INJURIES

Prevention of fall injuries requiring hospital treatment among community-dwelling elderly

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Background: To reduce the number of fall injuries requiring hospital treatment among community-dwelling elderly a community-based intervention programme was set up. The study was designed as a prospective intervention study with the intervention consisting of information and home visits with follow-up, removing physical hazards, treating somatic and psychiatric illnesses and dealing with improper drug consumption, diet insufficiencies and physical and mental inactivity. The setting was five municipalities of the county of Vejle, Denmark (intervention area) with 12,905 community-dwelling elderly (≥65 years) and four other municipalities in the same county (control area) with 11,460 community-dwelling elderly (≥65 years) from 1 January 1986 to 31 March 1988. Method: A separate injury register at hospitals, with catchment areas for the above study population, was established to collect information on fall-related injuries among the community dwelling elderly who were referred to out-patient treatment or hospitalization. The fall injuries requiring treatment were registered for nine months prior to the intervention and for 18 months during the implementation of the intervention programme. Results: The prevented fraction was estimated for all fractures, lower extremity fractures and hip fractures. A non-significant reduction of 14% in the number of all fractures was found in the intervention group compared with the control group. The reduction of lower extremity fractures in the intervention group was found to be significantly greater 33% (95% Cl: 3-63%), due to a highly significant reduction among women: 46% (95% Cl: 8-84%), but without reduction among men. Similarly a high, although non-significant, reduction of hip fractures among women was found: 43% (95% Cl: -2 - 88%). The reductions appeared to be highest in the last nine months of the intervention period and highest among women living alone. Conclusion: It is possible to reduce the number of major fall-related fractures among elderly with a well-integrated, community-based intervention programme having information, home visits and follow-up as major components and utilizing existing health personnel in a municipality.

Keywords: elderly, fall injuries, prevention

Accidents are cited as the sixth most frequent cause of death among the elderly and falls account for the absolute majority of these accidents. Falls are a frequent and recurrent event among the elderly as approximately 30% of the community-dwelling elderly (≥65 year-olds) fall once a year and 8–17% fall even more frequently. Fractures due to falls occur in 2–6% of the elderly each year, 1–2% involving the femoral neck and 1% the wrist. Studies have suggested that the age-specific rates of incidence for fall-related fractures in the elderly increased during the period 1970–1980. Although few falls result in serious injuries, the psychological consequences are often severe with loss of confidence in the ability to cope, which may lead to an increased fear of falling, again resulting in restriction of physical activity of the elderly person, dependency on others and social withdrawal. The falling accidents of the elderly are therefore both a considerable health problem for the elderly and a major socioeconomic problem. On that basis, in 1985 the prevention committee of the county council of Vejle (Denmark) in 1985 launched a project with the purpose of evaluating whether a community-based intervention among the community-dwelling elderly, utilizing existing care staff of the elderly and facilities, could prevent the many fall-related injuries, in particular the most serious ones which are usually referred to hospitals.

MATERIALS AND METHOD

The project was prepared and implemented during the period 1985–1988 as a community-based intervention trial, consisting of a baseline registration of 9 months, followed by an 18 months’ implementation of the intervention with a concurrent registration of outcomes. It was not possible to randomize the elderly people into an intervention and a control group, because of obvious risk of a considerable spill-over effect from the elderly receiving intervention to the elderly representing the reference group (controls). It was also found too difficult administratively to let the health personnel involved...
intervene among some elderly and exclude others in a small community. Furthermore, the politicians in the municipalities of the intervention area were only willing to join the intervention trial if all their elderly citizens were included.

Study design
Therefore a quasi-experimental design was chosen, where community-dwelling elderly of five municipalities were selected to constitute the intervention group, while the community-dwelling elderly of four other municipalities constituted the control group. The two groups were geographically separated to avoid the above-mentioned risk of a spill-over effect from the intervention group to the control group.

To assess comparability the following demographic and social characteristics of the elderly were controlled for:
- distribution in 5 year age groups;
- gender;
- marital status (single/cohabitant);
- institutionalized/home-living;
- fluoride content of drinking water: no difference was found;
- elderly care, private/public: no difference was found;
- current oestrogen therapy (hormone replacement therapy): no differences were observed between the general practitioners prescribing habits;
- referral patterns of the general practitioners for fall-related injuries: only a minute difference was detected and the referral pattern did not change during the trial;
- distances to casualty wards/hospitals: no differences were found.

The study population consisted of 13,921 elderly in the intervention area and 12,300 elderly in the control area. Furthermore, the following factors, which could be confounding factors or effect modifiers on the outcome measure (number of fall-related injuries) were controlled for:
- residency in countryside or town/city: a 10% difference was estimated;
- inactivity (both physical and mental) and gait disorders.

Study period
The prospective sequence was a 9 months' baseline registration and an 18 months' intervention period with effect registration in the same period.

