Preventing Falls in Community-Dwelling Frail Older People Using a Home Intervention Team (HIT): Results From the Randomized Falls-HIT Trial

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OBJECTIVES: To evaluate the effect of an intervention by a multidisciplinary team to reduce falls in older people's homes.

DESIGN: Randomized, controlled trial with follow-up of subjects for 1 year.

SETTING: University-affiliated geriatric hospital and older patients' homes.

PARTICIPANTS: Three hundred sixty subjects (mean age ± standard deviation = 81.5 ± 6.4) admitted from home to a geriatric hospital and showing functional decline, especially in mobility.

INTERVENTION: The participants were randomly assigned to receive a comprehensive geriatric assessment followed by a diagnostic home visit and home intervention or a comprehensive geriatric assessment with recommendations and usual care at home. The home intervention included a diagnostic home visit, assessing the home for environmental hazards, advice about possible changes, offer of facilities for any necessary home modifications, and training in the use of technical and mobility aids. An additional home visit was made after 3 months to reinforce the recommendations. After 12 months of follow-up, a home visit was made to all study participants.

MEASUREMENTS: Number of falls, type of recommended home modifications, and compliance with recommendations.

RESULTS: After 1 year, there were 163 falls in the intervention group and 204 falls in the control group. The intervention group had 31% fewer falls than the control group (incidence rate ratio (IRR) = 0.69, 95% confidence interval (CI) = 0.51–0.97). The intervention was most effective in a subgroup of participants who reported having had two or more falls during the year before recruitment into the study. In this subgroup, the proportion of frequent fallers and the rate of falls was significantly reduced for the intervention group compared with the control group (21 vs 36 subjects with recurrent falls, $P = .009$; IRR = 0.63, 95% CI = 0.43–0.94). The compliance rate varied with the type of change recommended from 83% to 33% after 12 months of follow-up.

CONCLUSION: Home intervention based on home visits to assess the home for environmental hazards, providing information about possible changes, facilitating any necessary modifications, and training in the use of technical and mobility aids was effective in a selected group of frail older subjects with a history of recurrent falling. **J Am Geriatr Soc 51:300–305, 2003.**

Key words: falls prevention; randomized controlled trial; environmental hazards; home intervention; frail older people

Falls in older people are a leading cause of disability, distress, admission to supervised care, and death.[1] About one-third of community-dwelling older persons aged 65 and older and 50% of those 80 and older fall each year.[2] At least half of the fallers experience multiple episodes per year, and one-third suffer moderate to severe injuries.[3,4]

The home environment has been implicated in one-third to one-half of all falls or injurious fall events in older persons.[5,6] Thus, it seems sensible to identify potential environmental hazards and to modify the home environment to reduce the fall risk. However, observational epidemiological studies have shown that only minor differences in environmental hazards exist between the homes of fallers and nonfallers.[2,7–11] Only one study has shown that, in a subgroup of older patients, a facilitated home modification program after hospital discharge was effective in reducing falls.[12] Otherwise modification of home environment without other components of multifactorial intervention have not been beneficial.[9,13–16]

This study examines the effectiveness of a home as-

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sessment and intervention program in reducing falls by community-living frail older persons experiencing a decline in functional capabilities, especially mobility.

METHODS

The subjects were recruited while they were inpatients in a geriatric clinic of a mid-sized town (approximately 140,000 inhabitants) in southern Germany. These patients were referred to the clinic directly by the general practitioner or admitted from the emergency wards of the departments of internal medicine, neurology, and surgery of the university hospital.

Older subjects who lived at home before admission, had multiple chronic conditions or functional deterioration after convalescence, and could be discharged to home (rather than nursing home) met the inclusion criteria. Those with terminal illness or severe cognitive decline were excluded. Patients who lived too far away (>15 km) for the home intervention team (HIT) to make regular visits were also excluded.

The ethical committee of the University of Heidelberg approved the study.

After giving informed consent, patients were randomly assigned to comprehensive geriatric assessment and postdischarge follow-up home visits from an interdisciplinary HIT or comprehensive geriatric assessment (CGA) with recommendations followed by usual care at home. The control group did not receive any type of home visit. Their general practitioners were responsible for postdischarge case management.

The randomization was implemented using sealed envelopes containing group assignments using a random number sequence.

