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INCIDENCE OF FRACTURES IN PERSONS OVER 35 YEARS OF AGE

A REPORT TO THE M.R.C. WORKING PARTY ON FRACTURES IN THE ELDERLY*

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At a conference on Fractures in the Elderly convened by the Medical Research Council in 1956, there was much discussion on the importance of fractures of the femur in old people as a manifestation of osteoporosis. Although it was agreed that such fractures occurred frequently, no precise data were available about the incidence of, as opposed to mortality from, these or other types of fractures in the elderly. A Working Party on Fractures in the Elderly* was, therefore, set up to examine this question and to provide information on these injuries.

Dependable morbidity data require, firstly, completeness of reporting of the disabilities and, secondly, the ability to relate the reported events to a known population at risk. The first requirement is fairly easy to satisfy, because in Great Britain there must be few fractures which do not bring the patients to hospital at some stage. A close study of hospital records should therefore give virtually complete reporting. The second requirement is, in general, more difficult to satisfy, because very few hospitals have a clearly defined drainage area, and casualties from a particular district may be seen in any of a number of different hospitals. This complication does not exist in the two cities chosen for study, namely Dundee and Oxford, because in both a single centralized service deals with all fractures, taking care of all those within the cities and some from the environs. For the purpose of estimating incidence, fractures suffered by patients living outside the city boundaries were excluded; the remainder, suffered by city residents, provided the data for this study.

Incidence rates obtained in this way might underestimate the true risk for two reasons. A few patients might be treated at home or in private nursing homes. These would usually be known to the orthopaedic consultants who could provide information on them. A second group would consist of those patients normally resident in the cities, who were injured and treated elsewhere when away from home. There is no easy way of searching the records of hospitals outside Dundee and Oxford to see how often this situation occurred, and unless global the search is incomplete. This source of error has perforce been disregarded.

For each fracture incident, information was extracted on the age, sex, and address of the patient, the date of the accident, the type of violence causing the injury, the site or sites of fracture, and the duration of stay in the acute hospital if the patient was admitted. In all cases the radiographs were

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examined to decide upon the site—especially in the case of femoral fractures.

Preliminary analysis of the fractures in 1955 showed that some items of information, *e.g.* the disposal of patients on discharge from the acute hospital, were incompletely recorded, and no attempt was made to extract these details for other years. Furthermore, the information on the type of violence was particularly difficult to extract and was omitted from the Oxford series except for the 1955 fractures.

For inter-censal years, estimates of the total populations of Dundee and Oxford are provided but the age distribution is given only in census publications. On the assumption, therefore, that the age distribution in each city remained constant since 1951, the census year, estimates of the population by age and sex in 1955, the mid-year of the study, were obtained by multiplying the 1951 census counts for the separate age groups and sexes by the ratio of the 1955 total population to that in 1951. Since this method was necessarily empirical, it was felt that little would be gained by making separate estimates for each year, and the 1955 distribution was used to calculate average annual rates for the whole period.

Incidence of Fractures

In the 5 years 1954–58, 4,260 Dundee residents and 2,213 Oxford residents over 35 years of age came into the survey. Each centre treated rather more women than men. The distribution of these patients by site of principal fracture is shown in Table I, which lists forty specifically-defined categories. Common combinations, such as fractures involving the lower ends of the radius and ulna, or the tibia and fibula, were classified by the principal bone fractured to a single site. Thus, of the 134 male patients in Dundee classified to site No. 19 (radius, lower end), 113 had fractures at this site alone, and the other 21 patients had fractures at this site plus the lower end of the ulna. Where there was the possibility of fractures of more than one bone in a site category, as in rib and phalangeal fractures, a patient was listed once only, however many members of the category were fractured. This method of classification of each patient to a single site left 186 patients with a variety of multiple fractures, and these were classified as such under No. 41.

The number of fractures of the skull listed in Table I greatly underestimates the total among the two populations. In Dundee patients with head injuries are often treated outside the fracture service. On the other hand, all head injuries are treated by the Oxford service, but are recorded on separate cards and were not generally included in this survey. Apart from this, it is unlikely that there are other circumstances leading to a serious deficiency in the numbers of fractures reported. In any case fractures of the skull, unlike fractures of long bones or vertebrae, are not related to weight-bearing, and consequently their study cannot throw light on the problem of osteoporosis.

TABLE I

NUMBER OF FRACTURES IN DUNDEE AND OXFORD RESIDENTS OVER 35 YEARS OF AGE, TREATED AS OUT-PATIENTS AND IN-PATIENTS, 1954–58, BY PRINCIPAL SITE OF FRACTURE, AND SEX

Site			Dundee		Oxford		Total
			Male	Female	Male	Female	
1	Head	Cranium	1	—	1	2	4
2		Zygoma	1	—	3	5	9
3		Maxilla	—	—	2	1	3
4		Mandible	—	—	4	4	8
5	Spine	Cervical	8	—	3	1	12
6		Dorsal	7	4	9	1	21
7		Lumbar	28	12	9	2	51
8		Sacrum and coccyx	3	10	3	9	25
9	Clavicle		42	23	28	17	110
10	Scapula		11	3	6	1	21
11	Humerus	Upper end	59	127	31	69	286
12		Shaft	11	19	6	2	38
13		Lower end	6	8	7	12	33
14	Ulna	Upper end	14	7	13	10	44
15		Shaft	5	6	6	2	19
16		Lower end	12	9	11	8	40
17	Radius	Upper end	22	54	29	50	155
18		Shaft	6	1	3	4	14
19		Lower end	134	751	75	387	1,347
20	Hand	Carpals	76	37	39	31	183
21		Metacarpals	108	75	41	29	253
22		Phalanges	508	213	158	58	937
23	Ribs		8	3	34	11	56
24	Sternum		2	—	—	—	2
25	Pelvis		18	24	7	18	67
26	Femur	Head	—	—	—	1	1
27		Neck	17	97	20	69	203
28		Trochanter	61	159	26	81	327
29		Shaft	17	34	7	11	69
30		Condyle	7	3	1	4	15
31	Tibia	Head	10	26	13	13	62
32		Shaft	31	42	23	19	115
33		Malleolus	48	108	32	49	237
34	Patella		23	18	20	13	74
35	Fibula	Head	7	4	1	4	16
36		Shaft	14	9	12	8	43
37		Malleolus	128	195	55	61	439
38	Foot	Tarsals	45	32	28	23	128
39		Metatarsals	92	96	59	69	316
40		Phalanges	296	58	116	34	504
41	Multiple (not otherwise classified)		61	46	39	40	186
All Sites			1,947	2,313	980	1,233	6,473

