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Review Article

Incidence of Hip Fractures in the Elderly: A Cross-National Analysis

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Abstract. This paper reviews international data on incidence rates of hip fracture in persons 50 years of age and older, based on a bibliographic search of articles published since 1960. Incidence rates are higher in white populations than in black, Asian, and Hispanic populations. In both sexes and in all ethnic groups and geographic areas, incidence rates increase markedly with age. The steep increase with age, however, occurs later in black, Asiatic and Hispanic populations than in whites. The ratio of female to male incidence rates is higher than 1.0 in whites, while in blacks and Asians it has often been the reverse, with higher rates among men. In recent years in Hong Kong incidence rates in females have increased more rapidly than incidence rates in males, so that now the incidence rates in females are higher than those in males. In addition to the study in Hong Kong, most studies in Northern Europe and North America show an increase in age-adjusted hip fracture incidence rates over time over the past few decades.

Methodological differences among the various studies (including differences in the definition of hip fracture, in case ascertainment, and in the selection and sample size of the study population) necessitate cautious interpretation of the findings of this report.

Keywords: Hip fracture; Incidence rates; International comparison; Osteoporosis

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Introduction

Hip fractures presently constitute a major public health problem in developed countries, where these fractures are an important cause of mortality, disability, and are associated with high economic cost. With the steady increase in the number of older persons in developing countries, in the near future hip fracture will become an important problem there as well.

A cross-national analysis of hip fracture incidence rates may be useful in developing etiological hypotheses that can be tested by analytic epidemiologic studies and clinical investigations. The comparisons of incidence rates of hip fractures in different countries and ethnic groups could provide relevant information regarding the influence of genetic, environmental, and behavioral factors on the occurrence of hip fractures. Unfortunately, different case ascertainment methods and sources of data present important constraints in making comparisons across countries. Nevertheless, we have undertaken a comprehensive review of the methods and data from studies available in the literature, which, in spite of these shortcomings, provide valuable cross-national information and permit some inferences.

Methods

This paper reviews information on incidence rates of hip fracture around the world, based on a bibliographic search of articles published since 1960. When available, data on trends in these rates over time are also presented.

Specific information on the methods used in each of the studies reviewed is given in Table 1, including the countries and the specific areas within the countries

Table 1. Description of studies of incidence rates of hip fracture included in this survey

Author [reference number]	Country	Years of study	Number of cases and source of data	Definition
Knowelden et al. 1964 [1]	UK (Oxford and Dundee)	1954–58	256 women and 78 men in Dundee, 150 women and 46 men in Oxford from hospital records	Femoral neck fracture
Wong 1966 [2]	Malaysia (Singapore)	1955–62	240 women and 402 men from the only hospital in Singapore	First fracture of head or subtrochanter (excluding pathologic fractures, but including severe trauma)
Chalmers et al. 1970 [3]	Hong Kong	1965–67	654 women and 386 men from three hospitals (95% of all fractures)	Hip fracture
Levine et al. 1970 [4]	Israel (Jerusalem	1957–66	339 women and 198 men from the two hospitals in Jerusalem	Intra/extracapsular fracture (including subtrochanteric within 1 cm of the lesser trochanter); 84% were due to minimal trauma
Alhava and Puittinen, 1973 [5]	Finland	1968	1025 women and 417 men from the National Board of Health Statistics	Fracture of upper end of femur
Pogrund et al. 1977 [6]	Israel (Jerusalem)	1967–71	396 women and 174 men from the two hospitals in Jerusalem	Intra/extracapsular fracture (including subtrochanteric within 1 cm of the lesser trochanter)
Solomon 1968 [7]	South Africa (Johannesburg)	1950–64	30 women and 48 men from records of all hospitals	Femoral neck fracture
Matkovic et al. 1979 [8]	Yugoslavia (Podravina and Istra)	1968–73	104 women and 83 men in Podravina and 225 women and 171 men in Istra from records of six hospitals	Fracture of proximal femur (from head to the subtrochanteric level)
Evans et al. 1979 [9]	UK (Newcastle)	1975	246 cases from teaching hospital	Cervical and intertrochanteric fractures
Baker et al. 1980 [10]	UK (Yorkshire and Humberside)	1973–77	7800 women and 2469 men from hospital activity analysis	Femoral neck fracture
Stott et al. 1980 [11]	New Zealand	1973–76	3480 women and 1166 men among Europeans; 61 women and 87 men among Maoris from the National Health Statistics Centre	Femoral neck fracture
Gallagher et al. 1980 [12]	USA (Rochester, MN)	1965–74	328 women and 87 men from Diagnostic Index for the Mayo Clinic and affiliated hospitals	Cervical and trochanteric fracture (only first, excluding those due to metastases or severe trauma)
Frandsen et al. 1983 [13]	Denmark (county of Funen)	1973–79	2313 fractures in women and 783 in men from the hospital discharge data	ICD 820.00–820.99
Swanson and Murdoch 1983 [14]	Scotland (Dundee)	1952–3 1975 1980	48 women in 1952; 87 women and 24 men in 1975; 102 women and 21 men in 1980 from Dundee Royal Hospital	Cervical and trochanteric fracture
Farmer et al. 1984 [15]	USA	1974–79	7278 cases (<85 years of age) from the National Hospital Discharge Survey	ICD 820.0–820.5 for 1974–78 ICD 820.0–820.9 for 1979
Elabdien et al. 1984 [16]	Sweden (Uppsala county)	1965–80	294 women and 95 men in 1980 from the hospital records	Fracture of femoral neck and trochanter
Falch et al. 1985 [17]	Norway (Oslo)	1978–79	102 women and 22 men from all hospitals	Cervical and trochanteric fracture excluding those intersecting greater trochanter