During the hospital stay, a CGA was implemented. Activities of daily living (ADLs) were assessed using the Barthel Index[17] and instrumental ADLs using the Lawton-Brody Questionnaire[18] and cognition and mood using the Mini-Mental-State-Examination (MMSE)[19] and the Geriatric Depression Scale.[20] Mobility was tested using the Performance Oriented Mobility Assessment[21] and the timed up-and-go test.[22] To test vision, manual skills, and cognitive capacity, the Timed Test of Money Counting[23] was performed. Vision was tested using a Jaeger eyesight card. Eyeglasses were permitted as appropriate. Data about chronic conditions (e.g., arthritis, stroke, hip fracture) and use of medications were obtained. Finally, subjects were asked about falls occurring during the previous 12 months.

Patients were classified as functionally deteriorated if they failed to reach the normal range on at least one of the assessment tests of ADLs or mobility. Multiple chronic conditions were determined as the patient having at least two chronic diseases (e.g., osteoarthritis, chronic cardiac failure, stroke, hip fracture, parkinsonism) or geriatric syndromes such as chronic pain, urinary incontinence, and malnutrition.

After discharge from the hospital, the participants were contacted monthly by telephone to obtain information on falls, fall-related injuries, and their circumstances. The interviewer was blinded to group allocation. A fall was defined as an event reported by a faller or a witness that resulted in a person inadvertently coming to rest on the ground or another lower level without loss of consciousness. Fall-related injuries others than fractures were defined as dislocations, injuries of chest, abdomen, or pelvis; open wounds requiring suturing; injuries to blood vessels; crushing injuries; and injuries to nerves and spinal cord.

Over the monitoring period participants additionally received a diary for recording falls and injuries that included the same questions asked during the telephone interview.

For analytical purposes, an event was defined as one reported by a telephone interview, recorded in the diary, or recorded by both methods.

Intervention

The HIT consisted of three nurses, a physiotherapist, an occupational therapist, a social worker, and a secretary. One home visit was made during the hospital stay to evaluate the patient's home and to prescribe technical aids when necessary. To identify home hazards, a standardized home safety checklist was used.[24] Usually, two members of the HIT (an occupational therapist with a nurse or a physiotherapist according to the anticipated needs and the functional limitations of the patient) made the first home visit. After discharge, at least one further home visit (mean = 2.6; range = 1–8) was performed to inform people about the possible fall risks in their home, to give advice on possible changes of the home environment, to facilitate any necessary home modifications, and to teach the persons in the use of technical and mobility aids when necessary. One year after randomization, home visits were made for all participants, and additional information about the rate of physiotherapy, medication, rehospitalization, nursing home placement and the use of home help services was obtained from the patients' general practitioners. A trained interviewer who was not a member of the HIT collected all follow-up data.

Statistical Analyses

Sample size calculation to demonstrate effects on fall rate reduction were based on a review of the existing literature.[25] Using an exact test with an alpha level of 0.05 and a power of 0.80, a sample size of 250 subjects was considered to be necessary to detect a 20% reduction of falls during the follow-up year. The Wilcoxon rank sum test was used to examine differences in continuous variables and the chi-square test for categorical variables (e.g., Barthel score, MMSE, state of health) with the modification for linear trend when appropriate.

Calculations assumed binomial distribution of endpoints. The number of falls per person per year in each group was compared using the negative binomial distribution.[26] The incidence rate ratio (IRR) with the corresponding 95% confidence intervals (CIs) was calculated. The model takes into account all falls and adjusts for the individual follow-up time in the trial. The first five falls for each participant were used in this analysis rather than all falls (maximum 22) to avoid over-weighting by subjects who fell more then five times. If it is assumed that everyone falls occasionally, whether the person falls once during the trial period may not be the best indication of whether the intervention is effective. Thus, a subgroup analysis of people with no or one fall versus people with two or more falls was also conducted. This analytical strategy was decided a priori.