The average annual incidence per 10,000 for all fractures are shown in Table II. In general the rates were slightly lower in Oxford than in Dundee. For men in both centres the rates were of the order of 100 per 10,000 (*i.e.* 1 per cent.) in each decade up to 85 years of age, with a slight dip at 65 to 74 years, but were rather higher in the oldest group of the population. In women the rates were much lower at 35 to 44 years than in men, but increased in each successive age group, so that from 55 to 64 years onwards they exceeded the corresponding male rates; in the two oldest groups they were approximately twice as high. The reasons for these contrasting patterns will emerge from a study of the rates for separate sites.

SITE.—The rates for separate sites in each centre are shown in Table III (opposite). Here some of the sites at which the number of fractures was small have been amalgamated. For most of the sites the numbers involved were still too small to enable meaningful rates for each centre to be calculated for each of the six age groups listed in Table II, and a further condensation has been made into three groups only, 35 to 54, 55 to 74, and 75 years and over.

For the separate sites the patterns in the two centres agreed closely. There were a few large apparent differences between Dundee and Oxford but these occurred where the rates were based on small numbers of cases and the estimates have correspondingly wide confidence limits, *i.e.* primarily in the oldest age group but also in the two other groups where rates are low. The differences between the rates for phalangeal fractures in the younger age groups were possibly due to the contrast between the main industries of the two cities. In view of their general similarity the two series have been combined in Table IV (overleaf) to give the pattern of fracture rates for each site in the original six age groups employed in Table II. As a guide to the significance of the rates in this Table a column is included which shows the rates corresponding to single reported cases in each age and each sex.

The pattern of age-specific rates for all sites combined was clearly made up of a mixture of patterns for the separate sites. Reference has already been made to the possibility that fractures accompanying head injuries were under-reported. Fractures of the spine also formed a small group in this study and showed no distinctive age or sex pattern; some, particularly pathological fractures, may not have been reported.

Humerus.—In both sexes the rates for the upper end of the humerus rose with age to reach peak levels in the oldest group, the gradient being steeper in women than in men (Fig. 1, overleaf). Fractures of the remainder of the humerus were less common but had similar trends.

Ulna.—Fractures of the ulna, as shown in Table IV, were not common and had no characteristic pattern. This finding is biased, because it refers to fractures of this bone alone, a number of fractures involving the lower end being incorporated in the group "radius, lower end" where both were affected.

TABLE II

AVERAGE ANNUAL AGE-SPECIFIC INCIDENCE RATES PER 10,000, ALL FRACTURES, IN PERSONS OVER 35 YRS OF AGE, DUNDEE AND OXFORD, 1954–58, BY SEX

Age Group (yrs)	Centres	Males			Females		
		Population	No. of Fracture Patients 1954–58	Annual Rate per 10,000	Population	No. of Fracture Patients 1954–58	Annual Rate per 10,000
35–44	Dundee	11,696	671	115	13,561	251	37
	Oxford	7,610	281	74	7,845	125	32
45–54	Dundee	10,351	619	120	13,083	527	81
	Oxford	6,607	346	105	7,127	255	72
55–64	Dundee	7,056	348	99	10,358	583	113
	Oxford	4,303	201	93	5,545	315	114
65–74	Dundee	4,765	192	81	7,518	497	132
	Oxford	2,695	93	69	4,300	268	125
75–84	Dundee	1,889	96	102	3,552	338	190
	Oxford	1,100	46	84	2,168	202	186
85+	Dundee	183	21	230	513	117	456
	Oxford	164	13	159	484	68	281
Total 35+	Dundee	35,940	1,947	108	48,585	2,313	95
	Oxford	22,479	980	87	27,469	1,233	90

