Osteoporos Int (1999) 10:66–72

Osteoporosis International

Original Article

Incremental Cost of Medical Care after Hip Fracture and First Vertebral Fracture: The Rotterdam Study

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Abstract. The aim of this study was to estimate the additional cost of medical care (the incremental cost) caused by incident hip and vertebral fractures, using a matched case cohort design within a longitudinal follow-up study. Incident hip fractures were recorded using the regular follow-up system of the Rotterdam Study. Incident vertebral fractures were recorded by morphometric comparison of spinal radiographs taken at intervals of 2.2 years on average. The matched control group was randomly selected from other participants of the Rotterdam Study in whom no fracture occurred during follow-up, but who were otherwise comparable at baseline. Cases were matched for age, gender, self-perceived health, ability to perform activities of daily life, living situation and general practitioner. Medical expenditure was assessed by retrieval of the general practice medical records and by recording all hospital and nursing home admissions, and all general practice and outpatient visits. Pharmaceutical consumption was recorded through the computerized records of the central pharmacy. Valid results were obtained for 44 pairs (91%) in the hip fracture and for 42 pairs (93%) in the vertebral fracture group. Cost of medical consumption in the year before the hip fracture was similar in patients and control subjects, but the incremental cost in the first year after the hip fracture was almost US$10 000. In the second year after hip fracture the incremental cost was still about $1000. Accounting for the excess mortality in hip fracture patients had little effect on cost in the first year, but cost in the second year was doubled to almost $2000. For vertebral fractures, we did not detect important acute care costs, but these fractures were associated with a yearly recurrent incremental cost of over $1000. However, almost half this difference was already present before the occurrence of the fracture, and was attributable to hospital admissions. The remainder of the incremental cost was mainly due to pharmaceutical consumption and to a lesser extent to admissions to orthopedic surgery wards. We conclude that hip fractures cause excess mortality and an important incremental cost especially during the first year, and that these could probably be avoided by prevention of hip fractures. For vertebral fractures we found no evidence of important acute care costs but we observed a yearly returning incremental cost. Part of this incremental cost, however, was pre-existing and might therefore by caused by co-morbidity.

Keywords: Aging; Cost; Hip fractures; Prospective studies; Vertebral fractures

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Introduction

In Western countries, osteoporotic fractures and especially hip fractures cause major morbidity and mortality in the elderly [1], and are associated with substantial public health costs due to acute hospital treatment and subsequent rehabilitation [2]. Improved life expectancy and demographic changes will cause the number of hip fractures worldwide to increase from around 1.7 million in 1990 to over 6 million in 2050 [1] and, therefore, medical expenditure will increase in the decades to come. In The Netherlands, we estimated the cost of osteoporotic fractures at 420 million guilders (US$240 million) in 1993 [3], while hip fractures accounted for 85% of this cost. In some studies it is argued, however, that the importance of non-hip fractures in the cost of osteoporotic fractures is underestimated: a US study estimated the health care expenditure attributable to osteoporotic fractures in the United States at US$13.8 billion in 1995 [4]. Moreover, this study concluded that only 60% of the cost was caused by hip fractures, while the remainder was due to fractures at all other skeletal sites, including vertebral fractures that came to medical attention. The difference between the findings of the two studies was probably caused by the fact that while our study included only hip, vertebral and wrist fractures as osteoporosis-related fractures, the US study included, based on expert opinion, a large proportion of all non-hip fractures as osteoporosis related.

To assess the cost of fractures it is, however, not sufficient to know the global health care expenditure. Some costs, such as for nursing home admissions, may also occur without a fracture, and it is therefore necessary to estimate the difference in health care expenditure between fracture patients and similar individuals in which a fracture did not occur.

Even though a hip fracture is easy to define, and case finding relatively easy, the estimated cost for a single hip fracture varies widely from under $6000 to over $40 000 [5–13], depending on country and timeframe of interest. The cost estimate also depends on whether the medical costs after fracture are simply summed, or whether incremental cost is calculated by comparing the cost with previous health care expenditure. A further source of variation is the choice whether to include only medical cost or to take into account indirect costs as well.

