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# Epidemiology of fractures in 15 000 adults

## THE INFLUENCE OF AGE AND GENDER

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**We report a prospective study of the incidence of fractures in the adult population of Edinburgh, related to age and gender. Over a two-year period, 15 293 adults, 7428 males and 7865 females, sustained a fracture, and 5208 (34.0%) required admission.**

**Between 15 and 49 years of age, males were 2.9 times more likely to sustain a fracture than females (95% CI 2.7 to 3.1). Over the age of 60 years, females were 2.3 times more likely to sustain a fracture than males (95% CI 2.1 to 2.4). There were three main peaks of fracture distribution: the first was in young adult males, the second was in elderly patients of both genders, mainly in metaphyseal bone such as the proximal femur, although diaphyseal fractures also showed an increase in incidence. The third increase in the incidence of fractures, especially of the wrist, was seen to start at 40 years of age in women.**

**Our study has also shown that 'osteoporotic' fractures became evident in women earlier than expected, and that they were not entirely a postmenopausal phenomenon.**

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In 1832 Astley Cooper recognised the effects of ageing on the skeleton,[1] and Bruns in 1882[2] discussed the influence of age and gender on the incidence of various types of fracture. Any accurate epidemiological study of fractures is difficult:[3] data from hospital coding systems[4,5] are likely to be less than 80% accurate.[6,7]

Buhr and Cooke[8] reported the fracture patterns of patients admitted to the Radcliffe Infirmary, Oxford, between 1938 and 1955, but they used demographic figures for England and Wales, not just Oxford, to calculate age-specific rates. A report by an MRC working party on fractures in the elderly for 1954 to 1958[9] corrected some methodological problems, but considered only patients over 35 years of age. The age-specific incidence of proximal femoral and femoral shaft fractures is reported to have been increasing since the 1950s and 1960s,[10,11] and a similar increase in the incidence of wrist fractures has also been observed.[12]

There appear to be no similar contemporary British studies, since most reports have concentrated on 'age-related' or 'osteoporotic' fractures, such as those of the distal forearm,[13] the vertebrae[14] and the proximal femur.[10,15,16]

## Patients and Methods

We began a prospective study of adult patients sustaining a fracture in January 1992. This was made possible because all adult fractures in Edinburgh and the surrounding district are managed at the Royal Infirmary. The catchment population for 1992 and 1993 was 595 600 and Table I shows the details of age and gender. All fracture patients attending the Accident and Emergency Service were either admitted or referred to a fracture clinic. Patients with soft-tissue injuries, dislocations and tertiary referrals were excluded. Those over 95 years of age were not considered further due

**Table I.** Mean populations at risk for 1992 to 1993 by age and gender

| Age group (yr) | Male | Female |
|---|---|---|
| 15 to 19 | 26724 | 26180 |
| 20 to 24 | 23854 | 22675 |
| 25 to 29 | 33446 | 31418 |
| 30 to 34 | 29483 | 28372 |
| 35 to 39 | 25536 | 25448 |
| 40 to 44 | 26338 | 26773 |
| 45 to 49 | 20896 | 21416 |
| 50 to 54 | 19714 | 20775 |
| 55 to 59 | 18239 | 19949 |
| 60 to 64 | 17123 | 19826 |
| 65 to 69 | 15791 | 19390 |
| 70 to 74 | 10867 | 15875 |
| 75 to 79 | 8555 | 14701 |
| 80 to 84 | 4871 | 10750 |
| 85 to 89 | 1811 | 5795 |
| 90 to 94 | 469 | 2558 |

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Fig. 1

The incidence of all fractures per 10 000 population per annum related to age and gender.


Fig. 2

The incidence of hip fractures per 10 000 population per annum related to age and gender.

to the small numbers involved. Demographic details, the cause of injury, injury classification and treatment were recorded prospectively on a computer database for subsequent analysis.

We tested the validity of the data by comparing the computer details of all admissions for one month, chosen at random, against ward admission registers and clinical records.

