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ORIGINAL ARTICLE

Osteoporotic fractures among foreign-born individuals: a national Swedish study

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Abstract

Summary In this national study of osteoporotic fractures in foreign-born individuals, we found a lower risk of osteoporotic fractures in general among foreign-born individuals compared with Swedish-born, especially in immigrants from southern Europe. A higher risk was found among some groups, i.e. men and women from Bosnia and Iraq and men from Lebanon.

Introduction The aim of this study was to analyse risk of osteoporotic fractures in foreign-born individuals compared with Swedish-born individuals.

Methods This was a nationwide study of individuals 50 years of age and older (N = 2,775,736). Osteoporotic fractures were defined as at least one registered diagnosis of fractures in the hip, humerus, forearm or vertebrae, in the National Patient Register between January 1, 1998, and December 31, 2012. Cox regression analysis was used to estimate the relative risk (hazard ratios (HR) with 99% confidence intervals (CI)) of incident osteoporotic fractures in foreign-born compared with Swedish-born individuals. The Cox regression models were stratified by sex and adjusted for age, comorbidities and sociodemographic status.

Results A total of 362,899 osteoporotic fractures were registered (96,847 among men and 266,052 among women), with hip fractures dominating (54.0% among men, 42.6% among women). Fully adjusted HRs (99% CI) were for all immigrant men 0.75 (99% CI, 0.73–0.78) and women 0.83 (99% CI, 0.81–0.84), with significantly lower HRs among most groups but with higher HRs in certain countries. For the specific fractures, higher HRs were found for lower forearm fractures for men from Asia and for vertebral fractures among women from Asia.

Conclusions We observed a generally lower risk of osteoporotic fractures among first-generation immigrants, with few exceptions.

Keywords Forearm fractures · Gender · Hip fractures · Humerus fractures · Immigrants · Neighbourhood · Osteoporotic fractures · Socioeconomic status · Vertebral fractures

Introduction

The number of osteoporotic fractures is on the rise worldwide owing to an increasing elderly population. Osteoporotic fractures [1], most often including hip fractures, forearm fractures and vertebral fractures but also humerus fractures [2], are also associated with a significant all-cause mortality and increasing healthcare costs, especially in developed countries

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[3], including the EU [4]. The geographic and ethnic patterns differ globally [1, 5], with hip fractures being of highest interest [6] but also other fractures, such as vertebral fractures [7, 8].

Osteoporotic fractures are especially high in Northern Europe. In a Norwegian study from the capital Oslo, the incidence of hip and forearm fractures was shown to be higher than in studies in other countries [9].

With an increasing number of immigrants in Europe during the last decades, the health and disease patterns in this group are of major interest. In Sweden, the proportion of first-generation immigrants, i.e. foreign-born individuals, in the population is around 17% [10]. As regards osteoporotic fractures in Sweden, the risk of hip fractures is shown to be lower among foreign-born compared with Swedish-born individuals [11, 12] and also of distal forearm fractures in first- and second-generation immigrants [13]. However, knowledge about other osteoporotic fractures in specific immigrant groups is scarce. In an earlier study on hip fractures, the incidence rates in individuals of Japanese ancestry living on Oahu, Hawaii, were on the same level as in Japanese living in Okinawa, Japan, but around half of that in Caucasians [14].

The aim of this study was to analyse national Swedish data as regards risk of osteoporotic fractures, including hip fractures, forearm fractures, vertebral fractures and forearm fractures, in several groups of first-generation immigrants compared with Swedish-born individuals. We hypothesise that the risk will be lower in general and in many groups of first-generation immigrants.

Methods

Design

In the present study, we used the Total Population Register and the National Patient Register (NPR). We included individuals aged 50 years of age and older to study first-generation immigrants compared with Swedish-born individuals. The follow-up period ran from January 1, 1998, until hospitalisation/out-patient treatment of an osteoporotic fracture at age of diagnosis of 50 years or more, death, emigration or the end of the study period on December 31, 2012, whichever came first. Out-patient diagnoses were included nationwide from 2001 and onwards from specialist open care but not primary health care as these diagnoses are not included in the NPR. We used a unique pseudonymized serial number for each individual which helped us to avoid double-counting.

Outcome variable

Osteoporotic fractures: humerus fractures (S42.2-S42.4), lower forearm fractures (S52.5 and S52.6), hip fractures (S72.0-S72.2), vertebral fractures (S12 (including S12.0-S12.9), S22.0 and S22.1, S32.0, T08)

Co-morbidities

We also identified co-morbidities according to ICD-10 for the following hospital diagnoses during the entire study period: malignant neoplasms (C00-C97), endocrine disorders (including thyrotoxicosis E05, hyperparathyroidism E21, hypopituitarism E23.0, primary ovarian failure E28.3, testicular hypofunction E29.1), diabetes (E10-E14), alcoholism (F10), hypertension (I10-I19), cerebrovascular diseases (I60-69), COPD (J40-J47), liver disease (K70-K76), intestinal malabsorption (K90), rheumatoid arthritis (M05 and M06) and systemic connective tissue disorders (M30-M36).

