13 (5%)
3	4 (2%)	3 (1%)

*For subjects recruited in hospital, excludes days in hospital on current admission.

†Self-care ADLs: bathe, groom, dress, eat, transfer, toilet, walk across a room.[14]

groups on the wide range of risk factors for falls that were assessed at baseline (see Table 2).

Median length of follow-up was 378 days (range: 7 to 559 days; interquartile range: 356–388 days). Median follow-up was 379 days for the intervention group and 378 days for controls. Two hundred fifteen subjects reported at least one fall during follow-up: 108 subjects reported one fall, 38 reported two falls, 29 reported three falls, seven reported four falls, 10 reported five falls, and 23 reported six or more falls. Three subjects each reported more than 50 falls.

The main results of our study are shown in Table 3. Results are given according to three different statistical techniques, all of which gave broadly similar results. There was a statistically significant interaction between the effect of the intervention and whether subjects gave a history of falling in the year before recruitment into the study (P for interaction = .007 by Breslow-Day test for interaction). This significant interaction supported our a priori decision to conduct subgroup analyses according to history of past falls.

Among all study subjects, there was some suggestion that the occupational therapy intervention might have reduced the risk of falling. Based on the analysis comparing the proportion of subjects who reported one or more falls during follow-up, the intervention appeared to reduce the risk of falling by 19% (P = .050). Table 3 shows clearly that the intervention had a different effect in subjects with and without a history of falls. Among people with a history of falls, the occupational therapy intervention reduced the proportion of people falling during follow-up by 36% (P = .001). In contrast, the intervention was not effective among people with no history of falls.

After excluding three subjects who each reported more than 50 falls during follow-up, there were 226 falls in the intervention group and 324 falls in the control group. The difference between groups was confined to subjects with a history of falls: in this sub-group, there were 99 falls in the intervention group (1.25 falls per person per year) and 193 falls in the control group (2.24 falls per person per year). The difference in fall rates was 0.99 falls per person per year (95% CI, 0.17–1.81 falls).

Our findings were similar for the first and second 6-month follow-up periods. In people with a history of falls, the relative risks for one or more falls were 0.62 during the

Table 3. Falls During 12 Months of Follow-up in all Subjects and in Subgroups According to History of Past Falls

Outcome	Intervention Group	Control Group	Relative Risk (95% CI)
All subjects (n = 530)	n = 264	n = 266	
≥1 fall (no., %)	96 (36%)	119 (45%)	0.81 (0.66–1.00)
Time to first fall			0.77 (0.58–1.00)
Andersen-Gill*			0.86 (0.71–1.03)
Subjects without falls in past year (n = 324)	n = 161	n = 163	
≥1 fall (no., %)	53 (33%)	52 (32%)	1.03 (0.75–1.41)
Time to first fall			1.01 (0.69–1.48)
Andersen-Gill*			1.06 (0.80–1.39)
Subjects with falls in past year (n = 206)	n = 103	n = 103	
≥1 fall (no., %)	43 (42%)	67 (65%)	0.64 (0.50–0.83)
Time to first fall			0.56 (0.38–0.82)
Andersen-Gill*			0.75 (0.58–0.96)

*The Andersen-Gill models include up to five falls for each subject.

first 6 months and 0.41 during the second 6 months. The differences in fall rates between intervention and control groups were 0.98 falls per person per year in the first 6 months and 0.73 falls per person per year in the second 6 months.

Our study was not designed to have the power to detect an effect of the intervention on injurious falls. Overall, 127 subjects (24%) reported that at least one of their falls resulted in an injury, and 91 subjects (18%) said they sought medical attention because of a fall. Among people with a history of falls, the relative risk for injurious falls was 0.75 (95% CI, 0.51–1.11) and the relative risk for falls requiring medical attention was 0.89 (95% CI, 0.56–1.42).

Among people with a history of falls, the occupational therapy home visit seemed to be equally effective in reducing the risk of falling at home and away from home (Table 4).

Eighty-six subjects died during follow-up, 45 subjects in the intervention group and 41 in the control group. Eleven subjects in the intervention group were admitted to a nursing home or hostel for the aged compared with 20 subjects in the control group (relative risk 0.57, 95% CI, 0.27–1.12).

Twenty-seven percent of subjects (n = 142) did not provide a full 12 months of fall data. The mean fall rates during follow-up were 1.98 per person per year among those subjects who died; 2.31 falls per person per year among those admitted to a nursing home or hostel; and 0.41 falls per person per year among those who left the study for other reasons. The mean fall rate was 1.34 falls per person per year among those who completed 12 months of follow-up.

