Calcif Tissue Int (1987) 41:57–64

Calcified Tissue International
© 1987 Springer-Verlag New York Inc.

Clinical Investigations

Secular Trends in the Incidence of Hip Fractures

L. Joseph Melton, III,[1] W. Michael O'Fallon,[1] and B. Lawrence Riggs[2]

[1]Department of Medical Statistics and Epidemiology and [2]Division of Endocrinology and Internal Medicine, Mayo Clinic and Mayo Foundation, Rochester, Minnesota 55905

Summary. To explore possible changes in proximal femur (hip) fracture incidence over time, an earlier study among Rochester, Minnesota residents for 1928–1977 was updated through 1982. Reanalysis of data demonstrated rising age-adjusted rates for men over this time. Crude rates rose for women as well, but age adjusted rates leveled off in the mid-1950s, as did overall rates, since the majority of hip fractures were in women. Secular trends were primarily due to changes in the incidence of initial hip fractures associated with moderate trauma, the sort usually attributed to osteoporosis. No differences were noted in trends for cervical vs. intertrochanteric femur fractures; and, excluding the low values for 1928–1942, no significant trends were noted for women within various age groups. Our results for women conflict with estimates from a number of other studies, but these differences may provide a basis for hypothesis development.

Key words: Proximal femur (hip) fracture — Incidence — Secular trends — Osteoporosis.

The number of proximal femur (hip) fractures seen each year is expected to rise dramatically [1, 2] as the population ages, even with steady age- and sex-specific incidence rates. However, recent reports from Great Britain [3–6] and Scandinavia [7–9] suggest that incidence rates are rising as well, although there is some disagreement on this point [10–12]. Because hip fractures have such a dramatic impact on the health of the elderly [2] and on the economics of medical care for this group [13], it is important to know whether or not they are increasing more rapidly than can be accounted for by demographic changes alone. This issue is addressed in Rochester, Minnesota, where detailed hip fracture incidence rates are now available for the 55-year period from 1928–1982.

Please send reprint requests to Dr. Melton at the above address.

Methods

Population-based epidemiologic research can be conducted in Rochester, Minnesota because the city is isolated from other urban centers, because medical care is virtually self-contained within the community, and because there are relatively few providers. Most orthopedic care, for example, is provided by the Mayo Clinic, which has maintained a common medical record system with its two large affiliated hospitals for nearly 80 years. The Mayo Clinic dossier-type record thus contains both inpatient and outpatient data. The diagnoses and surgical procedures recorded in these records are indexed. The index includes the diagnoses made for outpatients seen in office or clinic consultations, emergency room visits or nursing home care, as well as the diagnoses recorded for hospital inpatients, at autopsy examination or on death certificates [14]. Medical records of the other providers who serve the local population are indexed in the same way and are also retrievable. Thus, the details of almost all of the medical care provided to the residents of Rochester, regardless of the provider, are available for study. The potential value of this data system (the Rochester Epidemiology Project) for population-based studies has been described previously [15].

Using this unique data base, we identified all proximal femur fractures that occurred among Rochester residents during the period 1928–1982. All proximal femur sites were included except the uncommon isolated fractures of the greater or lesser trochanter. Fractures were divided into cervical (neck, intracapsular) and intertrochanteric (extracapsular) types. Subtrochanteric fractures and those more distal on the femur were excluded. The term "hip fracture" is used interchangeably with "proximal femur fracture" as the condition is defined here. Radiographic or autopsy confirmation was obtained for all but 13 (0.8%) fractures, where a clinical diagnosis alone was accepted. Trauma was classified as "severe"—that which could conceivably cause fractures in anyone (e.g., motor vehicle and recreational accidents and falls from heights), or "moderate"—that which would not usually be expected to result in a fracture (mainly falls from a standing height or less).

In calculating incidence rates, the entire population of Rochester was considered to be at risk. The population rose from 18,928 in 1930 to 56,447 in 1980; and the age- and sex-specific person-years (p-y) used as denominators in the incidence rates

were estimated from decennial census data for Rochester, with interpolation between census years as described previously [16]. Incidence rates were directly age- and sex-adjusted, or age-adjusted for comparisons of men and women, to the population structure of United States whites in 1980. Where possible, rates from other studies were adjusted comparably. Other authors sometimes reported rates only for those over 35 years of age or over 50 years; age-specific rates for younger people were assumed to be 0 in such instances. This should have had little effect: in Rochester, for example, only 4.5% of patients were less than 50 years old at the time of fracture and their deletion would have lowered the overall adjusted rate only slightly. Ninety-five percent confidence intervals (95% C.I.) for Rochester rates were estimated from the cumulative Poisson distribution [17]. Changes in age- and sex-specific incidence over time were assessed using trend tests [18], while changes in age-adjusted rates were evaluated using least squares regression analysis [19].

Results

Over the 55-year period of study, Rochester residents experienced 1701 proximal femur fractures, for an overall age- and sex-adjusted incidence rate of 108.3 per 100,000 p-y (95% C.I., 103.1–113.4). Crude incidence rates for all hip fractures rose steadily between 1928–32 and 1978–82, while age- and sex-adjusted rates rose rapidly from 24.3 per 100,000 p-y in 1928–32 to 105.7 per 100,000 p-y in 1943–47 (Table 1). Adjusted rates then leveled off, however, and the latter figure was not much different ($P = 0.51$) from the result obtained for 1978–82 (114.8 per 100,000 p-y). The overall trend in adjusted incidence from 1943–47 to 1978–82 was not statistically significantly greater than 0 (slope = 0.12 per 100,000 p-y per year; $P = 0.63$).