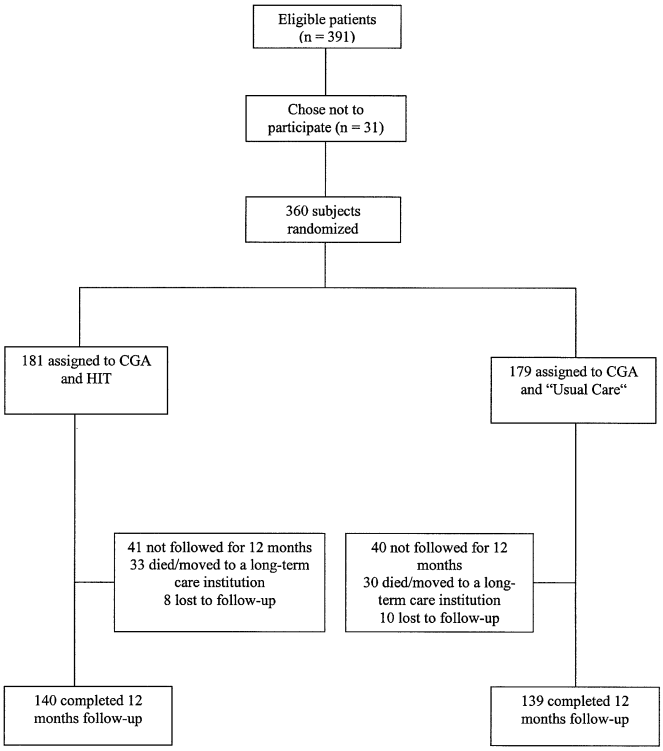

Figure 1. Design of Falls-HIT Trial. CGA = comprehensive geriatric assessment; HIT = home intervention team.

$P < .05$ was considered statistically significant. Analyses were conducted using SAS statistical software, version 6.12 (SAS Institute, Inc., Cary, NC). All analyses were by intention-to-treat.

RESULTS

Figure 1 shows the trial profile. The study included 360 community-dwelling frail older people with the mean age ± standard deviation of 81.5 ± 6.4; 264 (73.3%) were women. CGA showed a functional limitation in all study participants, especially in mobility, but with good cognitive capabilities (Table 1). The rate of physiotherapy and the use of home help services were similar in both groups during the observation period. One year after randomization, 33 participants in the intervention group and 30 participants in the control group were dead or had moved to a long-term care institution. The mortality in the observation period was similar in both groups. Eight patients of the intervention group and 10 of the control group were lost to follow-up. Baseline characteristics of these subjects were comparable with those of the whole study sample.

Table 2 shows the incidence of reported fall events and fall-related injuries during the trial. There was a 31% lower fall rate during the trial for the intervention group than for the control group (IRR = 0.69, 95% CI = 0.51–0.97), but the proportion of frequent fallers (≥2 falls) did not significantly differ between the groups.

Table 1. Baseline Characteristics of Study Population

Characteristic	Intervention Group (n = 181)	Control Group (n = 179)
Age, mean ± SD	81.2 ± 6.3	81.9 ± 6.5
Women, n (%)	131 (72.4)	133 (74.3)
History of stroke, n (%)	14 (7.7)	22 (12.3)
History of hip fracture, n (%)	17 (9.4)	13 (7.3)
Urinary incontinence, n (%)	53 (29.3)	58 (32.4)
Fallers in past year, n (%)		
≤1 fall	128 (70.7)	124 (69.3)
≥2 falls	53 (29.3)	55 (30.7)
Barthel activities of daily living, mean ± SD	91.0 ± 21.7	92. ± 122.1
Lawton instrumental activities of daily living, mean ± SD	5.3 ± 2.1	5.3 ± 2.1
Mini-mental state examination, mean ± SD	26.3 ± 4.8	26.5 ± 4.9
Geriatric depression scale, mean ± SD	3.1 ± 2.2	3.0 ± 2.0
Performance oriented mobility assessment, mean ± SD	20.8 ± 7.6	21.2 ± 7.4
Timed up and go, seconds, mean ± SD	20.4 ± 15.6	19.9 ± 16.1
Timed test for money counting, seconds, mean ± SD	57.6 ± 24.3	55.9 ± 24.0
Satisfactory vision (acuity >20/40), n (%)	112 (61.9)	110 (61.5)
Medication		
Sedatives/hypnotics, n (%)	16 (8.8)	7 (9.5)
Neuroleptics, n (%)	21 (11.6)	15 (8.4)
Antidepressants, n (%)	7 (3.9)	12 (6.7)
Nonsteroidal antiinflammatory drugs, n (%)	72 (39.8)	82 (45.9)
Diuretics, n (%)	70 (38.7)	64 (35.8)
Digoxin, n (%)	18 (9.9)	21 (11.7)
≥5 medications, n (%)	25 (13.8)	23 (12.8)

Note: There were no significant differences between groups.
SD = standard deviation.

