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Low risk for hip fracture and high risk for hip arthroplasty due to osteoarthritis among Swedish farmers

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Abstract

Purpose—The risks of hip fracture and hip arthroplasty are influenced by factors including socioeconomic status, education, urbanization, latitude of residence, and physical activity. Farming is an occupation encompassing rural living and high level of physical activity. Therefore, we aimed to study the risk of hip fracture and risk of hip arthroplasty amongst farmers in Sweden.

Methods—We studied the risk of hip fracture, and hip arthroplasty due to primary osteoarthritis, in all men and women aged 35 years or more in Sweden between 1987 and 2002. Documented occupations were available in 3.5 million individuals, of whom 97,136 were farmers. The effects of age, sex, income, education, location of residence and occupation on risk of hip fracture or hip arthroplasty were examined using a modification of Poisson regression.

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Conflict of interest

Helena Johansson, Cecilie Hongslo Vala, Anders Odén, Mattias Lorentzon, Eugene McCloskey, John A Kanis, Nicholas C Harvey, Claes Ohlsson, L Stefan Lohmander, Johan Kärrholm and Dan Mellström declare that they have no conflict of interest in relation to this manuscript

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Results—4,027 farmers and 93,109 individuals with other occupations sustained a hip fracture, while 5,349 farmers and 63,473 others underwent a hip arthroplasty. Risk of hip fracture was higher with greater age, lower income, lower education, higher latitude and urban area for all men and women. Compared to all other occupations, male farmers had a 20% lower age-adjusted risk of hip fracture (hazard ratio (HR) 0.80, 95%CI 0.77-0.84), an effect that was not seen in female farmers (HR 0.96, 95% CI 0.91-1.01). Both male and female farmers had a higher age-adjusted risk for hip arthroplasty.

Conclusions—Our results indicate that farming, representing an occupation with high physical activity, in men is associated with a lower risk of hip fracture but an increased risk of hip arthroplasty.

Keywords

osteoporosis; epidemiology; osteoarthritis; hip fracture; arthroplasty; occupation; physical activity; Sweden

Introduction

Fracture and osteoarthritis are the two most common conditions affecting the hip in older adults [1–3]. Whereas increasing age is a risk factor common to both diseases [1,4], heavy physical activity has been regarded as a risk factor for hip osteoarthritis [5–11] but a debated protective factor for hip fracture [12–24]. Results of research on occupational physical activity on fracture risk are inconsistent [12–24], with three studies finding that high physical loads at work were protective for hip fracture [19–21], several studies demonstrating no association [12–18,23], whilst others showed that high level of physical activity was a risk factor for hip fracture [22–24]. Farming is a rural occupation with longstanding exposure to high level of physical loading even after regular retirement age and often starting at a young age, together with a high occupational risk of accidents. Several studies have demonstrated an increased risk of hip osteoarthritis among farmers [5–11]. Thus, in terms of physical activity, farming might be expected to be associated with lower risk of hip fracture but higher risk of osteoarthritis and consequent arthroplasty [25]. There are many risk factors reported for hip fracture. These include low BMI, previous fracture, life style factors [26–30]. The risk of hip fracture is also associated with differences in latitude, population density and indices of socio-economic prosperity [4,31], factors that may also interact with the occupation of farming. The aim of the present study was to determine the risk of hip fracture, and of hip arthroplasty for osteoarthritis, amongst farmers compared to other occupations in Sweden accounting for covariates such as socioeconomic status, education, urbanization and latitude of residence.

Methods

Cohort

We studied all men and women, age 35 years or more, in the Swedish Patient Register from 1987 to 2002 i.e. the individuals were identified in 1987 and followed for up to 15 years or until death or emigration. The register documents each hospital admission on a continuous basis, and a unique personal identifier permits the tracking of individuals for multiple admissions. It includes all patients discharged from hospital according to the disease category and surgical procedure. Registration is a legal requirement, is backed by financial inducement, and has an accuracy that exceeds 90% for surgical admissions [32]. This register was linked with the register of cause of death and the National Census Register. We studied admissions to Swedish hospitals for hip fracture, or for elective hip arthroplasty due to primary osteoarthritis, between January 1987 and December 2002.