Demographic and socioeconomic variables

***Age* was used as a continuous variable in the analysis.**

Educational attainment was categorised as ≤ 9 years (partial or complete compulsory schooling), 10–12 years (partial or complete secondary schooling) and > 12 years (attendance at college and/or university).

Geographic region of residence was included in order to adjust for possible regional differences in hospital admissions and was categorised as (1) large cities with surrounding regions, (2) southern Sweden (southern and middle part of Sweden) and (3) northern Sweden (the five most northern regions). Large cities were defined as municipalities with a population of > 200,000 and comprised the three largest cities in Sweden: Stockholm, Gothenburg and Malmö. Southern Sweden and northern Sweden included both rural regions and smaller towns, and the geographic boundary between northern and southern Sweden was set at the river Dalälven, which by tradition is regarded to be the natural boundary to northern Sweden.

Neighbourhood deprivation

Neighbourhood socioeconomic status (NSES): This index was categorised into four groups: more than one standard deviation (SD) below the mean (low deprivation level or high SES), more than one SD above the mean (high deprivation level or low SES) and within one SD of the mean (moderate SES or moderate deprivation level) used as reference group and also unknown neighbourhood SES [15].

Statistical analysis

Baseline data are presented with continuous variables as mean and standard deviations and categorical variables as counts and percentages. We used Cox regression analysis to estimate

the risk (hazard ratios (HR) with 99% confidence intervals (CI)) of incident osteoporotic fractures in different first-generation immigrant groups compared with the control group, i.e. Swedish-born, during the follow-up time. All analyses were stratified by sex. Three models were used: model 1 with adjustment for age and region of residence in Sweden; model 2 with adjustment for age, region of residence in Sweden, educational level, marital status and neighbourhood SES, to examine to what extent SES explained the association between country of birth and fracture incidence; and model 3 as model 2 but with the inclusion of relevant co-morbidities, to examine if other diagnoses explained the association between country of birth and osteoporotic fracture incidence.

Results

Baseline data are shown in Table 1 and 2, with a total of 2,775,736 individuals 50 years of age and above included, i.e. 325,991 foreign-born (164,492 men, 161,499 women), and 2,449,745 Swedish-born (1,370,750 men, 1,311,995 women) (data for all men and women, respectively, in Supplementary Table 1). A total of 362,899 osteoporotic fractures were registered, i.e. 96,847 among men and 266,052 among women. Out of the fractures, hip fractures were most common, 54.0% among all osteoporotic fractures among men and 42.6% among women. However, among Swedish-born, the rate of hip fractures out of all studied osteoporotic fractures was more common than among foreign-born, while low forearm fractures were less common. Most fractures were noted in the age interval 70–79 years of age, i.e. 34.4% among men and 34.3% among women. Co-morbidities were, in general, more common among individuals with osteoporotic fractures than without, also among Swedish- and foreign-born women, with the exception of cancer among Swedish-born women (Table 1 and 2).

Having a higher educational level showed higher risk for fractures, especially among foreign-born individuals (Table 3 and 4). The risk was lower in individuals living in southern or northern Sweden compared with the large cities and for married individuals. Regarding co-morbidities, estimates were increased for most co-morbidities, except for hypertension (lower among Swedish-born men and women, and non-significant among foreign-born men and women), but decreased for cancer among Swedish-born women and non-significant for intestinal malabsorption and systematic connective tissue disorders for foreign-born men. Highest HRs were seen for alcoholism, for both Swedish-born men and women and foreign-born men and women (HRs 2.21–3.15).