(*Table continued on next page*)

where the studies were done, the number and the source of cases, and the definition of hip fracture used. Only data on the population over 50 years of age have been reviewed, because hip fracture is relatively rare at younger ages.

The criteria for including studies in this review were the following:

1. Selection of hip fracture cases based on hospital records
2. Specification of the time period of the survey
3. Definition of hip fracture as one of the following: ICD code 820.0–820.5 until 1978; 820.0–820.9 after 1978; fracture of femoral neck or proximal femur;

Table 1. Description of studies of incidence rates of hip fracture included in this survey (*continued*)

Author [reference number]	Country	Years of study	Number of cases and source of data	Definition
Boyce and Vessey 1985 [18]	UK (Oxford)	1983	89 women and 22 men from the Radcliffe hospital	Fracture of proximal femur, excluding: pathological fractures, subtrochanteric or greater trochanter or femoral head alone, effect of a previous fracture
Finsen and Benum 1987 [19]	Norway (Trondelag county)	1972–73 1983–84	422 women and 140 men in 1972–73 and 728 women and 281 men in 1983–84 from hospital records	Cervical and trochanteric fracture
Mannius et al. 1987 [20]	Sweden (Skaraborg county)	1974–82	3030 cases from hospitals' records	Cervical and trochanteric fracture
Hedlund et al. 1987 [21]	Sweden (Stockholm county)	1972–81	8883 women and 2929 men from the Inpatient Care Register	Fracture of femoral neck and trochanter, ICD 820.00/.01/.10/.11
Holmberg et al. 1987 [22]	Sweden (Stockholm county)	1975–77	2289 women and 764 men from hospitals' records	Femoral neck fracture
Lizaur et al. 1987 [23]	Spain (Alicante)	1974–82	848 women and 439 men from hospital records	Trochanteric fracture
Sernbo et al. 1989 [24]	Sweden (Malmo and Ystad)	1981–84	736 women and 269 men in Malmo 189 women and 97 men in Ystad from hospitals' records	Cervical and trochanteric fracture
Bauer 1989 [25]	USA (Texas, Bexar County)	1980	1346 cases from 17 hospitals in the county	Fracture of proximal femur (excluding subtrochanteric and major trauma)
Silverman and Madison 1988 [26]	USA (California)	1983–84	about 30000 women and about 10000 men from the California Discharge Data Program	Capsular and intertrochanteric fracture (ICDA-9 codes 820.0 to 820.9)
Naessen et al. 1989 [27]	Sweden	1965–83	12885 cervical and 5715 trochanteric fractures in women, 4893 cervical and 2706 trochanteric fractures in men from the hospitals' records	Cervical and trochanteric fracture
Rodriguez et al. 1989 [28]	USA	1970–83	2754899 cases from the National Hospital Discharge Survey	ICDA 820.0–820.5 ICD-9-CM 820.0–820.9
Martin et al. 1989 [29]	Canada (Saskatchewan)	1972–84	146 men and 353 women in 1972 and 252 men and 627 women in 1984 from the Hospital Discharge Data	Hip fracture
Caniggia et al. 1989 [30]	Italy (southern Tuscany)	1975–85	1197 women and 323 men who were patients of the University Orthopedic Department in Siena	Intracapsular (subcapital and cervical) and extracapsular due to minor trauma; excluded if due to traffic accident, tumours and infective diseases of bone
Ray et al. 1990 [31]	Canada (Saskatchewan)	1976–85	4486 women and 1781 men aged 65+, from hospital discharge data	ICD-9 codes 820.0–820.9
Lau 1989 [32]	Hong Kong	1966 and 1985	605 women and 275 men in 1985, from hospital admission records	Fracture of proximal femur
Kellie et al. 1990 [33]	USA (Illinois)	1980–82	14768 White women and 3575 White men, 523 Black women and 204 Black men from hospital discharge data	ICD 820.0–820.9