Since secular trends were accounted for by the initial fractures (Table 1), the remainder of the analysis was confined to that group. Age-adjusted incidence rates for initial hip fractures in men rose fairly steadily from 8.4 to 83.5 per 100,000 p-y between 1928–32 and 1977–82 (Fig. 1). This was consistent with a linear trend to increased hip fracture incidence of about 1.38 per 100,000 p-y per year ($P < 0.001$). Age-adjusted rates in women rose from 34.5 to 155.6 per 100,000 p-y between 1928–32 and 1953–57 but then fell to 113.9 per 100,000 p-y in 1977–82. The overall trend for women was nonlinear so could not be assessed in toto. Between 1953–57 and 1978–82, however, there was no significant trend in the adjusted incidence rates (slope = −0.98 per 100,000 p-y per year; $P = 0.17$).

Secular trends for cervical and intertrochanteric fractures were similar for men and women (Fig. 1). Both sites displayed the characteristic osteoporotic pattern of exponentially increasing rates with age (Fig. 2). In terms of trauma, secular changes were restricted to the fractures associated with moderate trauma (Fig. 1). The age-adjusted incidence of fractures due to more serious trauma showed no clear trend over time and also failed to show the typical age-related incidence pattern seen for moderate trauma fractures (Fig. 3).

When changes in age-specific incidence were examined for moderate trauma fractures, however, no consistent findings were evident (Fig. 4). Male rates increased significantly over time for age groups 65–74 and 75+ years, but changes in younger age groups were not statistically significant. Among women, rates increased significantly only in those aged 75 years and over. However, even this finding vanished when the very low values for 1928–42 were excluded.

Discussion

There seems to be general agreement that the crude incidence of proximal femur fractures is rising in conjunction with aging of the underlying population. Superimposed upon this change, it also appears that the age-adjusted incidence of hip fractures is rising in men. This is seen in Rochester and elsewhere (Fig. 5), with but few exceptions [3, 24].

It is less clear what the secular trend in age-adjusted incidence rates among women might be, as substantial variation in both timing and magnitude of change is seen from one study to another (Fig. 6). Rising rates have been seen in most settings [3, 4, 21, 23, 24, 26–28], however, and for women in Göteborg, Sweden [8], the increase was as steep as that seen for Rochester women in the 1930s and 40s. The early rise in Rochester was originally attributed to better case ascertainment associated with the introduction of hip pinning in the mid-1930s [29]. However, given similar observations in Scandinavia [8, 9, 22] at a later date, it is conceivable that this reflects instead the action of some etiologic factor. It may be of interest in this regard that a steep increase in deaths attributable to domestic falls (associated with osteoporotic, mainly hip, fractures) was also seen in England and Wales between 1920 and 1940 [30] prior to initiation of the incidence studies there.

In contrast, Jensen [11] reported no rise in hip-fracture incidence in suburban Copenhagen, Denmark over the period 1971–76 but noted that age-specific rates, especially for those 75 years old and over, were greater than the figures from Malmö 20 years earlier. Likewise, rates rose in Oslo, Norway between 1960 and 1970 [31] but no additional increase was seen in 1977–81 [12]. Hedlund et al. [32] also found rates for Stockholm County, Sweden in 1972–81 that were greater than those reported ear-

Table 1. Crude and adjusted hip-fracture incidence among Rochester, Minnesota residents by 5-year time periods, 1928–82

	All hip fractures				Initial hip fractures alone			
		Crude	Adjusted			Crude	Adjusted	
Time period	n	Rate[a]	Rate[b]	95% C.I.	n	Rate[a]	Rate[b]	95% C.I.
1928–32	13	13.2	24.3	8.9 – 39.8	13	13.2	24.3	8.9 – 39.8
1933–37	26	22.3	47.5	27.2 – 67.9	26	22.3	47.5	27.2 – 67.9
1938–42	50	40.4	73.4	52.2 – 94.6	46	37.2	66.4	46.4 – 86.4
1943–47	86	66.5	105.7	82.6 – 128.8	79	61.1	96.2	74.2 – 118.2
1948–52	111	78.4	112.0	90.4 – 133.5	99	69.9	98.9	78.7 – 119.0
1953–57	143	87.2	125.3	104.2 – 146.3	133	81.1	114.9	94.9 – 134.9
1958–62	152	77.9	103.7	87.0 – 120.3	138	70.7	94.2	78.3 – 110.1
1963–67	199	86.3	109.5	94.2 – 124.7	176	76.3	97.0	82.6 – 111.3
1968–72	279	106.2	122.3	107.8 – 136.8	254	96.7	111.1	97.3 – 124.9
1973–77	306	108.2	110.6	98.0 – 123.2	272	96.2	99.1	87.1 – 111.1
1978–82	336	117.9	114.8	102.2 – 127.5	295	103.5	102.1	90.1 – 114.1