TABLE III

AVERAGE ANNUAL RATES PER 10,000, BY SITE, AGE GROUP, AND SEX, DUNDEE AND OXFORD SEPARATELY, 1954–58

Site		Centre	Males			Females		
			35–54	55–74	75+	35–54	55–74	75+
5–8	Spine	Dundee	2·3	3·0	2·9	0·9	1·0	1·5
		Oxford	1·7	3·1	1·6	1·1	0·6	1·5
9	Clavicle	Dundee	2·6	1·7	2·9	0·5	1·3	2·5
		Oxford	3·0	1·4	3·2	0·5	2·2	1·5
11	Humerus—Upper end	Dundee	2·1	3·7	13·5	1·4	7·0	22·1
		Oxford	2·0	3·7	6·3	1·1	6·1	23·4
12 and 13	Remainder	Dundee	0·8	0·8	2·9	0·5	1·1	5·4
		Oxford	1·1	0·9	3·2	0·5	1·8	0·8
14-16	Ulna	Dundee	1·5	2·4	0·0	1·1	0·9	1·5
		Oxford	3·0	2·0	3·2	0·9	2·2	1·5
17	Radius—Upper end	Dundee	1·7	0·5	0·0	2·4	2·5	—
		Oxford	3·4	1·4	0·0	4·1	3·9	—
19	Lower end	Dundee	6·8	8·0	11·6	15·5	47·8	58·0
		Oxford	5·5	8·9	7·9	13·5	44·7	49·8
20	Carpals	Dundee	5·7	2·0	1·0	1·6	1·6	1·0
		Oxford	4·1	2·9	0·0	2·1	2·4	2·3
21	Metacarpals	Dundee	7·7	3·6	1·9	2·9	3·9	1·0
		Oxford	4·5	2·6	0·0	1·6	2·8	2·3
22	Phalanges (Hand)	Dundee	35·6	18·6	5·8	11·5	6·0	3·0
		Oxford	18·6	7·1	1·6	3·7	5·1	3·8
23	Ribs	Dundee	0·5	0·5	0·0	0·0	0·1	1·0
		Oxford	2·7	4·0	1·6	0·8	1·0	—
25	Pelvis	Dundee	0·5	1·2	4·8	0·2	1·0	5·9
		Oxford	0·1	0·3	7·9	0·4	1·6	5·3
27	Femur—Neck	Dundee	0·2	1·2	7·7	0·1	4·0	29·5
		Oxford	0·3	3·4	9·5	0·9	4·1	31·7
28	Trochanter	Dundee	0·7	4·1	28·0	0·1	4·4	58·5
		Oxford	0·7	2·3	20·6	0·3	4·7	42·2
29	Shaft	Dundee	0·5	0·7	7·7	0·2	2·5	4·4
		Oxford	0·3	1·1	1·6	0·1	1·0	3·8
31	Tibia—Head	Dundee	0·5	0·7	1·0	0·4	1·9	2·0
		Oxford	0·8	1·7	1·6	0·5	1·6	0·8
32	Shaft	Dundee	2·0	1·2	1·9	1·1	2·5	3·0
		Oxford	1·8	2·3	3·2	0·5	2·3	3·0
33	Malleolus	Dundee	3·4	1·2	2·9	3·7	5·7	3·9
		Oxford	2·8	2·9	3·2	2·3	4·9	6·0
34	Patella	Dundee	1·3	1·5	0·0	0·3	1·2	1·5
		Oxford	1·0	3·4	1·6	0·1	1·8	2·3
35 and 36	Fibula—Head and shaft	Dundee	1·5	0·7	0·0	0·4	0·6	1·5
		Oxford	1·3	1·1	0·0	0·9	1·0	—
37	Fibula—Malleolus	Dundee	6·4	8·8	5·8	5·4	12·2	6·9
		Oxford	4·4	5·7	6·3	3·2	6·1	5·3
38	Tarsals	Dundee	3·0	1·9	1·0	1·4	1·1	2·0
		Oxford	2·5	2·9	0·0	1·7	1·8	0·8
39	Metatarsals	Dundee	5·0	6·1	1·0	3·5	4·9	2·5
		Oxford	5·5	5·4	1·6	4·3	6·7	3·0
40	Phalanges—Foot	Dundee	19·8	12·9	1·9	2·8	2·4	—
		Oxford	12·5	7·4	1·6	2·7	2·2	2·3
41	Multiple—Not otherwise Classified ..	Dundee	3·6	2·9	3·9	1·0	2·6	4·9
		Oxford	2·5	5·1	4·7	1·6	3·9	6·8
All Other Sites		Dundee	1·2	1·7	2·9	0·2	0·4	0·5
		Oxford	2·3	0·9	1·6	1·1	1·8	3·8
All Sites		Dundee	117·0	91·4	112·9	58·4	120·9	223·9
		Oxford	88·2	84·0	93·3	50·8	118·4	203·6

Radius.—The upper end of the radius was not commonly fractured. There was a suggestion that female rates were higher than male, and there were no patients over 65 years of age of either sex. On the other hand, the lower end of the radius was an important site; in women, 32 per cent. of all fractures occurred there. At 35 to 44 years the male rates changed little with age, the female rates rose steeply

TABLE IV

AVERAGE ANNUAL RATES PER 10,000, BY SITE, DECADE OF AGE AND SEX, DUNDEE AND OXFORD COMBINED, 1954–58

Age Group (yrs)	Spine		Clavicle		Humerus Upper End		Humerus Remainder		Ulna		Radius Upper End		Radius Lower End		Carpals		Meta-carpals	
	M	F	M	F	M	F	M	F	M	F	M	F	M	F	M	F	M	F
35–	1·7	0·8	2·6	0·3	1·5	0·6	0·4	0·3	2·1	0·7	2·5	2·2	6·3	5·6	5·3	1·0	7·3	2·0
45–	2·5	1·1	2·9	0·7	2·7	2·1	1·5	0·7	2·1	1·1	2·5	3·9	6·3	24·4	4·8	2·6	5·5	2·9
55–	2·5	0·9	1·2	1·1	3·3	5·5	0·4	1·4	2·1	1·5	1·1	3·6	9·0	43·8	2·8	2·5	3·5	4·3
65–	4·0	1·2	2·1	2·4	4·3	8·3	1·6	1·4	2·4	1·2	0·5	2·0	7·2	50·6	1·6	1·0	2·7	2·5
75–	2·0	1·7	3·3	1·4	8·7	21·3	2·7	3·1	0·7	1·4	—	—	11·4	51·4	0·7	1·7	1·3	1·4
85+	5·8	—	—	6·0	28·8	30·1	5·8	6·0	5·8	2·0	—	—	—	74·2	—	—	—	2·0

Age Group (yrs)	Phalanges (Hand)		Ribs		Pelvis		Femur Neck		Femur Trochanter		Femur Shaft		Tibia Head		Tibia Shaft		Tibia Malleolus	
	M	F	M	F	M	F	M	F	M	F	M	F	M	F	M	F	M	F
35–	29·2	8·4	0·8	0·3	0·2	0·2	—	0·1	0·6	—	0·6	0·1	0·7	0·4	1·8	0·3	2·8	1·9
45–	28·5	9·0	1·9	0·3	0·6	0·4	0·5	0·7	0·8	0·3	0·1	0·3	0·5	0·5	2·1	1·5	3·7	4·6
55–	17·4	7·0	2·6	0·3	0·5	0·6	1·6	1·5	2·3	1·5	0·5	1·5	0·9	1·1	2·3	2·6	2·3	5·4
65–	9·7	3·9	0·5	0·7	1·3	2·0	2·7	7·4	5·1	8·5	1·3	2·5	1·3	2·7	0·5	2·0	1·1	5·4
75–	4·7	2·8	0·7	0·7	5·3	3·8	7·4	24·1	22·8	39·2	4·0	3·5	1·3	1·4	2·0	3·5	2·0	4·5
85+	—	6·0	—	—	11·5	16·0	17·3	66·2	46·1	126·4	17·3	8·0	—	2·0	5·8	—	11·5	6·0

