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ORIGINAL ARTICLE

Osteoporotic fractures in second-generation immigrants and Swedish natives

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Abstract

Summary In this national study of osteoporotic fractures in second-generation immigrants in Sweden, we found a similar risk of osteoporotic fractures in general compared to Swedish natives, which suggests that environmental factors are important for the high risk of osteoporotic fractures in Nordic countries.

Introduction Second generation immigrants may have a similar environment as individuals with two native-born parents. These individuals may be of interest to study concerning whether environmental or hereditary factors could be mostly associated to the risk of osteoporotic fractures. The aim of this study was to analyse the risk of osteoporotic fractures in second-generation immigrants compared to Swedish natives.

Methods This was a nationwide study of individuals aged 50 years of age and older (N = 1,377,035; 691,750 men and 685,285 women). 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 95% confidence intervals (CI)) of incident osteoporotic fractures in second generation immigrants compared to Swedish natives. The Cox regression models were adjusted for age, comorbidities and for sociodemographic status.

Results A total of 114,505 osteoporotic fractures were registered, 109,622 (8.4%) were among individuals with Swedish-born parents and 4883 (7.5%) among those with foreign-born parents, with distal forearm fractures dominating in general (44.9%). Fully adjusted HRs (95% CI) were for all immigrants 0.95 (95% CI, 0.91–0.99), for men 0.96 (95% CI, 0.89–1.04) and for women 0.95 (95% CI, 0.90–1.00).

Conclusions We observed a similar risk of osteoporotic fractures among second-generation immigrants as in Swedish natives, which suggests that environmental factors are important for osteoporotic fractures.

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

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Introduction

Osteoporotic fractures are increasing worldwide, mostly owing to a greater number of elderly individuals. Furthermore, osteoporotic fractures are associated with a heightened mortality rate, and also increasing global healthcare costs, which is most pronounced in developed countries [1], including in Europe [2]. There are differences in geographic and ethnic patterns [3, 4], depending on various factors, both genetic and environmental. Osteoporotic fractures have been shown to be high in the Nordic countries, with a Norwegian study finding a higher incidence of hip fractures than in other countries [5]. A review on the risk of hip fractures categorized countries into high, moderate or low risk according to annual incidence, or with 10-year probability of a new osteoporotic

fracture in individuals with a prior fracture based on measurement of bone mineral density (BMD) [6]. Besides the Nordic countries (Denmark, Norway and Sweden), other countries were also classified as high-risk countries, including other European countries, but also nonEuropean countries, such as Taiwan, Japan and Canada, especially among women. Some ethnic differences were also shown, with high risks in US Caucasians, and Singapore Chinese and Malay women. In addition, an earlier study of Hawaii Japanese or Hawaii Caucasians showed a similar or lower risk of hip fractures than Japanese living in Japan, and much lower risk (one-third to a half) compared to Caucasians living in North America or Europe [7].

With an increasing number of immigrants in Europe during the last decades, the topic of immigrant health has become more important. In Sweden, the proportion of foreign-born individuals is 17% [8], with consequences on health care planning and possible costs of increased risks, e.g. of diabetes [9, 10] for these immigrants. However, as regards osteoporotic fractures, earlier Swedish studies have shown lower risk of fractures among foreign-born compared to Swedish-born individuals, e.g. of hip fractures [11, 12], distal forearm fractures [13]; and also of osteoporotic fractures in general, with fully adjusted HRs (99% CI) for all immigrant men 0.75 (99% CI, 0.73–0.78) and women 0.83 (99% CI, 0.81–0.84) [14]. However, there are fewer studies among second-generation immigrants, i.e. among Swedish born individuals with foreign-born parents, which is of particular interest as environmental factors are more similar to the native population in second generation immigrants than in first generation immigrants. The earlier mentioned study on distal forearm fractures found a similar risk among first- and second-generation immigrants, with a slightly lower risk compared to Swedish-born or individuals with foreign-born parents, respectively [13]. As a consequence, we wondered if there would be similar results when looking at osteoporotic fractures.