[a] Incidence per 100,000 person-years
[b] Incidence per 100,000 person-years directly age- and sex-adjusted to the population structure of U.S. whites in 1980
C.I. = confidence interval

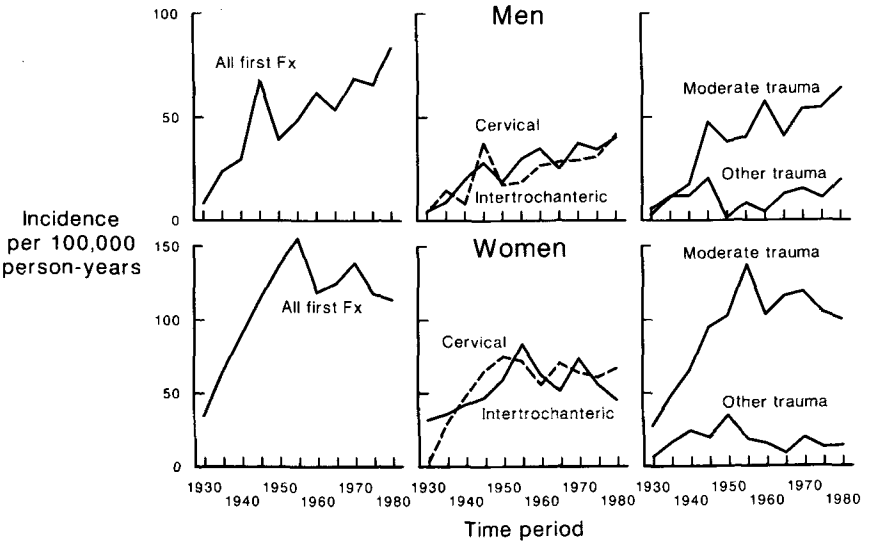

Fig. 1. Age-adjusted incidence over time for male and female Rochester, Minnesota residents with initial hip fractures, by site of fracture and degree of trauma, 1928–82.

lier from Malmö but noted no further increase during the study period among those under 75 years of age; continued increases were seen for men and, to a lesser extent, women aged 75 years and over, however. In Rochester there appears to have been no increase in age-adjusted female rates since the mid-1950s, as we reported previously [29]. At first glance, hospital discharge data for the United States seem to contradict this, showing a rise in crude incidence for women (Fig. 6) as well as men, but it was not possible to age-adjust the national figures, and demographic changes may account for much of the apparent increase. Unfortunately, there are no data from other communities in the United States with which to compare the Rochester figures. The population of Rochester is largely white, better educated than United States whites in general, and is slightly younger, more often employed in the health service industry, and has a somewhat higher median income. Nonetheless, hip fracture incidence rates from Rochester are quite similar to hospital discharge rates for hip fracture from the North Central Region of the United States [29].

Potential methodologic problems exist with some studies (Table 2). Some were not population based,

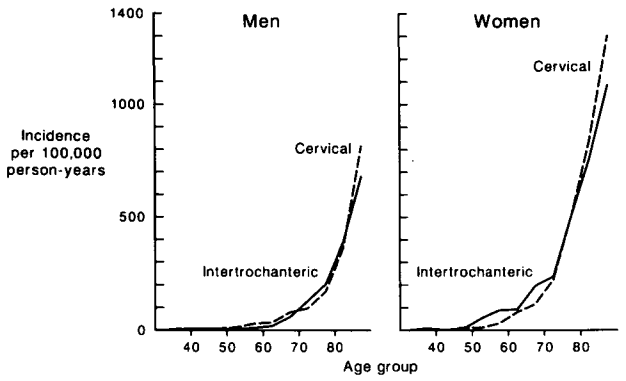

Fig. 2. Age- and sex-specific incidence of hip fracture by site among Rochester, Minnesota residents, 1928–82.

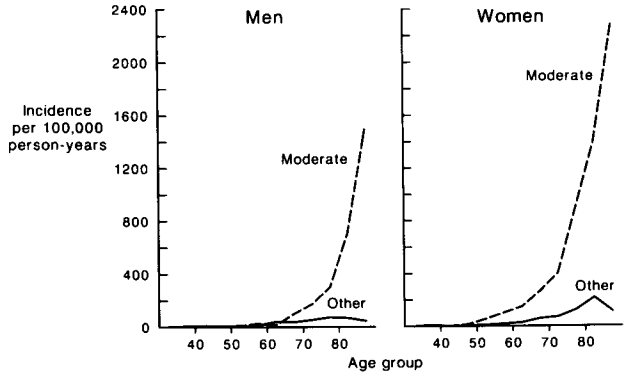

Fig. 3. Age- and sex-specific incidence of hip fracture by degree of trauma among Rochester, Minnesota residents, 1928–82.