Intervention
The intervention consisted of a community health programme with the aim of reducing:
- physical hazards for falling in the surroundings of the elderly, both in-door and out-door;
- somatic illness and age-debilities, which are related to dizziness and balance-disorders;
- psychiatric illness which affects mood and activity levels, and enhances isolation;
- diet insufficiency, particularly daily intake of fluid and vitamins/minerals and inactivity (both physical and mental) and gait disorders. The institutionalized elderly were excluded from the intervention, because they were regarded a priori as being in optimal conditions regarding the above-mentioned risks of falling and, as such, not the target of the intervention. This reduced the two groups to 12,905 elderly in the intervention group and 11,460 elderly in the control group.

A three-pronged intervention was carried out.
- information on the above risk factors to all the elderly, both in-door and out-door;
- homevisits to 70–74 year olds by district nurses in order to inform them of risk factors of falling and to identify and possibly correct them and to join the intervention trial if all their elderly citizens were included.

Furthermore the following factors, which could be confounding factors or effect modifiers on the outcome measure (number of fall-related injuries) were controlled for:
- residency in countryside or town/city: a 10% difference was estimated;
- inactivity (both physical and mental) and gait disorders.

Table 1 Characteristics of the elderly in the intervention (I) and control (C) groups

<table>
<thead>
<tr>
<th>Age (years)</th>
<th>Males/Females</th>
<th>Singles/Co-habitants</th>
<th>Home living/Institution</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>I/C</td>
<td>I/C</td>
<td>I/C</td>
</tr>
<tr>
<td>65–69</td>
<td>33/28</td>
<td>19/41</td>
<td>32/16</td>
</tr>
<tr>
<td>70–74</td>
<td>27/26</td>
<td>24/29</td>
<td>28/10</td>
</tr>
<tr>
<td>75–79</td>
<td>21/22</td>
<td>24/19</td>
<td>22/16</td>
</tr>
<tr>
<td>80–84</td>
<td>12/14</td>
<td>18/8</td>
<td>12/22</td>
</tr>
<tr>
<td>85–89</td>
<td>5/7</td>
<td>11/2</td>
<td>5/26</td>
</tr>
<tr>
<td>90+</td>
<td>2/3</td>
<td>5/1</td>
<td>1/19</td>
</tr>
<tr>
<td>All</td>
<td>100/99</td>
<td>101/100</td>
<td>100/99</td>
</tr>
</tbody>
</table>

All values are percentages

1: intervention group; C: control group
Prevention of fall injuries

Training
All the district nurses, general practitioners and home helpers underwent training in risk identification and risk management of falls of the elderly. The training was given at the beginning of the project and repeated halfway through. The training was differentiated according to the three groups of the health staff participating.

By using the existing personnel in the public health care system and only providing them with extra knowledge on identification and prevention of risks of falling among elderly and providing rather limited resources for home visits and follow-up, it was anticipated that the model could be directly applicable to other councils. The external validity played a major role in the design of the project.

The intervention model was approved in 1985 by the Scientific-Ethical Committee of the Counties of Fyn (Funen) and Vejle.

Monitoring of effect
For assessment of effect of the intervention, all fall incidents leading to contact with nearby hospitals either through casualty treatment or admission were recorded. It was found necessary to establish a separate injury register at the hospitals involved, because a testing of existing registries revealed that they were highly unreliable and could in no way be used for monitoring the effect of the intervention or for statistical analyses. Fall injuries which were either treated by the patients themselves or by the district nurses or a general practitioner on call or at his/her surgery were not included in the register.

An injury incident was included into the fall injury register, if the elderly person himself/herself informed that he/she had fallen prior to the incident. It was not regarded as being important to distinguish between the different definitions of falls, as both treatment and – to a large extend - prevention are the same, regardless of definitions. All fall injury incidents (both casualty and in-patients, i.e. both minor and major) were examined by the treating doctor and information on the circumstances (time, level, place, activity, treatment, etc.) plus diagnosis(es) were recorded by the doctor.

The injury recording system used was the one advised by Nomesco (Nordic Medical Statistical Committee).

If an incident had to be excluded because it had happened at an institution, the person was below 65 years, the incident had happened outside the project area, etc., this was done by the project secretariat, which scrutinized each and every record. Records were compared with the patient files at the hospitals and the national in-patient register every quarter. Furthermore, all patient files (casualty and in-patients from all nine nearby hospitals, a total of more than 175,000 files) were scrutinized every year to see whether the doctors performing the registration had failed to record cases.

The statistical analyses were based on the model consisting of two groups of elderly, which could be compared over time controlling for the most evident confounders such as age, gender and marital status. The fall injury incidents were regarded as Poisson distributed as the groups were openedended and stepwise logistic regression analysis of the cross-classified data was used to analyse differences between the two groups (pre-intervention, early intervention and late intervention) attributable to the intervention over time.