Age Group (yrs)	Patella		Fibula Head and Shaft		Fibula Malleolus		Tarsals		Meta-tarsals		Phalanges (Feet)		Multiple—not Otherwise Classified		All Other Sites		Rate per per Single Reported Case	
	M	F	M	F	M	F	M	F	M	F	M	F	M	F	M	F	M	F
35–	0·7	0·1	1·7	0·1	5·8	2·8	2·8	1·0	3·9	2·4	13·8	2·1	2·6	1·0	1·0	0·6	0·10	0·09
45–	1·7	0·4	1·2	1·1	5·3	6·5	2·8	2·0	6·6	5·2	20·5	3·5	3·9	1·4	2·5	0·4	0·12	0·10
55–	2·1	1·0	1·1	0·8	8·3	10·4	2·6	1·3	6·7	6·4	13·9	3·1	3·9	2·8	1·8	0·9	0·15	0·13
65–	2·4	2·0	0·5	0·7	6·7	9·5	1·6	1·5	4·6	4·4	6·2	1·2	3·5	3·4	0·8	0·8	0·27	0·17
75–	0·7	2·1	—	1·0	6·0	5·9	0·7	1·4	1·3	2·8	2·0	1·0	2·7	5·2	0·7	2·1	0·67	0·35
85+	—	—	—	—	5·8	8·0	—	2·0	—	2·0	—	—	17·3	8·0	17·3	—	5·76	2·01

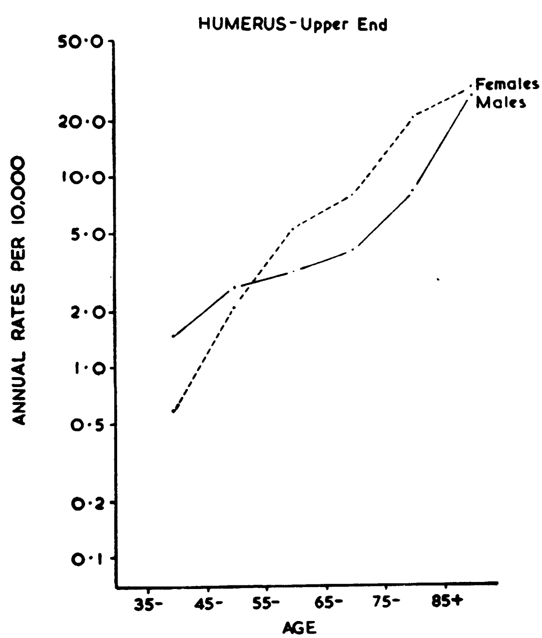

FIG. 1.

and then levelled off, so that from 55 years onwards they were about ten times those in the youngest group (Fig. 2).

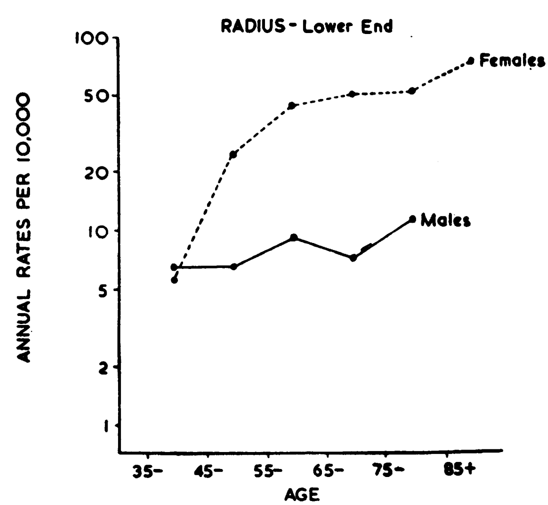

FIG. 2.

Wrist and Hand.—The liability to fracture the small bones of the wrist and hand did not alter much with age in women, but in men declined steeply from peak levels at 35 to 44 and 45 to 54 years. At these ages the male rates were about three times those for females, but among older persons there was little sex difference in the risk. Fractures of the phalanges comprised 23 per cent. of the total fractures reported in men, but only 8 per cent. of the total in women.

Ribs, Clavicle, Pelvis.—Fractures of the ribs, like those of the clavicle, were rather commoner in men than in women in the younger groups, but with some increase in the rate among women the rates were similar in older persons.

The risk of pelvic fractures increased steeply with age for both sexes (Fig. 3). The pattern was thus like that for the upper end of the humerus, but with no sex difference.

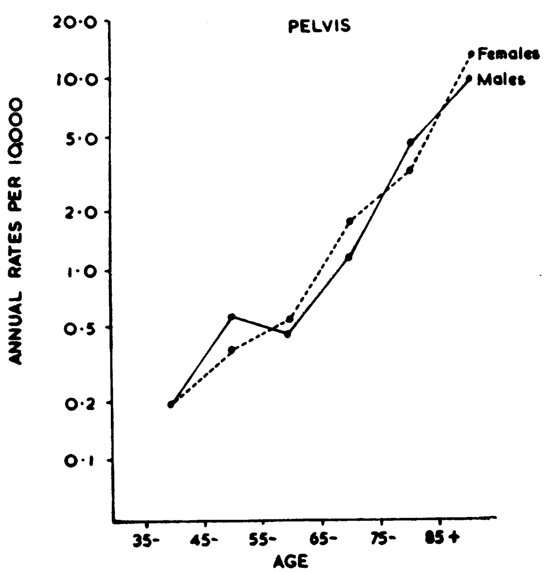

FIG. 3.