and the majority did not provide age- and sex-adjusted incidence rates. Studies based on a few widely scattered years of observation might have been influenced by the wide fluctuation in cases (and rates) seen from year to year, even in very large data sets [32]. In those studies based on routinely collected hospital discharge data, the quality of case ascertainment may have varied. Perhaps 10% of British hip fractures may be missed because of inappropriate coding [3, 34], although Rees [37] found data quality to be uneven—with half or more of cases missed at some centers—and suggested that improving quality might account for some of the temporal trend. However, increases in incidence were found even when direct case ascertainment was used [26, 34]. A bigger problem is duplication of cases: various reports suggest that 16% [4] to 29% or more [34] of hip fracture admissions in British data represent transfers from one hospital to another which are then counted twice [38]. The impact of this problem may have varied over time [39], although in his study of hip fracture hospitalizations in England and Wales, Lewis did not find this to be so [4]. Hospital discharge data may also include patients readmitted for additional therapy after the original fracture [10, 34]. Such admissions may have become more important as total hip arthroplasty became widely available in the late 1960s. In Rochester, for example, per capita utilization of total hip arthroplasty more than doubled between 1969 and 1980, and nearly a third of the procedures were for hip fracture [40], mostly for late complications [41]. In the Rochester hip fracture data presented here, all diagnosed patients were identified and none was counted twice. However, individual patients were also identified in the Scandinavian studies which reported rising hip fracture incidence rates. It seems unlikely, then, that methodologic problems alone account for the secular changes in hip fracture incidence or the differences from one center to another.

Since women contribute the majority of fractures, they largely determine overall hip fracture incidence in the community, but no one has advanced a detailed hypothesis to explain the temporal variations seen. A number of suggestions have been made, however, including earlier menopause through more frequent oophorectomy [3], increased use of alcohol [4, 8, 42] or cigarettes [8, 24], dietary [5, 7, 21] or environmental [43, 44] changes in calcium metabolism, or the effects of decreased physical labor [22, 30, 45] and activity [4, 5, 21, 22, 45, 46].

Oophorectomy prior to natural menopause is associated with accelerated bone loss and vertebral fractures [47, 48] but not as consistently with hip fractures [48–52]. The prevalence of bilateral oophorectomy among postmenopausal women in Rochester doubled from 4% in 1945–54 to 8% in 1965–74 [53], but this could not explain the increased fracture rate in men and, in any event, might have been offset by postmenopausal estrogen use [49–52]. While the plateau in hip fracture incidence was concurrent with the widespread use of postmenopausal estrogens, the greatest change in rates over the study period was among women 75 years of age or over; little decline in incidence was seen in the younger women more likely to have been exposed. Moreover, long-term postmenopausal estrogen use has been relatively low in Rochester, and incidence rates for endometrial cancer (to some degree an indicator for exogenous estrogen therapy) fell in this population between 1945–54 and 1965–74 [54]. Estrogen levels are also

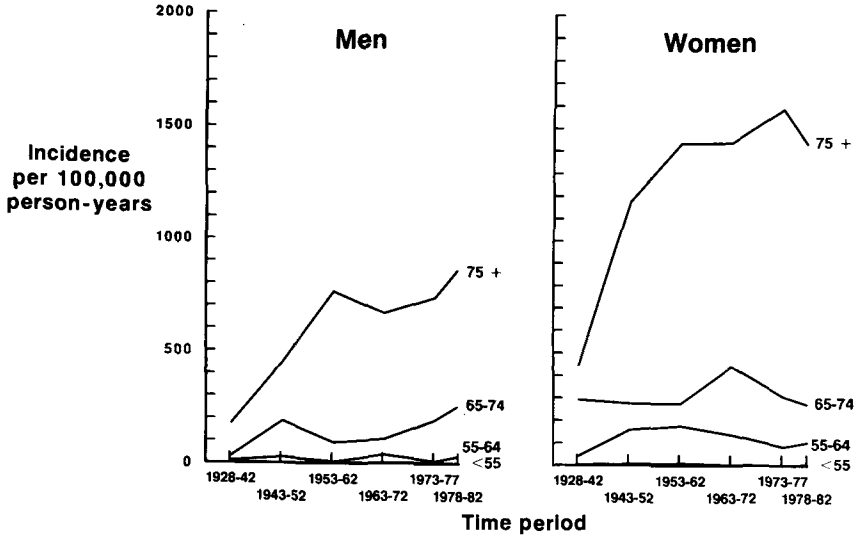

Fig. 4. Age- and sex-specific incidence over time of hip fractures due to moderate trauma among Rochester, Minnesota, residents, 1928–82.

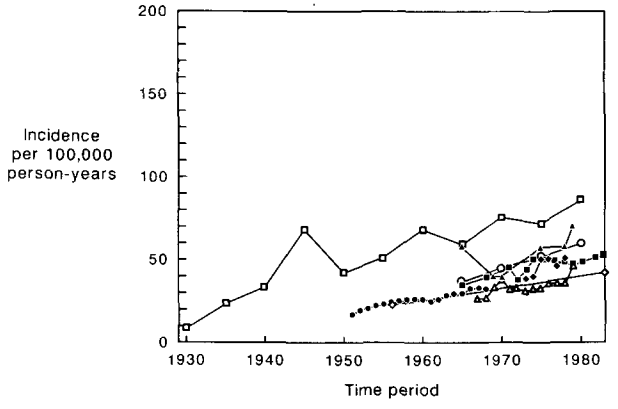

Fig. 5. Incidence of hip fractures over time for men as reported from various studies: □—□ Rochester, Minnesota (present study); ■—■ United States (1965–83); ◇—◇ Oxford, England [20]; ◆—◆ Funen County, Denmark [9]; △—△ Holland [21]; ▲—▲ Göteborg, Sweden [8]; ○—○ Uppsala, Sweden [22]; ●—● New Zealand [23].