Cost estimates of incident vertebral fractures are even less reliable. Vertebral fractures often remain asymptomatic, and it has been estimated that only a third of vertebral fractures spontaneously come to clinical attention [14–16]. The real incidence of vertebral fractures is therefore poorly known, but there is evidence that it increases with age in much the same way as the incidence of hip fractures [14]. Prevalence studies indeed show an increase both in all vertebral deformities and in severe deformities with age [16–19]. Therefore, estimates of the total cost depend heavily on the definition of a vertebral fracture and on the case-finding procedures. There are, however, a few estimates, which range from $270 up to $2400 [6,20–22]. In a recent review the cost of vertebral fractures was estimated to be $1200 [12].

In this study we estimated the incremental cost of direct medical care after hip and radiologically defined incident first vertebral fracture in a Dutch elderly population, by comparing the health expenditure in fracture patients with the costs generated in a comparable control group. We excluded indirect costs.

Patients and Methods

Setting

We estimated the cost of incident hip fractures and incident first vertebral fractures in a matched case cohort design within the Rotterdam Study. The Rotterdam Study is a prospective cohort study of the occurrence and determinants of disease and disability in the elderly. The design of this study has been described previously [23]. The Rotterdam Study focuses on neurogeriatric, cardiovascular, locomotor and ophthalmologic diseases. The study started in 1990 and all 10 275 men and women aged 55 years and over living in Ommoord, a district of Rotterdam, were invited to participate. The study was approved by the Medical Ethics Committee of Erasmus University Medical School, and participants provided written informed consent. By mid-1993 the cohort was completely assembled, and from those eligible for participation, 7983 did participate, bringing the overall response rate of the study to 78%.

The baseline survey included a home interview for all participants. The participants who were living independently were subsequently invited for two visits to the research center for an extensive series of clinical examinations and laboratory assessments. Baseline assessments in the home interview included self-perceived health and the assessment of the impairment of activities of daily living (ADL) using a questionnaire modified from the Stanford Health Assessment Questionnaire [18,24]. During the visit to the research center we performed a lateral radiograph of the spine from the fourth thoracic to the fifth lumbar vertebra, as described previously [18]. Between mid-1993 and 1995, all participants who were living independently were again invited for a follow-up visit to the research center, and at this time we performed a second lateral radiograph of the spine using the same protocol.

Incident Hip Fractures

Follow-up of hip fractures was achieved through a link with the computer systems of the general practitioners of the district and through hospital admission data, covering about 80% of the study population. For all participants not covered by this system, annual checks were performed on the complete medical records of their general practitioners. Reported fractures were verified by retrieval and review of the appropriate discharge reports from the patient record. Participants with an incident hip fracture between the beginning of 1991 and the end of 1994 were included as cases.

Incident Vertebral Fractures

Vertebral deformities were diagnosed by morphometry on the second radiograph according to the Eastell method [25], as modified by Black et al. [26]. As described previously [18], deformities were categorized as moderate or severe. Moderate deformities (grade I) were defined as a deviation of any ratio of the heights between the –3 and –4 SD threshold. Severe deformities (grade II) were defined as a ratio below the –4 SD threshold. These thresholds were obtained in the same study population and have been published [18]. For all participants with a prevalent vertebral deformity on the second radiograph, the first radiograph was also digitized and vertebral deformities were diagnosed using the same method. We defined a first vertebral fracture as at least one severe deformity on the second radiograph, without any vertebral deformity on the first.

Matched Control Group

For every participant with an incident fracture, we randomly chose a participant matched at baseline for age (within the same 5-year age group), gender, self-perceived health, composite ADL activity score [18], living situation (alone or with a partner; independently or in residential care) and general practitioner. This matching was an attempt to make medical consumption at baseline as similar as possible. For the same reason it was a prerequisite for the matched control to be alive at the time of the hip fracture, or at the time of the second radiograph in the case of vertebral fractures.

Medical Consumption

In The Netherlands the general practitioner (GP) is the gatekeeper of the healthcare system. This means that referrals need to be done by the GP, and that the GP record is the central repository of medical information about a patient. Medical consumption was assessed by retrieval of those medical records in the general practice. All hospital admissions and their duration from 1990 until the end of 1996 were recorded. Admission to nursing homes was recorded similarly. We also recorded all general practice and medical specialist visits. Pharmaceutical consumption was assessed by retrieval of the computerized records of the central pharmacy of the district, covering all participants.

