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Secular trends in fracture incidence in the United Kingdom between 1990 and 2012

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Abstract

Introduction—There is increasing evidence of secular changes in age- and sex- adjusted fracture incidence globally. Such observations broadly suggest decreasing rates in developed countries and increasing rates in transitioning populations. Since altered fracture rates have major implications for healthcare provision and planning, we investigated secular changes to age- and sex-adjusted fracture risk amongst the UK population aged 50 years or above from 1990 till 2012.

Methods—We undertook a retrospective observational study using the Clinical Practice Research Data link (CPRD), which contains the health records of 6.9% of the UK population. Site-specific fracture incidence was calculated by calendar year for men and women separately, with fracture type categorised according to ICD-9 classification. Linear regression analysis was used to calculate mean annualised change in absolute incidence. For presentational purposes, mean rates in the first 5 years and last 5 years of the period were calculated.

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Disclosure statement
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Results—Overall fracture incidence was unchanged in both women and men from 1990 to 2012. The incidence of hip fracture remained stable amongst women (1990-1994: 33.8 per 10,000 py; 2008-2012: 33.5 per 10,000 py; p trend annualised change in incidence=0.80), but rose in men across the same period (10.8 to 13.4 per 10,000py; p=0.002). Clinical vertebral fractures became more common in women (8.9 to 11.8 per 10,000py; p=0.005) but remained comparable in men (4.6 to 5.9 per 10,000 py; p=0.72). Similarly frequency of radius/ulna fractures did not change in men (9.6 to 9.6 per 10,000py; p=0.25), but, in contrast, became less frequent in women (50.4 to 41.2 per 10,000py; p=0.001). Secular trends amongst fractures of the carpus, scapula, humerus, foot, pelvis, skull, clavicle, ankle, patella and ribs varied according to fracture site and sex.

Conclusion—Although overall sex-specific fracture incidence in the UK population 50 years or over appears to have remained stable over the last two decades, there have been noticable changes in rates of individual fracture types. Given that the impact of a fracture on morbidity, mortality and health economy varies according to fracture site, these data inform the provision of healthcare services in the UK and elsewhere.

Mini abstract—We studied sex-specific incidence rates in the population 50 years or older in the UK. In the period 1990-2012 the overall rate of fracture did not change, but there were marked secular alterations in the rates of individual fracture types, paticularly hip and spine fractures in the elderly.

Keywords

Osteoporosis; epidemiology; fracture; incidence; secular trends

Introduction

Accurate characterisation of time-trends in fracture incidence is important for the prediction of the health care burden associated with such events, and to provide a platform on which to study factors influencing such alterations[1]. Future projections are dependent on the ageing of populations and are known to be highly sensitive to secular changes in age-adjusted incidence rates[2,3]. Secular trends in fracture incidence at a single anatomical location have been studied widely across the world, with hip being the site most frequently investigated. Such studies have been recently summarised[1] and have generally revealed an increase in age- and sex-adjusted incidence of hip fracture in the developed world until the last few decades[4], followed by either a plateau[5,6] or a decrease[7,8]. In contrast, in the developing world, hip fracture incidence rates are still increasing[9], except in some heavily urbanised areas[10]. Documentation of long-term secular trends for non-hip fractures is sparse[11–18], and very few studies have been able to simultaneously explore secular trends amongst a comprehensive range of individual fracture sites[19,20]. Given that non-hip fractures accounted for 52.7% of the total economic impact of osteoporotic fracture in the UK in 2010[21], and that the majority of major osteoporotic fractures are associated with a marked relative reduction in survival[22] and substantial morbidity for individuals[23], it is clearly important to characterise such alterations beyond hip fracture. We therefore aimed to describe secular trends for fracture in the population aged 50 years or above, stratified by sex and fracture location, from 1990 until 2012, using the UK Clinical Practice Research Datalink.

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Methods

Data sources

We conducted a retrospective observational study using data from the Clinical Practice Research Data link (CPRD), formerly known as the General Practice Research Database. In the universal health care system in the UK (the National Health System, NHS) general practitioners (GPs) play a pivotal role, providing primary health care for 98% of the population and referring patients for specialist consultations or hospital admissions. The medical records of the GPs contain prospective information on demographics, prescriptions and diagnoses made by GPs and diagnoses from specialist consultations, outpatient visits and hospitalizations[24]. The CPRD covers over 11.3 million individuals from 674 practices in the UK. Around 4.4 million individuals are active (alive, currently registered) and meet quality criteria, accounting for approximately 6.9% of the UK population[25]. The cohort has been shown to be broadly representative of the UK population in terms of age, sex and ethnicity when compared with the UK census in 2011[25], and the body mass index distribution is comparable to that in the Health Survey for England in most patient subgroups[25].