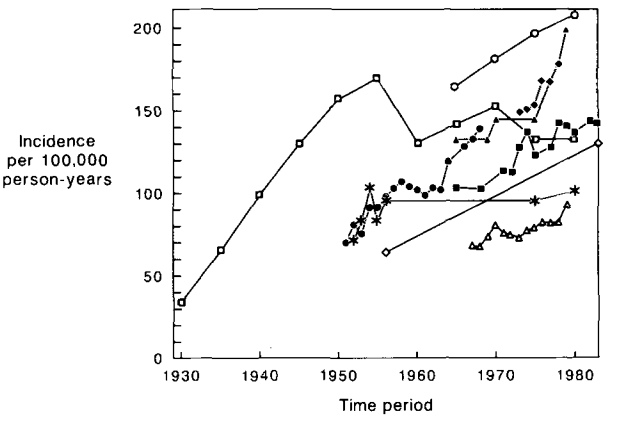

Fig. 6. Incidence of hip fractures over time for women as reported from various studies: □—□ Rochester, Minnesota (present study); ■—■ United States (1965–83); ◇—◇ Oxford, England [20]; ◆—◆ Funen County, Denmark [9]; △—△ Holland [21]; ▲—▲ Göteborg, Sweden [8]; ○—○ Uppsala, Sweden [22]; ●—● New Zealand [23]; *—* Dundee, Scotland [6, 25].

correlated with obesity in postmenopausal women [55, 56], however, and body weight has been increasing among American women [57] so that estrogen may still play some role.

Both alcohol use [51] and cigarette smoking [51, 58] have been associated with hip fracture risk in some but not all studies [52], but it is uncertain whether the effect is primary or secondary [59]. In Rochester, as in Europe [22], elderly women smoke and drink relatively little. Moreover, usage patterns seem out of phase with the secular changes observed in Rochester. Hip fracture incidence rates increased most steeply prior to the general acceptability of smoking and drinking among women; then, when these practices became more widespread among older women [60], hip fracture rates leveled off. Lung cancer rates (a reflection of smoking practices) have been rising in Rochester women [61], as they have in other countries.

Dietary influences have been invoked at both extremes of life. Dietary restrictions during World War II [5, 7, 21] may have influenced peak adult bone mass [62] and subsequent fracture risk in Europe. This cannot explain the rise among Roch-

Table 2. Methodologic features of various studies of hip fracture incidence over time

Study	Population-based	Rates presented	Rates adjusted[a]	Years covered	No. of data points	Data source	Nonresidents removed	Acute duplicates removed	Late duplicates removed
[33]	No	No	No	1938–55	19	Hospital admissions	No	Yes[c]	? Yes
[20]	Yes	Yes	No	1954–58	1	Hospital admissions	Yes	Yes[c]	? Yes
[26]	Yes	Yes	No	1983	1 (2)[b]	All providers	Yes	Yes	Yes
[25]	Yes	Yes	No	1952–57	5	All providers	Yes	Yes	Yes
[6]	Yes	Yes	No	1975, 1980	2 (3)[b]	All providers	Yes	Yes	? Yes
[4]	Yes	Yes	No	1968, 1977	2	Hospital discharges	? No	No	No
[5]	No	No	No	1971–81	11	Hospital discharges	? No	? No	? No
[3]	Yes	Yes	No	1973–77	1 (2)[b]	Hospital discharges	? No	Yes	? Yes
[34]	Yes	Yes	No	1971–72	1	Hospital discharges	Yes	Yes	No
[10]	Yes	Yes	No	1975	1 (2)[b]	Hospital discharges	Yes	Yes	No
[24]	Yes	Yes	Yes	1971–83	4	All providers	Yes	Yes	? No
[23]	? No	Yes	No	1951–68	18	Hospital discharge	? No	? No	? No
[21]	? Yes	Yes	Yes	1967–79	13	Hospital admissions	? No	? No	? No
[35]	Yes	Yes	Yes	1949–61	2	X-ray reports	Yes	Yes	Yes
[7]	Yes	Yes	Yes	1967–75	4 (5)[b]	X-ray reports	Yes	? Yes	? Yes
[22]	Yes	Yes	No	1965–80	4	Hospital admissions	Yes	Yes	Yes
[27]	Yes	Yes	Yes	1980–81	1 (4)[b]	X-ray reports	Yes	? Yes	? Yes
[8]	Yes	Yes	Yes	1965–79	6 (11)[b]	Hospital admissions	? Yes	? Yes	? Yes
[32]	Yes	Yes	Yes	1972–81	10	Hospital admissions	Yes	Yes	Yes
[36]	Yes	No	No	1968–76	9	Hospital admissions	? No	No	No
[9]	Yes	Yes	No	1973–79	6	Hospital admissions	No	Yes	Yes
[11]	Yes	No	No	1971–77	6	Hospital admissions	? No	? Yes	? Yes
United States	Yes	Yes	No	1965–83	13	Hospital discharges	No	No	No
Present study	Yes	Yes	Yes	1928–82	11	All providers	Yes	Yes	Yes

