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ORIGINAL ARTICLE

Impact of a community-based osteoporosis and fall prevention program on fracture incidence

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Abstract Associations between a 10-year community-based osteoporosis and fall prevention program and fracture incidence amongst middle-aged and elderly residents in an intervention community are studied, and comparisons are made with a control community. A health-education program was provided to all residents in the intervention community, which addressed dietary intake, physical activity, smoking habits and environmental risk factors for osteoporosis and falls. Both communities are small, semi-rural and situated in Östergötland County in southern Sweden. The analysis is based on incidences of forearm fractures in the population 40 years of age or older, and hip fractures in the population 50 years of age or older. Data for three 5-year periods (pre-, early and late intervention) are accumulated and compared. In the intervention community, forearm fracture incidence decreased in women. There are also tendencies towards decreasing forearm fracture incidence in men, and towards decreasing trochanteric hip fracture incidences in women and in men in the late intervention period. No such changes in fracture incidences are found in the control community. Cervical hip fracture incidence did not change in the intervention and the control communities. Although the reported numbers of fractures are small (a total of 451 forearm and 357 hip fractures), the numbers are based on total community populations and thus represent a true difference. The decrease in forearm fracture incidence among women, and the tendency towards decreasing trochanteric hip fractures, in contrast to the absence of change in cervical hip fractures, might be mainly due to a more rapid effect of fall preventive measures than an increase in bone strength in the population. For the younger age groups an expected time lag between intervention and effect might invalidate the short follow-up period for outcome measurements. Thus, the effect of the 10-year intervention program on fracture incidence should be followed during an extended post-intervention period.

Keywords Fracture outcome · Fragility fractures · Prevention · Quasi-experimental

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Introduction

Osteoporosis and fractures are increasing problems throughout the industrialized world. It has been estimated that the annual number of hip fractures worldwide will increase from 1.7 million in 1990 to 6.3 million in 2050 due to the growing population and increased life expectancy [1]. In another study it was assumed that the number of hip fractures could range between 7.3 million and 21.3 million by the year 2050, based on secular trends [2]. In Sweden, approximately 17,000–18,000 hip fractures occur each year. It has been estimated that about 50% of all Swedish women and 25% of all Swedish men over 50 years of age will sustain a fragility fracture [3]. The average age at hip fracture has increased significantly over the past decade and is now around 80 years in women and several years younger in men [4]. As early as the beginning of the 1990s there was a call for a scientific approach to the problem of the high and rising incidence of fall injuries [5]. The first community-based program that was specifically aimed at preventing unintentional injuries was initiated in a Swedish community in 1978. Since then, several community development programs in Scandinavia have focused on the prevention of falls and injuries [6, 7].

In Östergötland County (population 420,000 and area 10,000 km^2), Sweden, the number of hip fractures among people over 50 years of age increased almost fivefold during the period 1940–1986, from 120 in 1940 to 680 in 1986. It was forecast that there would be 70% more hip fractures in Östergötland County in 2000 than in 1985, if the age-specific incidence rates remained similar to those of previous years [8]. The magnitude of the problem of osteoporosis and fractures was presented to the County Council in the mid 1980s. This paved the way for decisions on activities in the county to prevent osteoporosis. As a consequence, an Osteoporosis Unit was established at the University Hospital in Linköping, and preventive programs were initiated.

Vadstena community was chosen for a local community-based osteoporosis prevention program. The intervention program was called the Vadstena Osteoporosis and fall Prevention Project (VOPP). It was initiated in 1989 and managed by the local primary healthcare center (PHCC). The Vadstena municipality politicians were informed and approved the project and the program was delivered to community residents. In the population-based part of the program, the public was informed about the importance of lifestyle behavior to prevent osteoporosis and falls. The consequences of osteoporosis were discussed repeatedly at public seminars, in the local press and on cable television. Posters were displayed in the community and checklists of environmental hazards for osteoporosis and falls were distributed via the pharmacy and the PHCC.

A health-education program was developed that addressed personnel working at schools, kindergartens, social welfare offices, nursing homes and municipal home-help service units, retired people's associations, study circles, sports clubs, grocery stores, larger companies and catering services. Direct collaboration was established with the electrical appliance shop, the sports shop and shoe shops to encourage the use of good lighting, sturdy shoes, and spikes [9]. Walking and weight-bearing training groups were introduced, and a gymnasium with sequence training equipment was expanded at the Vadstena PHCC [10]. Moreover, random samples of 15% of the women and men in each age decade between 20 years and 69 years were invited to participate in baseline measurements in 1989, which included bone mass measurements and a questionnaire with questions about hereditary factors, previous diseases, ages of menarche and menopause, and lifestyle factors such as physical activity level, calcium intake and smoking habits.