Clinical data for each patient are captured and stored in CPRD using READ codes for disease or causes of morbidity or mortality, which are cross-referenced to the International Classification of Diseases 9th edition (ICD-9)[26]. The database contains information on both hospital admissions and hospital outpatient attendances, for example those at an Emergency Department. Information including date of attendance and diagnosis is passed from the hospital to the general practitioner, coded, and recorded in the database. Data quality assessments are performed at the practice level[24]. Independent validation studies have reported that the clinical data in the CPRD are in general of high quality, including reliable recording of fracture events[27]. This research was conducted in accordance with the principles of the Helsinki Declaration and the protocol for this study was approved by CPRD's Independent Scientific Advisory Committee. All data on patients were stored anonymously in CPRD and, therefore, informed consent was not required for this study.

Study population

The study population consisted of women and men of 50 years or older who were registered at a participating GP practice. Fracture types were classified according to the ICD-9 classification including the following categories: skull (800-804), clinical vertebra (805,806), rib (807), pelvis (808), clavicle (810), scapula (811), humerus (812), radius/ulna (813), carpal (814-817), femur/hip (820,821), patella (822), tibia/fibula (823,824), foot (825, 826) and unspecified fractures (808, 818, 819, 827-829). Participants were followed from entry into the database until the occurrence of fracture or censoring (death, withdrawal from the database or the end of data collection), whichever came first. Fractures were studied individually, and as "all fractures". For ease of illustration by individual fracture type, fractures were grouped as "osteoporotic" (hip/femur, humerus, pelvis, vertebra, radius/ulna, rib) and non-osteoporotic (foot, tibia/fibula, clavicle, skull, ankle, carpus, scapula, patella). In CPRD, as in many similar datasets, differentiation of two distinct fracture events at the same site, from one fracture event recorded twice, is extremely difficult. In order to prevent

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double-counting, the incidence analyses were therefore based on the first-ever occurrence of a fracture at a particular location. If an individual had multiple records of fractures at the same location, only the first record was used in the incidence rate calculation.

Statistical analysis

Age- and sex-specific fracture incidence rates were calculated for all and individual fracture types. Data on the dates of start and end of follow-up and the date of any fractures were available for all patients in CPRD. However, the size of the database (including records of around 4.4 million individuals), prohibited the practical use of the exact person time, so pragmatically, we counted the number of patients who were enrolled in CPRD at each midyear point (stratified by age and sex) providing the sum of follow-up. We also counted the number of patients who suffered a fracture. The fracture incidence was then calculated by dividing the sum of patients with a fracture by the sum of person-time follow-up for each calendar year. In order to illustrate whether there was, overall, a statistically significant change in fracture rates over the full calendar period, we used linear regression to calculate the mean annualised change in absolute incidence and to test for trend by calendar year. For ease of presentation we also calculated the mean incidence in the first 5 years of follow-up (1990-1994) and in the last 5 years (2008-2012) of follow-up. Analyses were performed using SAS 9.3 (SAS Institute Inc., Cary, North Carolina, USA) and Stata 13.1 (Statacorp, College Station, Texas, USA).

Results

All fractures

From 1990 to 2012 a total of 182,907 fractures were recorded in women aged 50+ years and 73,718 fractures in men aged 50+ years, during 11,642,110 person-years (py) and 10,247,651py follow-up respectively. Overall, in women the annual incidence of fracture remained unchanged, such that the mean incidence over the first 5 years of follow-up was 168/10,000py and 170/10,000py in the final 5 year period (p trend=0.94). Amongst men, although the rate was greater in the last 5 years compared with the first 5 years (79 vs 75/10,000py) there was no evidence of a linear trend by calendar year (p trend=0.50) (Table 1).