Femur.—The frequency of fracture of the femur in old people, particularly women, is well known (Figs 4 and 5, and Fig. 6, overleaf). In this study those of the femoral neck, trochanteric region, and shaft formed over half the total in women 85 years and over, and gave a combined rate of 200 per 10,000, *i.e.* affecting 1 in 50 of this group each year. In both sexes the rates were small below 65 years of age and then rose steeply, more so in women than in men. The trochanteric region was more commonly involved than the neck. The shaft was the least common of the three sites shown in the Table, and unlike the other two had similar rates for men and women. In general the pattern was like that for the upper end of the

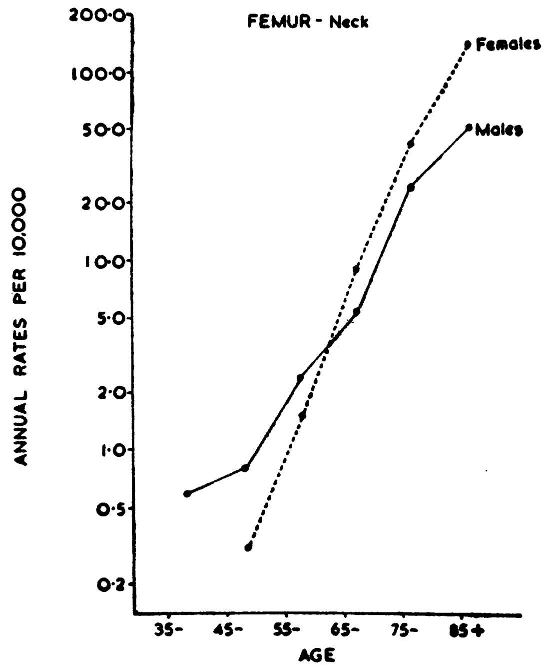

FIG. 4.

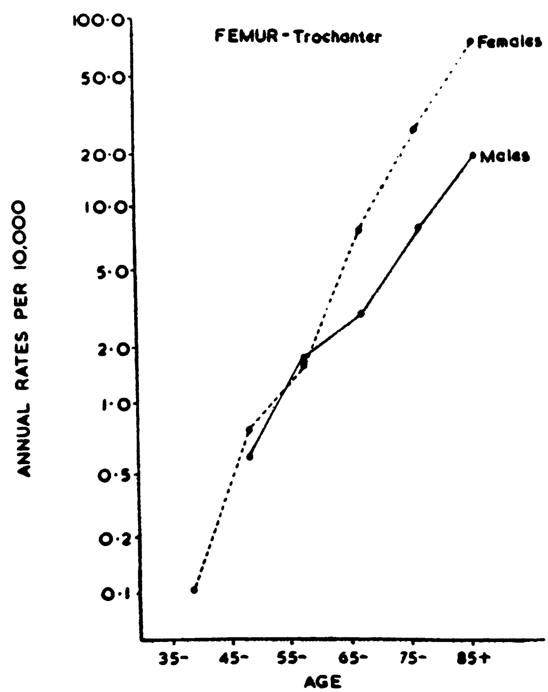

FIG. 5.

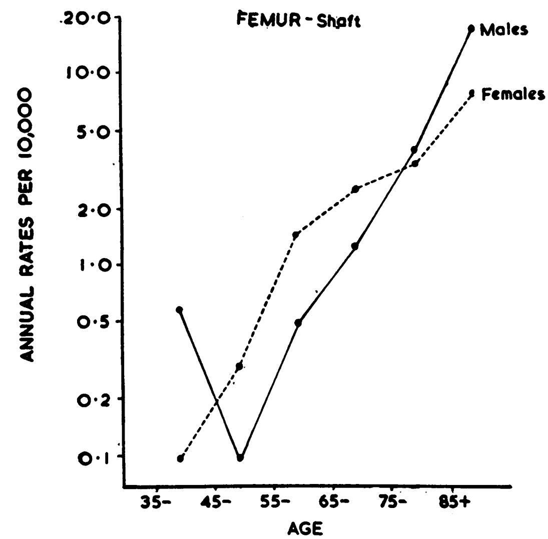

FIG. 6.

humerus. Fractures of the femoral head and condyles were too rare to be listed separately in Table IV.

Tibia and Fibula.—The age and sex distribution of fractures of the tibia and fibula were not remarkable, except that in the 35 to 44 age group they were far commoner in men, but at other ages were generally commoner in women. The fibular malleolus in particular was a frequent site of fracture, and added together the two malleoli suffered 9 per cent. of the fractures in men and 12 per cent. of those in women.

Ankle and Foot.—The bones of the ankle and foot repeated much the same pattern as that for the wrist and hand. The toes, like the fingers, were most commonly broken in the younger men, but the risk declined with age so that there was little if any difference between older men and older women. The figures for tarsal and metatarsal fractures suggested similar trends, but with far less difference between younger men and women.

FREQUENCY OF FRACTURE IN COMPACT AND CANCELLOUS BONE.—Whereas the shaft of a long bone is made of compact bone, its ends are made of cancellous bone but, since the ends of a bone are broader than its shaft, it would not necessarily follow that they were more vulnerable. Table A, derived from the combined Dundee and Oxford data, shows the frequency with which the ends and shafts of long bones were fractured. For each bone the cancellous ends were far more frequently the site of fracture than the compact shafts, the ratio ends : shaft ranging from a minimum of 2·6 : 1 for the tibia to as much as 107 : 1 for the radius.

TABLE A

FREQUENCY OF FRACTURE OF DIFFERENT PARTS OF LONG BONES

Bone	Upper End	Lower End	Shaft	Ratio Ends : Shaft
Humerus	286	33	38	8·4 : 1
Ulna	44	331	19	19·7 : 1
Radius	155	1,347	14	107·3 : 1
Femur	531	15	69	7·9 : 1
Tibia	62	237	115	2·6 : 1
Fibula	16	620	133	4·9 : 1
Radius and Ulna ..	199	1,387	33	48·1 : 1
Tibia and Fibula ..	78	676	158	4·8 : 1

Although osteoporosis is a generalized condition, its radiographic manifestations are more evident in cancellous than in compact bone. The marked reduction in cancellous bone in old age, as seen in *x*-ray photographs, might lead us to expect a higher incidence of fractures through cancellous bone as compared with compact. Table B shows this relative incidence in each sex for three age groups, 35 to 54, 55 to 74, and 75 years and over.

