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Long-Term Trends in the Incidence of Distal Forearm Fractures

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Abstract. In this population-based descriptive study covering the 50-year period, 1945–94, there was a statistically significant increase in distal forearm fractures due to severe trauma in both women and men ($p < 0.001$) but no secular increase in fractures due to moderate trauma (~ osteoporosis). Since fractures attributed to severe trauma comprised a greater proportion of the total in men (52%) than women (21%), an overall doubling of age-adjusted forearm fracture incidence in men between 1945 and 1994 was statistically significant ($p < 0.001$), but the 7% increase in age-adjusted rates among women was not ($p = 0.90$). While the epidemiological pattern of distal forearm fracture incidence in Rochester was similar to that seen elsewhere, the overall incidence rate of 287.4 per 100 000 person-years (95% CI 267.7–307.1) in 1985–94 was less than current rates in Sweden, presumably because the great increase in distal forearm fracture incidence seen, for example, in Malmö between 1953–57 and 1980–81 was not observed in Rochester. The trends in distal forearm fracture rates in Rochester men and women over the past 50 years are broadly consistent with trends in hip fracture incidence in this community over the same time span.

Keywords: Distal forearm (wrist) fracture; Epidemiology; Incidence; Osteoporosis; Secular trends

Introduction

Despite numerous reports that hip fractures are increasing faster than can be accounted for by aging of the population [1], age-adjusted incidence rates for proximal femur fractures in Rochester, Minnesota, have been more or less stable in recent years [2]. Age-adjusted rates increased dramatically among Rochester women between 1928 and 1950 only to fall slowly thereafter; rates in Rochester men rose steadily until 1980 but have since declined. Like the reported increases in hip fracture incidence, others have reported rising incidence rates for distal forearm fractures as well as for fractures of the proximal humerus, patella, proximal tibia and ankle [3–5]. For wrist fractures, specifically, there was almost a doubling of the incidence rates between 1953–57 and 1980-81 in Malmö, Sweden [6]. By contrast, in an earlier study in Rochester, we found no change in the incidence of distal forearm fractures between 1945 and 1974 [7]. Likewise, Lauritzen and colleagues saw no change in forearm fracture incidence in Copenhagen, Denmark between 1976 and 1984 [8]. However, the situation has not been reassessed in recent years despite growing concern about the societal impact of osteoporotic fractures, including those of the distal forearm [9,10]. Indeed, the lifetime risk of a distal forearm fracture in white women, about 15%, is as great as that for a hip fracture or a clinically evident vertebral fracture [11,12], and one recent study estimated expenditures for the care of distal forearm fractures in the United States in 1995 at $385 million [13]. The purpose of this report is to extend the previous study of distal forearm fractures in Rochester through 1994 in order to assess secular trends in incidence over an entire half-century.

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Methods

Population-based epidemiological research can be conducted in Rochester, Minnesota because medical care is virtually self-contained within the community and 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 in the community (St. Marys and Rochester Methodist) for the past 90 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. Medical records of the other providers who serve the local population, most notably the Olmsted Medical Group and its affiliated Olmsted Community Hospital, are also indexed and retrievable. Thus, the details of almost all the medical care provided to the residents of Rochester are available for study [14].

Using this unique database (the Rochester Epidemiology Project), we identified all distal forearm (wrist) fractures that occurred among Rochester residents age 35 years old and over during the 50-year period, 1945 through 1994. Less than 20% of patients with this condition are hospitalized [15], but it was possible in our data system to identify those treated solely on an outpatient basis. The complete (inpatient and outpatient) medical records were reviewed for all local residents with any diagnosis attributable to diagnostic rubrics 813.4 and 813.5 in the International Classification of Diseases, Ninth Revision, Clinical Modification [16]. All fractures were radiographically confirmed, but the original radiographs were not available for review. Fractures were also classified according to etiology: those caused by a specific pathological process (e.g. metastatic malignancy), those resulting from severe trauma (e.g. motor vehicle accidents or falls from greater than standing height) and those due to moderate trauma (by convention, falls from standing height or less).