Site specific secular changes

The secular patterns varied by individual fracture site and by sex and are illustrated graphically in Figure 1. Table 1A and 1B summarise the mean incidence in the first and last 5 years of follow up together with the mean annualised absolute change and p (test for trend). This reveals that amongst women, fractures of the carpus, scapula, humerus, foot, vertebrae, pelvis, and tibia/fibula became more common from 1990 to 2012. In contrast there was a decrease in rates of radius/ulna, patella and rib fractures, with no change in rates of fracture at the hip/femur, clavicle, ankle and skull. Amongst men, there was also a decrease in rates of skull, patella and rib fractures but no change in rates of fracture at the radius/ulna, vertebrae, and the foot. Fracture rates of the clavicle, humerus, ankle, scapula, hip/femur, carpus and tibia/fibula all increased over the period 1990-2012 in men.

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Secular changes in men and women stratified by age

Figures 2 and 3 demonstrate the secular changes in fracture incidence at the hip/femur, vertebra and distal forearm for men and women separately, stratified by 5-year age bands. These reveal that fracture rates appeared relatively constant at all ages for distal forearm fracture. At ages above 75 years vertebral fracture rates rose in both sexes, but a similar rise in hip fracture incidence was observed only in men 85+ years and women 90+ years.

Discussion

Overall, sex-specific fracture incidence in the UK population 50 years or over appears to have remained stable over the last two decades, but this encompasses much variation in fracture incidence according to sex and fracture site. Thus, for example, rates of hip fracture remained stable in women, but increased amongst men. In contrast, rates of vertebral fracture rose in women, but overall did not change in men. Incidence of radius/ulna fractures remained stable in men, but decreased in women. Rates of hip and vertebral fracture rates rose particularly in the oldest individuals. Given that the impact of a fracture on morbidity, mortality and health economy varies according to fracture site, and that populations are generally ageing, these data clearly inform the provision of healthcare services in the UK, and are likely to be of relevance in similar countries elsewhere.

The hip is the site of fracture which has most often been characterised in studies of secular variation in fracture rates. The stable rates of hip fracture amongst women that we observed in the present study are consistent with many other studies of populations in the developed world, some of which have even documented a decline in age- and sex-adjusted rates[1]. Thus studies in USA[7], Canada[8], Austria[28], France[29], Australia[30] and New Zealand[31] have demonstrated declining age- and sex-specific rates of hip fracture over recent decades, often following an increase in rates in the decades prior. In the UK, a plateau in rates of age-adjusted hospital admission for hip fracture[32] was observed over the years 1989 to 1998. A similar plateau in the incidence of hip fracture has been documented in recent studies from Scandinavia[6,33] and Central Europe[34–36]. However, in transitioning populations, there is evidence of increasing age- and sex-adjusted incidence rates[1], although recent data from Hong Kong, a highly urbanised area, suggest stabilisation of rates[10].

Studies with a long term follow-up of multiple types of fractures simultaneously are scarce, but recently two such investigations have been published with data from the USA[19] and Canada[20]. In the US study, the incidence of all fractures was 470/10,000py in women and 315/10,000py in men[19]. Of those, 70% of patients had a single fracture and 30% had two or more fractures. Compared with these US data[19], the overall fracture incidence in our study was much lower both in women (166 versus 320/10,000py) and men (79 versus 211/10,000py). The trends in the US and our study were concordant with an increasing incidence of vertebra, pelvis and ankle fractures in both sexes and decreasing incidence of radius/ulna fractures in women, and patella fractures in men and women. The changes in other fractures were discordant, such as hip, humerus and tibia/fibula fractures. In the study from Canada decreases in hip fractures in both sexes, and in forearm and humerus fractures in women, were reported, but there was no change in vertebral fracture incidence in either

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sex[20] . However, comparison of these findings with our study is difficult since high and low trauma fractures were analysed separately. The exact reasons for these differences in fracture incidence and secular trends over the last two decades between UK, Canada and US are unknown, but differences in study design, fracture ascertainment, approach to multiple fractures, and ethnic distribution are all likely to play a role.