Participants aged ≥70 years responded to the questionnaire only. Questions dealing with safety behavior at home and outdoors were addressed among the elderly, ≥65 years old. The participants received a personal letter after each registration, with individual feedback

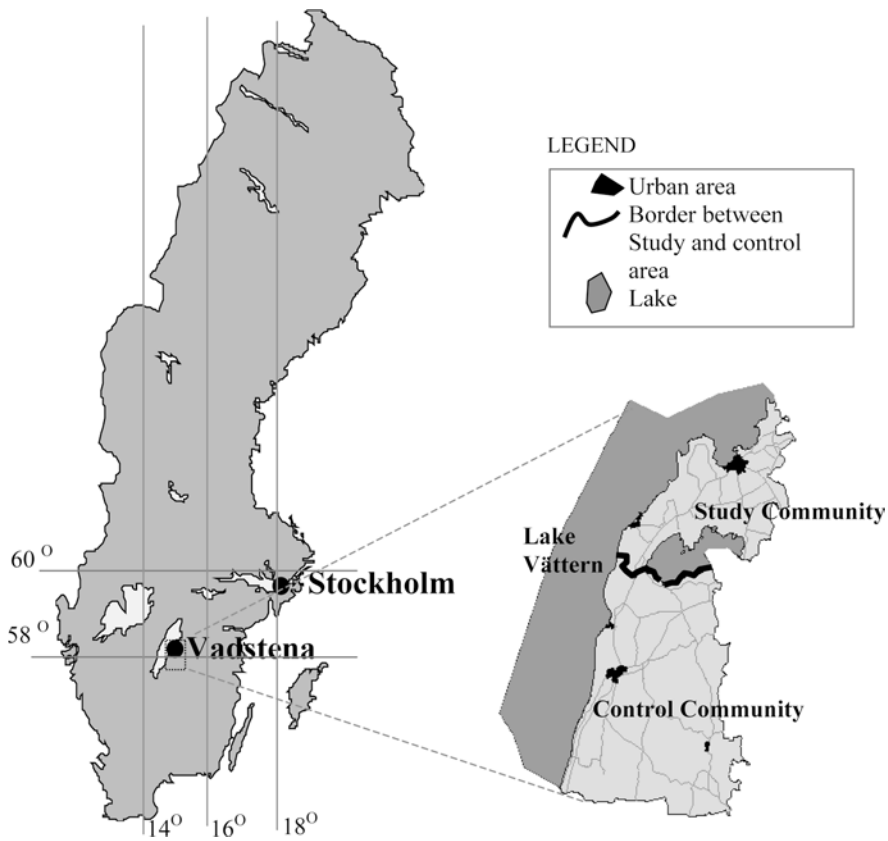

Fig. 1 Location, with close-up, of study and control areas

concerning bone densitometry results and possible risk-behavior for osteoporosis. Approximately 13% of the randomly selected participants aged 20–69 years in the intervention community (i.e., 2% of the community members in the age group) were identified as being osteopenic (z-score) and were consequently contacted by their family doctor. In 1992, 1994 and 1999, follow-up measurements were conducted and new invitations were sent out. Random samples in a neighboring control community were also invited to respond to the questionnaire. Those individuals were not offered bone densitometry and received no feedback [9].

The aim of the present study is to explore whether or not a community-based intervention program for osteoporosis and fall prevention after 10 years is associated with a reduction in the incidence of forearm and hip fractures amongst middle-aged and elderly community residents.

Materials and methods

A quasi-experimental design based on pre- and post-implementation measurements in the intervention community and in the control community (situated 30 km from the intervention area) was used for the evaluation of the VOPP [9]. The same county council board supervised the PHCCs in both communities, which meant that the control community could be advised not to start an intervention aimed at preventing osteoporosis. To compensate for the non-randomized study design, environmental and sociodemographic indicators were followed in both communities during the study period. The intervention and control areas are small semi-rural communities situated on Lake Vättern in the western part of Östergötland County in southern Sweden (Fig. 1). The communities were selected for the study because of their similarity as regards population structure and health care.