Incidence rates were estimated separately for the people affected by their first distal forearm fracture during the study period (first fractures) and for all forearm fracture events that occurred (all fractures). In calculating incidence rates, the entire population of Rochester age 35 years and over was considered to be at risk. Denominator age- and sex-specific person-years (p-y) were estimated from decennial census data with linear interpolation between census years [17]. In order to obtain some sense of variability, it was assumed that, given a fixed number of person-years, the number of fracture cases follows a Poisson distribution. This allowed for the estimation of standard errors and the calculation of 95% confidence intervals (95% CI) for the incidence rates. Overall rates were directly age and/or age–sex adjusted to the population distribution of United States whites in 1990. The standard errors and confidence intervals for the adjusted rates are based on the same assumption as above. The relationships of crude incidence rates to age, sex and calendar year of fracture were assessed using generalized linear models assuming a Poisson error structure [18]. Such models fit the natural logarithms of the crude incidence rates as linear combinations of gender, age group and year using the SAS procedure, GENMOD.

Results

Over the 50-year period covered by this study, 2464 Rochester residents age 35 years or older experienced 2786 fractures of the distal forearm for an overall age- and sex-adjusted (to 1990 United States whites) incidence rate for all fractures of 279.6 per 100 000 p-y (95% CI 269.3–290.2). The 2346 fractures in women outnumbered the 440 fractures in men for a female:male ratio of age-adjusted incidence rates for all fractures of 4:1 (416.1 per 100 000 p-y (95% CI 399.2–433.1) for women vs 104.8 per 100 000 p-y (95% CI 94.7–114.8) for men). Over 98% of the subjects were white, in keeping with the racial composition of the community. Their mean age at the time of fracture was 63.6 years (65.1 years for women and 55.4 years for men). The difference in ages reflects the fact that overall fracture rates among women increased dramatically between age 45 and 64 years and then levelled off before rising again among women age 85 years and over; rates in men, on the other hand, exhibited no strong trend with age (Table 1). Altogether, 2414 events represented the first distal forearm fracture that the patient had experienced (excluding fractures that occurred prior to age 35 years), while 372 were recurrences. One hundred and ten (30%) of the recurrences were in the same wrist as the initial fracture and 262 (70%) were in the contralateral wrist. Altogether, 1327 (48%) distal forearm fractures were in the right wrist and 1452 (52%) were in the left; the site of fracture was uncertain in seven cases. Two hundred and sixty-two patients had two separate fractures, while 33 patients had three, three patients had four, and one individual had five different forearm fractures. The overall age- and sex-adjusted incidence of first fractures alone was 241.4 per 100 000 p-y (95% CI 231.7–251.1).

Altogether, 718 (26%) of the fractures were attributed to severe trauma. Severe trauma accounted for 52% of the distal forearm fractures in men (228 of 440) but only 21% of those in women (490 of 2346). Nonetheless, the incidence of all fractures due to severe trauma was greater ($p < 0.001$) in women (88.3 per 100 000 p-y; 95% CI 80.5–96.2) than in men (50.6 per 100 000 p-y; 95% CI 43.9–57.3). The causes of these fractures were surprisingly similar for women and men, respectively, and included motor vehicle accidents (10% vs 12%), falls from greater than standing height (56% vs 47%), recreational activities (26% vs 29%) and miscellaneous circumstances (6% vs 9%); the cause was uncertain for 2% of the fractures in women and 3% of those in men. The remaining 2068 (74%) distal forearm fractures were due to moderate trauma as defined in methods. Unlike vertebral fractures, for example, no forearm fractures occurred ‘spontaneously’ in conjunction with the activities of daily living, and none was attributed

Table 1. Incidence of all distal forearm fractures among Rochester, Minnesota men and women by decade, 1945–94