For each of the five-year age groups and each gender we calculated the numbers with and without fractures and derived average annual age and gender-specific incidences. Odds ratios were calculated from these figures, with 95% confidence intervals (CI) to establish the significance of differences. When the odds ratios for our small age groups were homogenous, we calculated the Mantel-Haenszel[17] common odds ratio across wider age groups such as 60 to 94 years. The homogeneity of odds ratios was determined by means of the Breslow and Day[18] test, a significant Breslow statistic ($p < 0.1$) indicating evidence of heterogeneity. Statistical computations were performed using StatXact ((c) 1989 Cytel Software Corporation).

## Results

During the two-year period, 15 293 adults, 7428 (48.6%) males and 7865 (51.4%) females, sustained 16 432 fractures; 534 (3.5%) sustained more than one fracture. A total of 5208 (34.0%) adults was admitted, 2148 (41.2%) males and 3060 (58.8%) females. The other 10 085 (66.0%), including 5280 (52.4%) males and 4805 (47.6%) females, had outpatient treatment. The age- and gender-specific incidences of all fractures are shown in Figure 1.

There was a higher incidence of fractures in men than women in all age groups from 15 to 49 years. The total male incidence is bimodal, with peaks at 20 to 24 years and 90 to 94 years. Females have a smaller peak from 20 to 24 years, with a steady increase later from 46 at 40 to 44 years to 774 per 10 000 population per annum in females aged 90 to 94 years.

Under the age of 35 years males are 2.9 times more likely to sustain a fracture than females (95% CI 2.7 to 3.1). Over the age of 60 years, females are 2.3 times more likely to sustain a fracture (95% CI 2.1 to 2.4).


Fig. 3

The incidence of vertebral fractures per 10 000 population per annum related to age and gender.


Fig. 4

The incidence of wrist fractures per 10 000 population per annum related to age and gender.

As regards hip fractures there was no significant gender difference from 15 to 60 years, with zero to five cases per 10 000 population per annum. Over 60 years the incidence rose in both genders and the common odds ratio from 60 to 94 years was 1.9 more for females (95% CI 1.7 to 2.2; Fig. 2).

Pelvic fractures showed a similar pattern with an overall incidence of 0 and 3 cases per 10 000 population per annum from 15 to 59 years. After this age the female incidence rose from 3 to 67 cases per 10 000 population per annum, and the male incidence from 1 to 17 cases, giving an odds ratio of 2.7 (95% CI 1.8 to 4.0).

The incidence of vertebral fractures is shown in Figure 3. They were more common in males than females under 55 years, but after this the apparent difference is statistically unreliable.

The incidence of wrist fractures is shown in Figure 4. Under 40 years, these are 1.4 times more likely in males (95% CI 1.1 to 1.7), but after this there is an almost linear rise for females of about 10 cases per 10 000 population per five-year group. For the age groups 40 to 94 years the Breslow and Day test showed that the odds ratios were not homogenous and a common odds ratio could not be calculated. For the age range 60 to 94 years, there was borderline evidence of heterogeneity ($p = 0.07$) with a common odds ratio of 6.2 (95% CI 5.1 to 7.5). The age range 70 to 94 years showed homogeneity ($p = 0.29$) with a common odds ratio of 5.2 (95% CI 4.1 to 6.5).

The incidence of diaphyseal fractures is shown in Table II. For fractures of the humeral shaft there was no obvious gender difference, with relatively constant rates between 15 and 64 years at about 0 and 2 per 10 000 per annum. After 65 years the rates rose. Variability in the rates prevented the calculation of a common odds ratio.

The incidence of forearm fractures was generally low (at 0 to 4 per 10 000 population per annum), but consistently higher for males from 15 to 44 years with a common odds ratio of 5.4 (95% CI 3.2 to 9.0). Variability in the rates in the older age groups prevented the calculation of a common odds ratio.

The incidence of femoral and tibial shaft fractures is shown in Figure 5. In both the rates are greatest in both the young (15 to 34 years) and the elderly (over 70) age groups.