[a] Rates adjusted in original report
[b] Numbers in parentheses indicate that additional data points were obtained from previous studies
[c] Studies from a single institution are assumed to have counted each patient only once
? Yes = apparently "yes" but not explicitly stated; ? No = apparently "no" but not explicitly stated

ester men, and dietary restrictions in Asia [63, 64] and Africa [65] do not seem closely correlated with fracture risk. Dietary deficiencies late in life, especially those leading to osteomalacia, have also been implicated [8, 43]. However, osteomalacia is apparently more prevalent among hip fracture patients in Europe [66, 67] than in Rochester [68]. It has been suggested that vitamin D metabolism could also be influenced by declining levels of ultraviolet radiation over time, thus leading to more osteomalacia and a greater risk of hip fractures [43, 44]. This has also been proposed to explain latitudinal changes in fracture-associated death rates from falls in the United Kingdom [69]. However, hip fracture incidence rates in Rochester are no higher than those of southern United States whites [70].

Physical labor and exercise might exert a more direct effect since bone mass, and thus fracture risk [71], is correlated with activity [72, 73], while disuse is associated with very rapid bone loss [74]. The amount of labor performed by both men and women in developed countries seems to have declined over time [5, 22, 64], as has walking in lieu of transportation [21, 22]. It is conceivable, perhaps, that labor-saving devices were widely available to Rochester women [75] before some of their European counterparts, but it is not obvious why this influence would have diminished in elderly Rochester women while causing accelerating hip fracture rates in Europe.

All of the above factors relate to reduction in bone strength due to osteoporosis or osteomalacia. However, the frequency of falls may also have risen, especially with the widespread use of psychotropic drugs which seem to have a significant influence on hip fracture risk [76, 77]. However, Rochester women are as likely to be exposed to such drugs as European men or women. Moreover, most falls do not result in a hip fracture [78, 79].

It is obvious that none of these hypotheses is based on very satisfactory data and new, or at least more refined, hypotheses are necessary. The regional differences described in this paper—in the time that hip fracture rates began to increase, in the rapidity of change, and in the age and sex groups most affected—may provide an opportunity to correlate secular trends in hip fracture incidence with changes in the prevalence of various potential risk factors. Such information could form the basis for testable hypotheses regarding etiology.

Acknowledgments. The authors wish to thank Mrs. Janet Deaner for data collection, Ms. Kay Hurless for computer programming, Ms. Chu-Pin Chu for help with data analysis, and Ms. Mary Ramaker for assistance in preparing the manuscript. This investigation was supported in part by research Grants AG 04875 and AM 30582 from the National Institutes of Health.