TABLE B

RATIO OF FREQUENCY OF FRACTURE IN CANCELLOUS (UPPER AND LOWER ENDS) TO THAT IN COMPACT BONE (SHAFT)

Bone	Sex	Age Group (yrs)		
		35 to 54	55 to 74	75+
Humerus	M	5·0	9·8	4·8
	F	8·2	13·0	8·8
Radius and Ulna ..	M	15·7	14·7	19·0
	F	96·0	100·4	94·5
Femur	M	3·3	6·5	6·3
	F	3·0	4·6	19·9
Tibia and Fibula ..	M	3·3	4·5	4·2
	F	6·7	6·1	3·6

For the purposes of this Table the radius and ulna and tibia and fibula have been taken as two groups; the conventions are the same as in the main tables, *i.e.* a patient suffering a fracture of the lower ends of both radius and ulna or of both malleoli was counted once only. In Table A, however, the figures for the ulna and fibula include fractures of these bones alone, Sites 14–16 and 35–37 plus those in combination with the corresponding radius and tibia, part of Sites 17–19 and 31–33.

The ratio of frequency of fractures at the ends to that of fractures of the shaft increases with age only in femoral fractures in women. The ratios for all the other sites in Table B show no such change and do not support the idea that with increasing age cancellous bone is more likely to break than compact bone.

Types of Accident

Table V and Table VI (overleaf) show the types of accident causing fractures in Dundee patients in the years 1954–58. The pattern was similar in Oxford in 1955 but data were not available for the remaining 4 years. The classification shown in the Tables, a condensation of a more extensive number of categories, is based on the hospital notes. The clinician treating a patient is much more concerned about the exact nature of the injury than about its method of production. Consequently the information available was often scanty. Nevertheless the analysis is sufficient to indicate how some of the fracture patterns described may have come about.

Industrial.—If we combine fractures at all sites, it is seen that industrial accidents caused a large proportion of the total in the younger men and a smaller proportion in the younger women, but that such accidents ceased to be an important factor beyond 75 years in men and 55 years in women. This clearly reflected the pattern of employment.

If individual sites are considered, industrial accidents gave rise to most of the finger and toe fractures in men and many of those in women, and explained the large number of these fractures in younger men and the decline in rates with age. They also figured prominently in fractures of the metatarsals in men, but rather less in those of other small bones of the hands and feet. It is well recognized that one of the commonest types of industrial accident occurs in the handling of materials with the risk of objects being dropped on the hands and feet.

Traffic Accidents.—These appeared most often in fractures of the pelvis, tibia and fibula, and multiple sites in both sexes, and of the clavicle, ribs, and patella in men. Examination of the data in more detail suggested that, at the ages studied, women who suffered fractures from traffic accidents were nearly all pedestrians, while among men in this category there were about equal numbers involved as pedestrians, pedal cyclists, motor cyclists, and occupants of cars and lorries. In no age group or sex did traffic accidents cause more than a small proportion of the total.

Falls.—These were responsible for about one-quarter of the fractures in men and one-half of those in women aged 35 to 44 years, the proportion rising steadily with age, more steeply in men, so that in the oldest group the vast majority arose from this type of accident. As might be expected falls at home caused a much larger proportion of the fractures in younger women than in younger men; they became of prime importance to both sexes in old age.

Falls accounted for the majority of many different types of fracture, particularly those with a rise in risk with age, *e.g.* upper end of humerus, pelvis, and femur.

Femoral fractures, with their very high rates in old age, were largely the result of falls at home, where old people spend most of their time. On the other hand, most of the fractures of the clavicle, upper and lower ends of the radius, and tibia and fibula in women, occurred away from home.

Duration of Stay in Hospital

As a measure of the load on the hospital service produced by fractures, Table VII (overleaf) shows for the separate sites the proportion treated as in-patients

Table V

NATURE OF ACCIDENT CAUSING FRACTURES TO DUNDEE PATIENTS, 1954–58, BY AGE AND SEX

Age Group (yrs)	Sex	Total Patients	Type of Accident (per cent.)					
			Falls		Traffic	Industrial	Other	Not Known
			At Home	Other				
35–	M	671	2	22	9	42	20	5
	F	251	18	29	4	20	22	8
45–	M	619	3	20	5	47	18	7
	F	527	23	40	2	13	16	6
55–	M	348	6	24	4	41	17	9
	F	583	28	42	2	5	15	8
65–	M	192	12	37	7	26	11	7
	F	497	40	36	4	1	10	9
75–	M	96	32	36	7	2	15	8
	F	338	56	29	4	—	4	7
85+	M	21	62	24	5	—	—	10
	F	117	67	18	3	—	2	10
All Ages	M	1,947	7	23	6	39	18	7
	F	2,313	34	36	3	6	12	8

TABLE VI

NATURE OF ACCIDENT CAUSING FRACTURES TO DUNDEE PATIENTS, 1954–58, BY SITE AND SEX

Site		Sex	Total Patients	Type of Accident (per cent.)					
				Falls		Traffic	Industrial	Other	Not Known
				At Home	Other				
5–8	Spine	M	46	7	54	7	9	9	15
		F	26	58	34	—	4	4	—
9	Clavicle	M	42	19	31	24	7	5	14
		F	23	39	48	4	—	—	9
11	Humerus—Upper end	M	59	17	63	10	—	2	8
		F	127	47	40	4	—	2	7
12 and 13	Remainder	M	17	24	35	6	12	6	18
		F	27	48	15	—	7	15	15
14–16	Ulna	M	31	13	22	10	29	16	10
		F	22	23	36	14	14	9	5
17	Radius—Upper end	M	22	9	55	14	14	9	—
		F	54	22	72	—	—	2	4
19	Lower end	M	134	11	57	4	11	10	7
		F	751	36	50	1	1	1	11
20	Carpals	M	76	5	57	4	13	17	4
		F	37	22	64	3	3	5	3
21	Metacarpals	M	108	5	23	8	29	27	8
		F	75	28	37	1	12	13	8
22	Phalanges (Hand)	M	508	0	4	1	71	18	5
		F	213	6	9	1	49	28	7
23	Ribs	M	8	—	63	37	—	—	—
		F	3	67	—	—	—	—	33
25	Pelvis	M	18	39	39	17	—	6	—
		F	24	29	34	29	—	4	4
27	Femur—Neck	M	17	24	52	12	—	—	12
		F	97	66	29	—	—	1	4
28	Trochanter	M	61	48	29	13	2	3	5
		F	159	70	24	1	—	1	4
29	Shaft	M	17	35	47	6	—	6	6
		F	34	62	29	—	—	3	6
31	Tibia—Head	M	10	10	40	10	40	—	—
		F	26	38	39	19	—	—	4
32	Shaft	M	31	—	23	29	26	13	10
		F	42	38	31	21	—	5	5
33	Malleolus	M	48	10	34	6	19	27	4
		F	108	27	43	2	1	19	7
34	Patella	M	23	9	39	26	9	13	4
		F	18	39	55	6	—	—	—
35 and 36	Fibula—Head and shaft	M	21	5	33	24	24	14	—
		F	13	54	23	—	—	8	15
37	Malleolus	M	128	3	28	4	13	39	12
		F	195	20	30	2	1	38	9
38	Tarsals	M	45	4	47	4	20	22	2
		F	32	41	18	3	3	31	3
39	Metatarsals	M	92	2	5	5	58	24	7
		F	96	24	13	2	2	52	6
40	Phalanges (Foot)	M	296	1	3	—	69	21	6
		F	58	5	5	2	28	57	3
41	Multiple—Not Otherwise Classified	M	61	7	36	25	18	8	7
		F	46	24	33	35	—	2	7
All Other		M	28	11	21	21	29	11	7
		F	7	57	29	14	—	—	—
All Sites		M	1,947	6·6	23·2	6·4	39·5	17·6	6·7
		F	2,313	34·2	36·1	3·2	6·4	12·5	7·7