Table 2. Incidence of Reported Fall Events and Fall-Related Injuries within Study Groups During Follow-Up Period

Fall Event	Intervention Group	Control Group
Falls, n	163	204*
Falls per 100 person years, n	96.5	124.3
Fallers in follow-up period, n (%)		
≤1 fall	130 (71.8)	118 (65.9)
≥2 falls	51 (28.2)	61 (34.1)
Fall-related injuries, n (%)		
Fractures	4 (2.2)	3 (1.7)
Other	10 (5.5)	13 (7.3)
Injurious falls per 100 person years, n	8.29	9.75
Follow-up time, months, mean ± standard deviation	11.2 ± 1.9	11.0 ± 1.7
Total follow-up time, person years	168.93	164.08

*Incidence rate ratio = 0.69, 95% confidence interval = 0.51–0.97, $P = .032$.

This study was not designed to examine fall-related injuries as an endpoint. Nevertheless, the figures are listed in Table 2. Three patients in the intervention group had hip fractures and one a fracture of the forearm, and two patients in the control group had a hip fracture and one a vertebral fracture. Ten subjects in the intervention and 13 subjects in the control group reported that at least one of their falls resulted in an injury. The reported rate of outdoor falls was too low to make statistical comparisons (9 falls away from home in the intervention group and 11 in the control group).

The intervention program had a different effect on subjects with and without a history of falls (see Table 3). The proportion of frequent fallers among those with a history of frequent falls could be reduced but not among those who did not report frequent falls in the past year (Breslow-Day test for interaction; $P = .009$).[27] In this subgroup of subjects with a history of frequent falls, there was also a 37% lower fall rate for the intervention group than for the control group (IRR = 0.63, 95% CI = 0.43–0.94; $P = .028$).

Table 3. Subgroup Analysis of Fall Rates and Proportion of Frequent Fallers According to Prior Falls

Falls	Intervention Group	Control Group
Subjects with no or one fall in past year, n (n = 252)	128	124
Falls, n	100	115*
Fallers with ≥2 falls in follow-up period, n (%)	30 (23.4)	25 (20.2)
Subjects with two or more falls in past year, n (n = 108)	53	55
Falls, n	63	89†
Fallers with ≥2 falls in follow-up period, n (%)	21 (39.6)	36 (65.5)

*Incidence rate ratio = 0.91, 95% confidence interval = 0.72–1.22.
†Incidence rate ratio = 0.63, 95% confidence interval = 0.43–0.94, $P = .028$.

Table 4. Compliance with Recommendations of Home Intervention Team After 12 Months of Follow-Up

Recommendation	Compliance Rate n (%)
Shower seat	23 (82.6)
Emergency call	14 (78.6)
Grab bars	27 (77.8)
Night light in bedroom/bath	20 (70.0)
Anti-slipping mat in bath-tub	12 (66.6)
Elevation of bed	19 (63.2)
Rollator	37 (56.8)
Elevation of toilet seat	43 (54.3)
Removal of rugs/carpets	12 (41.7)
Removal of obstructions in walkways	15 (33.3)

Overall, 222 home modifications were recommended. There were 137 homes with at least one recommended change (75.7%). The most commonly recommended home modifications were elevation of toilet seat (n = 43), use of a rollator (n = 37), and fixing grab bars in the bathroom (n = 27). Three months after discharge, a follow-up visit was made to check whether recommendations were being implemented and technical aids used and to identify any new problems.

The compliance with recommendations for home modifications is shown in Table 4. In 105 homes, at least one recommended change had been implemented (compliance rate 75.7%) after 12 months of follow-up. Participants who made at least one of the recommended changes experienced a significant reduction in the rate of falls (IRR = 0.64, 95% CI = 0.37–0.99; $P = .047$) The number of falls in those subjects in the intervention group with no home modifications was not significantly different from those in the control group (IRR = 1.05, 95% CI = 0.82–1.41). The compliance rate in the use of shower seats, emergency calls, and grab bars was high, whereas less than one-half followed the recommendations to remove rugs/carpets or obstructions in walkways. Nearly half of the originally implemented elevation of toilet seats were withdrawn.