Accordingly, the aim of this study was to analyse nationwide Swedish data as regards risk of osteoporotic fractures, including hip fractures, forearm fractures, vertebral fractures and forearm fractures [15], in several groups of second-generation immigrants compared to Swedish-born individuals with Swedish-born parents, i.e., Swedish natives.

Methods

Design

The registers used in the present study were the Total Population Register and the National Patient Register (NPR). Subjects aged 50 years of age and older were included in the study. The follow-up period ran from January 1, 1998, until hospitalisation/outpatient treatment for osteoporotic fracture at age of diagnosis of 50 years or more, death, emigration or the end of the study period on December 31, 2015, whichever came first. From 2001 onwards, outpatient diagnoses were included from specialist care, but primary health care were not included in the NPR and thus not in this study. However, fractures are almost never treated in primary health care.

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)

Comorbidities

We identified comorbidities from the NPR with a registered diagnosis on at least one occasion during 1998–2015 according to ICD-10 for the following diagnoses: 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

The study population was stratified by sex, but in the Cox regression analysis, we combined men and women owing to a low number of cases in some groups.

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, (2) southern Sweden and (3) northern Sweden. Large cities were defined as municipalities with a population of > 200,000 and comprised the three largest cities in Sweden: Stockholm, Gothenburg and Malmö.

Immigrant status: This information was obtained from the Total Population Register, and second-generation immigrants were defined as Swedish-born individuals with at least one foreign-born parent. The control group consisted of Swedish-born individuals with Swedish-born parents, i.e. Swedish natives.

Neighbourhood deprivation

Neighbourhood socioeconomic status

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.

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 95% confidence intervals (CI)) of incident osteoporotic fractures in different second-generation immigrant groups compared to the control group, i.e. Swedish born individuals with Swedish born parents in the second-generation study, during the follow-up time. Owing to the low number of fractures among the second-generation immigrants, men and women were combined. Interaction analysis showed no significant gender interaction (p = 0.3066). 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 forearm fracture incidence; and Model 3 as Model 2 but with the inclusion of relevant comorbidities, to examine if other diagnoses explained the association between country of birth and osteoporotic fracture incidence. Additionally, age stratified sensitivity analyses (at age 60 years) were conducted as there were a higher proportion of younger individuals in the immigrant groups. Besides, sensitivity analyses were performed including only individuals with parents from the same country of origin, i.e. compatriots.

Results

In total, 1,377,035 Swedish-born individuals were included, 1,312,027 with Swedish-born parents, and 65,008 with foreign-born parents (Table 1). Out of all included, 691,750 were men and 685,285 were women (Supplementary Table S1). The total number of osteoporotic fractures registered was 114,505 (8.3%), i.e. 109,622 (8.4%) among individuals with Swedish-born parents and 4,883 (7.5%) among those with foreign-born parents (Table 1). Regarding gender patterns in the whole sample, among men a total of 34,337 (5.0%) cases were registered, and among women it was 80,168 (11.7%). Distal forearm fractures were, in general, most common (n = 51,404, 44.9%), followed by humerus fractures (n = 26,714, 23.3%), hip fractures (n = 25422, 22.2%) and finally vertebral fractures (n = 10,965, 9.6%) (Supplementary Table S1). The patterns among individuals with Swedish-born parents and those with foreign-born parents were similar, but with a higher rate of distal forearm fractures among those with foreign-born parents compared to those with Swedish-born parents, 46.9% vs 44.8%, and lower rate of hip fractures, 19.3% vs 22.3%.