and the average duration of stay in the acute general hospital. The data for the two centres are shown separately because there were important differences in their management of some types of fracture, but for each centre information on the two sexes has been combined because there were no consistent differences between them.

In both centres about one-quarter of the fracture patients treated in the period 1954–58 were admitted to hospital but, whereas their average stay in the

TABLE VII

DURATION OF STAY IN ACUTE HOSPITAL, DUNDEE AND OXFORD, 1954–58, BY SITE OF FRACTURE

Site		Dundee				Oxford			
		Total Patients	In-patients (per cent.)	Total Days	Days per In-patient	Total Patients	In-patients (per cent.)	Total Days	Days per In-patient
5–8	Spine	72	29	338	16	37	59	195	9
9	Clavicle	65	3	38	19	45	16	52	7
11	Humerus—Upper end	186	16	236	8	100	9	63	7
12 and 13	Remainder	44	25	95	9	27	26	23	3
14–16	Ulna	53	23	130	11	50	22	44	4
17	Radius—Upper end	76	21	97	6	79	5	20	5
19	Lower end	885	10	477	5	462	3	150	11
20	Carpals	113	1	11	11	70	1	2	2
21	Metacarpals	183	3	97	16	70	6	70	17
22	Phalanges (Hand)	721	10	387	6	216	3	37	5
23	Ribs	11	27	58	19	45	20	55	6
25	Pelvis	42	64	760	28	25	84	434	21
27	Femur—Neck	114	83	4,419	47	89	93	1,697	20
28	Trochanter	220	99	8,660	40	107	99	2,349	22
29	Shaft	51	94	3,820	80	18	83	990	66
31	Tibia—Head	36	86	1,196	39	26	50	102	8
32	Shaft	73	93	2,023	31	42	83	343	9
33	Malleolus	156	60	1,724	19	81	60	326	7
34	Patella	41	83	972	29	33	64	176	8
35 and 36	Fibula—Head and shaft	34	6	37	19	25	—	—	—
37	Malleolus	323	5	120	7	116	6	55	8
38	Tarsals	77	34	601	23	51	10	55	11
39	Metatarsals	188	3	67	13	128	2	29	10
40	Phalanges (Foot)	354	2	51	9	150	1	7	3
41	Multiple—Not Otherwise Classified	107	66	2,408	34	79	68	1,077	20
All Other Sites		35	37	305	23	42	43	207	11
All Sites	M	1,947	19·6	9,649	25·3	980	22·6	3,219	14·6
	F	2,313	27·2	19,478	30·9	1,233	24·8	5,339	17·4
	Total	4,260	23·8	29,127	28·8	2,213	23·8	8,558	16·2

Dundee acute hospitals was about 4 weeks, in Oxford it was only just over 2 weeks. An analysis of the data for the 1955 patients only gave a similar picture, but showed that in Oxford the shorter stay in acute hospital beds was compensated by a very much longer period in other hospitals, an average of about 15 weeks in Oxford compared with only 2 weeks in Dundee. This great contrast clearly reflects differences in organization, and arises mainly because in Oxford many of the elderly women patients were discharged to geriatric hospital accommodation.

Nearly all patients with fractured femurs were admitted to hospital. For the neck and trochanter the mean duration of stay was about 6 weeks in Dundee acute hospitals compared with 3 in Oxford, and for fractures of the shaft it was much longer, over 11 weeks in Dundee and 9 in Oxford. The three femoral sites accounted between them for 40 per cent. of the total bed-days for all fractures in men 35 years and over, and for 70 per cent. in women.

There was a large difference between the two centres in the duration of stay for fractures of the tibia and patella, of the order of 1 week in Oxford but 3 or more weeks in Dundee. In males these fractures were responsible for about a fifth of all in-patient care at the ages studied. Multiple fractures in the same patient and pelvic fractures, often the result of considerable violence, were also responsible for an appreciable amount of the total. Only a small proportion of patients with minor fractures of the hands and feet were admitted to hospital but those who were had a surprisingly long average stay, presumably because of the necessity to treat associated soft-tissue injuries.

Discussion

The study described in this report serves to put in quantitative and nearly in absolute terms some of the general impressions held on the pattern of fractures in middle and later life. In the main the patterns of incidence are similar to those described by Buhr and Cooke (1959), although they were unable to give rates based on a population at risk. However, by relating the number of fractures to the whole population of England and Wales, they were able to indicate the relative risks of fracture at different ages.

