# The Harstad injury prevention study: community based prevention of fall-fractures in the elderly evaluated by means of a hospital based injury recording system in Norway

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**Abstract**

***Study objective* – To describe a community based programme to prevent fractures resulting from falls and evaluate the outcome in terms of changes in fracture rates and short term hospital care costs.**

***Design* – Prospective intervention study.**

***Setting* – The Norwegian municipalities of Harstad (intervention) and Trondheim (reference) from 1 July 1985 to 30 June 1993.**

***Participants* – The person-years of the study were estimated from yearly census data on people aged 65 years and over. There were 22 970 person years in Harstad and 158 911 in Trondheim.**

***Measurements and main results* – The variables were selected and coded according to the Nordic system and the data were collected as part of a national injury surveillance system. The first three years of the study provided baseline data, while the last five years involved community based interventions – eg, the removal of environmental hazards in homes and promotion of the use of safe footwear outdoors in winter. Rates of fracture from falls did not decline in nursing homes but decreased 26.3% in private homes ($p<0.01$). In 65–79 year olds, there was a 48.7% reduction in fall-fracture rates for men in traffic areas in winter ($p<0.05$). The data from the reference city, Trondheim, suggested a significant rise in fractures caused by falls. There was a 16.7% reduction in hospital admission rates of fall-fracture patients from private homes, indicating a substantial saving in short term hospital costs. The observed fall-fracture rate reductions in private homes and traffic areas suggest that major parts of the interventions were effective.**

***Conclusion* – Fall-fracture prophylaxis in the aged is possible in a community based setting that utilises high quality, local injury data.**

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Fractures in the aged are a major health problem in Norway[1-3] and other industrialised countries.[4-9] They are a challenge to orthopaedic surgeons, health administrators, and epidemiologists committed to injury prevention.

The study of fracture epidemiology in the aged has for many years focused on hip fractures.[1 6 7] The age specific incidence of hip fractures has been reported to have increased from 1970 in Europe[3 6 7 10] and in most of the world.[2 3 11] In addition to the human suffering they cause, hip fractures are costly for society. The average per capita cost of a hip fracture in the USA was estimated to be $41 500 in 1993 current dollars, for an annual expenditure of 10 billion dollars.[9] In Denmark hip fractures are now reported to be more expensive and to consume more hospital bed-days than any other diagnosis.[12] Hip fractures, however, represent only a part of the whole problem of fractures in the elderly. Fractures of the forearm and vertebrae also present major challenges.[13-15]

Epidemiological studies of fractures in the aged have revealed both *endogenous* and *environmental* factors that may be manipulated for preventive purposes. Very often a fracture is caused by a combination of factors. Many studies have reported the impact on bone density or fracture rates of *endogenous* factors – eg, hormones, dietary factors, physical activity, alcohol, cigarette smoking, and medication.[16] Improvements in *environmental* factors like walking surfaces, stairs, railings, lighting, and design of chairs and beds are also reported to have the potential for reducing the incidence and severity of falls,[17] particularly in "younger" and healthier elderly people.[18] Studies of elderly people seeking care after falls have attributed 28%–51% of the falls to environmental causes.[5 19 20 21]

Some intervention studies targeting falls in the elderly have not documented a significant reduction in injuries or fracture rates.[22 23] A community based intervention study in Sweden documented a significant reduction in accidental injuries (all ages) in homes, but the reduction of injuries in the elderly (65 years or more) was not significant.[24] A recent Danish study of a health services intervention, reported a reduction in fall-fractures in elderly people living in private homes.[25] External hip protectors can prevent hip fractures in nursing home residents.[26]

The aim of this study was to evaluate the outcome of a community based programme of prevention of falls in the elderly (65 years or

more) in terms of a) fall-fracture rate changes and b) changes in short term hospital care cost of fall-fracture treatment connected to the intervention.

## Methods

STUDY DESIGN

The present study consists of prospective, hospital based injury recording combined with a fall prevention programme and was conducted in the Norwegian city of Harstad (population 22 500), which is located 250 km north of the Arctic Circle. The intervention against falls was part of a larger injury prevention programme[27-29] and targeted members of the population aged 65 years or more. A quasi-experimental design[30] was used. Study end points were fracture rates. To get an indication of national historical trends, the fracture rates of Trondheim (population 135 000) were used. In addition, the fracture rates of six municipalities (population 15 000), referring patients only to Harstad Hospital, were used as an indication of local trend. The six municipalities are close to Harstad, making intervention diffusion probable. Trondheim is geographically far from Harstad (1000 km) and has the only other hospital in Norway which has recorded the same type of longitudinal injury data from 1985.