Regarding background factors, the pattern was similar among individuals with Swedish-born parents vs those with foreign-born parents. Fewer individuals in the immigrant group were in the age-group ≥ 60 years (Table 1), but individuals with fractures were older than in the total sample. The risk was lower in both southern and northern Sweden, in higher educational groups and in individuals not being married, however with a slightly lower risk for all men with highest educational level (Tables 1 and 2 and Supplementary Table S2). The most common comorbidities were hypertension and cancer, with rates above or close to 20%. In the Cox regression, the HRs were increased for all comorbidities in the group with Swedish-born parents, and for most comorbidities, among the immigrant group, except for liver diseases, endocrine disorders, intestinal malabsorption and systemic connective tissue disorders. Regarding men and women in the whole sample, HRs were increased for all comorbidities in both sexes (Supplementary Table S2). The highest relative excess risk was seen for alcoholism and related disorders, with HR exceeding 3 for men, and close to 2.5 for women.

The risk of osteoporotic fractures among second-generation immigrants was similar to that for individuals with Swedish-born parents (Table 3), even if the risk was somewhat lower in the full model, i.e. when also adjusting for comorbidities. This was also seen in the risk of hip fractures in women (Table 4). Regarding stratification by age, the results for individuals 50–59 years of age and 60 years and above were similar (Supplementary Table S3a). We also performed a sensitivity analysis only including individuals with compatriot parents (Supplementary Tables 3b and 3c), which showed lower HRs only among individuals with compatriot parents from Southern and Central Europe; fully adjusted HRs were 0.40 (99% CI 0.18–0.87) and 0.72 (99% CI 0.52–0.99), respectively. Among specific groups, individuals with foreign-born parents from Italy were the only group with a statistically significant lower risk (Supplementary Table S4), HR in model 1, i.e. adjusted for age and region of residence in Sweden, 0.42 (0.22–0.80), and fully adjusted model 0.46 (0.24–0.87). For specific fractures, no such results were found (Supplementary Table S5).

Table 1 Population in study of individuals with Swedish-born parents and foreign-born parents, with number of cases of osteoporotic fractures

	With Swedish-born parents				With foreign-born parents			
	Population		Osteoporotic fractures		Population		Osteoporotic fractures	
	No.	%	No	%	No.	%	No	%
Total population	1312027		109622		65008		4883	
Subtype of events								
Humerus fractures			25528	23.3			1186	24.3
Low forearm fractures			49113	44.8			2291	46.9
Hip fractures			24480	22.3			942	19.3
Vertebral fractures			10501	9.6			464	9.5
Sex								
Males	658868	50.2	32825	29.9	32882	50.6	1512	31.0
Females	653159	49.8	76797	70.1	32126	49.4	3371	69.0
Age (years)								
50–59	950795	72.5	70096	63.9	52293	80.4	3577	73.3
≥ 60	361232	27.5	39526	36.1	12715	19.6	1306	26.7
Educational level								
≤ 9	493951	37.6	41066	37.5	22228	34.2	1507	30.9
10–12	365716	27.9	33733	30.8	16810	25.9	1486	30.4
> 12	452360	34.5	34823	31.8	25970	39.9	1890	38.7
Region of residence								
Large cities	584451	44.5	51562	47.0	32564	50.1	2729	55.9
Southern Sweden	458462	34.9	38087	34.7	16985	26.1	1290	26.4
Northern Sweden	269114	20.5	19973	18.2	15459	23.8	864	17.7
Marital status								
Married	881242	67.2	67143	61.2	42573	65.5	2790	57.1
Not married	430785	32.8	42479	38.8	22435	34.5	2093	42.9
Neighbourhood deprivation								
Low	235271	17.9	19020	17.4	10242	15.8	789	16.2
Middle	681812	52.0	57164	52.1	27135	41.7	2109	43.2
High	135746	10.3	11807	10.8	6524	10.0	549	11.2
Unknown	259198	19.8	21631	19.7	21107	32.5	1436	29.4
Hospital diagnosis for COPD	76455	5.8	10173	9.3	3598	5.5	479	9.8
Hospital diagnosis for diabetes	115171	8.8	11585	10.6	5418	8.3	523	10.7
Hospital diagnosis for alcoholism	37715	2.9	6647	6.1	2257	3.5	385	7.9
Hospital diagnosis for stroke	90033	6.9	11442	10.4	4043	6.2	500	10.2
Hospital diagnosis for hypertension	276126	21.0	27306	24.9	12914	19.9	1212	24.8
Hospital diagnosis for cancer	276399	21.1	23907	21.8	12186	18.7	1042	21.3
Hospital diagnosis for liver disease	14600	1.1	2085	1.9	789	1.2	102	2.1
Hospital diagnosis for endocrine disorders	21086	1.6	2684	2.4	998	1.5	94	1.9
Hospital diagnosis for systemic connective tissue disorders	24846	1.9	3189	2.9	985	1.5	111	2.3
Hospital diagnosis for rheumatoid arthritis	25340	1.9	3664	3.3	1038	1.6	120	2.5
Hospital diagnosis for intestinal malabsorption	4880	0.4	630	0.6	206	0.3	24	0.5