RESULTS
During the project period (27 months) a total of 2,006 fall injuries among the approximately 24,500 home-living elderly were registered at the nearby hospitals. The 2,006 treatments were distributed across 720 admissions and 1,284 out-patient treatments and two dead on arrival at hospital. In total, fractures constituted 1,115 cases, equivalent to 56% of all recorded injuries. Of these, fractures to the neck and head constituted 3%, to arms and wrist 54% and to legs and feet 37%. In the latter group hip fractures constituted the absolute majority, equivalent to 67.3% of all lower extremity fractures (table 2).

Results from the logistic regression analysis, where selected effect variables (fractures) in the two groups (intervention and control) were assessed controlling for age, gender and marital status, show that a different development in the two groups took place during the intervention period, both when looking at the entire period of 18 months and when dividing this period into an early 9 months' period and a late 9 months' period (table 3). The
Inc (pr.1000,pr.month) regression analysis was done by examining the incidence during the intervention period (both the 'early' and 'late' phase) relative to the incidence in the pre-intervention period in both groups (intervention and control).

It appears that, for all fractures a reduction was seen in the intervention group compared to the control group, but the reduction was not statistically significant. For the lower extremity fractures a significant difference between the two groups was seen and the effect seemed to be smoothly spread throughout the intervention period. However, when the figures were stratified on gender it appears, that for the lower extremity fractures no difference was found for men between the groups over time, while for women the reduction was highly significant. Interestingly the effect seemed to appear in the late phase of the intervention period. When looking at hip fractures, constituting more than two-thirds of the lower extremity fractures, the same pattern was found.

The 'prevented fraction' (table 3) is an estimate of the proportion of the different fracture categories prevented during the 18 months of intervention in the intervention group compared with the control group. The reduction is only significant for fractures of lower extremities among women. Separate analyses (not shown) reveal that no particular age group seems to have benefited more than others from the intervention, but single women seem to have benefited more than the married ones.

**DISCUSSION**

In this intervention study among community-dwelling elderly we found a significant and important reduction (46%) in lower extremity fractures among women in the intervention group compared to the control group, but no reduction among men.

Earlier intervention trials have found an effect on fall accidents, including fractures, but not always a significant reduction and only few of these studies were controlled trials. In a randomized controlled trial in general practice in Wales\(^7\) and in a Danish 3 year eldersudy from Rødovre,\(^8\) the effect of visits by health visitors on morbidity and mortality was significant, but the effect on fall accidents was not reported. In a randomized clinical trial in old people's home Rubinstein et al.\(^9\) found a non-significant reduction in falls. In addition the Swedish community intervention study in Skaraborg County showed a non-significant reduction in injuries among elderly.\(^10\) However, the Norwegian 'Harstad Injury Prevention Study', where, as in our study, the fall fractures were evaluated by means of a hospital-based injury recording system, showed a significant reduction of 26% in fall-related fractures among 65–79 year old community-dwelling elderly.\(^11\) A very high reduction in falls

| Table 3 Results of logistic regression analysis and estimation of prevented fraction (%) |
|-----------------------------------------------|-----------------------------------------------|-----------------------------------------------|-----------------------------------------------|-----------------------------------------------|-----------------------------------------------|-----------------------------------------------|

<table>
<thead>
<tr>
<th>Effect variable</th>
<th>Intervention period</th>
<th>Early part</th>
<th>Late part</th>
<th>Prevented fraction (%)</th>
<th>95% CI</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Effect est.</td>
<td>p-value</td>
<td>Effect est.</td>
<td>p-value</td>
<td>Effect est.</td>
</tr>
<tr>
<td>All fractures</td>
<td>0.85</td>
<td>0.23</td>
<td>0.90</td>
<td>0.47</td>
<td>0.79</td>
</tr>
<tr>
<td>Lower extremity fractures</td>
<td>0.63</td>
<td>0.03</td>
<td>0.62</td>
<td>0.06</td>
<td>0.62</td>
</tr>
<tr>
<td>Women</td>
<td>0.54</td>
<td>0.02</td>
<td>0.63</td>
<td>0.11</td>
<td>0.47</td>
</tr>
<tr>
<td>Men</td>
<td>0.84</td>
<td>0.78</td>
<td>0.58</td>
<td>0.29</td>
<td>1.30</td>
</tr>
<tr>
<td>Hip fractures, women</td>
<td>0.55</td>
<td>0.06</td>
<td>0.73</td>
<td>0.38</td>
<td>0.40</td>
</tr>
</tbody>
</table>

a: Effect estimate = OR\(_x\)/OR\(_j\). P-values based on logistic regression analysis, adjusting for the covariates of gender, age and marital status

b: The method is less reliable at effect estimates near zero
(approximately 60 percent) was recently found among community-dwelling elderly in the USA\textsuperscript{12} and among elderly in old peoples' homes in Australia\textsuperscript{13} after implementation of community-based programmes.