In Table 5 the fracture risk in general for osteoporotic fractures for men and women is shown, with lower risk in general for all foreign-born individuals (number of all individuals and cases in Supplementary Table 2; with numbers in relation to stay in Sweden in Supplementary Table 3). Most regions or specific countries showed lower risks compared with Swedish-born men and women; however with non-significant estimates in full models for men from Baltic countries in general, Northern America and Russia. For specific countries (Supplementary Table 4), higher risks in all models were found among men from Iraq; in models 1–3, the HRs (99% CI) were 1.36 (1.02–1.80), 1.77 (1.34–2.35) and 1.79 (1.35–2.37), respectively. In models 2 and 3, the HRs were among men from Bosnia, 1.82 (1.32) and 1.78 (1.29–2.46), respectively, and, in the fully adjusted model (Model 3) in men from Lebanon, 1.51 (1.01–2.27). Among women (Supplementary Table 5), a higher risk was found only in models 2 and 3 and among women from Norway; the HRs were 1.07 (1.01–1.13) and 1.05 (1.00–1.11), respectively. Risks with fully adjusted models for the specific osteoporotic fractures are shown in Table 6 with a higher risk of forearm fractures among men from Asia and, for vertebral fractures, among women from Asia. Even if risk estimates were similar for the specific fractures in relation to all osteoporotic fractures, however, with fewer statistically significant results, this was most evident for vertebral fractures, and to some extent for humerus and forearm fractures. As regards specific countries (Supplementary Tables 6 and 7), a significantly higher risk (shown as HR; 99% CI) was found for lower forearm and hip fractures for men from Bosnia (1.78; 1.03–3.06), Turkey (1.52; 1.02–2.25), Lebanon (2.39; 1.26–4.53 and Iraq (1.85; 1.12–3.05).

Discussion

The main results of this study were that the risk of osteoporotic fractures in general was lower among first-generation men and women compared with Swedish-born. A higher risk was only observed in some specific groups, i.e. consistently so in men from Iraq in all statistical models and, for specific fractures the in fully adjusted models, in men from Asia (for distal forearm fractures) and in women from Asia (for vertebral fractures).

The risk of osteoporotic fractures is very high in northern Europe, hence, why a lower risk among first-generation immigrants compared with Swedish-born is not surprising. This is also shown in earlier Swedish studies of hip fractures [11, 12] and distal forearm fractures [13]. Furthermore, a lower risk of forearm fractures among Asian immigrants in Norway has also been found [9].

The earlier Swedish studies of hip fractures included individuals from 16 years [11] and 50 years of age [12], respectively, and with data from 1987–1999 [11] to 1987–2002 [12], respectively. In the 2010 study by Albin et al. [11], the risk was lower among all foreign-born individuals; the overall odds ratio (OR) was 0.82, with a higher risk only among men from Iceland/Norway, OR 1.13, and a similar risk among

Table 1. Population and number of cases of osteoporotic fractures in men

	Swedish-born				Foreign born			
	Population		Osteoporotic fractures		Population		Osteoporotic fractures	
	No.	%	No	%	No.	%	No	%
Total population	1,137,750		89,733		164,492		7114	
Subtype of events								
Humerus fractures			13,261	14.8			1188	16.7
Low forearm fractures			14,575	16.2			1731	24.3
Hip fractures			49,256	54.9			3058	43.0
Vertebral fractures			12,641	14.1			1137	16.0
Age (years)								
50–59	447,600	39.3	19,037	21.2	84,859	51.6	2338	32.9
60–69	294,690	25.9	20,190	22.5	49,845	30.3	2198	30.9
70–79	249,602	21.9	31,363	35.0	23,566	14.3	1956	27.5
≥ 80	145,858	12.8	19,143	21.3	6222	3.8	622	8.7
Educational level								
≤ 9	547,053	48.1	47,220	52.6	91,861	55.8	3155	44.3
10–12	228,003	20.0	17,517	19.5	26,942	16.4	1541	21.7
> 12	362,694	31.9	24,996	27.9	45,689	27.8	2418	34.0
Region of residence								
Large cities	365,628	32.1	31,476	35.1	60,548	36.8	3553	49.9
Southern Sweden	527,435	46.4	41,544	46.3	44,195	26.9	2594	36.5
Northern Sweden	244,687	21.5	16,713	18.6	59,749	36.3	967	13.6
Marital status								
Married	885,874	77.9	67,169	74.9	130,075	79.1	5032	70.7
Not married	251,876	22.1	22,564	25.1	34,417	20.9	2082	29.3
Neighbourhood deprivation								
Low	182,199	16.0	12,925	14.4	13,247	8.1	784	11.0
Middle	599,642	52.7	49,077	54.7	47,381	28.8	2760	38.8
High	124,103	10.9	10,758	12.0	18,417	11.2	1056	14.8
Unknown	231,806	20.4	16,973	18.9	85,447	51.9	2514	35.3
Hospital diagnosis of COPD	88,840	7.8	10,508	11.7	11,426	6.9	1061	14.9
Hospital diagnosis of diabetes	142,412	12.5	13,142	14.6	19,215	11.7	1259	17.7
Hospital diagnosis of alcoholism	35,820	3.1	5387	6.0	4714	2.9	615	8.6
Hospital diagnosis of stroke	175,183	15.4	21,042	23.4	17,257	10.5	1628	22.9
Hospital diagnosis of hypertension	298,500	26.2	25,293	28.2	34,051	20.7	2278	32.0
Hospital diagnosis of cancer	303,808	26.7	26,894	30.0	28,206	17.1	1981	27.8
Hospital diagnosis of liver disease	11,585	1.0	1307	1.5	1518	0.9	141	2.0
Hospital diagnosis of endocrine disorders	9076	0.8	937	1.0	1208	0.7	99	1.4
Hospital diagnosis of systemic connective tissue disorders	16,489	1.4	1839	2.0	1255	0.8	106	1.5
Hospital diagnosis of rheumatoid arthritis	13,796	1.2	1635	1.8	1245	0.8	134	1.9
Hospital diagnosis of intestinal malabsorption	2711	0.2	308	0.3	158	0.1	12	0.2
All	113,7750	100.0	89,733	100.0	16,4492	100.0	7114	100.0