Analysis

Unit prices for cost of medical consumption were based on the Dutch guidelines for cost calculations in health research for 1993 [27]. Those guidelines use comprehensive per diem prices including medical care and hotel costs: for hospital admissions these were ƒ773 (Dutch guilders) per day and ƒ209 for nursing homes. The price for a GP visit was ƒ30, the price for a medical specialist contact ƒ200. For pharmaceutical consumption, the net cost to society was used. Costs in guilders were converted into US$, using a conversion rate of 2 guilders to the dollar. For hip fracture we calculated the cost during the year preceding the hip fracture, and compared it with the cost in the 2 years following the hip fracture. For the control group we did the same, using as reference the date of hip fracture of the matching case. Survival was described with Kaplan–Meier survival analysis.

Since we did not know the exact date of incident vertebral fractures, we compared the average yearly cost in the years preceding the first radiograph with the average yearly cost in the years following the second radiograph (until the end of 1996 or until death). To account for the period between the two radiographs, where important acute care costs might be incurred, we also calculated the average yearly cost for this period.

Because the distribution of the cost data was extremely skewed, we did not use conventional parametric tests for assessing the precision of the estimates. As an alternative we used the bootstrap method to calculate the averages and the 95% confidence intervals (CI) [28]. Cases and controls were sampled as pairs, and for every parameter 100 000 Monte Carlo bootstraps were calculated.

Results

During the follow-up period 48 hip fractures occurred, and an equal number of matched controls were selected. In two cases of hip fracture and in two controls we were not able to obtain all the necessary information to calculate medical costs. Therefore, those 4 pairs were deleted from the analysis, giving us valid information on 44 pairs (91%).

We detected 45 severe first vertebral deformities, and again selected matched controls. Here, we did not obtain

Table 1. Overview of participants

	Hip fractures		Vertebral fractures	
	Cases	Controls	Cases	Controls
Total no.	44	44	42	42
Women	34	34	32	32
Living independently	31	31	42	42
Mean age in years (SD)	81.6 (7.9)	81.3 (8.2)	73.1 (7.3)	73.0 (7.3)
Alive at end of 1996	22	30	38	40

Table 2. Average incremental cost in (US $) after hip fracture (cost difference between cases and controls)

	Year before	All subjects in study		Surviving subjects only	
		First year	Second year	First year	Second year
Pharmacy	78	–135	51	–46	269
Hospital admissions (orthopedic surgery)	35	7.528*	42	7.593*	111
Other hospital admissions	–167	–360	–70	–348	100
Nursing home	211	2.532*	1.029	2.955*	1.461
Physician visits	–17	–25	–35	3	2
Total	140	9.540*	1.017	10.157*	1.943
(95% CI)	(–937 to 1220)	(7054 to 12 343)	(–717 to 3254)	(7369 to 13 378)	(–418 to 5073)

*Significant within 95% confidence limits.

all the information on medical consumption for 3 cases, and those 3 pairs were deleted from the analysis, leading to valid information on 42 pairs (93%). Table 1 presents the baseline characteristics of the four groups.

Incident Hip Fractures

In the year preceding the hip fracture, the total cost of medical consumption was similar in the two groups: average cost was $1805 in the hip fracture group and $1665 in the control group. In the first year following the hip fracture the average cost increased to $11 172 in the hip fracture group and remained at the same level in the control group ($1632).

Table 2 presents the estimated incremental cost between the hip fracture and control group broken down by area of health care expenditure. The increased costs were mainly incurred during the first 3 months after the hip fracture, the main component being the initial hospital stay on the orthopedic ward. The cost difference in those first 3 months was $8022 (95% CI: 6483–9630). During the remainder of the first year there was an additional cost of $1518 (27–3352) mainly associated with nursing home stays. In the second year the average cost in cases was $2580 compared with $1563 in controls. Again, this additional cost was associated with nursing home admissions.