The mechanisms underlying the observed secular changes in age- and sex- adjusted fracture rates are poorly characterised, but broadly fall into three categories[1]. Firstly, rates may be affected by factors related to the distribution of age and demographics within age and sex strata. Secondly, factors may relate to the period in which the fractures occur. Thus improved nutrition and a decreased cigarette smoking, lower levels of manual work and outdoor activity, and changes in BMI are all likely to influence fracture rates[1]. The use of anti-osteoporosis medication, which has increased markedly over the last 20 years, has been shown to be unlikely to explain more than a small portion of any decrease in hip fracture rates[7]. Indeed in a recent study from the UK using the CPRD only 51.3% of women and 33.6% of men received anti-osteoporosis treatment after a hip fracture, despite this being a marked improvement on 10 years prior where 8.2% of women and 4.1% of men received treatment[37]. This dramatic "treatment gap" has been documented in other populations and should act as a huge incentive to improve identification of treatment of patients for treatment[38]. Interestingly, although there were differences by fracture type, there did not seem to be any overall difference in secular trend between fractures types classified as osteoporotic, compared with those which are not. Several studies have demonstrated the possibility of a third mechanism, that of factors acting early in life, that is, a "birth cohort" effect. Thus prospective cohort studies from the USA[4] and UK[39] have both demonstrated altered age- and sex-specific fracture rates according to the year of birth after accounting for period and age. There is increasing evidence that the early life environment has effects on acquisition of peak bone mass, and that poor growth in early life is associated with reduced bone mass at peak and in old age[40], and with increased risk of hip fracture[41]. The specific environmental influences that might underlie these associations are beginning to be characterised and include factors such as maternal diet, lifestyle and physical activity during pregnancy[42], and maternal gestational 25(OH)-vitamin D concentrations[43,44]. Finally, it is possible that changes in clinical practice may have influenced the ascertainment and reporting of certain fracture types: For example, rib fractures in the UK are now rarely the subject of radiographic confirmation; in contrast, there has been a great deal of effort internationally to increase awareness of vertebral fractures, both clinically and radiographically[45]. Such changes might have contributed to the decrease in the incidence of rib fractures and the increase in vertebral fractures that we observed.

We studied age- and sex-specific rates of a wide range of fractures in the population 50 years or over, across a total of 23 years in a single database, in which such events were captured uniformly. However there are some limitations that should be considered in the interpretation of our results. Firstly, although hip and vertebral fractures recorded in CPRD have been shown to be reliably coded[27], it is nevertheless possible that some fractures may have been misclassified as soft tissue injuries or incorrectly coded. In common with many other primary care databases, it is possible that fractures treated purely on an outpatient basis

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may have been less reliably captured than those necessitating hospital admission, most likely leading to an underestimation of incidence rates overall. Secondly, we were not able to examine in detail potential reasons for changes in incidence rates, or to investigate, for example, whether alterations to the age and sex structure of the population and changes in factors such as adiposity, physical activity, alcohol intake and smoking might explain any of the secular trends observed. Thirdly, owing to the difficulty in distinguishing two separate fractures of the same site, close in time, from a second reporting of a first fracture, we did not include second fracture at an individual site, which again will lead to an underestimate of fracture incidence. Fourthly, owing to the extremely large number of individuals in the dataset, it was not possible to readily calculate incidence on the basis of exact dates of fracture and time at risk. Although this will have led to some minor loss of resolution in the results, the same methodology was used for all fractures across the whole calendar period, there is no reason to think that it will have systematically changed our findings overall. Finally, CPRD covers 7% of the UK population[25] and therefore may not fully represent fracture rates in all areas of the UK. However the GP practices are widely distributed around the UK, and the dataset has been shown to be generally representative of the UK population[25].

In conclusion, in contrast to the plateau or decrease in age- and sex-adjusted rates of hip fracture observed in many studies, we observed an increasing rate in men, and for many other facture sites in either men, women or both sexes. Given the exponential rise of incidence with age for fractures at many sites[23], and the increasingly elderly demographic globally[2], we are clearly facing a growing burden from osteoporotic fracture in future years. Our findings thus add support to the call for global action to detect, assess and appropriately treat those at high fracture risk, and to close the treatment gap[38] for those who experience a low trauma fracture.