Results from these studies support the hypothesis that community-based interventions can reduce falls and fall-related fractures considerably among the community-dwelling elderly. One community-based study from Wales\textsuperscript{14} could, however, not demonstrate any effect, although a very well-controlled prevention trial, using home-visits for the home-visits of the community-dwelling elderly, was applied for 4 years.

Other ways and means in the prevention of fall-related injuries have been used. A number of preventive trials have been made within the field of strengthening the bones of the elderly, where oestrogen therapy and physical activity have proved effective. Hormone replacement therapy is thought to be able to reduce hip fractures by 35\%,\textsuperscript{15} while physical activity is thought to be able to increase the bone density in women\textsuperscript{16} and protect against femoral neck fractures.\textsuperscript{17} A recent trial in France,\textsuperscript{18} with the intention to treat senile secondary hyperthyroidism, showed a reduction of hip fractures by 23\% among women living in nursing homes. In a Danish, randomized clinical trial, external hip protectors were found to significantly prevent hip fractures in nursing homes residents.\textsuperscript{19}

The strength of our study was the implementation of intervention in a real-life setting provided by existing health personnel to the community-dwelling elderly. The intervention consisted of information and home-visits emphasizing a reduction in environmental hazards, somatic and psychiatric illness, improper consumption of drugs, diet insufficiency and physical and mental inactivity (note 1).

Another strength was that important confounders and effect modifiers, such as residency, fluoride content of drinking water, hormone replacement therapy, the type of elder care, the distances to casualty wards and GPs referral patterns for fall-related injuries, were all equally distributed among the elderly in the intervention and control areas. The most important confounders such as sex, age and marital status were also controlled for in the logistic regression analysis.

Furthermore, the measurement of the outcomes with respect to hospital-treated injuries can be considered very complete, due to the separately established injury register. The referral pattern for GPs for fall-related injuries was assessed by a questionnaire sent out to all GPs in both the intervention and control areas. It appeared that only the most severe diagnosis were regularly referred to the nearby hospitals, i.e. severe dilacerations and fractures. Among the fractures only lower extremity fractures sooner or later end up in hospital. It is therefore assumed that, for lower extremity fractures only, the injury register was complete enough to allow for rigorous testing and analyses.

This assumption was supported by comparing the number of hip fractures included in this injury register to findings in other studies.\textsuperscript{4,8,6} Between 173 and 262 hip fractures per year was to be expected in our study population using the incidences from these studies. We found 207 hip fractures reported in the first year of the study. This supports the assumption that the project injury register was most likely complete with regard to hip fractures and most likely as well to lower extremity fractures.

The weakness of our study was the lack of an exact quantitative registration of the practical implementation of the intervention programme. Written information was sent to the elderly at the beginning of the intervention, but further direct information about prevention of fall injuries in the form of home visits and group meetings probably reached only 60–70\% of all elderly. However, the qualitatively most intensive intervention by the home visits alone encompassed approximately half the group of elderly. Advice and guidance on practical and personal scope for prevention in the home was given to approximately one-third of the elderly visited and changes to their physical surroundings or adjustment of medicine and treatment of disease was carried out in approximately one-quarter of the elderly. It can, however, be concluded that the implementation of the intervention programme has been somehow dissimilar both in intensity and quality. These experiences characterize the practical difficulties implicated in the planning and implementation of intervention programmes and research in a community setting, quite well.

It could therefore also be concluded that a more rigorous implementation of the intervention programme probably would have produced a greater effect on the reduction of fractures. Maybe this could partly explain why we did not find any reduction of lower extremity fractures in elderly men, while a statistically significant reduction was found in women. Although, we do not know the real explanation for this difference between genders, it can be assumed that either the health visitors were more active in the application of the intervention among women than among men or that women were more susceptible to the intervention than men. This latter assumption was the conclusion of some recent research among social classes in Denmark.\textsuperscript{20}

The effect on women can be assumed to be related to the performed intervention. In particular the fact that the effect on lower extremity fractures, including hip fractures, did not occur until the late phase of the intervention suggests an effect of the intervention. However, we cannot exclude the possibility that the differences found can be attributed to random variation in the two groups. Neither the registration before the intervention nor the intervention period was long enough to eliminate this possibility completely. Different seasonal variation between the intervention and control groups was, however, not likely, as the two areas involved were only separated by 30 km.

\textbf{NOTE}

1 For detailed information on the schedule of visits and follow-up activities, definition of inactivity, improper drug consumption etc. please contact the authors.
A special thanks to professor Michael Vaeth, Department of Biostatistics, Århus University for valuable advices and support in the statistical aspects of the study.

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