COPD chronic obstructive pulmonary disease

Table 2 Population and number of cases of osteoporotic fractures in women

	Swedish-born				Foreign-born			
	Population		Events		Population		Events	
	No.	%	No	%	No.	%	No	%
Total population	1,311,995		245,486		161,499		20,566	
Subtype of events								
Humerus fractures			46,627	19.0			3902	19.0
Low forearm fractures			76,395	31.1			8371	40.7
Hip fractures			106,460	43.4			6814	33.1
Vertebral fractures			16,004	6.5			1479	7.2
Age (years)								
50–59	461,985	35.2	47,241	19.2	73,026	45.2	5205	25.3
60–69	318,812	24.3	55,061	22.4	49,818	30.8	6559	31.9
70v79	311,110	23.7	84,807	34.5	29,203	18.1	6476	31.5
≥ 80	220,088	16.8	58,377	23.8	9452	5.9	2326	11.3
Educational level								
≤ 9	700,005	53.4	147,279	60.0	95,597	59.2	10,991	53.4
10–12	363,200	27.7	61,709	25.1	35,611	22.1	5391	26.2
> 12	248,790	19.0	36,498	14.9	30,291	18.8	4184	20.3
Region of residence								
Large cities	434,045	33.1	86,752	35.3	62,655	38.8	9919	48.2
Southern Sweden	612,897	46.7	114,481	46.6	49,162	30.4	7651	37.2
Northern Sweden	265,053	20.2	44,253	18.0	49,682	30.8	2996	14.6
Marital status								
Married	1,069,274	81.5	186,477	76.0	141,416	87.6	16,677	81.1
Not married	242,721	18.5	59,009	24.0	20,083	12.4	3889	18.9
Neighbourhood deprivation								
Low	194,570	14.8	34,053	13.9	13,981	8.7	2200	10.7
Middle	713,264	54.4	136,888	55.8	55,067	34.1	8886	43.2
High	152,496	11.6	29,300	11.9	19,752	12.2	2835	13.8
Unknown	251,665	19.2	45,245	18.4	72,699	45.0	6645	32.3
Hospital diagnosis of COPD	106,912	8.1	24,390	9.9	12,911	8.0	2620	12.7
Hospital diagnosis of diabetes	127,633	9.7	26,916	11.0	15,769	9.8	2593	12.6
Hospital diagnosis of alcoholism	13,516	1.0	3692	1.5	2011	1.2	523	2.5
Hospital diagnosis of stroke	177,517	13.5	44,891	18.3	16,777	10.4	3692	18.0
Hospital diagnosis of hypertension	356,966	27.2	77,779	31.7	41,217	25.5	7279	35.4
Hospital diagnosis of cancer	279,069	21.3	50,671	20.6	25,922	16.1	4088	19.9
Hospital diagnosis of liver disease	10,065	0.8	2222	0.9	1241	0.8	225	1.1
Hospital diagnosis of endocrine disorders	28,512	2.2	6430	2.6	3139	1.9	562	2.7
Hospital diagnosis of systemic connective tissue disorders	37,356	2.8	8689	3.5	3287	2.0	677	3.3
Hospital diagnosis of rheumatoid arthritis	31,845	2.4	7543	3.1	3202	2.0	686	3.3
Hospital diagnosis of intestinal malabsorption	4177	0.3	895	0.4	302	0.2	64	0.3
All	1,311,995	100.0	245,486	100.0	161,499	100.0	20,566	100.0

COPD chronic obstructive pulmonary disease

women from Denmark compared with Swedish-born women, OR 0.98. In the 2015 study by Johansson et al. [12], the overall risk among foreign-born individuals was around half of that of Swedish-born. Besides, even if the incidence increased slightly by time after immigration, it remained on a substantially lower level than among Swedish-born. In comparison with the present study, where we included individuals from 50 years of age and older, we also found lower risks of