The Harstad study started 1 July 1985, lasted eight years, and was divided into two periods. Period 1 (baseline) lasted for three years, comprised 8120 person–years, and included hardly any local intervention. Period 2 lasted five years, comprised 14 850 person years, and included a community based fall-fracture prevention programme.

*Data recording and analysis*

All injured persons treated in the hospital emergency rooms were recorded in an injury data base (IDB). The variables for each injured person were selected in cooperation with The National Institute of Public Health[31] as part of a national injury surveillance system and followed the Nordic coding system.[32] Name, date of birth, sex, and place of residence were obtained. Activity type, type of product involved, and time and place of injury were also recorded. An open ended question (free text) described the event leading to the injury. Medical variables were injury type, injury mechanism, body part injured, and admission to the hospital. The recorded variables, data recording procedure, and measures taken to ensure data validity and reliability are described in more detail elsewhere.[28] For geographical reasons, treatment of patients at hospitals other than Harstad is virtually precluded.

*Changes in short term hospital costs*

To study some of the short term hospital costs of fall-fracture treatment connected to the intervention, eight years of hospital data (retrospectively, from 1 July 1985) were collected from the medical records of Harstad residents admitted after falls in private homes. Half of all fall-fractures in the study were in subjects living in private homes. The variables were as follows:

(1) Number of admissions,
(2) Consumption of hospital bed–days, and
(3) Number of operations related to the falls.

INTERVENTIONS

The present paper describes part of a more comprehensive, community based programme designed to prevent accidental injuries. The theoretical concepts and strategies used for the community based intervention included Haddon's matrix[33] and the distinction between "active" and "passive" interventions,[34] and are described in more detail elsewhere.[27-29] The community intervention was aimed at activating public and private resources in accordance with the Ottawa charter for health promotion[35] and the Manifesto for Safe Communities.[36] Agenda setting, population salience, diffusion of communication, long term maintenance of the programme and social legitimacy of educational forces, were other important concepts and strategies.[37]

*Injury prevention group*

An injury prevention group (IPG), established in 1985, comprised representatives from the hospital and several public and private organisations.[28] When promotion of safety for the elderly was on the IPG agenda, every possible relevant cooperation partner was invited to establish a network of communication. This strategy aimed at promoting community "ownership" of the problem and diffusion of information and programme messages. Based on analysis of local injury data, the IPG selected different target groups.

*Identification of targets for intervention*

Local data from period 1 showed that 9 out of 10 fractures in the elderly (defined as people aged 65 or more years) were caused by falls, and about 50% occurred in homes (including the immediate surroundings – garage, driveway, and garden). A further 25% occurred in public traffic areas (non-traffic accidents). These fractures were five times as frequent during the seven months in which there was snow compared with the snow-free months.

Residents of nursing homes in Harstad and the surrounding municipalities had very high accident injury rates compared with the elderly living in their own homes.[38]

The IPG decided to focus primarily on the problem of fall-fractures in the elderly with emphasis on detecting and preventing environmental hazards. It started the intervention by inviting public and private organisations concerned with promoting safety for senior citizens to a health fair in January 1989. This event was reported by the local media and the scene was set for the implementation of change.

THE ROLE OF DIFFERENT INDIVIDUALS, PROFESSIONAL SERVICES AND ORGANISATIONS

With regard to leadership of and responsibility for segments of the programme, the investigator and the injury secretary were responsible for hospital data recording and contributing information about local epidemiological characteristics to the IPG. A retired city veterinary surgeon, another member of the IPG, had the important role of planning and implementing education for relevant health personnel concerning the problem of fall-fractures in the elderly and environmental hazards in private homes and nursing homes. She also arranged meetings with pensioners to inform them about ways of avoiding falls by eliminating such things as loose cords and sliding mats on floors, installing grab bars and better lighting. General information was also given about risk factors like inebriation, medication, smoking, deficient diet and inactivity. The press was invited to meetings, generating a great deal of media coverage.