Age group (years)	1945–54 *n*	1945–54 Rate[a]	1945–54 95% CI	1955–64 *n*	1955–64 Rate[a]	1955–64 95% CI	1965–74 *n*	1965–74 Rate[a]	1965–74 95% CI	1975–84 *n*	1975–84 Rate[a]	1975–84 95% CI	1985–94 *n*	1985–94 Rate[a]	1985–94 95% CI	1945–94 *n*	1945–94 Rate[a]	1945–94 95% CI
Men																		
35–44	7	41.2	16.6–84.8	10	46.2	22.1–84.9	21	76.9	47.6–117.5	35	104.5	72.8–145.4	45	90.1	65.7–120.6	118	79.0	65.4–94.6
45–54	16	110.7	63.3–179.8	10	57.3	27.5–105.3	29	133.3	89.3–191.4	35	142.1	99.0–197.7	36	113.0	79.1–156.4	126	114.4	95.3–136.2
55–64	8	70.3	30.4–138.6	7	53.0	21.3–109.3	21	128.8	79.7–196.9	27	138.8	91.4–201.9	27	116.5	76.8–169.5	90	107.8	86.7–132.5
65–74	3	46.2	9.5–134.9	10	110.6	53.1–203.5	16	154.8	88.5–251.4	9	75.4	34.5–143.1	19	119.9	72.2–187.3	57	106.2	80.5–137.7
75–84	2	77.3	9.4–279.4	4	111.9	30.5–286.6	8	147.4	63.7–290.5	13	204.7	109.0–350.1	13	160.5	85.4–274.4	40	153.6	109.8-0-209.2
⩾85	0	0	0–760.5	0	0	0–446.6	0	0	0–284.9	4	227.1	61.9–581.6	5	189.4	61.5–442.0	9	128.4	58.7–243.8
Subtotal[b]	36	64.6	42.6–86.6	41	65.2	44.6–85.7	95	115.8	92.1–139.6	123	127.0	104.0–150.0	145	114.2	95.1–133.3	440	104.8	94.7–114.8
Women																		
35–44	26	122.9	80.3–180.1	21	88.5	54.8–135.4	35	125.5	87.4–174.5	35	99.4	69.2–138.2	70	131.0	102.1–165.5	189	115.9	99.8–133.7
45–54	52	280.3	209.3–365.5	62	286.1	219.4–366.8	79	318.2	251.9–396.5	73	274.7	215.3–345.3	92	268.4	216.3–329.1	358	284.3	255.6–315.4
55–64	89	627.5	503.9–772.2	110	592.0	486.6–713.6	140	623.6	524.5–735.8	140	598.7	503.7–706.5	157	605.3	514.4–707.8	636	608.4	562.0–657.6
65–74	71	753.2	588.2–950.0	71	535.2	418.0–675.1	139	781.7	657.1–923.0	158	775.8	659.6–906.6	148	671.0	567.3–788.3	587	708.1	652.0–767.8
75–84	17	398.1	231.9–637.4	36	505.1	353.8–699.3	75	659.2	518.5–826.3	117	785.8	649.9–941.8	147	811.3	685.5–953.6	392	702.7	634.9–775.9
⩾85	6	604.2	221.7–1315	19	1042.8	627.8–1628	24	663.0	424.8–586.5	55	908.6	684.5–1183	82	864.1	687.2–1072	186	846.3	729.0–977.1
Subtotal[b]	261	393.3	344.3–442.3	319	363.9	323.5–404.3	492	432.1	393.7–470.4	578	427.7	392.4–463.0	696	421.3	389.2–453.5	2346	416.1	399.2–433.1
Total[c]	297	246.1	216.7–275.5	360	232.6	207.9–257.4	587	292.7	268.8–316.5	701	297.5	275.3–319.6	841	287.4	267.7–307.1	2786	279.7	269.3–290.2

[a]Incidence per 100 000 person-years.
[b]Incidence per 100 000 person-years directly age-adjusted to the population structure of 1990 United States whites.
[c]Incidence per 100 000 person-years directly age- and sex-adjusted to the population structure of 1990 United States whites.

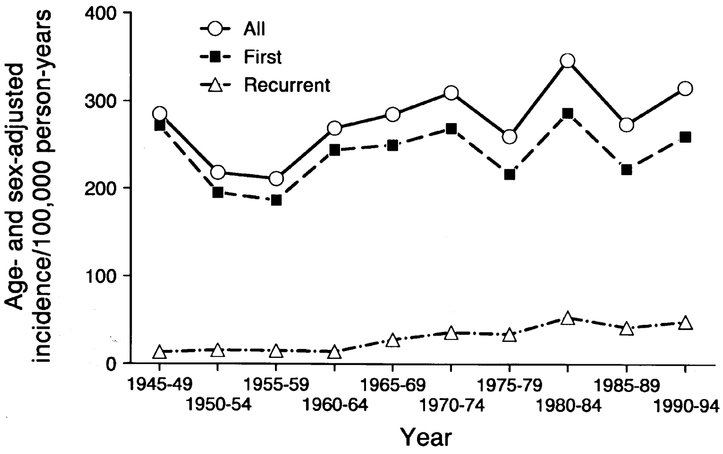

Fig. 1. Age- and sex-adjusted incidence of first, recurrent and all distal forearm fractures among Rochester, Minnesota residents, by time period, 1945–94.