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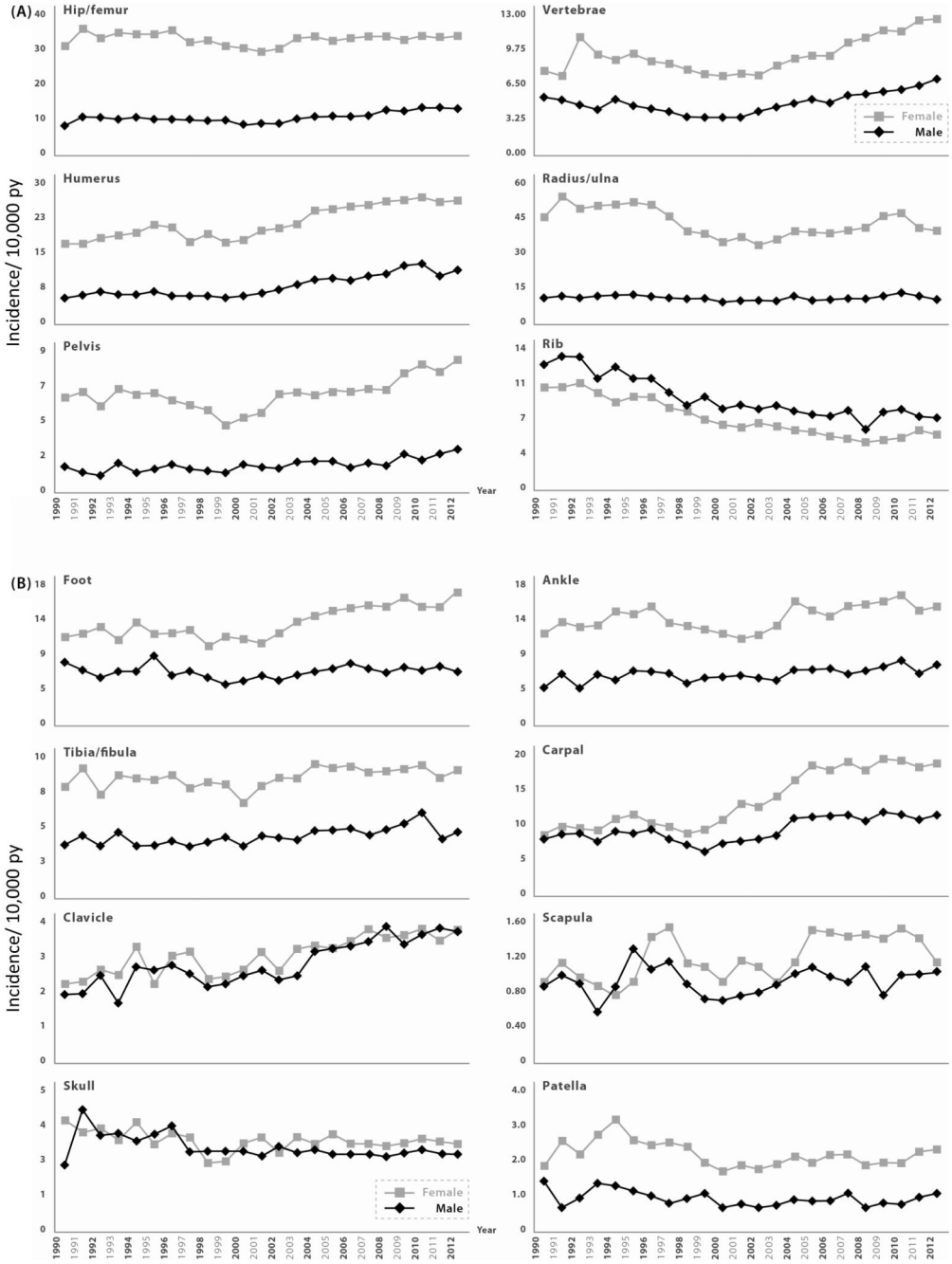

Figure 1.

Yearly incidence rates in the years 1990 to 2012 of (A) osteoporotic fractures and (B) other fracture sites.