*Public health services*

Throughout the study a yearly mean of 759 dysfunctional, high risk elderly people living in their own homes was visited by the local public health service. Relative to the population at risk there was a negligible reduction in these services from period 1 to period 2. The frequency of visits ranged from several times a day to once a week and visits were made by nurses, nurses-aids, and other helpers. In 1989 these and other health personnel from Harstad attended a course about detecting and remedying home hazards. They learned about local epidemiological characteristics and national know how relevant to fall and fracture prevention in the elderly. Some professionals and health administrators from the six surrounding municipalities also attended. To promote the use of safety items and the perception of their usefulness, "victim stories" from the local IDB were used when educating both health workers and pensioners.

From 1991 all Harstad residents aged 75 or 79 years were offered a home visit by health personnel. Altogether 80% agreed to this and were visited. The aim of these visits was to promote environmental safety, a healthy diet and lifestyle, and the reduction of isolation and inactivity. From 1991 a special health station was established where Harstad's senior citizens could come for routine health consultations. Home safety education was carried out there by public health nurses. Physical exercise for elderly people was promoted by physiotherapists in weekly "work out" sessions in gymnasia.

*Pensioners' service*

To fix detected home hazards, the IPG established a service in 1989 whereby pensioners skilled in manual work could be summoned to improve the physical environment in a clients' home. The cost of this work was a third of market price and paid for by the client. A telephone answering service was organised by the local pensioners society for making appointments.

*Voluntary organisations*

To promote the spread of the programme's message and its longterm effect, attempts were made to activate as many voluntary organisations as possible in order to reach a high proportion of the elderly population. The Lions Club, church organisations, the pensioners society, and the Norwegian Women's Public Health Organisation were all involved.

SAFETY EQUIPMENT

Safety items like anti-slide material (under mats) and grab bars for stairs and bathrooms were made available at the city pensioners' centre, and the use of these items was promoted. The availability and use of "safety boots" was promoted through local media and the injury prevention network. These boots were extra sturdy and had spiked soles, well designed for walking on icy pavements and roads. The "spiking" of boots was done by a garage as a low cost service to senior citizens (done in the same way that automobile tyres are "spiked"). The pensioner's service arranged the delivery of sand to homes for gritting driveways, stairs, and yards.

STATISTICS

For database handling *Epi Info* version 5.01 was used.[39] The $\chi^2$ test was used as statistical approximation of the comparison of two incidence rates.[40] Mantel–Haenszel weighted relative risk and summary $\chi^2$ were utilised. p values below 0.05 were regarded as significant.

## Results

RATE CHANGES FOR FRACTURES (ALL INJURY MECHANISMS, ALL PLACES OF OCCURRENCE)

In Harstad a 9.7% reduction in overall fracture rates for all ages and both sexes was observed from period 1 to period 2 ($p=0.20$). In the 6 municipalities a corresponding 2.6% decrease was found ($p=0.58$) while the Trondheim rates increased 32.7% ($p<0.001$) (table 1).

RATE CHANGES FOR FALL-FRACTURES IN HARSTAD

*All fall-fractures ($n=671$)*

For overall fall-fracture rates, a 14.7% reduction was observed from period 1 to period 2 ($p=0.055$). A reduction was found for all age and sex groups, but only significant for males below 80 years ($p<0.02$) (table 2).

*Private homes ($n=357$)*

A 29.1% reduction in fracture rates between periods 1 and 2 was observed for females below 80 years ($p<0.03$). A reduction was also found in the other age and sex groups, but this was not significant. The overall rate for all ages and

*Table 1 Comparison of overall fracture rates (per 1000 person-years) for all injury mechanisms and all places of occurrence in residents 65+ years of Harstad, the six municipalities and Trondheim in relation to study period, sex and age group.* The study started 1 July 1985. Period 1 (3 years) was the "baseline". Period 2 (5 years) contained the community based intervention to prevent accidental fall-fractures in Harstad*