COPD Chronic obstructive pulmonary disease

Discussion

The main findings of this study were that the risk of osteoporotic fractures in second-generation immigrants was close to that of Swedish natives. We found only a slightly lower risk for hip fractures, especially among women with foreign-born parents.

In contrast to the earlier mentioned study of first-generation immigrants [14], second-generation immigrants showed a

Table 2 Background factors for osteoporotic fractures for in second-generation immigrants and individuals with Swedish-born parents expressed as hazard ratios (HR) with 99% confidence intervals (99% CI)

	With Swedish-born parents			With foreign-born parents		
	HR*	99% CI		HR*	99% CI	
Age at baseline (years)	*1.05*	*1.05*	*1.05*	*1.05*	*1.04*	*1.06*
Gender to males (ref. females)	*0.40*	*0.39*	*0.41*	*0.41*	*0.38*	*0.45*
Educational level (ref. ≤ 9 years)						
10–12	*1.03*	*1.01*	*1.05*	*1.14*	*1.03*	*1.27*
> 12	*1.02*	*1.00*	*1.04*	1.09	0.98	1.20
Region of residence (ref. large cities)						
Southern Sweden	*0.95*	*0.93*	*0.97*	*0.87*	*0.78*	*0.97*
Northern Sweden	*0.88*	*0.86*	*0.90*	*0.73*	*0.65*	*0.82*
Marital status (ref. married)	*0.80*	*0.78*	*0.81*	*0.77*	*0.70*	*0.83*
Neighbourhood deprivation (ref. low)						
Middle	1.00	0.97	1.02	0.99	0.88	1.12
High	1.00	0.97	1.04	1.05	0.89	1.23
Unknown	*0.95*	*0.92*	*0.98*	*0.83*	*0.73*	*0.94*
Hospitalization for COPD	*1.39*	*1.35*	*1.44*	*1.49*	*1.30*	*1.72*
Hospitalization for diabetes	*1.20*	*1.16*	*1.23*	*1.25*	*1.09*	*1.43*
Hospitalization for alcoholism	*2.96*	*2.84*	*3.07*	*3.07*	*2.60*	*3.62*
Hospitalization for stroke	*1.55*	*1.50*	*1.59*	*1.59*	*1.39*	*1.83*
Hospitalization for hypertension	*1.04*	*1.02*	*1.06*	1.07	0.97	1.18
Hospitalization for cancer	*1.10*	*1.08*	*1.12*	*1.17*	*1.05*	*1.29*
Hospitalization for liver disease	*1.26*	*1.18*	*1.35*	1.11	0.82	1.50
Hospitalization for endocrine disorders	*1.18*	*1.11*	*1.25*	0.94	0.70	1.27
Hospitalization for rheumatoid arthritis	*1.43*	*1.36*	*1.50*	1.22	0.93	1.59
Hospitalization for intestinal malabsorption	*1.34*	*1.19*	*1.50*	1.31	0.73	2.35
Hospitalization for systemic connective tissue disorders	*1.15*	*1.09*	*1.21*	1.08	0.82	1.42