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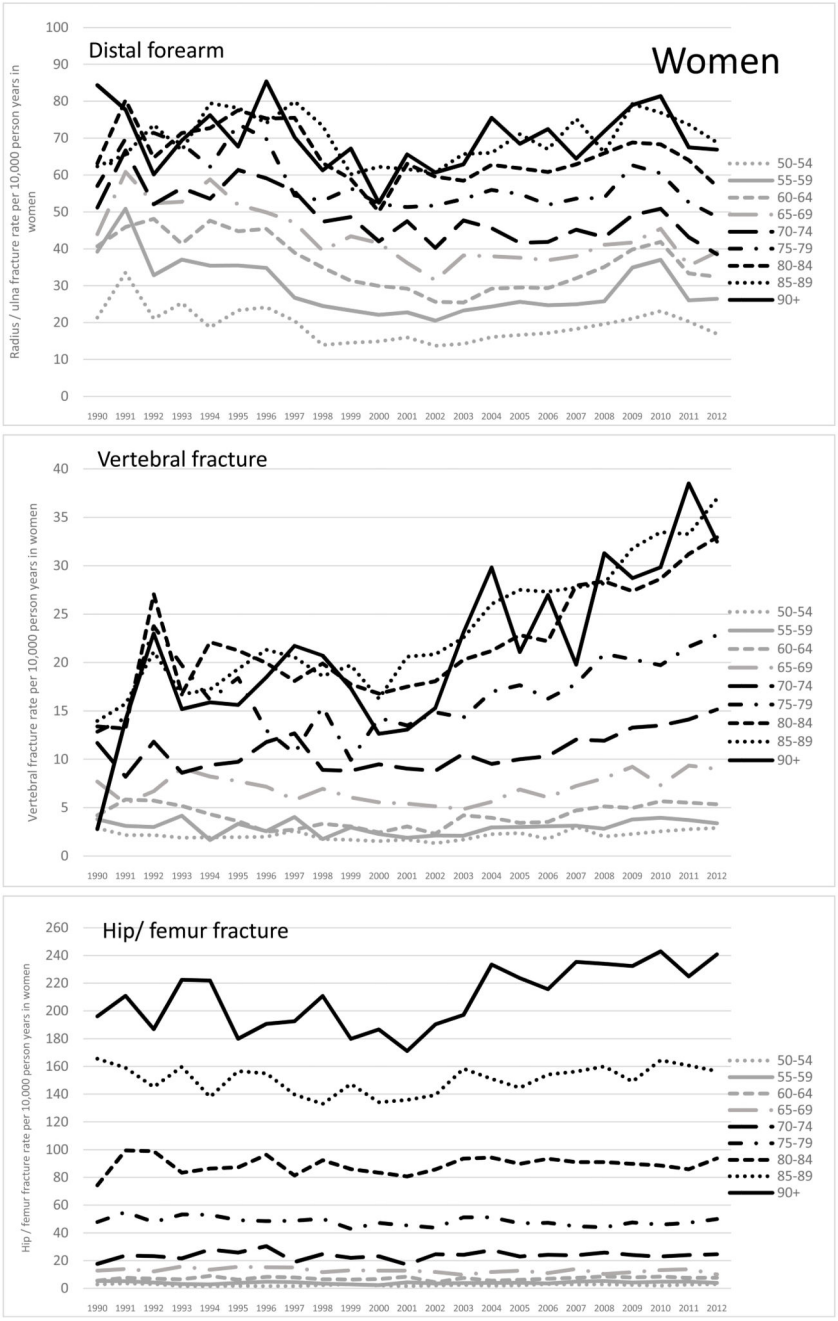

Figure 2.

Incidence (per 10,000 py) of distal forearm, vertebral and hip fractures in women 1990-2012 in the UK, stratified by 5-year age band.