DISCUSSION

Several observational epidemiological studies of risk factors for falls have included an assessment of home environmental hazards.[1–3,8–12] Most of these studies have found that the number and type of hazards in the homes of fallers and non-fallers were similar. Failure to find associations between home hazards and falls could be due to inherent limitations in observational epidemiological studies. Longitudinal studies are problematic because hazards identified at baseline may no longer be present by the time a fall occurs. Case-control studies involve home assessment after a fall, by which time the offending hazard may have been removed.

Our randomized trial provides the best evidence to date that home modifications might prevent falls.[19] However, we believe the results need careful interpretation because the intervention group had fewer falls both at home and away from home. A direct effect of home modifications on falls away from home is difficult to explain. Rather than conclude that home modifications are effective, a better interpretation of our findings is that home visits by occupational therapists can prevent falls.

There are several reasons why home visits by occupational therapists for assessment of hazards might be more successful than other forms of home hazard assessment such as a hazard checklist completed by older people themselves or by lay volunteers. Occupational therapists are carefully trained and have experience in assessing homes for hazards and making home modifications. They take into account the characteristics of the person living with the hazard, such as limited mobility and poor vision, when they assess a home for hazards. When a hazard cannot be removed, occupational therapists provide advice on how to live more safely with the hazard. A recent qualitative study suggests that working with an occupational therapist in assessing and modifying home hazards encourages older people to consider fall prevention strategies in a wide variety of situations.[20] A home visit by an occupational therapist is also likely to have the effect of raising general awareness of falls and their prevention as occupational therapists tend to stress the seriousness of falls in order to enhance compliance with recommended home modifications. For all of these reasons, we believe our positive findings apply only to home hazard assessment by occupational therapists. Our study should not be used to justify widespread, untargeted, home modification programs implemented by people without skills in the care of older people.

Unlike some other randomized trials of falls prevention interventions, control subjects in our study did not receive any form of home visit. It is possible that the effect we observed was simply caused by raised awareness about falls. It is also conceivable that intervention subjects underreported falls because they wanted to please the study occupational therapist. If this were so, we would have expected a greater apparent effect of the intervention in the early months of follow-up, closer to the time of the study home visit. However, we found the same magnitude of effect during the first and second 6 months of follow-up.

In our study, the occupational therapist home visit was effective only among people who had a history of falling.

Table 4. Falls at Home and Falls Away from Home During 12 Months of Follow-up in Subjects with a History of Falls in the 12 Months Before Recruitment

Outcome	Intervention Group	Control Group	Relative Risk (95% CI)
	n = 103	n = 103	
Falls at home*			
≥1 fall at home	34 (33%)	42 (43%)	0.77 (0.54–1.10)
Time to first fall			0.73 (0.46–1.41)
Andersen-Gill†			0.76 (0.55–1.04)
Falls away from home			
≥1 fall away from home	18 (17%)	27 (26%)	0.67 (0.39–1.13)
Time to first fall			0.64 (0.36–1.17)
Andersen-Gill†			0.81 (0.50–1.29)

*Seven subjects were excluded from this analysis because it was not possible to determine whether they had had a fall at home.
†The Andersen-Gill models include up to five falls for each subject.

There are several possible explanations for this. It may simply be attributable to greater statistical power in this sub-group, inasmuch as people with previous falls were more likely to fall during follow-up. It is also possible that compliance with recommendations by the occupational therapist was better in people with experience of falling. There is also some evidence that environmental hazards may be particularly important fall risk factors only among frail older people who are at high risk of falling because they are mobile but unstable.[9] However, two studies have found that environmental hazards are more likely to be involved in falls in active older people than in the more frail.[10,21]

Most of the subjects in our study were recruited while in an acute care hospital, but home visits by an occupational therapist were not planned for any of them as part of their usual care. Our findings suggest that the benefits of home visits are not confined to people with obvious impairments in activities of daily living (such as inability to shower in those who have had a stroke). Home visits around the time of discharge should be considered for all hospitalized older people who have fallen in the year before hospital admission.

In conclusion, our randomized trial shows that home visits by occupational therapists can prevent falls among older people who have fallen in the previous year. We believe this effect is unlikely to be caused by home modifications alone. Home visits by occupational therapists may also lead to changes in behavior that enable older people to live more safely in both the home and external environment.

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