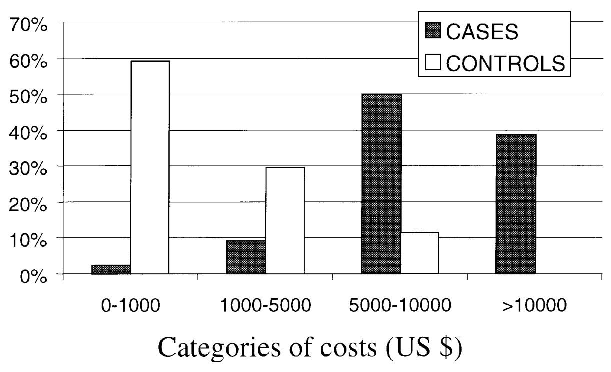

Fig. 1. Distribution of the cost of medical care in the year after hip fracture.

Figure 1 indicates the distribution of yearly direct medical costs in cases and controls during the first year following the hip fracture. It shows that about 60% of the controls had a yearly cost below $1000 while cost exceeded $5000 in only 10%. In cases, however, cost exceeded $5000 in almost 90%.

In this cost calculation we disregarded the important extra mortality after a hip fracture. There was indeed an obvious increase in the death rates in the hip fracture patients in the 6 months following the event. Figure 2 gives the Kaplan–Meier survival curves comparing the survival of hip fracture cases with controls. When we excluded participants from the time they died, the average incremental cost during the first year rose only slightly to $10 157. The main reason for this modest increase was that the majority of costs were incurred immediately after the hip fracture, also in people dying subsequently. In the second year, however, the cost difference almost doubled, from $1017 to $1943, mainly caused by nursing home and pharmacy costs.

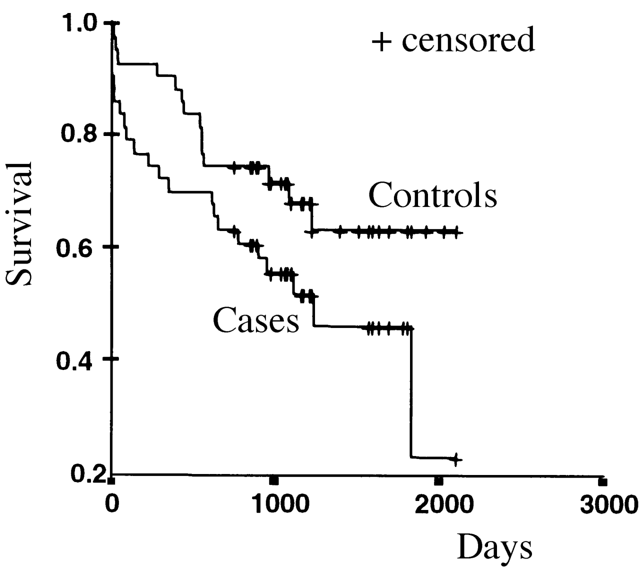

Fig. 2. Survival after hip fracture (cases vs controls).

Incident Vertebral Fractures

For vertebral fractures the cost differences were less pronounced, as shown in Table 3. In this population the average cost of medical consumption before the first radiograph was $1178 for cases and $670 for controls. During the period between the two radiographs the average yearly cost was $1629 for cases and $1198 for controls. The second radiograph was taken an average of 2.2 years after the first, and the average yearly cost afterwards was $3125 for cases versus $2068 for control subjects. In the GP records we could find evidence of vertebral deformities in only 14 of the cases (33%). Moreover, 4 of those were only detected after the second radiograph in our study, indicating that these vertebral deformities were not detected at the time of their occurrence.

Table 3 presents the estimated incremental cost between cases and controls broken down by area of health care expenditure. The cost difference before the vertebral fracture was almost entirely due to hospital admissions. After the second radiograph this difference in hospital costs persisted, while the remainder of the increase was mainly associated with pharmacy costs and, to a lesser extent, with admissions to orthopedic surgery wards.

The $353 incremental pharmacy cost was not attributable to specific medication, and the cost difference was present in almost every drug category. The most marked increase in yearly cost ($150) was in the category of anti-ulcer drugs, and the use of omeprazole and ranitidine was responsible for most of this difference, although this was not due to volume but to the price levels of those products. Incremental cost was also recorded in several other drug categories such as the cardiovascular, hormonal and respiratory drugs, and also in the non-steroidal anti-inflammatory drugs without, however, presenting a clear pattern. For the period between the two radiographs we saw no indication of any acute phase costs, apart from a significantly increased cost of physician visits, but these represent low costs. However, since we do not know the exact timing of the vertebral deformity these costs are more difficult to interpret.