**Table II.** The incidence of diaphyseal fractures per 10 000 population per annum related to age and gender

| Age (yr) | Humerus | | Forearm | | Femur | | Tibia | |
|---|---|---|---|---|---|---|---|---|
| | M | F | M | F | M | F | M | F |
| 15 to 19 | 1.31 | 0.38 | 4.49 | 0.76 | 3.55 | 0.57 | 8.14 | 1.90 |
| 20 to 24 | 1.26 | 0.66 | 3.14 | 0.66 | 3.56 | 0.88 | 5.88 | 3.52 |
| 25 to 29 | 1.20 | 0.32 | 2.24 | 0.16 | 1.64 | 0.64 | 6.00 | 2.56 |
| 30 to 34 | 0.85 | 0.70 | 2.71 | 0.70 | 3.73 | 0.18 | 6.12 | 0.35 |
| 35 to 39 | 0.78 | 0.98 | 3.33 | 0.98 | 0.39 | 0.20 | 2.73 | 2.34 |
| 40 to 44 | 0.19 | 1.87 | 1.33 | 0.00 | 0.57 | 0.37 | 0.76 | 1.11 |
| 45 to 49 | 0.24 | 0.47 | 0.24 | 0.47 | 0.72 | 0.47 | 3.36 | 3.29 |
| 50 to 54 | 0.25 | 0.48 | 2.03 | 0.00 | 0.76 | 1.20 | 3.57 | 1.92 |
| 55 to 59 | 0.55 | 1.50 | 0.27 | 0.50 | 0.27 | 0.25 | 1.65 | 1.50 |
| 60 to 64 | 1.46 | 1.01 | 0.29 | 1.77 | 0.00 | 1.01 | 0.58 | 1.50 |
| 65 to 69 | 0.32 | 1.55 | 0.32 | 0.52 | 0.00 | 1.81 | 3.78 | 1.04 |
| 70 to 74 | 1.84 | 3.78 | 0.46 | 3.15 | 2.30 | 3.15 | 4.60 | 5.04 |
| 75 to 79 | 1.17 | 4.76 | 0.58 | 0.68 | 0.58 | 3.74 | 1.17 | 2.04 |
| 80 to 84 | 3.08 | 1.40 | 1.03 | 1.86 | 4.11 | 10.70 | 2.05 | 1.86 |
| 85 to 89 | 5.52 | 4.31 | 0.00 | 4.31 | 2.76 | 16.39 | 11.04 | 6.90 |
| 90 to 94 | 10.66 | 7.82 | 0.00 | 1.95 | 0.00 | 37.14 | 21.32 | 11.72 |