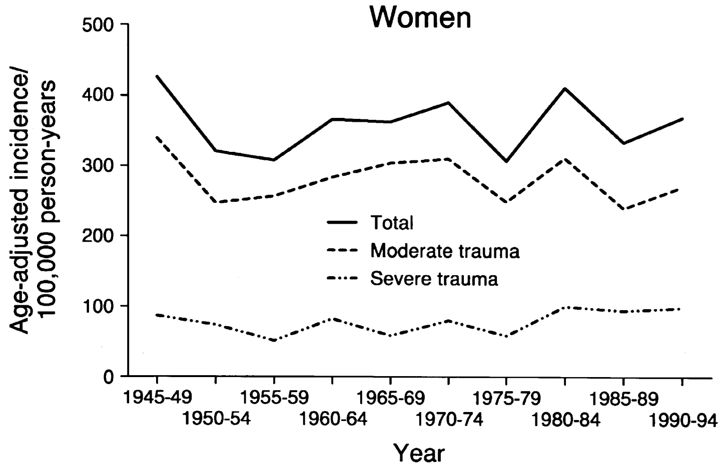

Fig. 2. Age-adjusted incidence of first distal forearm fractures among Rochester, Minnesota women, by time period and degree of trauma, 1945–94.

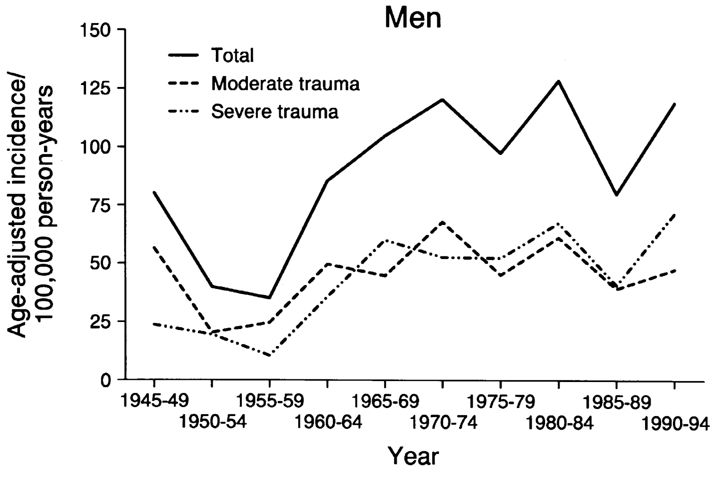

Fig. 3. Age-adjusted incidence of first distal forearm fractures among Rochester, Minnesota men, by time period and degree of trauma, 1945–94.

primarily to a specific local pathological process in bone of the affected wrist. Instead, they were all attributed to falls from standing height or less. The incidence of all fractures due to moderate trauma in men (54.1 per 100 000 p-y; 95% CI 46.6–61.6) was equivalent to the incidence of severe trauma fractures in men and much less than the incidence of moderate trauma fractures in women (327.4 per 100 000 p-y; 95% CI 312.4–342.5). The overall age- and sex-adjusted incidence of severe trauma fractures was 71.7 per 100 000 p-y (95% CI 66.4–76.9) compared with 207.9 per 100 000 p-y (95% CI 198.9–217.0) for distal forearm fractures due to moderate trauma.

The number of distal forearm fractures rose over the study period, from 159 in 1945–49 to 475 in 1990–94. However, the population of Rochester was also rising,

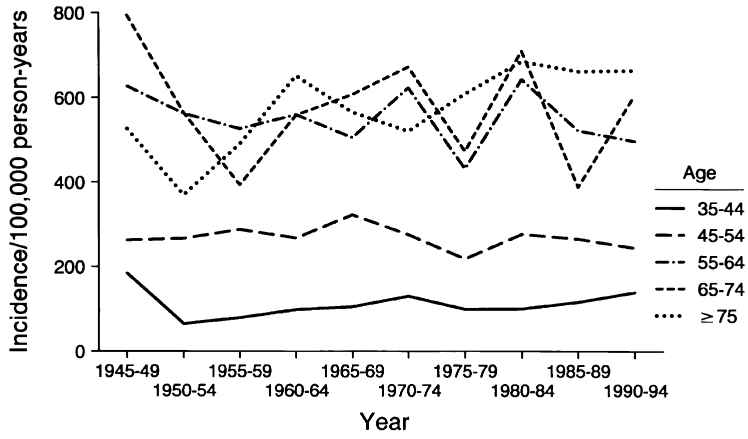

Fig. 4. Age-specific incidence of first distal forearm fractures among Rochester, Minnesota women, by time period, 1945–94.