Outdoor life is rather similar in the two communities, and there is, for example, a common adjacent national park. Both communities have ancient histories, (the first settlement in the control community dates from about 3000 B.C.). However, the city centers in the intervention and the control communities differ in terms of architectural standards, for example, with regard to walkways and residence designs. There is a mediaeval city center in the intervention community, while the city center in the control community dates from the 19th century. Vadstena's cultural heritage attracts many visitors, especially during the summer, and the town has also become increasingly attractive for permanent residence [11]. Another characteristic of Vadstena is that nursing care has been provided in the town since the 15th century. No such nursing tradition has been rooted in the control community.

The incidences of forearm and hip fractures were followed in the intervention community (population of approximately 7,500 in 1989) and in the control community (population of approximately 5,900 in 1989) from 1987 to 2001. The follow-up study period was separated into three phases, based on the fact that the activities of the intervention program differed in nature during the VOPP period and also that today it is well established that while "passive" intervention for health promotion (changes in the physical environment, new legislation, etc.) leads to an immediate effect, "active" intervention (health education, etc.) is connected with a time-lag before the effect is achieved. Consequently, to be able to evaluate the effect of educational interventions with regard to fracture incidences, the follow-up study period was extended and separated into the following phases: the 1987–1991 interval was called the pre-intervention period, the 1992–1996 and the 1997–2001 intervals were called the early and the late intervention periods, respectively.

Individuals that were aged ≥40 years were included in the study of forearm fractures and those that were aged ≥50 years were included in the study of hip (cervical and trochanteric) fractures. In 2001 the total population ≥40 years was 4,240 in the intervention community and 3,045 in the control community. Cervical and trochanteric hip fractures were analyzed separately because of the epidemiological and proposed etiological differences between the two fracture types [12].

Individuals with fractures were identified from files in the Department of Radiology at the local county hospital. There was no routine at the Department for registering persons who died before 1991. Although there was no validation of the radiological diagnoses made from the X-rays, two nurses and an assistant nurse cross-validated the recorded radiological fracture codes against clinical records. All patients were allocated to either the intervention or the control community based on their registered residence for the year of fracture. This was done by an overlay technique in a geographic information system that used the X- and Y-coordinates of the centroid of the residences. The software used was MapInfo version 7.0 [13]. The coordinates were retrieved by the matching of a 12-digit personal identification number, unique for all Swedish residents, from the population register with the property register from the Swedish Land Survey Authorities. The residencies were then geocoded in a digital map using the national grid (RT 90). Demographic data used for the calculation of gender specific and age-standardized rates were derived from the continuously updated official population register.

The VOPP was approved by the Regional Ethics Research Committee for Human Research, Faculty of Health Sciences, Linköping University.

Statistical analysis

Cumulative incidences (expressed as per 1,000 population) of forearm and hip fractures were calculated by community (Vadstena and control community) for each study period of 5 years between 1987 and 2001 (1987–1991, 1992–1997, 1998–2001) and by gender. Data were standardized for age by a direct standardization method with the mean Östergötland population between 1987 and 2001 as the standard population. The 95% confidence intervals (CIs) were calculated for the cumulative incidences. Repeated registrations of the same fracture type were excluded from the calculations.

A two-way analysis of variance (ANOVA) was performed that compared mean ages of the individuals with fractures between communities and genders. A P value <0.05 was considered as statistically significant. All statistical computations were performed with the SPSS statistical software (release 11.0).

Results

Environmental and sociodemographic indicators

There was a greater increase in the number of persons aged ≥40 years in Vadstena than in the control community, where the increment was modest for the study period (Table 1). The proportion of persons aged ≥65 years was slightly higher, both in the Vadstena community and in the control community (21%–22%), than the average for Sweden as a whole (18%) [14]. The proportion of community residents ≥80 years was 7% in both communities in 2001. Migration to and from Vadstena community was almost evenly balanced, while a greater number moved away from the control community than moved into it (the net migration was −50 persons) at the turn of the century. Nevertheless, some people in Vadstena that had recently moved there and that had sustained a fracture during the study period might not have received any intervention at all. For instance, 414 persons aged ≥65 years moved into the Vadstena community between 1989 and 2001. The proportion of young people aged 18–24 years that had moved away was 27% in Vadstena and 24% in the control community. The university education level amongst persons aged 25–74 years in Vadstena community almost agreed with the average level in Östergötland County, while the educational level in the control community was slightly lower.