cervical, trochanteric, intracapsular, extracapsular or intertrochanteric fracture; and hip fracture without further specification of the location

4. Sufficient information for the calculation of age and sex-adjusted incidence rates of hip fracture. Those studies without sufficient information for the calculation of age- and sex-adjusted rates have been included only in the general discussion, but not in the cross-national comparisons.

Results

Overview

The age- and sex-adjusted incidence rates of hip fracture for the population over 50 years of age in various geographic areas are presented in Table 2. For ease of presentation, we have arbitrarily defined the rates for both sexes as high (350/100 000 or more), intermediate (150–349/100 000), and low (149/100 000 or less).

Table 2. Age-adjusted[a] incidence rates (per 100000) of hip fracture by sex in the population over 50 years of age, by geographic area

Geographic area, years of survey, [Reference number]	Age-adjusted rates		Age and sex-adjusted rates: total
	Women	Men	
Norway 1983–84 [19]	1293	551	968
Oslo, Norway 1978–79 [17]	701	310	530
Stockholm, Sweden 1972–81 [21]	622	291	477
Denmark 1973–79 [13]	620	203	437
New Zealand, Whites, 1973–76 [11]	620	151	414
California, USA Whites 1983–84 [26]	559	207	402
Texas, USA Whites, 1980 [25]	530	205	384
Rochester, USA 1965–74 [12]	510	174	364
Hong Kong 1985 [32]	353	181	277
California, USA Asians 1983–84 [26]	338	104	235
Texas, USA Hispanics, 1980 [25]	263	118	197
Yorkshire, UK 1973–77 [10]	275	96	196
California, USA Blacks, 1983–84 [26]	219	144	185
Kuopio, Finland 1968 [5]	100	249	183
California, USA Hispanics, 1983–84 [26]	197	90	151
New Zealand Maori, 1973–76 [11]	107	182	149
Hong Kong 1965–67 [3]	153	96	128
Singapore 1955–62 [2]	75	100	86
Johannesburg Bantu, 1950–64 [7]	26	38	31

[a]Rates adjusted to the USA population over 50 years of age, 1985.

Table 3 presents age- and sex-specific incidence rates of hip fracture in whites, blacks, Asians, and Hispanics. In both sexes and in all geographic areas and ethnic groups, incidence rates increase with age.