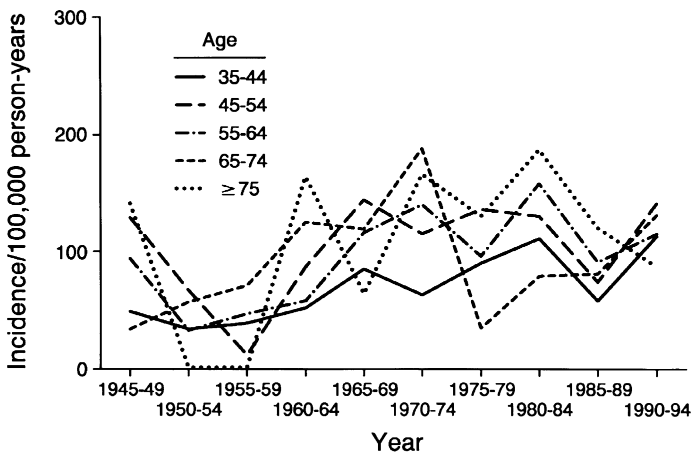

Fig. 5. Age-specific incidence of first distal forearm fractures among Rochester, Minnesota men, by time period, 1945–94.

from 9664 people aged 35 years old and over in the 1940 census to 29 632 in 1990. When the demographic changes in the underlying population were taken into account by age-adjusting the rates, there was a slight increase in the incidence of forearm fractures by decade (Table 1). The overall age- and sex-adjusted incidence rose at the rate of 0.5% per year ($p < 0.001$). There were modest but statistically significant ($p < 0.001$) increases in the incidence both of recurrent fractures and of first distal forearm fractures (Fig. 1). The overall age- and sex-adjusted incidence of first forearm fractures was 260.6 per 100 000 p-y in 1990–94 (95% CI 234.7–286.6) compared to 271.6 per 100 000 p-y in 1945–49 (95% CI 225.1–318.1). Trends in first distal forearm fractures are shown separately for women and men in Figs 2 and 3. There was a significant increase over time in total age-adjusted rates for men ($p < 0.001$) but not for women ($p = 0.90$). This discrepancy was due to the greater relative contribution in men of first fractures due to severe trauma, which increased significantly ($p < 0.001$) in both women and men. Conversely, there was no significant increase in either gender of first fractures due to moderate trauma. It was difficult to discern any consistent trend in age-specific incidence rates for first fractures in women, except perhaps for an increase over time among those 75 years of age or older (Fig. 4). The secular increase in the incidence of first fractures among men seemed to be reflected in all age groups (Fig. 5).

Discussion

In contrast to the report by Bengnér and Johnell [6] that the overall incidence of distal forearm fractures almost doubled in Malmö between 1953–57 and 1980–81, we found only a modest 17% rise in incidence between the first decade of our study and the last, although the increase over time was statistically significant given the large number of cases. Comparably age- and sex-adjusted to the population structure of United States whites in 1990, our estimated annual incidence for 1945–54 (246 per 100 000) resembled Malmö rates in 1953–57 (207 per 100 000) from an earlier report [19]. However, the annual incidence of distal forearm fractures in Rochester in 1975–84 (297 per 100 000) was only about two-thirds of the rate in Malmö in 1980–81 (482 per 100 000) or a similarly high annual rate of 411 per 100 000 in Stockholm in 1981–82 [20]. Thus, the greater forearm fracture rates in Malmö seem due to a dramatic increase in incidence that was not seen in Rochester. Indeed, age- and sex-adjusted Rochester rates for the subsequent decade, 1985–94, were slightly lower at 287 per 100 000 p-y, but rates in Uppsala, Sweden in 1989–90 were still high at 416 per 100 000 per year [21]. We did see a more substantial increase in distal forearm fracture incidence in men, where age-adjusted rates doubled in Rochester between 1945–54 and 1975–84 before falling again in 1985–94. This increase is consistent with our finding that age-adjusted hip fracture incidence rates in Rochester men rose 46% between 1943–52 and 1973–82 [2]. Hip fracture rates in Rochester women declined 16% between 1953–62 and 1983–92 in contrast to the 7% increase in forearm fracture incidence between 1945–54 and 1985–94 seen here. Like others [22], we have found no evidence of an increase in the incidence of vertebral fractures in Rochester in recent years [23].