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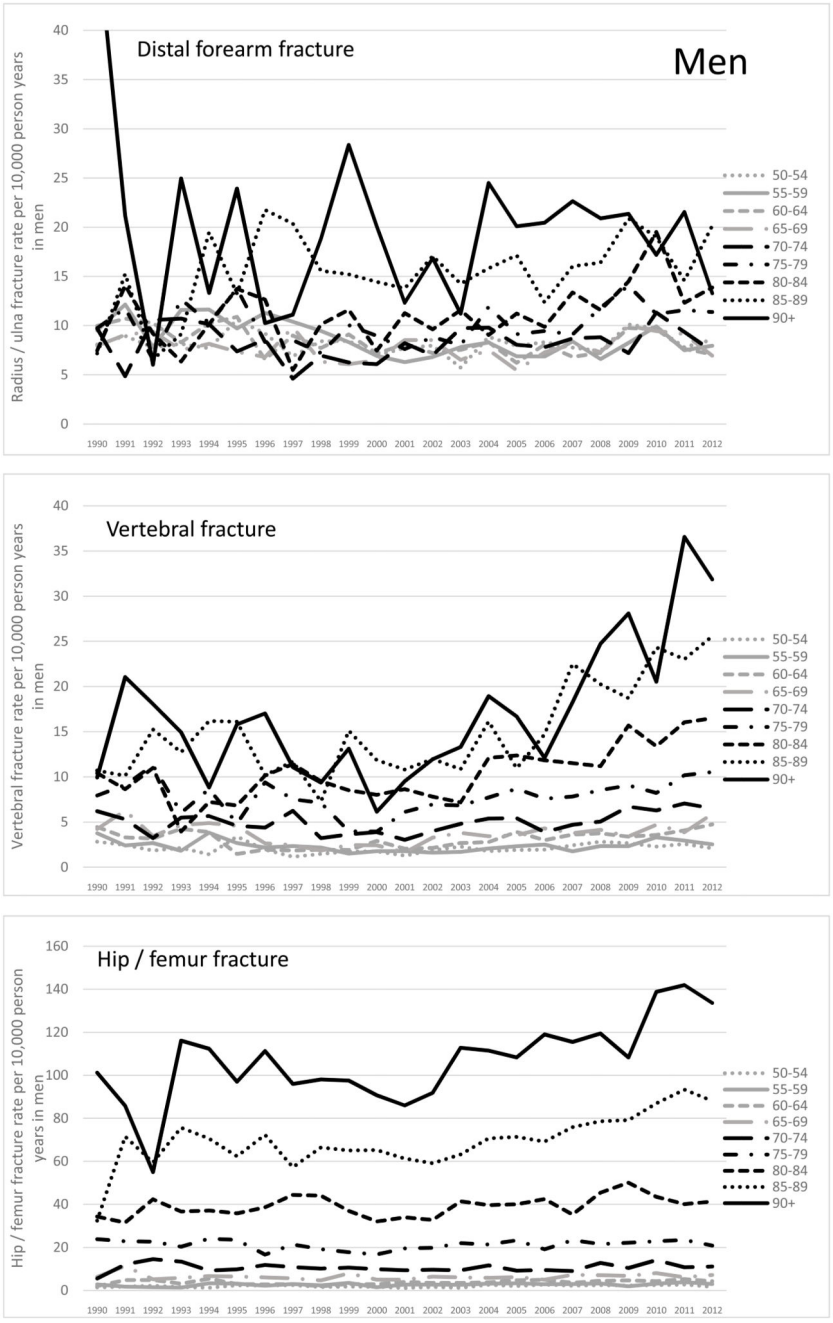

Figure 3.

Incidence (per 10,000 py) of distal forearm, vertebral and hip fractures in men 1990-2012 in the UK, stratified by 5-year age band.

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Table 1

Mean annual incidence rates [per 10,000 person-years (py)] 1990-1994 and 2008-2012, and annualised mean change in absolute incidence rates with test for trend across calendar years. Amongst A) women and B) men.

A) Women

Fracture	Incidence/10,000 py 1990-1994	Incidence/10,000 py 2008-2012	Annualised incidence change/10,000 py	p for trend
Increase:				
Carpal	9.7	18.3	0.445	<0.001
Scapula	0.9	1.3	0.025	0.003
Humerus	17.7	25.2	0.384	<0.001
Foot	12.2	16.1	0.181	0.001
Vertebrae	8.9	11.8	0.122	0.005
Pelvis	6.0	7.4	0.085	0.001
Tibia/Fibula	8.2	8.8	0.071	0.001
No change:				
All	168.2	170.0	-0.034	0.935
Skull	3.6	2.9	-0.017	0.280
Clavicle	2.6	3.6	0.033	0.077
Ankle	13.0	15.4	0.010	0.889
Hip/femur	33.8	33.5	0.013	0.798
Decrease:				
Radius/Ulna	50.4	41.2	-0.574	0.001
Patella	2.5	2.0	-0.022	0.019
Rib	9.9	5.6	-0.251	<0.001

B) Men

Fracture	Incidence/10,000 py 1990-1994	Incidence/10,000 py 2008-2012	Annualised incidence change/10,000 py	p for trend
Increase:				
Clavicle	2.2	3.7	0.076	<0.001
Humerus	5.8	9.6	0.119	0.048
Ankle	5.3	7.5	0.108	<0.001
Scapula	0.8	1.0	0.017	0.010
Hip/femur	10.8	13.4	0.116	0.002
Carpal	8.9	10.9	0.110	0.001
Tibia/Fibula	4.2	4.8	0.057	0.001
No change:				
All	74.8	78.9	-0.181	0.496
Radius/ulna	9.6	9.6	-0.090	0.251

Vertebrae	4.6	5.9	-0.020	0.718
Pelvis	1.5	2.0	0.009	0.496
Foot	6.9	6.9	0.006	0.796
Decrease:				
Skull	3.4	2.6	-0.033	0.046
Rib	12.3	7.0	-0.307	<0.001
Patella	1.0	0.8	-0.015	0.007

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