The ratio of female to male cases are shown in Table 4. They are greater than 1.0 in the white populations; however, for blacks and Asians the sex ratios are generally reversed in the studies using data from 1950–64, 1955–62 and 1965–67 [2,3,7], while recent studies in Asian populations in California [26] and in Hong Kong [32] show higher age-specific incidence rates in females than males. The rates tend to be higher in females than males in Hispanics, but the number of cases on which the rates in each group are based are not large enough to allow the calculation of very precise ratios.

White Populations. As shown in Tables 2 and 3, among the white populations high rates of hip fractures have been reported in Norway, Sweden, Denmark, New Zealand, and the USA; intermediate rates have been reported in the UK and Finland.

Table 3 presents the age- and sex-specific incidence rates for hip fracture from selected countries. The highest annual incidence rates are in older individuals, particularly among the oldest women (e.g., 5.7% per year among women 80 years of age and older in Central Norway) [19]. Several other studies beside those presented in Tables 2 and 3 have been reviewed. Most have not been included in the tables because differing age-intervals were used and it was impossible to calculate the rates according to the 10-year intervals used in our review, or because data must be inferred from figures, rather than actual numbers and rates, or because rates were reported only for trochanteric fractures [1,4,6,8,9,14,16,18,20,22,23,24,27,28,30,31,33]. We will discuss briefly some of the studies excluded from the table, which, despite the differences in the presentation of the results, may be relevant for cross-national comparisons.

In Sweden, Mannius et al. [20] used data from the computerized register of the hospitals in the Skaraborg county, a rural area in the south-western part of Sweden, and compared them with the data collected in Göteborg by Zetterberg [38], who used the same method. The age-standardized incidence rate of hip fracture in the rural area was significantly lower than in the city of Göteborg. This rural/urban difference has been reported also from Stockholm [22], and from Malmo in Sweden [34], in Central Norway [19], and in Canada [31]. Levine et al. [4] and Pogrund et al. [6] found significant differences in hip fracture rates among the three ethnic groups in Jerusalem, Israel. The highest rates were among the European and American born Jews and the lowest among the Sabras, born in Israel, with intermediate values among the Asian and African born individuals. Matkovic et al. [8] evaluated hip fracture rates in two populations in Yugoslavia in which dietary calcium intake differed, and found lower rates among the individuals with higher calcium consumption. The magnitude of the rates reported in Yugoslavia were lower than those reported in the USA and Scandinavia at all ages in both sexes. Knowelden et al. [1] evaluated the total fracture rate in Dundee and Oxford and found that in the population 85 years of age and older, fractures of the femur accounted for more than half of the total number of fractures in women, with trochanteric fractures being the most common. In both sexes the rates were low below the age of 65 years and then rose steeply, particularly in women. In the USA, similar results to those presented in Tables 2 and 3 [12,25,26] were found by Rodriguez et al. [28]. These authors used data from the National Hospital Discharge Survey of the National Center for Health Statistics for the period 1970–83. The age-specific incidence rates of hip fracture in women were twice those in men; there was a steady increase in rates with age in both sexes.

Table 3. Age- and sex-specific incidence rates (per 100000) of hip fracture

Geographic area, years of survey, [Reference number]	Women, age (years)				Men, age (years)			
	50–59	60–69	70–79	80+	50–59	60–69	70–79	80+
White populations								
Kuopio, Finland 1968 [5]	27	85	331	1130	24	54	154	559
Yorkshire, UK 1973–77 [10]	34	104	371	1200	20	51	140	548
New Zealand 1973–76 [11]	34	122	494	1988	27	51	186	862
Rochester, USA 1965–74 [12]	62	250	674	2108	37	92	192	1281
Funen, Denmark 1973–79 [13]	90	217	935	2533	48	129	307	1119
Oslo, Norway 1978–79 [17]	130	289	1022	2736	54	226	523	1598
Central Norway 1983–84 [19]	213	513	1611	5689	67	346	867	3234
Stockholm, Sweden 1972–81 [21]	79	227	820	2770	78	182	478	1419
Texas, USA 1980 [25]	45	235	726	2263	31	104	192	1641
California, USA 1983–84 [26]	65	213	726	2502	37	90	334	1209
Black populations								
Johannesburg, South Africa 1950–64 [7]	10	20	30	80	20	30	40	170
Texas, USA 1980 [25][a]		123	240	910				
California, USA 1983–84 [26]	35	80	270	990	46	84	190	816
Asian populations								
Singapore 1955–62 [2]	10	50	100	270	20	70	210	350
Hong Kong 1965–67 [3]	23	57	173	716	17	71	224	321
California, USA 1983–84 [26]	17	90	320	1930	16	49	155	739
Hong Kong 1985 [32]	32	135	501	1521	28	54	339	1156
Hispanic populations								
Texas, USA 1980 [25]	10	25	340	1423	18	31	214	816
California, USA 1983–84 [26]	16	60	250	960	15	34	150	600