This study confirms the very different epidemiological pattern of distal forearm fractures compared with fractures of the hip or spine [24]. As in most similar investigations [25–34], we observed a rapid rise in the incidence of forearm fractures with age in women up to about 10 years past the menopause, with a slowing of the age-related increase thereafter. Consequently, the incidence of distal forearm fractures in elderly women is much lower than that of hip or spine fractures [24]. In Rochester women 85 years of age and older, for example, the incidence of hip fractures was 2741 per 100 000 p-y [2] and the incidence of clinically evident vertebral fractures was 1214 per 100 000 p-y [35] compared with a rate for distal forearm fractures in this age group of only 864 per 100 000 p-y in recent years. The perimenopausal increase in distal forearm fracture rates has been attributed both to a reduction in bone strength caused by cortical porosity and trabecular perforation that develop with the accelerated phase of bone loss at the menopause [36] and to a sharp increase in the likelihood of falling at the same period in life [37]. There is no convincing explanation for the subsequent plateau in forearm fracture incidence, which has been blamed on the loss of protective reflexes with a resulting reduction in the tendency to break falls with an outstretched arm [38]. It is not clear how this explanation might relate to the high incidence of forearm fractures among the oldest women as seen here and in some other studies [6,21,39–41]. Even among elderly women, distal forearm fractures are associated with falling on the hand or wrist [42].

With a few exceptions in low-risk populations [43,44], the incidence of distal forearm fractures is much lower in men compared with women [24]. In Rochester, age-adjusted incidence rates in women were 4 times higher than those in men. The explanation for this is not completely clear. Men have a substantial risk of falling each year, although it is less than that in women [37]. Between ages 35 and 84 years, about 20% of men report having fallen in the previous year, and this rises to about a third of men age 85 years and over. Likewise, men lose bone from the distal forearm with aging like women do, although peak bone mass is greater in men and age-related bone loss less pronounced [45]. In Malmö, for example, women lost 30% of their bone density at the 1 cm site in the distal radius between age 50 and 80 years; men lost only 14% over this age span and, at 80 years, their bone density values were 80% higher [46]. In addition, the relationship between areal bone density (g/cm^2) and fracture risk in men is not as strong as it is in women [47–50]. This may relate to sex-specific differences in bone geometry [51,52] since volumetric bone density measurements (g/cm^3) predict fractures similarly in women and men [53]. Nonetheless, because of their higher bone mass, there is a lesser contribution from fractures due to moderate trauma (~ osteoporosis) in men, and fractures caused by severe trauma make up a greater proportion of the total – in this study 52% versus 21% in women. This has also been seen in other studies [6,25]. We have no explanation, however, for the apparent increase in fractures due to severe trauma in men over time.

A limitation of this study is the generalizability of these data from a small Midwestern community that is predominantly white (96% in 1990) and better educated than the white population of the United States [14]. Thus, there is evidence of variation in distal forearm fracture incidence by race; forearm fractures seem to be less frequent in populations of African or Asian heritage [34,43,44,54–56], although there is some evidence of recent increases [57] as seen also for hip fractures [58]. This issue could not be addressed in Rochester, where the non-white population is very small. However, the overall age- and sex-adjusted incidence of hip fractures among local residents age 50 years and older (385 per 100 000 p-y) is very close to the comparably adjusted rate (394 per 100 000) reported for United States whites generally [59]. Age-adjusted to the total population of the United States in 1990, the incidence of distal forearm fractures among Rochester residents 65 years of age or older in this study was 494 per 100 000 p-y in 1985–94. This is somewhat higher than the annual rate of 396 per 100 000 p-y reported for whites from the Medicare population in 1991–92 [56]. However, the Medicare data excluded persons with previous fractures, and case ascertainment from that source is probably not as complete as in Rochester [60]. Taking this into account, the Rochester data are probably not out of line for United States whites generally.

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