| | Age group | Period 1 | | | | Period 2 | | | | $\chi^2$ | p value |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | No | Person-years | Rate | Relative risk | No | Person-years | Rate | Relative risk | | |
| *Harstad* | | | | | | | | | | | |
| Females | 65–79 | 132 | 3750 | 35.20 | 1.0 | 227 | 6710 | 33.83 | 0.96 | 0.09 | 0.764 |
| | 80+ | 77 | 1071 | 71.90 | 1.0 | 137 | 1975 | 69.37 | 0.97 | 0.03 | 0.866 |
| Males | 65–79 | 57 | 2844 | 20.04 | 1.0 | 74 | 5281 | 14.01 | 0.70 | 3.73 | 0.053 |
| | 80+ | 18 | 455 | 39.56 | 1.0 | 31 | 884 | 30.07 | 0.89 | 0.06 | 0.806 |
| Total | 65+ | 284 | 8120 | 34.98 | 1.0 | 469 | 14850 | 31.58 | 0.91† | 1.66† | 0.197 |
| *Six municipalities* | | | | | | | | | | | |
| Famels | 65–79 | 78 | 3546 | 22.0 | 1.0 | 136 | 5925 | 23.35 | 1.06 | 0.12 | 0.731 |
| | 80+ | 78 | 1227 | 63.57 | 1.0 | 122 | 2257 | 54.05 | 0.86 | 1.02 | 0.312 |
| Males | 65–79 | 30 | 2927 | 10.25 | 1.0 | 54 | 4703 | 11.48 | 1.12 | 0.15 | 0.701 |
| | 80+ | 19 | 759 | 25.03 | 1.0 | 19 | 1244 | 15.27 | 0.62 | 1.83 | 0.176 |
| Total | 65+ | 205 | 8459 | 24.23 | 1.0 | 331 | 14029 | 23.59 | 0.95† | 0.30† | 0.582 |
| *Trondheim* | | | | | | | | | | | |
| Females | 65–79 | 811 | 26597 | 30.49 | 1.0 | 1835 | 45889 | 39.99 | 1.30 | 39.96 | 0.000 |
| | 80+ | 404 | 8642 | 46.75 | 1.0 | 945 | 15258 | 61.93 | 1.31 | 21.16 | 0.000 |
| Males | 65–79 | 289 | 19388 | 14.91 | 1.0 | 33 | 931 | 19.98 | 1.33 | 16.96 | 0.000 |
| | 80+ | 105 | 3187 | 32.95 | 1.0 | 275 | 6019 | 45.69 | 1.37 | 7.59 | 0.006 |
| Total | All | 1609 | 57814 | 27.83 | 1.0 | 3733 | 101097 | 36.92 | 1.31† | 86.31† | 0.000 |

* Comparisons were made for overall fracture rates because of missing values in the Trondheim data (period 2) for the variables injury mechanism (30%), and place of occurrence (33%). †Mantel–Haenszel weighted relative risk and summary $\chi^2$.

*Table 2 Fracture rates (per 1000 person-years) from falls for all Harstad residents aged 65+ years for all places of occurrence in relation to study period, sex, and age group. The study started 1 July 1985. Period 1 (3 years) was the "baseline". The intervention aimed at preventing accidental fall-fractures took place in period 2 (5 years).*

| | Age group | Period 1 | | | | Period 2 | | | | $\chi^2$ | p value |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | No | Person-years | Rate | Relative risk | No | Person-years | Rate | Relative risk | | |
| Female | 65–79 | 124 | 3750 | 33.07 | 1.00 | 205 | 6710 | 30.55 | 0.93 | 0.39 | 0.531 |
| | 80+ | 7 | 1071 | 65.36 | 1.00 | 122 | 1975 | 61.77 | 0.95 | 0.08 | 0.774 |
| Males | 65–79 | 50 | 2844 | 17.58 | 1.00 | 56 | 5281 | 10.60 | 0.61 | 6.27 | 0.012 |
| | 80+ | 18 | 455 | 39.56 | 1.00 | 26 | 884 | 29.41 | 0.75 | 0.63 | 4.428 |
| Both sexes | All ages | 262 | 8120 | 32.27 | 1.00 | 409 | 14850 | 27.54 | 0.86* | 3.69* | 0.055 |

* Mantel–Haenszel weighed risk and summary $\chi^2$.

*Table 3 Fracture rates from falls in private homes* (per 1000 person-years) in Harstad residents aged 65+ years in relation to study period, sex, and age group. The study started 1 July 1985. Period 1 (3 years) was the "baseline". Period 2 (5 years) contained the community based intervention to prevent accidental fall-fractures.*

| | Age group | Period 1 | | | Period 2 | | | $\chi^2$ | p value |
|---|---|---|---|---|---|---|---|---|---|
| | | No | Rate | Relative risk | No | Rate | Relative risk | | |
| Female | 65–79 | 78 | 20.8 | 1.00 | 99 | 14.75 | 0.71 | 4.75 | 0.029 |
| | 80+ | 48 | 44.82 | 1.00 | 68 | 34.43 | 0.78 | 1.63 | 0.202 |
| Males | 65–79 | 18 | 6.33 | 1.00 | 27 | 5.11 | 0.81 | 0.30 | 0.586 |
| | 80+ | 8 | 17.58 | 1.00 | 11 | 12.44 | 0.71 | 0.25 | 0.618 |
| Total | 65+ | 152 | 18.72 | 1.00 | 205 | 13.80 | 0.74† | 7.50† | 0.006 |