[a]There was only one fracture among black men.

Ray et al. [31] ascertained the incidence of hip fractures for the population 65 years and older in Saskatchewan, Canada, from the computerized hospital discharge data and reported that the incidence in women was twice that in men, and that the incidence in urban areas was 27% greater than in non-urban areas; no increase in incidence rates over time was found. The Saskatchewan incidence rates are similar to those found in the UK, that is lower than those reported in Scandinavia, and in most reports from the USA [12,13,15,17,19,25,26].

Black Populations. As shown in Table 2, the age- and sex-adjusted rates among blacks aged 50 years and older range from 31/100000 in the Bantu population in Johannesburg in 1950–64 [7] to 185/100000 in California in 1983–84 [26] and are among the lowest reported in the literature. Table 3 presents data by age and sex for the black population in South Africa and in the USA [7,25,26]. Although in all the studies blacks have increased incidence rates of hip fractures with age, their rates in each group are lower than among whites. The

Bantu population shows rates that are much lower than those for blacks in the USA in each age group. The fracture rates in Bantu women and men of age 80 years and older were 80/100 000 and 170/100 000 respectively, compared with rates of 990/100 000 and 816/100 000 in black women and men, respectively, of the same age in California [7,26]. Bauer [25] reported hip fracture rates in black women from Texas that were very similar to the rates reported for black women from California. The Bantu women present lower rates than men in each age group, with sex ratios ranging from 0.5 to 0.8 (Table 4). In this survey the hip fractures were identified through hospital records [7]. The validity of this approach was evaluated in a small, direct survey of the population which confirmed that all patients in this town who had hip fractures had been hospitalized.

Farmer et al. [15] reported rates for the black population in the District of Columbia. The rates were lower than those reported for the whites at each age group in both sexes. The increase in hip fracture rates with age in black women started only in the age group of 60 years and older, about 10 years later than in white women.

Kellie and Brody [33] used Health Care Financing Administration data for Illinois for the calculation of sex-race and age-specific hip fracture rates. They found lower rates for blacks compared with whites. Age-specific rates in women were higher than in men for both groups, although the sex difference occurred at older ages in blacks than in whites. These findings are in agreement with those reported by Silverman and Madison [26].

Asian Populations. Age-adjusted incidence rates among Asian individuals living in three different areas [2,3,26,32] may be found in Table 2. The age-adjusted rates for Singapore in 1955 [2] and Hong Kong in 1965 [3] were lower than those for the white population studied at those times, while the age-adjusted rates reported among the Asian population in California [26] and in a recent survey in Hong Kong [32] are similar to those of countries with intermediate rates. The same characteristics can be seen in Table 3 for the age- and sex-specific incidence rates.

Table 3 shows that rates in Singapore in 1955–62 [2] were higher among men than women in each age group and rates in Hong Kong in 1965–67 [3] were higher for men in each age group, except for those aged 80 years and older. However, the most recent results from surveys in the Asians of California [26] and Hong Kong [32] show that data are similar to those in white populations, with rates higher in women than in men.