Table 3 Incidence of osteoporotic fractures in Swedish-born and foreign-born men expressed as hazard ratios (HR) with 99% confidence intervals (99% CI)

	Born in Sweden			Foreign-born		
	HR*	99% CI		HR*	99% CI	
Birth year	0.94	0.94	0.94	0.93	0.93	0.93
Time of stay in Sweden (ref. ≥ 30 years)						
Unknown				0.94	0.85	1.04
< 10				1.82	1.54	2.14
10–19				0.95	0.82	1.10
20–29				0.85	0.77	0.93
Educational level (ref. ≤ 9 years)						
10–12	1.08	1.05	1.10	1.26	1.14	1.38
> 12	1.03	1.00	1.05	1.19	1.10	1.29
Region of residence (ref. Large cities)						
Southern Sweden	0.71	0.69	0.73	0.85	0.78	0.93
Northern Sweden	0.49	0.48	0.51	0.35	0.31	0.39
Marital status (ref. Married)	0.72	0.70	0.73	0.78	0.72	0.84
Neighbourhood deprivation (ref. Low)						
Middle	1.11	1.08	1.15	1.01	0.90	1.13
High	1.14	1.10	1.19	1.02	0.88	1.16
Unknown	0.57	0.55	0.59	0.71	0.62	0.80
Hospitalization of COPD	1.40	1.36	1.45	1.57	1.43	1.73
Hospitalization diabetes	1.15	1.12	1.18	1.19	1.09	1.30
Hospitalization of alcoholism	2.57	2.46	2.68	3.15	2.77	3.59
Hospitalization of stroke	1.42	1.38	1.45	1.53	1.40	1.66
Hospitalization of hypertension	0.89	0.87	0.91	1.03	0.96	1.11
Hospitalization of cancer	1.10	1.08	1.12	1.25	1.16	1.35
Hospitalization of liver disease	1.21	1.11	1.31	1.24	0.96	1.60
Hospitalization of endocrine disorders	1.23	1.12	1.35	1.43	1.07	1.91
Hospitalization of rheumatoid arthritis	1.50	1.39	1.61	1.81	1.41	2.33
Hospitalization of intestinal malabsorption	1.49	1.27	1.75	1.35	0.59	3.07
Hospitalization of systemic connective tissue disorders	1.14	1.06	1.22	1.07	0.81	1.41

*Fully adjusted: COPD: Chronic obstructive pulmonary disease

hip fractures among all foreign-born men and women with fully adjusted HRs of 0.70 and 0.78, respectively. In our present study, we had the opportunity to provide more granularity in terms of country of origin and type of fractures, with a significantly lower risk in foreign-born individuals from most regions of the world.

In a recent study of ours on distal forearm fractures, individuals from 20 years of age and older were included [13] and with the same follow-up as in the present study. In that study, the fully adjusted HR among all foreign-born men and women was 0.95, with an increased risk by region for men from Asia; the fully adjusted HR for men born in Asia was 1.17. Notably, an increased risk for specific countries in all models was found in men from Bosnia, Poland, Turkey and Iraq and in women from Iraq. Besides, the HRs among second-generation immigrants overall were on a similar level as in first-generation immigrants. In the present study, we found a lower overall risk of distal forearm fractures among immigrants; the fully adjusted HRs were 0.89 among men and 0.93 among women, respectively, with a significantly lower risk among men from most regions of the world, except among men from Asia; the fully adjusted HR for men born in Asia was 1.43. The risk was significantly lower only in women from Southern Europe and North and Latin America. Thus, the results for our two studies are quite similar, but with a slightly lower relative risk compared to Swedish-born men and women when only including individuals of 50 years of age and above, compared with those of 20 years of age and above.

The osteoporotic risk was especially low among immigrants from southern Europe. One question is whether higher 25-hydroxyvitamin D levels could be of importance, but the 25-hydroxyvitamin D levels have actually been shown to be higher in northern Europe, which could be owed to a higher intake of fish and vitamin D supplements [16, 17]. Otherwise the 25-hydroxyvitamin D levels have been shown to be low, or actually very low, among non-Western immigrants to the

Table 4 Incidence of osteoporotic fractures in Swedish-born and foreign-born women expressed as hazard ratios (HR) with 99% confidence intervals (99% CI)