Values in italic are statistically significant

*Full adjusted

similar risk as in individuals with Swedish-born parents. As the peak bone mass develops during childhood and early adulthood, the environmental conditions may be quite similar for second-generation immigrants and individuals with Swedish-born parents. The peak bone mass is thus dependent on factors during this period in early and adolescent life, i.e. levels of physical activity and vitamin D, and also of dietary factors [16]. Comparing the results from our earlier first-generation immigrant study [14] with the present study indicates that environmental factors might be the most important behind the high risk of osteoporotic fractures in Nordic countries. For first-generation immigrants, it has been suggested that the risk instrument FRAX could be used for the country of origin for immigrants instead of for the new home country [12, 17]. Even if the risk of hip fractures has decreased in women in Norway, according to a study from Oslo, the capital and the largest city of Norway, it is still the highest in the world [18]. Furthermore, the differences between first-generation immigrants and native individuals in the Nordic countries seem to be more pronounced for hip fractures [11, 12, 14], and we still found a marginally lower risk of hip fractures among second-generation women. This could possibly indicate that factors other than environmental might also be involved.

As mentioned, earlier migration studies from the Nordic countries have shown a lower risk of osteoporotic fractures in most first-generation immigrants [5, 11, 12], with a few exceptions. Even if ethnic differences in bone metabolism are described [19, 20], we in general found no large differences between the second-generation immigrant groups. However, for some groups, this was partly due to a rather low number of fractures, and thus a too low statistical power. An earlier study from Hawaii showed that Hawaii Japanese and Hawaii Caucasians exhibited a similar or lower risk of hip fractures than Japanese living in Japan, and much lower risk compared to Caucasians living in North America or Europe [7], thus pointing out the importance of environmental factors. The earlier mentioned review article also found that other populations beside the populations in the North European countries showed a high risk of osteoporosis fractures, i.e. other European countries, but also non-European countries, such as

Table 3 Risk of osteoporotic fracture events, expressed as Hazard ratios (HRs) with 99% confidence intervals (99% CI), in groups of second-generation immigrants compared to individuals with Swedish-born parents

	No.	Model 1			Model 2			Model 3		
		HR	99% CI		HR	99% CI		HR	99% CI	
Swedish-born parents	109622	1			1			1		
All second-generation	4883	0.96	0.92	1.00	0.96	0.92	1.00	*0.95*	*0.91*	*0.99*
Second-generation men	1512	0.97	0.90	1.05	0.97	0.90	1.05	0.96	0.89	1.04
Second-generation women	3371	0.95	0.90	1.00	0.95	0.90	1.00	0.95	0.90	1.00
Nordic countries	2871	0.99	0.94	1.05	0.99	0.94	1.04	0.97	0.92	1.03
All nonNordic countries	2010	0.91	0.85	0.97	0.91	0.86	0.97	0.92	0.87	0.99
Southern Europe	58	0.69	0.48	1.01	0.72	0.49	1.04	0.75	0.51	1.08
Western Europe	609	*0.86*	*0.77*	*0.97*	*0.88*	*0.78*	*0.98*	0.89	0.79	1.00
Eastern Europe	22	0.58	0.32	1.06	0.58	0.32	1.07	0.58	0.32	1.07
Baltic countries	443	0.92	0.80	1.05	0.92	0.80	1.05	0.93	0.81	1.06
Central Europe	168	0.84	0.67	1.04	0.84	0.67	1.04	0.84	0.67	1.05
Africa	5	0.45	0.13	1.61	0.46	0.13	1.64	0.49	0.14	1.76
Northern America	469	1.00	0.88	1.14	1.01	0.88	1.15	1.02	0.90	1.17
Latin America	12	1.01	0.44	2.29	1.01	0.44	2.29	1.07	0.47	2.43
Asia	33	0.89	0.54	1.48	0.92	0.56	1.52	0.94	0.57	1.56
Russia	191	1.10	0.89	1.35	1.09	0.88	1.34	1.10	0.89	1.35