Table 2 Crude numbers of forearm fractures (in persons aged ≥40 years) and trochanteric and cervical hip fractures (persons aged ≥50 years) in women and men for the 5-year intervals of the study period

Period	Women		Men	
	Intervention community	Control community	Intervention community	Control community
Forearm fractures				
1987–1991	89	43	15	12
1992–1996	90	47	17	11
1997–2001	55	54	7	11
Trochanteric hip fractures				
1987–1991	35	10	10	7
1992–1996	24	18	12	7
1997–2001	22	10	6	8
Cervical hip fractures				
1987–1991	21	18	7	5
1992–1996	31	16	13	10
1997–2001	33	17	12	5

Forearm and hip (cervical and trochanteric) fracture incidences

In the intervention community 234 forearm fractures were observed in women and 39 in men. The numbers of hip fractures were 85 cervical and 81 trochanteric in women and 32 cervical and 28 trochanteric in men. In the control community 144 forearm fractures were observed in women and 34 in men, while there were 51 cervical and 38 trochanteric hip fractures in women and 20 cervical and 22 trochanteric in men (Table 2).

The mean age at forearm fracture was 68 years (95%CI 67–69), while mean ages at cervical and trochanteric hip fracture were 80 years (95%CI 79–82) and 82 years (95%CI 81–83), respectively. There was no significant difference between the communities regarding mean ages at any fracture type. However, a significant difference was found between the genders in the mean age at forearm fracture, which was 69 years in women and 61 years in men ($P < 0.001$). The median and the mean ages were the same for each respective gender.

There was no change regarding general fracture incidence between the communities during the study periods. However, in the intervention community the

Table 1 The mean number of persons aged ≥40 years and ≥50 years in the intervention community and in the control community for the various study periods

Period	Gender	Persons aged ≥40 years		Persons aged ≥50 years	
		Intervention community	Control community	Intervention community	Control community
1987–1991	Women	2,084	1,535	1,536	1,148
	Men	1,799	1,492	1,260	1,059
1992–1996	Women	2,190	1,578	1,647	1,173
	Men	1,873	1,499	1,316	1,063
1997–2001	Women	2,264	1,565	1,772	1,203
	Men	1,934	1,490	1,433	1,120

forearm fracture incidence decreased from 8.32 per 1,000 population (pre-intervention) to 4.62 per 1,000 population (late intervention) in women, and there was also a tendency toward a decreasing forearm fracture incidence in men, from 1.70 per 1,000 population (pre-intervention) to 0.68 per 1,000 population (late intervention). This decrease was not found in the control community. In the intervention community there was a tendency toward a decreasing trochanteric hip fracture incidence in women, from 3.02 per 1,000 population (pre-intervention) to 1.50 per 1,000 population (late intervention), and in men, from 1.04 per 1,000 population (pre-intervention) to 0.54 per 1,000 population (late intervention). This was not found in the control community. No similar decrease was found for the incidence of cervical hip fracture in either the intervention or the control community, or in the respective genders (Table 3).

Discussion

The present study is an explorative 10-year evaluation of the effects of a community-based osteoporosis and fall prevention program with regard to the development of fracture incidence before intervention, early in the intervention period, and late in the intervention period. Other evaluations concerning the VOPP have previously been reported [9, 10, 15]. The VOPP integrates a population-wide strategy with a high-risk strategy in the prevention of disease and injury [16]. The core of the VOPP was health education delivered in a combination of these intervention strategies [9, 10, 15]. A particular characteristic of the VOPP intervention program was that it was aimed at residents of all ages throughout the entire community [9]. Experiences from the injury prevention project in the nearby Motala community indicated that the effect of community-based prevention programs must be considered from a long-term perspective, preferably after more than 10 years [6]. From this perspective, the moderate effect of the VOPP interventions on fracture incidence in the present study is in agreement with other community-based health promotion programs that have relied mainly on interventions based on health education [17, 18].

The gender and age-specific patterns in the studied populations were in striking accordance with other studies, which have found that there is a large predominance of women with forearm fractures, with a linear increase in fracture incidence up to 60 years of age [19]. The decreasing incidence rate of forearm fracture, observed in women in the intervention but not in the control community, for the late intervention period might indicate an effect of the intervention program. However, it is possible that the tendency towards a decreasing incidence rate of forearm fracture in men in the intervention community is not due to the intervention program, as forearm fractures in men often are caused by high-energy trauma such as falls from ladders or buildings. The crude forearm fracture numbers in women were higher in the intervention than in the control community in the pre- and early intervention periods. The medieval architecture in Vadstena city center with lanes of cobblestones may play a role in increased risk of slipping and sustaining a forearm fracture.