	Born in Sweden			Foreign born		
	HR*	99% CI		HR*	99% CI	
Birth year	0.94	0.94	0.94	0.93	0.93	0.93
Time of stay in Sweden (ref. ≥ 30 years)						
Unknown				0.85	0.80	0.90
< 10				1.38	1.20	1.59
10–19				0.80	0.71	0.90
20–29				0.82	0.77	0.87
Educational level (ref. ≤ 9 years)						
10–12	1.03	1.02	1.05	1.20	1.14	1.26
> 12	1.01	0.99	1.03	1.20	1.14	1.27
Region of residence (ref. Large cities)						
Southern Sweden	0.80	0.79	0.81	0.78	0.74	0.82
Northern Sweden	0.64	0.63	0.66	0.42	0.39	0.44
Marital status (ref. Married)	0.86	0.85	0.87	0.91	0.86	0.96
Neighbourhood deprivation (ref. Low)						
Middle	1.03	1.01	1.05	1.05	0.98	1.12
High	1.03	1.00	1.05	0.99	0.91	1.07
Unknown	0.72	0.70	0.73	0.66	0.61	0.71
Hospitalization of COPD	1.28	1.26	1.31	1.36	1.28	1.45
Hospitalization diabetes	1.07	1.05	1.09	1.08	1.01	1.15
Hospitalization of alcoholism	2.21	2.10	2.32	2.58	2.26	2.94
Hospitalization of stroke	1.18	1.16	1.20	1.27	1.20	1.34
Hospitalization of hypertension	0.95	0.94	0.97	1.02	0.98	1.07
Hospitalization of cancer	0.98	0.97	0.99	1.06	1.01	1.12
Hospitalization of liver disease	1.24	1.17	1.32	1.17	0.96	1.42
Hospitalization of endocrine disorders	1.14	1.10	1.18	1.16	1.03	1.31
Hospitalization of rheumatoid arthritis	1.36	1.31	1.40	1.50	1.34	1.68
Hospitalization of intestinal malabsorption	1.29	1.17	1.42	1.65	1.16	2.36
Hospitalization of systemic connective tissue disorders	1.09	1.06	1.13	1.13	1.01	1.27

*Fully adjusted; COPD: Chronic obstructive pulmonary disease

Nordic countries [18]. Peak bone mass develops during childhood and early adulthood and is thus dependent on factors during this period in life, i.e. levels of physical activity and vitamin D, and also of dietary factors [19]. These factors are also of importance to maintain bone quality during later life. The effect of low 25-hydroxyvitamin D levels in adult immigrants could be expected only to modulate the risk of osteoporosis later in life, and supplements with vitamin D and calcium may prevent fractures among the elderly population [20].

Another factor of importance could be the "healthy migrant" effect, i.e. that migrants tend to have a better health status than their compatriots in the country of origin [21]. This might be true for several groups, especially for migrants from other Nordic or European countries or migrants from North America.

In addition, hormone replacement therapy in women may lower the fracture risk [22]; this treatment, however, is given more restrictedly due to increased health risks, such as breast cancer [23], stroke and venous thromboembolism [24]. We had no information on differences in hormone replacement therapy between Swedish and immigrant women.

It is interesting that the risk was higher in some specific groups, i.e. for osteoporotic fractures in men from Iraq, and for distal forearm fractures in fully adjusted models in men from Asia, especially from countries in the Middle East region, and for vertebral fractures in fully adjusted models in women from Asia. Interestingly, the Iraqi group has the highest rate of refugees in Sweden together with the Bosnian group [25], and Middle Eastern countries have been war-torn. The higher risk in some specific countries could indicate that environmental factors are important for the global differences concerning incidence of osteoporotic fractures. Furthermore, an increased fracture risk in foreign-born men and women was observed during the first 10 years of stay in Sweden. However, there are racial/ethnic differences in bone

Table 5 Incidence of osteoporotic fractures in foreign-born men and women vs Swedish-born men and women, respectively, expressed as hazard ratios (HR) with 99% confidence intervals (99% CI)