References

1. Lindsay R, Dempster DW, Clemens T, Herrington BS, Wilt S (1985) Incidence, cost, and risk factors of fracture of the proximal femur in the USA. In: Christiansen C, Arnaud CD, Nordin BEC, Parfitt AM, Peck WA, Riggs BL (eds) Osteoporosis. Copenhagen, pp 311–315
2. Cummings SR, Kelsey JL, Nevitt MC, O'Dowd K (1985) Epidemiology of osteoporosis and osteoporotic fractures. Epidemiologic Reviews 7:178–208
3. Baker MR (1980) An investigation into secular trends in the incidence of femoral neck fracture using hospital activity analysis. Public Health (London) 94:368–374
4. Lewis AF (1981) Fracture of neck of the femur: changing incidence. Br Med J 283:1217–1220
5. Wallace WA (1983) The increasing incidence of fractures of the proximal femur: an orthopaedic epidemic. Lancet 1:1413–1414
6. Swanson AJG, Murdoch G (1983) Fractured neck of femur: pattern of incidence and implications. Acta Orthop Scand 54:348–355
7. Nilsson BE, Obrant KJ (1978) Secular tendencies of the incidence of fracture of the upper end of the femur. Acta Orthop Scand 49:389–391
8. Zetterberg C, Andersson GBJ (1982) Fractures of the proximal end of the femur in Göteborg, Sweden, 1940–1979. Acta Orthop Scand 53:419–426
9. Frandsen PA, Kruse T (1983) Hip fractures in the county of Funen, Denmark. Acta Orthop Scand 54:681–686
10. Evans JG, Prudham D, Wandless I (1979) A prospective study of fractured proximal femur: incidence and outcome. Public Health (London) 93:235–241
11. Jensen JS (1980) Incidence of hip fractures. Acta Orthop Scand 51:511–513
12. Engesaeter LB, Søreide O (1984) Incidence of hip fractures based on hospital admission rates. Acta Orthop Scand (Abstract) 55:707
13. Holbrook TL, Grazier K, Kelsey JL, Stauffer RN (1984) The frequency of occurrence, impact and cost of selected musculoskeletal conditions in the United States. American Academy of Orthopaedic Surgeons
14. Kurland LT, Molgaard CA (1981) The patient record in epidemiology. Sci Am 245:54–63
15. Kurland LT, Elveback LR, Nobrega FT (1970) Population studies in Rochester and Olmsted County, Minnesota, 1900–1968. In: Kessler II, Levin ML (eds) The community as an epidemiologic laboratory: a casebook of community studies. Johns Hopkins Press, Baltimore, Maryland, pp 47–70
16. Schroeder DJ, Offord KP (1982) A SAS Macro which utilizes local and reference population counts appropriate for incidence, prevalence, and mortality rate calculations in Rochester and Olmsted County, Minnesota. Technical Report Series, No. 20, Section of Medical Research Statistics, Mayo Clinic, Rochester, Minnesota
17. Beyer WH (ed) (1966) C.R.C. handbook of tables for probability and statistics. Chemical Rubber Company, Cleveland, pp 58–64
18. Armitage P (1955) Tests for linear trends in proportions and frequencies. Biometrics 11:375–386
19. Draper NR, Smith H (1966) Applied regression analysis. John Wiley and Sons, New York
20. Knowelden J, Buhr AJ, Dunbar O (1964) Incidence of fractures in persons over 35 years of age: a report to the M.R.C. working party on fractures in the elderly. Br J Prev Soc Med 18:130–141
21. Hoogendoorn D (1982) Mededelingen stichting medische registratie. Ned T Geneesk 126:963–968
22. Elabdien BSZ, Olerud S, Karlström G, Smedby B (1984) Rising incidence of hip fracture in Uppsala, 1965–1980. Acta Orthop Scand 55:284–289
23. Cave W, Nordin BEC (1972) International fracture survey first year report to the International Health Foundation, privately published
24. Evans JG (1985) Incidence of proximal femoral fracture (Letter). Lancet 1:925–926
25. Stewart IM (1958) Fracture of neck of femur: the rate risk and casualty planning. The Medical Officer 100:100
26. Boyce WJ, Vessey MP (1985) Rising incidence of fracture of the proximal femur. Lancet 1:150–151
27. Johnell O, Nilsson B, Obrant K, Sernbo I (1984) Age and sex patterns of hip fracture—changes in 30 years. Acta Orthop Scand 55:290–292
28. Lüthje P (1983) Fractures of the proximal femur in Finland in 1980. Ann Chir Gynaecol 72:282–286
29. Melton LJ, Ilstrup DM, Riggs BL, Beckenbaugh RD (1982) Fifty-year trend in hip fracture incidence. Clin Orthop 162:144–149
30. Eddy TP (1972) Deaths from domestic falls and fractures. Br J Prev Soc Med 26:173–179
31. Falch J, Ilebekk A (1978) Fractures of the proximal end of the femur: prevalence and incidence in Oslo, 1950–1975. Tidsskr Nor Laegeforen 98:738–739
32. Hedlund R, Ahlbom A, Lindgren U (1985) Hip fracture incidence in Stockholm 1972–1981. Acta Orthop Scand 57:30–34
33. Buhr AJ, Cooke AM (1959) Fracture patterns. Lancet 1:531–536
34. Evans JG (1979) Fractured proximal femur in Newcastle upon Tyne. Age Ageing 8:16–24
35. Alffram P-A (1964) An epidemiologic study of cervical and trochanteric fractures of the femur in an urban population: analysis of 1,664 cases with special reference to etiologic factors. Acta Orthop Scand (Suppl) 65:9–109
36. Waris P, Kankaanpää, Karaharju E, Michelsson J-E, Ryöppy S, Snellman O (1979) Fractures of the proximal femur in Finland in 1975. Ann Chir Gynaecol (Suppl) 68: 85–89
37. Rees JL (1982) Accuracy of hospital activity analysis data in estimating the incidence of proximal femoral fracture. Br Med J 284:1856–1857
38. Williams BT (1977) Femoral neck fractures. Br Med J 1:171–172
39. Baldwin JA (1982) Fracture of neck of the femur. (Letter) Br Med J 284:271
40. Melton LJ III, Stauffer RN, Chao EYS, Ilstrup DM (1982) Rates of total hip arthroplasty: a population-based study. N Engl J Med 307:1242–1245
41. Melton LJ, Stauffer RN, Chao EYS, Ilstrup DM (1983) Rates of total hip arthroplasty: a population-based study (Letter). N Engl J Med 308:726–727