Figure 3 shows the distribution of average yearly cost in cases and controls after the second radiograph. For controls this distribution is similar to that in the hip fracture control patients. In cases, however, the majority had a yearly cost of over $1000, and 20% had an average yearly cost exceeding $5000.

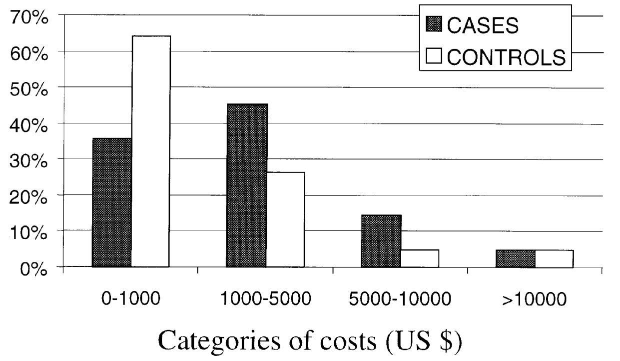

Fig. 3. Distribution of the yearly cost of medical care after just vertebral fracture.

Discussion

Main Findings

We estimated that, in this population, a hip fracture caused an extra cost of almost $10 000 during the first year and $1000 in the subsequent year. There was an important extra mortality in the 6 months after the hip fracture as other studies have reported previously [29,30]. Taking this excess mortality into account and calculating the average cost for surviving patients and controls did not dramatically change our estimate during the first year, since most of the costs were incurred directly after the fracture. However, assessing surviving participants only, incremental cost in the second year went up to almost $2000, mainly due to nursing home admissions and pharmacy costs. In two other studies that also compared costs before and after the event, incremental cost during the first year was estimated at between $16 000 and $19 000 for the US [13] and $22 000 for Sweden [11]. These costs are higher than those in our Dutch population. The main reason for this difference appears to be the cost per day for hospital admissions, which is substantially lower in The Nether-

Table 3. Average incremental cost (in US $) after first vertebral fracture(cost difference between cases and controls)

	Years before first radiograph	Years between radiographs	Years after second radiograph
Pharmacy	28	178	353*
Hospital admissions (orthopedic surgery)	–41	–49	150
Other hospital admissions	476*	230	498
Nursing home	–14	0	12
Physician visits	59	73*	44
Total	508	431	1057
(95% CI)	(–184 to 1337)	(–229 to 1173)	(–712 to 2920)

*Significant within 95% confidence limits.

lands. Estimates from UK studies are generally lower [8–10], but these studies focused only on the acute phase costs. The UK estimates, however, correspond to our results for the first 3 months after the event.

Costs of vertebral fractures are largely unknown, and cost estimates based on prevalent fractures are bound to be biased, since, in practice, these fractures often remain undiagnosed. Therefore, estimates vary widely. In our study we determined vertebral fractures by comparing radiographs made in a population-based cohort, thereby also detecting vertebral fractures that never came to clinical attention. In this population we found that, even before the occurrence of the fracture, the average yearly cost was over $500 higher in cases compared with their matched controls. This incremental cost was largely caused by hospital admissions and this seems to point to pre-existing co-morbidity that was not avoided by the matching procedure used.

Most of the vertebral deformities in our study remained undiagnosed. Therefore, it is no surprise that the observed incremental cost is only modest. While the higher cost for admissions to orthopedic surgery wards after the occurrence of a vertebral deformities is not surprising, the observation of a higher pharmacy cost is, and in particular the lack of a specific drug category causing this. The single category causing most of this cost difference was that of anti-ulcer drugs, although this was not due to volume but to the price levels of those products. Other extra consumption was recorded in the groups of cardiovascular, hormonal and respiratory drugs and in the non-steroidal anti-inflammatory drugs. This cost for vertebral fractures becomes important, however, since it appears to be a yearly recurrent cost, at least during the first few years following the vertebral fracture.