		Model 1			Model 2			Model 3		
	Obs.	HR	99% CI		HR	99% CI		HR	99% CI	
Men										
Sweden	89,733	1			1			1		
All foreign born	7114	**0.68**	**0.65**	**0.70**	**0.74**	**0.72**	**0.77**	**0.75**	**0.73**	**0.78**
Nordic countries	3563	**0.74**	**0.70**	**0.78**	**0.82**	**0.78**	**0.86**	**0.81**	**0.77**	**0.85**
Southern Europe	266	**0.33**	**0.28**	**0.39**	**0.40**	**0.33**	**0.47**	**0.43**	**0.36**	**0.51**
Western Europe	826	**0.59**	**0.54**	**0.66**	**0.66**	**0.59**	**0.72**	**0.67**	**0.61**	**0.74**
Eastern Europe	530	**0.60**	**0.53**	**0.68**	**0.61**	**0.54**	**0.70**	**0.64**	**0.57**	**0.73**
Baltic countries	336	0.86	0.73	1.00	0.91	0.78	1.07	0.91	0.78	1.06
Central Europe	516	**0.69**	**0.61**	**0.78**	**0.69**	**0.61**	**0.78**	**0.71**	**0.62**	**0.80**
Africa	91	**0.54**	**0.40**	**0.73**	**0.62**	**0.46**	**0.84**	**0.65**	**0.48**	**0.88**
Northern America	183	**0.76**	**0.62**	**0.94**	0.86	0.69	1.06	0.86	0.70	1.07
Latin America	96	**0.45**	**0.34**	**0.61**	**0.51**	**0.38**	**0.68**	**0.56**	**0.42**	**0.75**
Asia	587	**0.78**	**0.69**	**0.87**	0.92	0.82	1.04	0.97	0.86	1.09
Russia	115	0.95	0.73	1.24	0.96	0.74	1.26	0.95	0.73	1.24
Women										
Sweden	245,486	1			1			1		
All foreign born	20,566	**0.78**	**0.72**	**0.79**	**0.83**	**0.81**	**0.84**	**0.83**	**0.81**	**0.84**
Nordic countries	12,821	**0.84**	**0.81**	**0.86**	**0.89**	**0.82**	**0.86**	**0.88**	**0.87**	**0.91**
Southern Europe	402	**0.34**	**0.29**	**0.39**	**0.39**	**0.30**	**0.39**	**0.41**	**0.34**	**0.45**
Western Europe	2580	**0.73**	**0.69**	**0.77**	**0.78**	**0.69**	**0.78**	**0.78**	**0.74**	**0.82**
Eastern Europe	926	**0.67**	**0.61**	**0.73**	**0.69**	**0.61**	**0.74**	**0.71**	**0.63**	**0.76**
Baltic countries	851	**0.80**	**0.72**	**0.88**	**0.84**	**0.72**	**0.88**	**0.84**	**0.76**	**0.93**
Central Europe	1207	**0.77**	**0.71**	**0.84**	**0.79**	**0.71**	**0.84**	**0.79**	**0.72**	**0.85**
Africa	58	**0.60**	**0.42**	**0.88**	0.69	0.47	1.00	0.71	0.49	1.03
Northern America	462	**0.76**	**0.66**	**0.86**	**0.82**	**0.72**	**0.94**	**0.82**	**0.72**	**0.94**
Latin America	210	**0.57**	**0.47**	**0.70**	**0.64**	**0.47**	**0.69**	**0.65**	**0.52**	**0.77**
Asia	729	**0.73**	**0.66**	**0.82**	**0.81**	**0.66**	**0.82**	**0.83**	**0.73**	**0.90**
Russia	308	0.87	0.74	1.02	0.89	0.76	1.05	0.89	0.75	1.04

Model 1: adjusted for age and region of residence in Sweden; model 2: adjusted for age, region of residence in Sweden, educational level, marital status, and neighbourhood deprivation; model 3: model 2 + comorbidities.

metabolism [26, 27], which could indicate genetic factors as being important. However, the present study could not address if the differences in fracture rates are related to race/ethnicity, genetic factors or environmental/societal factors, including lifestyle and dietary factors.

There are certain limitations with this study. We performed many statistical analyses, but subsequently used 99% CI to partly compensate for multiple testing. However, we consider the overall results to be more valid, and results for specific regions of the world, and especially for specific countries, should be interpreted with more caution. We chose to include fractures of the hip, forearm, vertebrae and humerus as osteoporotic fractures, as these are often considered to be the most important and relevant osteoporotic fractures [2]. Sometimes, other fractures could also be included [4], e.g. fractures of the pelvis, rib, tibia, fibula, clavicle, scapula, sternum or other femoral fractures. Fractures are mostly treated at emergency departments of hospitals hence why the coverage could be regarded as high, even if fractures in some cases in northern Sweden are treated at some specific primary healthcare centres. Besides, vertebral fractures are most probably under-reported, but also most probably on the same level in Swedish- and foreign-born individuals. For some of the co-morbidities, the results might have been biased, as COPD, diabetes and hypertension are mostly treated in primary care, and the NPR does not include diagnoses from primary care [28]. Otherwise, the validity of Swedish patient registers is regarded to be high [29].