In order to determine if the low rates among the Asian populations occurred because Oriental people seek treatment among traditional health practitioners instead of hospitals, Chalmers and Ho carried out an inquiry among bone setters in Hong Kong in 1968 [3]. They reported that hip fractures were almost invariably treated in hospitals, although frequently after a delay of several weeks. Therefore, access to "alternative health care sources" should not introduce a large error, and the lower rates among Asian individuals compared with Western individuals should be considered real, not artifactual. However, the delay of several weeks in hospitalization after the fracture could mean that some deaths occur among persons with hip fracture before they have a chance to be hospitalized, leading to the lower hip fracture rates reported in the hospital discharge data in this country.

Hispanic Populations. Tables 2 & 3 present data on Hispanic populations in Bexar County, Texas, and in California [25,26]. Among the Hispanics living in Texas, the rates are lower than among non-Hispanic whites in each age group. In California the age-specific rates and the age- and sex-adjusted rates among Hispanics are lower than the rates among whites, blacks and Asians [26]. As shown in Table 3, Texas women aged 50–69 years present rates lower than men, but the number of fractures in these age groups is too small to place much confidence in these differences [25]. In California the incidence rates among women are higher than among men [26]. It is interesting to note, however, that the sex ratio among Hispanics is lower in each age group than in whites.

Maori Populations. The rates for Maoris living in New Zealand [11] are among the lowest found in this review, while rates for the white population living in the same area are among the highest reported. The age- and sex-adjusted incidence rates are 149/100 000 in the Maori population, compared with 414/100 000 in the white population [11].

Time Trends in the Incidence of Hip Fractures

Unfortunately, data on the time trends for incidence rates of hip fracture are available only for white populations [10,13,21,23,24,27–32,34–43], except for Asians in Hong Kong [32].

Most studies have shown an increase in hip fracture incidence rates in the last 30 years in such countries as the UK [18,37,39,43], Denmark [36], Sweden [16,21, 24,34,38,40,41], Norway [17,19], Spain [23], the USA [28], Canada [29], and Hong Kong [32]. Sernbo and Johnell [24] report an increase of hip fracture rates between 1950–58 and 1983–85 in Malmo, Sweden. They compared roentgenograms of patients in the two different periods and found a significant lower femoral neck index (FNI) in 1980, both in females and males; this could explain, at least in part, the increased rates of fractures.

According to some reports, much of the increase occurred in men [27,42], while in others the increase occurred only in women [10,13,14,20,30]. Hip fracture rates seemed to increase faster in Sweden [21,34,38] and the UK [10,18] than in the USA [28].

In Newcastle, UK, Evans et al. [35] reported no temporal increase from 1971–75, as well as Nilsson and

Table 4. Age-specific sex ratio of incidence of hip fracture

Country Years of survey [Reference]	Age-specific sex ratio [F/M]			
	50–59	60–69	70–79	80+
White populations				
Kuopio, Finland 1968 [5]	1.1	1.6	2.1	2.0
Yorkshire, UK 1973–77 [10]	1.7	2.0	2.7	2.2
New Zealand 1973–76 [11]	1.3	2.4	2.7	2.3
Rochester, USA 1965–74 [12]	1.7	2.7	3.5	1.6
Funen, Denmark 1973–76 [13]	1.9	1.7	3.0	2.3
Oslo, Norway 1978–79 [17]	2.4	1.3	2.0	1.7
Central Norway 1983–84 [19]	3.2	1.4	1.9	1.8
Stockholm, Sweden 1972–81 [21]	1.0	1.2	1.7	2.0
Texas, USA 1980 [25]	1.5	2.3	3.8	1.4
California, USA 1983–84 [26]	1.8	2.4	2.2	2.1
Black populations				
Johannesburg, South Africa 1950–64 [7]	0.5	0.7	0.8	0.5
California, USA 1983–84 [26]	0.8	0.9	1.4	1.2
Asian populations				
Singapore 1955–62 [2]	0.5	0.7	0.5	0.8
Hong Kong 1965–67 [3]	1.4	0.8	0.8	2.2
California, USA 1983–84 [26]	1.0	1.8	2.1	2.6
Hong Kong 1985 [32]	1.1	2.5	1.5	1.3
Hispanic populations				
Texas, USA 1980 [25]	0.6	0.8	1.6	1.7
California, USA 1983–84 [26]	1.1	1.8	1.7	1.6
Maori populations				
New Zealand 1973–76 [11]	1.2	0.8	1.9	1.4