* Includes immediate surroundings, eg garage and yard. † Mantel–Haenszel weighted relative risk and summary $\chi^2$.

both sexes was reduced by 26.3% ($p<0.01$) (table 3). The home accidents included 32 fractures (n=12 in period 1 and n=20 in period 2) which resulted from falls on an icy surface in the driveway, yard, or on outdoor stairs. A 9.5% reduction of rates was found for this subgroup of fractures (p=0.94).

*Traffic areas in winter (n=155)*

For men aged less than 80 years, there was a 51.3% reduction in the fracture rate ($p<0.04$). In women, however, there was a 23.4% increase (p=0.41). The overall rate for all ages and both sexes was reduced by 13.4% (p=0.45) (table 4).

*Nursing homes (n=87)*

The overall fracture rate for all ages and both sexes increased 15.1% between periods 1 and 2 (p=0.72). A 58.2% increase was observed for women aged 80 and more (n=47, p=0.22), but a reduction was found in the other age and sex groups. In no age or sex group was the rate change significant (data not shown).

*Other places (n=50)*

In other areas, eg production, commerce, public entertainment and outdoor recreation, rates increased 40.7% (p=0.34). In no age or sex group was the rate change significant (data not shown).

*Table 4 Fracture rates* (per 1000 person years) in Harstad residents aged 65+ years from falls in traffic areas on snow or ice.† Data are shown for the seven months of snow in relation to study period, sex, and age group. The study started 1 July 1985. Period 1 (3 years) was the "baseline". Period 2 (5 years) contained the community based intervention to prevent accidental fall-fractures.*

| | Age group | Period 1 | | | Period 2 | | | $\chi^2$ | p value |
|---|---|---|---|---|---|---|---|---|---|
| | | No | Rate | Relative risk | No | Rate | Relative risk | | |
| Females | 65–79 | 29 | 13.25 | 1.0 | 64 | 16.35 | 1.23 | 0.68 | 0.409 |
| | 80+ | 7 | 11.20 | 1.0 | 9 | 7.81 | 0.70 | 0.20 | 0.651 |
| Males | 65–79 | 21 | 12.66 | 1.0 | 19 | 6.17 | 0.49 | 4.59 | 0.032 |
| | 80+ | 3 | 11.32 | 1.0 | 3 | 5.81 | 0.52 | — | 0.41‡ |
| Total | 65+ | 60 | 12.67 | 1.0 | 95 | 10.97 | 0.87§ | 0.57§ | 0.450 |

* The denominator is calculated for the seven months with snow and ice. † Fractures from road traffic accidents and 22 fractures occurring in the five snow-free months are excluded. ‡Fisher exact two-tailed test. § Mantel–Haenszel weighted relative risk and summary $\chi^2$.

CHANGES IN SHORT TERM HOSPITAL COSTS FOR HARSTAD RESIDENTS RELATED TO THE INTERVENTION AGAINST FALL-FRACTURES IN PRIVATE HOMES

A rate reduction was observed from baseline to the intervention period for admissions (16.1%), hospital bed–day consumption (16.7%), and operations (35.1%) (table 5).

## Discussion

RATE CHANGES FOR FRACTURES (ALL INJURY MECHANISMS, ALL PLACES OF OCCURRENCE)

When using overall fracture rates for showing trends, road traffic injuries could be a confounder in the context of the present study. Excluding road traffic injuries, there was an overall fracture rate reduction of 11.0% from period 1 to period 2 in Harstad and an increase of 0.1% in the six municipalities (data not shown). Traffic injury rates in elderly Harstad residents were higher in period 2 than in period 1. This was reported in an earlier paper from the Harstad injury prevention study.[27]

*Private homes*

The observed significant reduction of fall-fractures was consistent with an intervention that particularly focussed on the physical environment, education and information about fall accidents, and fracture risk reduction in private homes. The appreciable reduction in fracture rates in women 65–79 years old living in their own homes was also consistent with recent findings from a similar Danish intervention study.[25] An alternative, possible explanation for this reduction could be that high risk residents were more likely to move from their own homes to nursing homes during period 2 compared with period 1. This would leave a younger and healthier elderly population at home in period 2. However, this explanation is an unlikely one for two reasons. Firstly, the mean yearly numbers of publicly financed nursing home beds were 178 in period 1 and 179 in period 2. There are no private nursing homes in Harstad. Secondly, the mean age for three out of the four sex and age groups increased between periods 1 and 2. The mean age for the group of men aged 80 years or more decreased from 84.4 to 84.0 years, but these elderly men contributed least to the overall person–years participating in the study (table 1).