The characteristically high rates for femoral fracture in very old age, greater in women than in men, have prompted much speculation about the role of osteoporosis which might be secondary to hormonal changes after the menopause. Osteoporosis in both sexes may be related to inadequate diet or to inactivity; again in both sexes deterioration in sight, balance, and neuromuscular co-ordination make falls of any kind more likely. These hypotheses derive not only from the high risk in old age, but also from the rapid change in this risk from about 65 years of age, and from the extreme rarity of these fractures in younger people. Where rates are relatively low it is difficult to be certain of sex differences and trends with age, particularly if they are plotted graphically on an arithmetic scale which has to accommodate high values as well as low. The combination of the Dundee and Oxford data enables some examination to be made of these trends and Figs 1 to 6 show the rates for several selected sites plotted on a logarithmic scale.

Fractures of the lower end of the radius have a pattern distinct from the remainder, with the wide separation between female and male rates after 35 to 44, but thereafter little change in rate in either sex. For the upper end of the humerus, and the femoral neck and trochanter, however, there is a common pattern. The rates increase at a remarkably constant proportional rate throughout the age range from 35 to 44 years onwards, the gradient being slightly steeper for women than for men. For women the rates for the neck and trochanteric region double for about every 5 years increase in age, for men every 7 years. For the upper end of the humerus the gradient is rather less, and for fractures of the femoral shaft and pelvis the gradient is fairly constant and steep but similar for the two sexes. Nothing of these patterns suggests a sudden change in trend coincident with the menopause or senile deterioration. Since these hormonal events are more abrupt and earlier in women than in men, it would be expected that hormonal-dependent events would show earlier in women. No such trend is seen, and it seems more likely that the aetiology of these fractures is multi-factorial and that, if changes in bone play a large part, they have their origin far earlier than the conventional boundaries of old age. It would be interesting to know whether data from younger patients would confirm this surmise. In any case it is widely, if not generally, accepted that the thinning of bones is due to negative calcium balance over very prolonged periods.

This report, so far as we are aware, is the first attempt to discover the absolute incidence of fractures in older people in this country. The absolute incidence below 35 years is not yet known.

It is too much to expect that an inquiry like this, namely an analysis of information entered in hospital records for quite another purpose, would give us a glimpse into the problem of causation of fractures in the elderly. There is indeed no mystery about the immediate cause of any fracture—it is, of course, that the stress produced by the forces applied to the bone has exceeded the breaking stress. There is no proof from either animal or human experiments that bone quality, that is breaking stress, decreases in old age. The bone is, of course, decreased in amount—the compact shaft walls and trabeculae becoming thinner and therefore weaker.

The captious critic might well find justification in complaining that we might have spent our energy more profitably in investigating the 98 per cent. of the old ladies over 85 years of age who escape fractures of the upper end of the femur.

The information in our Tables may be of value to those who are planning accident services in a new area, but adequate information for this purpose might be obtained by less sophisticated means unless the planner is looking ahead to a time when the age distribution is very different from the present one. Another use of the data would be to apply the age distribution data to the population served by the National Health Service to estimate the cost, for example, of femoral fractures. This could only be approximate since the stay in hospital and the manner of convalescence is not uniform over the country. The minimum cost amounts, however, to many millions of pounds—and this is quite heavy, whether as the taxpayers' burden or as the patient's suffering.

Apart from those which occur in traffic and industrial accidents, fractures occur because the bones are weak and the problem of prevention may simply be that of preserving bony material. This involves a knowledge of the conditions for better supply and better absorption of calcium and phosphate and, some would say, a better supply of protein. It may be also that the 98 per cent. of old persons referred to earlier are more active than the 2 per cent. of unfortunates; there is no doubt that in some way as yet unknown muscular activity maintains or even increases bone formation.

The data presented here are consistent with the idea that thinning of the bones is a chronic process, perhaps due to a long-standing slight negative balance of minerals and a long-continued deficiency of activity. This conclusion, whether right or wrong, is hardly dramatic and cannot, unfortunately, lead immediately to any simple means of mitigation of the problem.

Summary

In the 5 years 1954 to 1958, 4,260 Dundee residents and 2,213 Oxford residents aged 35 years and over were treated by the fracture services of those cities. The annual fracture rates for men were 108 per 10,000 in Dundee and 87 in Oxford, and for women 95 and 90 per 10,000. In men the rates did not vary much with age, except that those for men aged 85 years and over were about twice those for younger men. The rates for women were only about 35 per 10,000 at 35 to 44 years but increased with age to levels about ten times as great over 85 years.

The distribution for individual sites was similar in both cities except for a much greater risk of phalangeal fracture in Dundee than in Oxford, possibly related to differences in their main industries. The commonest sites of fracture in men of this age were the small bones of the hands and feet, the lower end of the radius, and the malleoli; in women they were the lower end of the radius, the femur, and the small bones of the hands and feet.

The outstanding features of the pattern for individual sites were:

(*i*) Femoral fractures were rare in the younger groups but the incidence rose steeply in old age so that they became the commonest type, affecting approximately 2 per cent. of women and 1 per cent. of men 85 years and over annually.

(*ii*) Fractures of the upper end of the humerus and of the pelvis showed a somewhat similar pattern.

(*iii*) Fractures of the lower end of the radius were equally common in men and women of 35 to 44 years of age but, whereas in men the rate remained fairly constant, in women it rose to a level about ten times as high in those aged 65 years and over.

(*iv*) Fractures of the small bones of the hand and feet were commoner in the younger men and arose chiefly as the result of industrial accidents.

Although for several sites the rates increased with age there was no evidence of a change in trend coincident with the menopause or with senile deterioration.

Industrial accidents were responsible for 40 per cent. of the fractures in younger men and 20 per cent. in women, but in older persons falls at home were the commonest cause. Traffic accidents were most commonly associated with multiple fractures, but caused less than 10 per cent. of the fractures in any age group or in either sex.

In both centres about one-quarter of the patients were admitted to hospital. In Dundee their average stay was 4 weeks compared with just over 2 in Oxford; this difference was compensated for by a longer stay in non-acute hospitals in Oxford. The longest stays in acute hospitals (averaging 11 weeks at Dundee and 9 at Oxford) were for femoral fractures, which were responsible for 40 per cent. of the male fracture in-patients and 70 per cent. of the females.

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