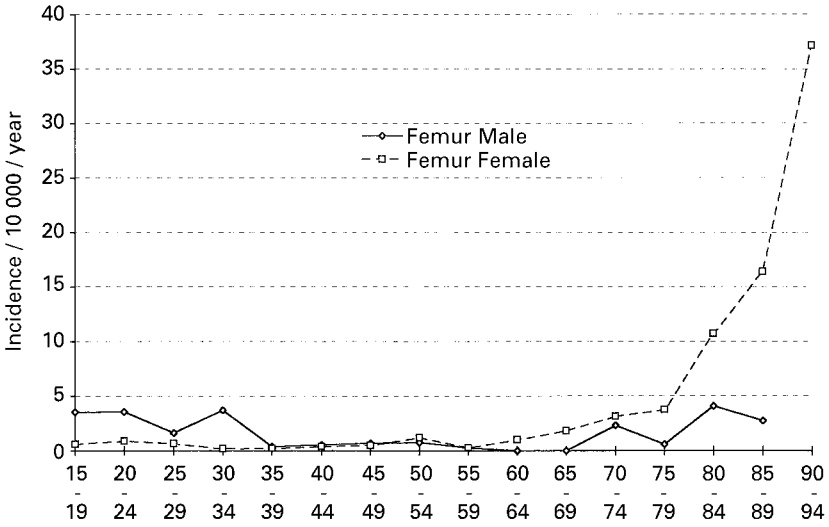


Fig. 5a

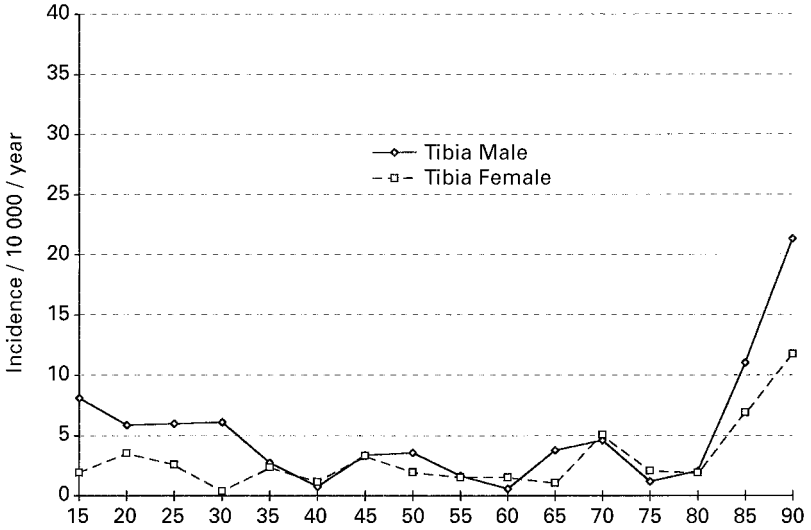


Fig. 5b

The incidence of fractures of the femoral (a) and tibial (b) shaft, per 10 000 population per annum related to age and gender.

The incidence of metaphyseal fractures is shown in Table III. There are minor gender differences in the rates of elbow or knee fractures, but ankle fractures are more common in young men. In the elderly, both ankle and proximal humeral fractures are more common in women. Heterogeneity in the incidence rates, however, prevented the calculation of common odds ratios.

Shaft (diaphyseal) fractures were more common than end (metaphyseal) fractures only in the femur in young adults. End fractures were more common than shaft fractures in the forearm and tibia in all age groups, and in the humerus and femur after the age of 35 years.

Although common, hand and foot fractures are not presented due to the wide range of fractures in each region.

Audit of 356 consecutive admissions showed that 12 (3.4%) had not been coded and the details of 10 (2.8%) had been miscoded. The total error rate in this sample was therefore 6.2%.

## Discussion

We report the incidence of fractures in a well-defined adult population in the United Kingdom, and recognise that the quality of the collected data is important. We believe that our accuracy compares favourably with that of other orthopaedic data collection systems,[19] with the exception of that on vertebral fractures. Osteoporotic fractures are often asymptomatic, with difficulties in their radiological definition, and there have been few epidemiological studies.[20,21] The incidence of osteoporotic vertebral fractures recorded in our series is lower than in other reported studies,[14,22] probably because many such patients are managed in the community without reference to the orthopaedic trauma service.

In general, our findings on age and gender incidence agree with those of other observers,[8,9,23] but there are some differences. The incidence of fractures in elderly men is only about half that in women, but they are a significant cause of morbidity. We have confirmed that the burden of osteoporotic fractures in men is greater than had been appreciated in the past.[22]

The steep rise in the incidence of wrist fractures, in women only, began as early as 45 years of age with smaller increases in proximal humeral and ankle fractures. None of these increases was seen in men. Riggs and Melton,[24] using unpublished data, describe a similar pattern, but with an increase only after 50 years of age and considered it to be due to postmenopausal (type 1) involutional osteoporosis. Other reports by Alffram and Bauer,[2] Knowelden et al[9] and Miller and Evans[13] confirm the steep rise in the incidence in women after the age of 40 years. The median age of the menopause is 50 years, with 45 and 55 years as approximate 95% confidence limits.[25] We therefore believe that the earlier increase in the incidence of wrist, vertebral, proximal humeral and ankle fractures should not be regarded as simply postmenopausal.

The incidence of hip fractures showed a similar pattern in both genders, being uncommon in the young, with an exponential increase from the age of 65 years. The absolute male incidence, however, lags behind the female by approximately ten years. There are three interacting factors: bone strength, the risk of falling, and the efficiency of neuromuscular responses which protect the skeleton. In the age group 50 to 74 years, Cooper et al[26] found that reduced bone mass was a strong independent risk factor for hip fracture, but that over 75 years, osteoporosis may be less important than impairment of protective neuromuscular responses.

The epidemiology of diaphyseal fractures has been less well studied. Shaft fractures of cortical bone are considered to be associated with severe trauma, therefore having a different age incidence than cancellous bone fractures.[2,24,27] Jensen et al,[28] excluding the humerus and distal forearm, reported that diaphyseal injuries were not associated with a decrease in bone mass or the earlier onset of the menopause.