*Traffic areas in winter*

The significant reduction in the rate of fall-fractures in traffic areas among men aged 65–79 years contrasted with the non-significant increase seen in women. One explanation could be that men comply more readily than women with the recommendations about safe footwear. A recent study assessed the attitudes toward the use of fall-safe sturdy shoes. It was found that foot problems, expense, style ,and lack of knowledge about their importance were barriers to their use.[41] Shoe style may be less important to men than women. Another possibility could be changes in exposure – eg if men went shopping more often by car and less frequently on foot in period 2. Unfortunately, we have no data that enable us to assess compliance with different safety recommendations or gender differences in exposure. Municipal spending (adjusted for inflation) for removal of ice and snow, sanding and salting did not increase between periods 1 and 2 in spite of the recommendations from the injury prevention group.

*Nursing homes*

Fracture rates increased in nursing homes, but not significantly. This may reflect the difficulties inherent in a nursing home population of ageing elderly people, particularly women 80+ years old. It is possible that the fracture rates could have increased more *without* the interventions. The problem of frequent accidental injury in the Harstad nursing homes

*Table 5 Short term hospital costs of treatment of accidental fall-fractures sustained at home for people aged 65+ years. Rates for Harstad residents are given for period 1, "baseline" (3 years from 1 July 1985) and period 2, intervention period (5 years from 1 July 1988) (per 1000 person-years) for admission to hospital, hospitalisation bed–day consumption, and operations related to the falls.*

| | Admissions | | Hospitalisation bed–days | | Operations* | |
|---|---|---|---|---|---|---|
| | No | Rate | No | Rate | No | Rate |
| All fractures | | | | | | |
| Period 1 | 73 | 8.99 | 2531 | 312 | 79 | 9.7 |
| Period 2 | 112 | 7.54 | 3588 | 260 | 94 | 6.3 |
| Hip fractures | | | | | | |
| Period 1 | 44 | 5.42 | 1836 | 226 | 59 | 7.3 |
| Period 2 | 56 | 3.77 | 2470 | 166 | 71 | 4.8 |

* Primary internal fixation, reoperations, hemi or total hip prosthesis.

has been described earlier[38] and was recently addressed in the IPG. From published reports we know that the greatest number of falls in nursing homes and rehabilitation hospitals occur on the day shift when activity is at its peak.[42] A policy of reducing falls through inactivity seems unacceptable. A promising intervention for nursing-home residents is the use of external hip protectors.[26]

## HAS THE INTERVENTION BEEN EFFECTIVE?

Effective "passive interventions"[34] have been difficult to implement in the heterogenous environments found in areas of production, commerce, public entertainment, and outdoor recreation. This may partly explain the rising fall-fracture rates in these areas. Significant decreases in fall-fracture rates were observed in homes and among men aged 65–79 years old in traffic areas in winter. These reductions in fall-fractures occurred in a population of ageing elderly people, suggesting that major parts of the interventions were effective. The principal threats to the validity of this statement are registration effect, regression to the mean effect, and national and local historic trends.[30]

### *Registration effect*

If registration loss at emergency visits increased during the study, this could account for the fracture rate decrease. To counteract registration loss, we established emergency room routines to ensure that the injury form was filled in for every patient treated. Random checks by the author or other surgeons in the staff showed good compliance with the registration instructions. Motivation strategies for emergency-room personnel and physicians were implemented. The injury data base (IDB) and the hospital data (medical records) were compared to ensure that the admitted cases were not omitted from the IDB.

If there had been a trend during the second period of more minor fractures among Harstad residents being treated in general practitioner's surgeries, there would have been lower rates in the second period. Two counteractive arguments seem to be relevant. Increasing demands for health service cost effectiveness could contribute to fracture treatment at lower levels in the health services. On the other hand, medicolegal problems and physician liability have increasingly been focused on by authorities and the press. This could be considered to produce the opposite effect – an increase of minor injuries referred to the hospital for assessment and treatment. The relative weight of these two arguments is difficult to assess.