The finding of this pre-existing incremental hospital cost and the nonspecific drug usage in patients with incident vertebral fractures may have important implications. When confirmed by additional research this would mean that the cost-effectiveness of strategies to prevent vertebral fractures might be overestimated, since at least part of the cost appears to be pre-existing and therefore, probably, not avoidable.

Strengths and Limitations

International comparisons of cost are difficult, because health care is organized differently in different countries. The average initial stay in the orthopedic ward, for instance, is only 11 days in Sweden [11] while it is 26 days in The Netherlands [3]. However, in Sweden it is followed by a longer stay in a geriatric ward. Moreover, the definition of what is included in health care costs and what is not differs from one country to another. While the severity of hip fractures is probably comparable between studies, the severity of vertebral deformities depends heavily upon the definition. Here we chose to include all severe incident deformities whether or not they caused complaints.

In this study we investigated the incremental cost caused by fractures by comparing health care costs directly between individuals with and without a fracture, matching for potential determinants of health care consumption, while previous studies on incremental costs utilized health care use by the patient in the months before the hip fracture rather than using control patients [11,13]. This method allowed us to compare cost directly, but also to take into account the excess mortality in the hip fracture group compared with the control group. For hip fractures, the matching appears to have achieved its purpose, since the average cost before fracture was roughly equal between cases and controls. For vertebral fractures however, there was, even before any fracture, a cost difference of over $500 between cases and controls. This was possibly caused by underlying co-morbidity that was not avoided by the matching, and it clearly underlines the need for a control group when assessing the cost of vertebral fractures. Since the exact date of the vertebral deformity was impossible to determine, we accounted for those costs by analyzing the complete period between the two radiographs.

In this study we included only direct medical costs, and the average cost was small compared with the average health care costs for individuals of the same age in The Netherlands [31]. This is because we included only relatively healthy individuals who were mostly living independently. We also investigated only the incremental cost after a first severe vertebral deformity, and this study gives no information on the cost consequences of multiple vertebral fractures. Moreover, we included a large proportion of vertebral deformities that never came to clinical attention, and this has to be considered when extrapolating these results to other populations. In calculating the medical consumption we did not include health care costs such as home care and home help, paramedical care, ambulatory physiotherapy, equipment costs and transportation costs. From Dutch health expenditure data [31] we estimated that these costs account for about 15% of all health care costs in these age groups. Indirect costs due to lost production were not included as we felt these were irrelevant in this elderly population, but this is an important reason why our estimates are low.

The most important limitation, however, is that this study for assessing the cost of incident fractures by direct comparison of patients with a control group was relatively small, and although the approach appears feasible the results should be interpreted with caution, as is obvious from the relatively wide confidence intervals. Further investigation is needed, especially to validate our finding that co-morbidity might be an important determinant in the cost of vertebral fractures. The observation of the increased and nonspecific drug consumption is intriguing, and to our knowledge no other study has included this individual pharmaceutical consumption in a cost analysis of fractures.

Conclusions

In this study we used a novel approach for assessing the cost of incident fractures by direct comparison of medical expenditure in fractures patients with that in a matched control group. While, for hip fractures, our results largely confirm previous cost estimates both in The Netherlands and in other countries, the results for vertebral fractures are surprising. Hip fractures cause an important cost and excess mortality, and prevention of hip fractures would probably avoid those. For vertebral fractures we could not detect important acute care costs, but we did observe a higher medical expenditure even before the occurrence of the fracture, while an important part of the additional incremental cost after fracture was caused by nonspecific use of pharmaceutical drugs. This appears to point to co-morbidity, and it is therefore unlikely that prevention of vertebral fractures will eliminate all the incremental cost. If confirmed, this finding would have important implications for the evaluation of the cost-effectiveness of preventive strategies.

Acknowledgements. We are grateful to the participants in the Rotterdam Study, the general practitioners and pharmacists of Ommoord, the many field workers and researchers in the research center and at the department of Epidemiology & Biostatistics, and especially to Anja van der Riet and Koretta Buikema who, with great care, reviewed the complete medical records of the subjects in this study. This study is part of the research program of the Erasmus Center for Research on Aging of the Erasmus University Rotterdam and the University Hospital Rotterdam Dijkzigt, The Netherlands.

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Received for publication 29 July 1998
Accepted in revised form 11 December 1998