Values in italic are statistically significant

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

Taiwan, Japan and Canada [6]. However, in the study of osteoporosis fractures among first-generation immigrants most European group, except men from Baltic countries, showed a lower risk compared to Swedish-born individuals, with fully adjusted HRs (99% CI) for all immigrant men 0.75 (99% CI, 0.73–0.78) and women 0.83 (99% CI, 0.81–0.84) [14].

Table 4 Risk of different osteoporotic fractures, expressed as hazard ratios (HRs) with 99% confidence intervals (99% CI), in groups of second-generation immigrants vs individuals with Swedish-born parents

	Humerus fractures				Low forearm fractures				Hip fractures				Vertebral fractures			
	No.	HR*	99% CI		No.	HR*	99% CI		No.	HR*	99% CI		No.	HR*	99% CI	
Swedish-born parents	25528	1			49113	1			24480	1			10501	1		
All second-generation	1186	0.98	0.90	1.07	2291	0.97	0.91	1.03	942	*0.89*	*0.81*	*0.98*	464	0.95	0.83	1.08
Second-generation men	332	0.94	0.80	1.11	488	1.02	0.89	1.16	423	0.93	0.81	1.07	269	0.94	0.79	1.13
Second-generation women	854	1.00	0.90	1.10	1803	0.96	0.89	1.03	519	*0.86*	*0.76*	*0.98*	195	0.95	0.77	1.17
Nordic countries	704	1.01	0.90	1.13	1341	1.00	0.92	1.08	552	0.91	0.80	1.02	274	0.95	0.80	1.13
Non-Nordic countries	481	0.94	0.82	1.07	949	0.94	0.85	1.03	390	0.87	0.75	1.01	190	0.94	0.76	1.16
Southern Europe	11	0.60	0.26	1.42	26	0.71	0.40	1.24	14	0.93	0.43	1.99	7	0.94	0.32	2.75
Western Europe	154	0.96	0.76	1.21	271	0.85	0.72	1.01	118	0.84	0.65	1.10	66	1.04	0.73	1.47
Eastern Europe	4	0.44	0.10	1.81	13	0.70	0.32	1.55	2	0.30	0.04	2.21	3	0.83	0.16	4.30
Baltic countries	114	1.01	0.77	1.32	220	1.00	0.83	1.21	75	0.74	0.53	1.03	34	0.79	0.48	1.28
Central Europe	47	0.98	0.64	1.48	88	0.90	0.66	1.21	24	0.68	0.38	1.21	9	0.48	0.19	1.25
Africa	2	0.85	0.11	6.39	2	0.37	0.05	2.80		-			1	1.08	0.06	18.66
Northern America	99	0.92	0.69	1.22	216	1.02	0.84	1.24	109	1.08	0.82	1.42	45	1.04	0.68	1.60
Latin America	5	1.96	0.55	7.02	1	0.19	0.01	3.12	5	2.28	0.64	8.15	1	0.95	0.05	16.43
Asia	8	0.88	0.30	2.58	16	0.96	0.47	1.95	6	0.94	0.29	3.00	3	0.92	0.18	4.79
Russia	37	0.89	0.55	1.41	96	1.20	0.90	1.61	37	0.97	0.61	1.56	21	1.28	0.69	2.39

Values in italic are statistically significant

*Fully adjusted

Our earlier study on distal forearm fractures included individuals aged 20 years of age and above, with both first- and second-generation immigrants [13]. The risk in both groups was marginally lower than in the control groups, i.e. Swedish-born individuals, or individuals with Swedish-born parents. In the study of osteoporotic fractures among first-generation immigrants [14], the risk of distal forearm fractures was not as low as the risk of hip fractures or humerus fractures. The risk factors of the studied fractures and the included age groups might be multifaceted and represent more than osteoporosis. In addition, the risk for injuries might differ between different groups [21].