42. Falch JA, Ilebekk A, Slungaard U (1985) Epidemiology of hip fractures in Norway. Acta Orthop Scand 56:12–16
43. Burton JL, Ensell FJ, Leach JF, Hall KA (1975) Atmospheric ozone and femoral fractures. Lancet 1:795–796
44. Leach JF, Beadle PC, Pingstone AR (1978) Effect of ozone variation on disease in Great Britain. II. Femoral neck fracture. Aviat, Space, Environ Med 49:1014–1018
45. Stott S, Gray DH (1980) The incidence of femoral neck fractures in New Zealand. N Zealand Med J 91:6–9
46. Lawrence JS (ed) (1977) Diseases of bone. In: Rheumatism populations. William Heinemann Medical Books Ltd, London, pp 398–434
47. Lindsay R, Hart DM, Forrest C, Baird C (1980) Prevention of spinal osteoporosis in oophorectomised women. Lancet 2:1151–1154
48. Ettinger B, Genant HK, Cann CE (1985) Long-term estrogen replacement therapy prevents bone loss and fractures. Ann Intern Med 102:319–324
49. Hutchinson TA, Polansky SM, Feinstein AR (1979) Postmenopausal oestrogens protect against fractures of hip and distal radius: a case-control study. Lancet 2:705–709
50. Weiss NS, Ure CL, Ballard JH, Williams AR, Daling JR (1980) Decreased risk of fractures of the hip and lower forearm with postmenopausal use of estrogen. N Engl J Med 303:1195–1198
51. Paganini-Hill A, Ross RK, Gerkins VR, Henderson BE, Arthur M, Mack TM (1981) Menopausal estrogen therapy and hip fractures. Ann Intern Med 95:28–31
52. Kreiger N, Kelsey JL, Holford TR, O'Connor T (1982) An epidemiologic study of hip fracture in postmenopausal women. Am J Epidemiol 116:141–148
53. Annegers JF, Strom H, Decker DG, Dockerty MB, O'Fallon WM (1979) Ovarian cancer: incidence and case-control study. Cancer 43:723–729
54. McDonald TW, Annegers JF, O'Fallon WM, Dockerty MB, Malkasian GD, Kurland LT (1977) Exogenous estrogen and endometrial carcinoma: case-control and incidence study. Am J Obstet Gynecol 127:572–580
55. Grodin JM, Siiteri PK, MacDonald PC (1973) Source of estrogen production in postmenopausal women. J Clin Endocrinol Metab 36:207–214
56. Bates GW, Whitworth NS (1982) Effects of obesity on sex steroid metabolism. J Chron Dis 35:893–896
57. Abraham S, Johnson CL, Najjar MF (1979) Weight by height and age for adults 18–74 years: United States, 1971–74. Data from the National Health Survey, Series 11, Number 208, DHEW Publication No. (PHS) 79-1656, Hyattsville, Maryland
58. Williams AR, Weiss NS, Ure CL, Ballard J, Daling JR (1982) Effect of weight, smoking, and estrogen use on the risk of hip and forearm fractures in postmenopausal women. Obstet Gynecol 60:695–699
59. Baron JA (1984) Smoking and estrogen-related disease. Am J Epidemiol 119:9–22
60. Harris JE (1979) Cigarette smoking in the United States, 1950–1978. In: Smoking and health, a report of the surgeon general. Washington, DC, DHEW Publication No. (PHS) 79-50066, A-3–A-29
61. Beard CM, Annegers JF, Woolner LB, Kurland LT (1985) Bronchogenic carcinoma in Olmsted County, 1935–1979. Cancer 55:2026–2030
62. Matković V, Kostial K, Šimonović I, Buzina R, Brodarec A, Nordin BEC (1979) Bone status and fracture rates in two regions of Yugoslavia. Am J Clin Nutr 32:540–549
63. Wong PC (1964) Femoral neck fractures among the major racial groups in Singapore. Incidence patterns compared with non-Asian communities. No. II. Singapore Med J 5:150–157
64. Chalmers J, Ho KC (1970) Geographical variations in senile osteoporosis: the association with physical activity. J Bone Joint Surg 52-B:667–675
65. Solomon L (1968) Osteoporosis and fracture of the femoral neck in the South African Bantu. J Bone Joint Surg 50-B:2–13
66. Aaron JE, Gallagher JC, Nordin BEC (1974) Seasonal variation of histological osteomalacia in femoral-neck fractures. Lancet 2:84–85
67. Parfitt AM, Duncan H (1982) Metabolic bone disease affecting the spine. Chapter 13. In: Rothman RH, Simeone FA (eds) The spine. WB Saunders Company, Philadelphia, pp 775–905
68. Riggs BL (1984) Vitamin D and involutional osteoporosis. In: Kumar R (ed) Vitamin D: basic and clinical aspects. Martinus Nijhoff Publishing, Boston, pp 560–577
69. Evans JG (1982) Epidemiology of proximal femoral fractures. In: Recent advances in geriatric medicine, Vol. 2, Churchill-Livingstone, London, pp 201–214
70. Melton LJ III, Riggs BL (1983) Epidemiology of age-related fractures. In: Avioli LV (ed) The osteoporotic syndrome. Grune and Stratton, New York, pp 45–72
71. Melton LJ, Wahner HW, Richelson LS, O'Fallon WM, Riggs BL (1986) Osteoporosis and the risk of hip fracture. Am J Epidemiol 124:254–261
72. Doyle F, Brown J, Lachance C (1970) Relation between bone mass and muscle weight. Lancet 1:391–393
73. Dalén N, Olsson KE (1974) Bone mineral content and physical activity. Acta Orthop Scand 45:170–174
74. Mazess RB, Whedon GD (1983) Immobilization and bone. Calcif Tissue Int 35:265–267
75. Cowan RS (1987) Less work for mother? The American Heritage of Invention and Technology 2:57–63
76. Macdonald JB (1985) The role of drugs in falls in the elderly. Clin Geriatr Med 1:621–636
77. Ray WA, Griffin MR, Schaffner W, Baugh DK, Melton LJ III (1987) Psychotropic drug use and the risk of hip fracture. N Engl J Med 316:363–369
78. Rodstein M (1964) Accidents among the aged: incidence, causes and prevention. J Chron Dis 17:515–526
79. Ashley MJ, Gryfe CI, Amies A (1977) A longitudinal study of falls in an elderly population. II. Some circumstances of falling. Age Ageing 6:211–220

Received October 3, 1986, and in revised form January 30, 1987.