From 1991 we included injury data from primary health care centres in the Harstad Hospital database. Three years of recording showed that 2.5% (n = 8) of fractures in elderly Harstad people were treated in primary health care. The recording routines for primary health care are not as well established as those in place in the hospital. Nevertheless, these figures seem to support the argument that registration effect does not explain the recorded reduction of fall-fracture rates.

### *Regression to the mean effect*

The phenomenon of regression to the mean could operate if Harstad had a particularly high fracture rate during period 1. A reduction would then occur even if there had not been an intervention. The difference in period 1 fracture rates between the three study populations could indicate this. However, there are some geographical differences in fracture rates in Norway.[2] This could explain some of the difference in overall fracture rates between Harstad and Trondheim in period 1. For reasons pertaining to both geography and transportation problems, many smaller or undislocated fractures are likely to be treated in primary health care in the six municipalities. This accounts for their low overall fracture rates in both periods (table 1). The baseline (period 1) is quite long (three years) and should contain periods of both particularly high and particularly low fracture rates. Regression to the mean can not be entirely ruled out, but is not considered to be a very likely explanation for the observed reduction in fall-fracture rates in Harstad from period 1 to period 2.

### *National historical trend*

Epidemiological studies in Norway have shown an increasing age-specific incidence of hip fractures in some regions.[1–3] However, the national historical trend for overall fracture rates in the elderly is unknown as complete national fracture data are not available. The Trondheim data are therefore used as an indication of this trend. The choice of Trondheim was not ideal, this city being more than six times larger than Harstad. Variations in fracture rates might occur in a city for reasons that the investigator can not control for. The significant overall fracture rate increase in Trondheim between periods 1 and 2 contrasts with the decrease in Harstad and stability in the six municipalities (table 1). This suggests that the national historical trend does not explain the fall-fracture rate reductions observed in Harstad.

### *Local trend*

The stable fracture rates in the six rural municipalities close to Harstad can be explained by geography and/or diffusion of the intervention. Finsen and Benum showed that secular increases in hip fracture rates were smaller in rural than in urban areas of central Norway.[2] Falch *et al* reported that the hip fracture rate in rural Sogn og Fjordane was only 65% of the rate in urban Oslo in 1988–89.[3]

Intervention diffusion might have occurred as a result of: (i) intervention items occurring in media (local newspaper and radio); (ii) the communication between health service professionals, organisations, and individuals in Harstad and in the six municipalities; and (iii) the increased availability of safety equipment

for elderly people shopping out of town in Harstad. Intervention diffusion may have biased the trend in the six municipalities downwards. This suggests that local trend is not a threat to validity.

*Confounders*

Generally speaking, the age distributions in most industrialised countries show that there are more elderly people. If this development differed markedly in the three populations described in this study, a confounding effect could occur. The mean age variations through the periods were, however, practically identical (data not shown) in these populations. Weather observations[27] showed similar data for Harstad and Trondheim and suggested that icy and slippery roads in winter were more likely to occur in period 2 than in period 1.

Other confounders could be differences between Harstad and Trondheim regarding changes in drug prescription patterns, general health condition, or the proportion of the population living alone. No data were available for investigating these confounders. However, the likelihood of appreciable differences between the two cities is regarded as very low.

## Conclusion

Registration effect and historic trend are not considered to be probable explanations for the fall in fracture rates observed in the Harstad population. Although regression to the mean effect can not be entirely ruled out, the present study suggests that the community based intervention has been instrumental in the significant reduction of fall-fractures among elderly people living in private homes. The reduction in fracture rates from falls on snow and ice among men may suggest a preventive effect of promoting the outdoor use of safe footwear.

Even if fracture rate reductions were not observed in some areas ("other places" nursing homes, women in traffic areas), the present study indicates that substantial parts of a prevention programme targeting fall-fractures in the elderly can be effective when based upon sound local epidemiological studies and community based intervention.

Fractures in the elderly are very costly to society. The observed 16.1% reduction in hospital admission rates for fall-fractures in private homes indicates that there is considerable potential for hospital care savings. These results reinforce the need for the investment of resources in hospital based injury registration programmes as well as investment in local community based fracture prevention programmes for the elderly.

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