Regarding environmental factors, the tendency of higher risk at higher latitudes in the world could suggest a positive effect from sun exposition and thus of vitamin D. However, when looking at vitamin D levels in Europe, the levels were found to be higher in the Nordic countries compared to southern Europe [22, 23]. For first-generation immigrants in the Nordic countries from the Middle East and South Asian regions, vitamin D levels in studies from the Nordic countries, especially Norway, were found to be low or very low [9]. When looking at the risk for osteoporotic fractures among first-generation immigrants in general, it was lower than among Swedish-born, but the risk seemed to be higher for men from the Middle East and especially for forearm fractures [14]. Thus, the potential association between low vitamin D levels and osteoporotic fractures could be questioned. We can only speculate that sun exposition could have other important effects, or being more important than the effect of dietary or dietary supplements of vitamin D. As regards the effect of other factors, such as physical activity, dietary factors or smoking, we do not have evidence that supports the importance of these.

There are limitations with this study. As pointed out, the number of incident fractures was rather low among the second-generation immigrants, and especially in the specific groups. Thus, the risk for different immigrant groups must be interpreted with caution. However, we have chosen to show the results for groups with only a few cases owing to completeness. The number of cases among second-generation immigrants from some regions, i.e. Africa, Asia and Latin America, was low, thus limiting the possibility to determine the effect of genetic factors. The sample was relatively young, with low forearm fractures being most common, and a later follow-up at an age where hip fractures are more common would be of value. The NPR does not include diagnoses from primary care hence why the presence of some comorbidities, such as diabetes and hypertension, may be underestimated. [24]. On the other hand, most fractures in Sweden are treated at hospitals, especially at emergency departments hence why the ratio of treated osteoporotic fractures could be regarded as good, especially as the quality of Swedish registers has been shown to be high [25]. For vertebral fractures, these could be expected to be underreported, but probably on the same level for second-generation immigrants and individuals with Swedish-born parents.

In conclusion, we found the risk of osteoporotic fractures among Swedish second-generation immigrants to be on a similar risk level as individuals with Swedish-born parents, thus indicating that environmental factors are primarily responsible for the high incidence of osteoporotic fractures in Northern Europe.

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

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.

The study was approved by the Regional Ethical Review Board in Lund.

Consent to participate Informed consent was not applicable, as the study was based on secondary data from registers.

Code availability Not applicable.

References

1. Johnell O, Kanis JA (2006) An estimate of the worldwide prevalence and disability associated with osteoporotic fractures. Osteoporos Int 17:1726–1733