Obrant in Malmo between 1967 and 1974 [34], Spector et al. in England and Wales from 1979 to 1985 [43] and Farmer et al. in the USA from 1974–79 [15]. One study has failed to show any increase over time in Saskatchewan, Canada, in the period 1976–85 [31]. The absence of a notable increase over time could be in part due to the short period of observation in these studies. However, another report on the population of Saskatchewan and Manitoba shows an increase of 59.7% in women and 42.2% in men over 50 years of age in the period between 1972 and 1984 [29].

Discussion

The incidence rates of hip fractures increased with age in all the ethnic groups considered. The increase occurs later in life in black, Asian, and Hispanic populations than in whites. Most studies, with one exception [50], show higher bone mineral content among blacks than among whites at each age [53,54,56]. Solomon [50,58] found that Caucasians in Johannesburg present a phase of slight, but continuous, reduction in metacarpal bone density between 30 and 50 years of age, while blacks have their metacarpal bone density sustained at maximum levels or actually increasing at the same age. This could contribute to the later rise in hip fracture rates in blacks, but it needs to be confirmed by further investigations. Except for a study in Ecuador [51], no information has been published on bone density in Hispanic populations. Japanese individuals have lower bone mineral content than whites [52], despite the lower rates of hip fracture. Therefore, there must be other important factors beside bone mineral content that should be considered as etiologic agents for fractures among the elderly, such as those predisposing to falls and those related to neuromuscular reactions [45–49,59].

The degree of industrialization might also lead to different incidence rates of hip fracture across the countries. In less developed countries, as well as in rural communities, the level of physical labour is higher and probably increases bone strength [19,20,22,31,34]. Since lowest incidence rates have been reported in tropical countries and the highest rates in Scandinavia, it has been postulated that lack of exposure to sunlight might be associated with fractures. Moreover, a recent report on the geographic pattern of hip fractures in the USA has shown a positive association with reduced sunlight exposure [66]. However, the lower rates reported in the United Kingdom compared with Scandinavia, and in Canada compared with the USA, do not support this hypothesis.

It is of interest to note the higher rates among Asians and blacks living in Western countries than among those living in Asia and Africa. This observation seems to support an effect of environmental factors in the etiology of hip fracture. However, the lower rates reported in Saskatchewan, Canada [31], compared with Rochester, Minnesota [61] might be attributed in part to ethnic differences. Residents of Saskatchewan are predominantly of English ancestry, while the Rochester population has a greater German and Scandinavian heritage. This is in agreement with the data we have seen in this review, with the rates of hip fracture in England being lower than those reported in Scandinavia.

Also notable are the differences in the sex-ratio of hip fracture incidence rates among ethnic groups (Table 4).

The lower rates in black women in the USA could be explained in part by their higher frequency of obesity [55], which has been positively correlated with the bone density and might be a protective factor in case of falls [45].

Most of the studies of time trends show an increase in age-adjusted incidence rates of hip fracture among whites and Asians. The reasons for such a trend are not clear. Unfortunately, data on other ethnic groups are not yet available. Rees [44] suggested that improved case ascertainment might be responsible in part for the higher rates seen in the recent years. However, if the increase in incidence rates in some areas is real, several explanations have been offered. Changes in life style such as the increased frequency of cigarette smoking and alcohol consumption could be partly responsible for this increase. The decreased amount of heavy physical labor might also explain part of the increase. This theory is supported by the findings of lower hip fracture rates in the rural communities, where the amount of physical labor is higher than in the urbanized areas [19,20,22,31,34].

According to Finsen [62], patients with trochanteric fractures report more chronic conditions than those with cervical fractures and they are usually older. Improvements in health care have increased the lifespan of a subset of the elderly consisting of weak and debilitated individuals who are more prone to fall. This could result in a rise particularly of trochanteric fractures. Another possible reason for some of the increase might be an increase in falls, some of which may be related to the use of psychotropic drugs [60].