In conclusion, we found a lower risk of osteoporotic fractures among foreign-born individuals compared with Swedish-born, with some exceptions. A higher risk was found among some specific groups of foreign-born individuals, i.e. men from Iraq, and also for specific fractures for distal

Table 6 Incidence of osteoporotic fractures in foreign-born men and women vs Swedish-born men and women, respectively, expressed as hazard ratios (HR) with 99% confidence intervals (99% CI)

	Humerus fractures			Low forearm fratures			Hip fractures			Vertebral fractures		
	HR	99% CI		HR	99% CI		HR	99% CI		HR	99% CI	
Men												
Sweden	1			1			1			1		
All foreign-born	**0.74**	**0.68**	**0.81**	**0.89**	**0.83**	**0.96**	**0.70**	**0.66**	**0.74**	**0.77**	**0.70**	**0.84**
Nordic countries	**0.77**	**0.68**	**0.87**	**0.88**	**0.79**	**0.98**	**0.81**	**0.75**	**0.86**	**0.79**	**0.70**	**0.90**
Southern Europe	**0.55**	**0.37**	**0.80**	**0.46**	**0.32**	**0.66**	**0.36**	**0.27**	**0.49**	**0.49**	**0.32**	**0.74**
Western Europe	**0.64**	**0.50**	**0.82**	**0.79**	**0.64**	**0.96**	**0.59**	**0.51**	**0.69**	0.85	0.68	1.07
Eastern Europe	**0.70**	**0.53**	**0.94**	0.93	0.75	1.16	**0.44**	**0.35**	**0.55**	**0.69**	**0.51**	**0.93**
Baltic countries	1.05	0.72	1.53	1.23	0.86	1.74	0.83	0.66	1.03	0.94	0.61	1.44
Central Europe	0.78	0.58	1.05	0.87	0.67	1.13	**0.63**	**0.52**	**0.76**	**0.70**	**0.50**	**0.98**
Africa	0.45	0.21	1.00	0.98	0.61	1.56	**0.48**	**0.27**	**0.84**	0.62	0.30	1.30
Northern America	0.67	0.37	1.23	0.48	0.24	0.93	1.10	0.84	1.42	0.78	0.43	1.39
Latin America	**0.47**	**0.23**	**0.96**	0.87	0.55	1.37	**0.36**	**0.21**	**0.64**	0.53	0.25	1.10
Asia	0.84	0.62	1.13	**1.43**	**1.18**	**1.74**	**0.72**	**0.58**	**0.89**	0.89	0.66	1.21
Russia	1.03	0.52	2.01	1.05	0.54	2.06	0.88	0.61	1.27	1.19	0.62	2.29
Women												
Sweden	1			1			1			1		
All foreign-born	**0.76**	**0.72**	**0.79**	**0.93**	**0.90**	**0.96**	**0.78**	**0.76**	**0.81**	**0.93**	**0.86**	**1.01**
Nordic countries	**0.80**	**0.76**	**0.85**	0.97	0.93	1.01	**0.87**	**0.83**	**0.91**	0.95	0.86	1.05
Southern Europe	**0.39**	**0.28**	**0.54**	**0.47**	**0.38**	**0.58**	**0.36**	**0.27**	**0.47**	**0.51**	**0.30**	**0.85**
Western Europe	**0.74**	**0.65**	**0.84**	0.94	0.86	1.02	**0.72**	**0.65**	**0.79**	0.85	0.68	1.05
Eastern Europe	**0.55**	**0.44**	**0.69**	0.91	0.80	1.03	**0.49**	**0.40**	**0.61**	0.85	0.60	1.22
Baltic countries	0.80	0.64	1.02	1.05	0.89	1.24	**0.77**	**0.66**	**0.90**	0.87	0.59	1.26
Central Europe	**0.79**	**0.66**	**0.94**	0.88	0.78	1.00	**0.66**	**0.57**	**0.77**	0.95	0.71	1.28
Africa	0.48	0.19	1.25	0.81	0.48	1.36	0.67	0.32	1.40	0.80	0.19	3.32
Northern America	0.78	0.57	1.08	**0.67**	**0.51**	**0.88**	0.98	0.81	1.18	0.96	0.59	1.55
Latin America	**0.59**	**0.39**	**0.91**	**0.75**	**0.57**	**0.98**	**0.47**	**0.30**	**0.75**	0.57	0.24	1.34
Asia	**0.64**	**0.50**	**0.82**	0.97	0.84	1.13	**0.59**	**0.47**	**0.75**	**1.48**	**1.07**	**2.05**
Russia	1.07	0.76	1.51	1.09	0.83	1.43	0.69	0.52	0.91	1.07	0.60	1.91

*:Fully adjusted.

Bold figures denote statistically significant values

forearm fractures in men from Asia, especially from the Middle East region, and for vertebral fractures in women from Asia. On the other hand, an especially lower risk was found among immigrants from southern Europe. Different factors could be of importance for the differences being found, and further studies on risk factors of osteoporotic fractures among immigrants are warranted. Furthermore, studies of second-generation immigrants could be of value.

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Compliance with Ethical Standards

Conflicts of Interest None.

Ethical approval All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards.

Informed consent was not applicable, as the study was based on anonymised data from registers.

The study was approved by the regional ethics boards at Karolinska Institutet and Lund University.

The authors are not allowed to share the used data from the data sources being used.

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