In the control group, there were no recommendations of home modifications, but for 29 subjects a rollator was prescribed as part of general care.

DISCUSSION

The intervention reduced reported falls by 31% in a group of frail older people. However, the proportion of frequent fallers (≥2 falls) was not significantly different for the intervention and control groups. The subgroup analyses suggest that the intervention was particularly successful in those with a history of two or more falls in the previous year. In this subgroup, the proportion of frequent fallers and the rate of falls could be reduced significantly by the home intervention program.

It seems appropriate to identify environmental hazards and to recommend modifications to make peoples' homes safer. But what should these modifications be and who will benefit most from these modifications?

The majority of observational epidemiological studies have found only minor differences in environmental hazards between the homes of fallers and nonfallers, leading to the conclusion that modification of the home environment is unlikely to be useful for falls prevention.[2,7–10,28–30] One major critique is that therapists, not the people themselves, define a home hazard.

Older persons may adapt to the environmental hazards and indeed may use these purported hazards to enhance their indoor mobility. One example was given by Rubenstein,[31] who noted that a carefully laid out series of chairs, which might otherwise be judged as obstructing the pathway, might instead provide support for walking from one room to another. An observational study by Connell et al.[5] with an in-depth examination of environmental and behavioral circumstances associated with falls and near falls demonstrated that there is a dynamic interaction between environmental conditions and behavior. Obstacles increase the risk of falling when they are temporary or unexpected (e.g., telephone cord in the path of travel).

A community-based program with home safety inspection and simple home modifications in Australia resulted in a reduced risk of falling in several age groups. The authors concluded that behavioral change, rather than the environmental change, probably played a significant role in lowering the rate of falls in their nonrandomized trial.[16]

In the subgroup of people who had fallen twice or more before the study, the home intervention was most effective. They also showed a higher compliance rate with the recommendations. One can hypothesize that this subgroup had been suffering for a long time from falls and were more open to information to modify their home environment and to adapt their own behavior in accordance with their functional decline. Compliance seems to be a crucial issue with respect to the effectiveness of a home intervention. Participants in the intervention group who did not implement any of the recommended changes experienced the some amount of falls as participants in the control group.

This leads to one key question: What should be modified, the environment, the individual, or both? Gill et al.[32] showed in a cross-sectional study, that there are mismatches between the home environment and physical capabilities of community-living older persons. Connell et al.[5] showed that there is a close relationship between environmental and behavioral circumstances.

Another study showed that, after a home visit by an occupational therapist, a subgroup of older people reduced the overall number of falls in the home and in the external environment, but not in the home alone.[12] The vast majority of the participants were recruited during an admission to an acute care or rehabilitation hospital. In contrast to this study, they were not selected based on their level of frailty or risk of falls. The mean age of the current study's participants was 4.5 years higher, and the study sample was selected with respect to functional decline, especially deterioration of mobility. A subgroup analysis was also performed by dividing the participants into a group with none or one fall and a group with two or more falls, because of better discrimination between people with a low and a high risk for falling. One fall can happen by chance. In contrast to the study of Cumming et al.,[12] the current study had different therapists. Thus, it is unlikely that the effect of the program is only the result of the skills of one therapist. Additional data from the general practitioners could be obtained to ascertain, for instance, that physical therapy in the observational period was equally distributed in both groups.

As part of the intervention, rollators were prescribed. The prescription rate of rollators was similar in the control group and the intervention group (20.4% for the intervention group vs 16.2% for the control group). Thus, the effects (if any) of the intervention are likely based on home modifications and not on the prescription of mobility aids.

Like many other studies, this study was dependent on self-reporting of falls; this method may be open to criticism. There is always some uncertainty whether all falls are recalled exactly, even if different methods of data collection are used. Further work needs to be done to observe falls and to use technical devices to record falls. This will allow a better understanding of circumstances as to why people fall repeatedly and the classification of different types of falls.

This study has demonstrated that a home intervention based on home visits to assess for environmental hazards, provide information about possible changes, facilitate any necessary home modifications, and teach the use of technical and mobility aids when necessary is effective in a subgroup of frail older individuals with a high risk of repeated falls. To improve the effectiveness of further home assessment procedures, intervention should be targeted toward high-risk frail older subjects. Not only environmental risk factors but also associated behavior that require change must be identified and modified.

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