**Table III.** Incidence of metaphyseal fractures per 10 000 population per annum related to age and gender

| Age (yr) | Proximal humerus | | Elbow | | Wrist | | Hip | | Knee | | Ankle | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | M | F | M | F | M | F | M | F | M | F | M | F |
| 15 to 19 | 2.62 | 0.57 | 9.92 | 5.16 | 22.08 | 9.36 | 0.75 | 0.38 | 0.19 | 0.57 | 28.34 | 15.16 |
| 20 to 24 | 0.84 | 1.10 | 15.93 | 8.38 | 23.90 | 10.36 | 0.63 | 1.32 | 1.89 | 2.21 | 20.75 | 12.35 |
| 25 to 29 | 1.05 | 0.64 | 8.97 | 3.18 | 10.91 | 6.21 | 1.20 | 0.48 | 0.90 | 0.48 | 12.11 | 6.68 |
| 30 to 34 | 1.70 | 0.35 | 5.09 | 2.64 | 10.34 | 8.64 | 2.54 | 0.18 | 0.17 | 1.06 | 12.89 | 3.35 |
| 35 to 39 | 2.74 | 1.18 | 4.50 | 4.52 | 9.01 | 7.27 | 0.39 | 0.59 | 1.37 | 0.79 | 10.96 | 4.91 |
| 40 to 44 | 1.33 | 1.68 | 5.13 | 3.74 | 9.11 | 6.54 | 0.95 | 0.75 | 0.57 | 0.56 | 9.87 | 7.10 |
| 45 to 49 | 4.31 | 3.97 | 5.50 | 4.20 | 9.33 | 16.58 | 4.31 | 3.50 | 0.96 | 0.70 | 10.53 | 8.87 |
| 50 to 54 | 3.30 | 5.78 | 2.28 | 8.66 | 10.40 | 25.51 | 2.03 | 4.09 | 2.54 | 0.96 | 9.89 | 15.88 |
| 55 to 59 | 5.21 | 8.52 | 5.48 | 12.28 | 6.03 | 37.35 | 5.48 | 5.01 | 1.10 | 2.51 | 7.13 | 18.30 |
| 60 to 64 | 5.55 | 13.62 | 4.67 | 8.83 | 6.13 | 46.66 | 4.96 | 8.32 | 0.29 | 2.02 | 7.30 | 16.39 |
| 65 to 69 | 7.60 | 12.64 | 5.38 | 8.25 | 6.33 | 57.25 | 11.40 | 15.73 | 1.27 | 2.84 | 6.65 | 19.86 |
| 70 to 74 | 11.96 | 24.57 | 4.14 | 10.39 | 16.10 | 69.92 | 28.53 | 48.50 | 1.84 | 2.20 | 6.44 | 19.53 |
| 75 to 79 | 4.68 | 30.61 | 2.92 | 11.22 | 9.35 | 69.72 | 29.81 | 70.74 | 4.09 | 3.40 | 7.60 | 11.22 |
| 80 to 84 | 12.32 | 37.21 | 8.21 | 10.70 | 17.45 | 74.88 | 70.83 | 143.72 | 2.05 | 3.26 | 7.19 | 9.77 |
| 85 to 89 | 16.57 | 36.24 | 2.76 | 12.08 | 13.80 | 100.09 | 132.52 | 276.10 | 0.00 | 5.18 | 13.80 | 13.81 |
| 90 to 94 | 0.00 | 39.09 | 42.64 | 17.59 | 31.98 | 91.87 | 223.88 | 385.07 | 0.00 | 1.95 | 0.00 | 19.55 |

We found that diaphyseal fractures of the forearm, femur and tibia all had a peak incidence in young men (15 to 34 years), but only in the femur were they more common than metaphyseal fractures. In elderly women, diaphyseal fractures became increasingly common, reaching an incidence equal to, or even greater than that in young men. The patterns of incidence were very similar to those for osteoporotic metaphyseal injuries, especially for the femur.

It has been reported that the incidence of humeral shaft fractures[29] and forearm shaft fractures[12] did not increase with age, but an association between femoral shaft fractures and increasing age has recently been described.[11,27]

We found an increase in recognised 'osteoporotic' fractures in women from the age of 45 years onwards, an important incidence in elderly men, and in diaphyseal as well as metaphyseal bone. There may have been too much emphasis on the importance of the menopause in osteoporotic fractures; young adults should be encouraged to adopt healthy lifestyles, including more protective factors, such as exercise, and the avoidance of risk factors, such as smoking and alcohol.

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