2. Hernlund E, Svedbom A, Ivergard M, Compston J, Cooper C, Stenmark J, McCloskey EV, Jonsson B, Kanis JA (2013) Osteoporosis in the European Union: medical management, epidemiology and economic burden. A report prepared in collaboration with the International Osteoporosis Foundation (IOF) and the European Federation of Pharmaceutical Industry Associations (EFPIA). Arch Osteoporos 8:136
3. Cauley JA, Chalhoub D, Kassem AM, Fuleihan Gel H (2014) Geographic and ethnic disparities in osteoporotic fractures. Nat Rev Endocrinol 10:338–351
4. Wang XF, Seeman E (2012) Epidemiology and structural basis of racial differences in fragility fractures in Chinese and Caucasians. Osteoporos Int 23:411–422
5. Lofthus CM, Frihagen F, Meyer HE, Nordsletten L, Melhuus K, Falch JA (2008) Epidemiology of distal forearm fractures in Oslo, Norway. Osteoporos Int 19:781–786
6. Kanis JA, Oden A, McCloskey EV, Johansson H, Wahl DA, Cooper C, Epidemiology IOFWGo, Quality of L (2012) A systematic review of hip fracture incidence and probability of fracture worldwide. Osteoporos Int 23:2239–2256
7. Ross PD, Huang C (2000) Hip fracture incidence among Caucasians in Hawaii is similar to Japanese A population-based study. Aging (Milano) 12:356–359
8. Statistics Sweden (2016) Foreign-born persons in Sweden by country of birth, age and sex. Year 2000 - 2015. Statistics Sweden,
9. Wandell PE (2013) Population groups in dietary transition. Food Nutr Res 57:21668
10. Wandell PE, Carlsson A, Steiner KH (2010) Prevalence of diabetes among immigrants in the Nordic countries. Curr Diabetes Rev 6: 126–133
11. Albin B, Hjelm K, Elmstahl S (2010) Lower prevalence of hip fractures in foreign-born individuals than in Swedish-born individuals during the period 1987-1999. BMC Musculoskelet Disord 11: 203
12. Johansson H, Oden A, Lorentzon M, McCloskey E, Kanis JA, Harvey NC, Karlsson MK, Mellstrom D (2015) Is the Swedish FRAX model appropriate for Swedish immigrants? Osteoporos Int 26:2617–2622
13. Wandell P, Li X, Carlsson AC, Sundquist J, Sundquist K (2020) Distal forearm fractures in immigrant groups: a national Swedish study. Bone 138:115508
14. Wandell P, Li X, Carlsson AC, Sundquist J, Sundquist K (2020) Osteoporotic fractures among foreign-born individuals: a national Swedish study. Osteoporos Int. https://doi.org/10.1007/s00198-020-05597-5
15. Kanis JA, Johnell O, Oden A, Sembo I, Redlund-Johnell I, Dawson A, De Laet C, Jonsson B (2000) Long-term risk of osteoporotic fracture in Malmo. Osteoporos Int 11:669–674
16. Sandhu SK, Hampson G (2011) The pathogenesis, diagnosis, investigation and management of osteoporosis. J Clin Pathol 64: 1042–1050
17. McCloskey EV, Harvey NC, Johansson H, Kanis JA (2016) FRAX updates 2016. Curr Opin Rheumatol 28:433–441
18. Stoen RO, Nordsletten L, Meyer HE, Frihagen JF, Falch JA, Lofthus CM (2012) Hip fracture incidence is decreasing in the high incidence area of Oslo, Norway. Osteoporos Int 23:2527–2534
19. Gutierrez OM, Farwell WR, Kermah D, Taylor EN (2011) Racial differences in the relationship between vitamin D, bone mineral density, and parathyroid hormone in the National Health and Nutrition Examination Survey. Osteoporos Int 22:1745–1753
20. Redmond J, Jarjou LM, Zhou B, Prentice A, Schoenmakers I (2014) Ethnic differences in calcium, phosphate and bone metabolism. Proc Nutr Soc 73:340–351
21. Tiruneh A, Siman-Tov M, Radomislensky I, Itg PK (2017) Characteristics and circumstances of injuries vary with ethnicity of different population groups living in the same country. Ethn Health 22:49–64
22. Lips P (2007) Vitamin D status and nutrition in Europe and Asia. J Steroid Biochem Mol Biol 103:620–625
23. Lips P (2010) Worldwide status of vitamin D nutrition. J Steroid Biochem Mol Biol 121:297–300
24. Carlsson AC, Johansson SE, Theobald H, Wandell PE (2013) Blood pressure measures and their predictive ability of cardiovascular mortality: a 26-year follow-up. Blood Press Monit 18:72–77
25. Ludvigsson JF, Andersson E, Ekbom A, Feychting M, Kim JL, Reuterwall C, Heurgren M, Olausson PO (2011) External review and validation of the Swedish national inpatient register. BMC Public Health 11:450