This review, as well as previous ones [64,65], shows remarkable differences in the incidence of hip fracture from one country to another. However, available information does not allow exact comparisons because of methodological constraints such as those described below.

Differences in Definition of Fracture

Only a few studies [13,15,21,26,28,31,33] used the ICD code in their analyses and sometimes the term 'proximal femur' or 'hip fracture' is used without any further specification. In most of the studies no mention has been made about the trauma leading to the fracture ('minor', or 'major' trauma). However, those authors who have considered the nature of the accidents have reported minor trauma as responsible for the great majority of fractures (about 90% and 70% of fracture in women and men, respectively, over 50 years of age).

A related problem could be incorrect coding. There have been few reports on the validity of hospital discharge data. In the United Kingdom, Rees [44] reports a wide variation among regional hospitals in the accuracy of coding, with gross errors in the generation of the Hospital Activity Analysis in some centers, particularly in the peripheral hospitals.

Differences in Case Ascertainment

Incomplete ascertainment of cases should be considered as a possible source of bias, and its extent may differ from one country to another. In the USA, a study done in Charlottesville, Virginia [63], did not find any cases that had not been treated in a hospital. However, in the UK, Knowelden et al. [1] reported that, at least in the early 1960s, from 7% to 17% of patients with hip fracture were not hospitalized, but instead were treated at home or in nursing homes.

Few authors have discussed the possibility that some cases have been counted twice. This may introduce important ascertainment biases, given the high rate of transfer of hip fracture patients from one hospital to another: 16% to 41% of hip fracture admissions in the UK are transfers [9,37]. Readmissions for second fractures or for complications consequent to first fractures are also included in the hospital discharge data in the USA. The probability of a second fracture can be as high as 16% [9,35,57]. According to Wallace, there has been in recent years an increase in the numbers of patients with second fractures, probably because of the improved survival after treatment of a first hip fracture [39].

Availability of health services and accuracy of health statistics may also differ from one country to another; these factors could explain some of the differences reported in various studies, particularly when the comparisons are made between developed and developing countries.

Differences in Selection of Study Population

Differences in selection of study population may be responsible for differing rates among studies. The best situation occurs, of course, when the authors are able to identify all cases in a defined population, yet several studies reported data only on selected groups (e.g., individuals referred to one single hospital). This is probably the reason for the very low rates reported in Siena, Italy [30]. The authors used as numerator the number of patients with hip fractures referred to the Department of Orthopedics in the University of Siena and as a denominator the total population of South Tuscany. Because there are other departments and hospitals in that area where patients seek care for fractures, it is likely that some cases have been treated in different settings and have not been counted.

Differences in the Period of Ascertainment

Differences in the period of ascertainment may be responsible for some of the differences seen across countries. If we assume, as has been shown in most of the studies, that there is a secular trend in hip fracture rates, with an increase over time, comparisons of studies done in different periods may be inappropriate. For

example, in many cross-national comparisons, the only data available for the Asian and black populations were based on studies done in the period 1960–70, and the comparison with recent studies done in the Western population leads to the conclusion that Asians and blacks have much lower rates [2,3,7].

Considering the most recent report on the population in Hong Kong [32], we have seen a significant increase in the age- and sex-specific incidence rates, so that now the age-adjusted rates are similar to those found in some Western countries with intermediate rates.

Sample Size

The sample size in many of the studies reviewed is small, particularly for cases 85 years and older. As a consequence, the rates calculated may be very unstable and generalizations inappropriate.

The Age Group 80 Years and Older

In the table presenting the age-specific incidence rates, the oldest category is 80 years of age and above. There is no upper bound, which reduces the validity of comparisons of rates for this age group. For example, in well-developed countries a greater proportion of the population can be expected to live well beyond 80 years compared with developing countries. Therefore, the population at risk may be very different across countries.

If we are able to overcome these methodological problems with the implementation of coordinated and standardized international multi-centre collaborations, we might be able to obtain more reliable comparisons of incidence rates and to assess the effect of still controversial risk factors across countries and races.

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