Fractures in the elderly are usually the result of both a fall and concurrent fragile bones. Successful intervention against the risk of falling may be expected to yield a more prompt (direct) effect than against the prevention of osteoporosis itself, where the effect may be delayed by a certain time lag. Thus, according to the decreasing forearm fracture incidence in women and the tendency toward a decreasing incidence of trochanteric hip fracture in both genders in the intervention population, the part of the VOPP program that focuses on the prevention of falls seems to have had the most obvious effect. In contrast to the decreasing incidence of trochanteric hip fractures in the intervention community

Table 3 Cumulative incidence (*Cum inc.*) per 1,000 population of forearm, trochanteric and cervical hip fractures in women and men for the 5-year intervals of the study period. CIs with a 95% confidence level

Type of fracture	Women				Men			
	Intervention community		Control community		Intervention community		Control community	
	Cum inc.	CI	Cum inc.	CI	Cum inc.	CI	Cum inc.	CI
Forearm								
1987–1991	8.32	(6.59–10.04)	5.54	(3.87–7.21)	1.70	(0.84–2.57)	1.75	(0.74–2.77)
1992–1996	7.88	(6.25–9.51)	5.85	(4.18–7.52)	1.95	(1.02–2.88)	1.35	(0.54–2.16)
1997–2001	4.62	(3.38–5.86)	6.56	(4.81–8.31)	0.68	(0.17–1.18)	1.49	(0.60–2.38)
Trochanteric hip								
1987–1991	3.02	(2.02–4.01)	1.37	(0.51–2.22)	1.04	(0.39–1.69)	0.85	(0.22–1.48)
1992–1996	1.82	(1.09–2.54)	2.11	(1.14–3.07)	1.14	(0.50–1.79)	0.80	(0.20–1.41)
1997–2001	1.50	(0.87–2.13)	1.18	(0.45–1.92)	0.54	(0.10–0.97)	0.79	(0.24–1.34)
Cervical hip								
1987–1991	1.92	(1.10–2.75)	2.32	(1.23–3.41)	0.69	(0.18–1.20)	0.59	(0.08–1.10)
1992–1996	2.46	(1.59–3.33)	1.93	(0.99–2.87)	1.22	(0.56–1.88)	1.05	(0.40–1.71)
1997–2001	2.36	(1.54–3.18)	1.99	(1.05–2.93)	1.02	(0.44–1.59)	0.51	(0.07–0.96)

during the late intervention period, the incidence of cervical hip fractures showed no similar change. The observation of more rapid changes in incidence of trochanteric hip fracture than that of cervical hip fracture, regardless of direction, is in accordance with the results from several epidemiological studies [4]. Trochanteric hip fractures occur in a predominantly more trabecular region than the cervical site, which in turn comprises a higher proportion of compact (cortical) bone. Trabecular (or cancellous) bone is reported to respond more rapidly to metabolic changes than does compact bone. Since trabecular bone is characterized by a higher surface-to-volume ratio it may represent a tissue compartment of relatively higher bone turnover [20]. It is, therefore, reasonable for it to be assumed that trabecular bone also possesses a higher potential to respond more rapidly to the impact of preventive measures following the intervention.

It might be particularly difficult to influence nursing home residents by means of community-based intervention. This population also represents a less healthy group of general citizens. One way of preventing falls in these persons is to educate the staff and to choose a "fall prevention representative" at each ward who would survey the circumstances surrounding each fall and document the history of the fall. Furthermore, according to several papers, the use of hip protectors is a promising intervention that mitigates falls and reduces hip fractures in nursing home residents [21]. Such external hip protectors became available and were marketed at the turn of the early and late intervention periods.

The study involves rather small populations, which decreases the possibility for changes to be detected in the studied phenomena, especially over the rather short follow-up period. Nevertheless, bias due to random sample variation does not have to be considered when one is interpreting the study results, because the total population of each respective area is included. Therefore, the observed differences can be regarded as real differences. Furthermore, the fracture outcome following preventive measures directed at younger age groups could not be recorded, as this will not be possible until those groups have reached typical fracture ages.

Since the start of the VOPP, general awareness concerning osteoporosis as a major public health problem, as well as concerning its consequences in terms of fragility fractures, has increased substantially. The mass media directed much attention to medical progress in the area in the 1990s. A general background "noise" of information that describes risk factors for osteoporosis and falls might have influenced both the intervention and the control populations and decreased the difference in risk potential for the studied health outcome. The present study indicates that a community-based intervention program may reduce the number of forearm and trochanteric hip fractures in the population. The effect on fracture incidence could, however, become more apparent in a longer perspective, and thus an extended post-intervention follow-up period may be needed.

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