Outcome events

Time to first hip fracture in one analysis and time to first hip arthroplasty in another was studied in the same cohort.

Hip fracture—Each patient identified as having sustained a hip fracture had to have both ICD codes (International Statistical Classification of Diseases and Related Health Problems) for hip fracture and codes for surgical procedures related to hip fracture; ICD-9 codes for diagnosis 820A-D (Fracture of neck of femur) and surgery procedure codes 8200-8219 (Treatment of closed fracture), 8413 (Hemiarthroplasty), 8414 (Total hip arthroplasty) or ICD-10 codes for diagnosis S720-S722 (Fracture of neck of femur, Pertrochanteric fracture and Subtrochanteric fracture) and surgical procedure codes NFB (Hip replacement) and NFJ (Fracture surgery of femur).

Hip arthroplasty—Each patient identified as having had a total hip arthroplasty had to have both ICD codes for osteoarthritis and ICD codes for surgical procedures related to hip arthroplasty; ICD-9 codes for diagnosis 715B (Osteoarthrosis), and surgery procedure codes 8414 (Total hip arthroplasty) or ICD-10 codes for diagnosis M160-161 (Primary osteoarthritis of hip) and surgical procedure codes NFB29, NFB39 and NFB49 (Primary total hip arthroplasty with or without cement or hybrid technique.)

Covariates

The relationships between occupation and fracture or arthroplasty risk were studied as a function of age, sex, income, education, latitude and urbanization of place of residence. Population and Housing Census 1975 and 1985 (FoB) [33] provided the self-reported profession based on Nordic class of profession (NYK), which in turn follows the International Standard Classification of Occupations (ISCO). Code 401 (farmers, foresters and market gardeners) was identified and termed farming for this analysis. Individuals with no profession given in either FoB 1975 or 1985 were omitted from analysis, resulting in 3,560,496 individuals, of whom 97,136 (2.7%) were identified as farmers. In all analysis farmers were compared to all other occupations combined into a single variable. Details of income were available from the years 1991, 1996 and 2002, and the highest value (inflation-adjusted) was used. Quintiles of income were calculated separately for each 5-year birth year group for the analysis. Level of education was categorised on a 7-point scale, where 1 represented <9 years in school, 2 was 9 years, 3 was 10-11 years, 4 was 12 years, 5 was university <3 years, 6 was university >3 years and 7 denoted postgraduate education. In the results, these categories were collapsed to ≤9 years, 10-12 years and University. Latitude was categorised on a 4-point scale (South (55-57˚N), Middle-south (57-59˚N), Mid-north (59-61˚N) and North (61-69˚N)). Urbanization was categorised on a 6-point scale, where 1

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is >200 thousand, 2 is 100-200 thousand, 3 is 50-100 thousand, 4 is 25-50 thousand, 5 is 15-25 thousands and 6 is <15 thousand inhabitants in the municipality of residence.

Statistical analysis

A modification of the Poisson regression model was used to study the relationship between age, occupation, income, education, latitude and urbanization of place of residence on the one hand and on the other hand, first hip fracture or first elective hip arthroplasty [34]. The modification was to study small intervals of time of follow up so that the probability of having more than one endpoint per person within each interval was vanishingly small. The observation period of each individual was divided into intervals of one month. In contrast to logistic regression, the Poisson regression uses the length of each individual's follow-up period and the hazard function is assumed to be for example exp($\beta_0 + \beta_1 \cdot$ current time from baseline + $\beta_2 \cdot$ current age + $\beta_3 \cdot$ farmer or other occupation). One fracture per person, and time to the first fracture, were counted, and time at risk was censored at the time of first fracture (or hip arthroplasty in a separate analysis), migration or death. Separate analyses for men and for women were performed. The beta coefficients of the hazard function reflect the importance of the variables. All associations were adjusted for age and time since baseline (Year 1987). Interactions with age were investigated to determine whether the association with outcomes changed with age. In a sensitivity analysis, the risk of hip fracture was explored when the follow up time was censored additionally at the time for hip arthroplasty. The associations between predictive factors and risk of the two endpoints were presented as hazard ratios (HR) and 95% confidence intervals (CI). The hazard ratios are given by $e^{(\beta i)}$. Farmers were compared with all other occupations combined regarding variables at baseline using Fisher's permutation test (table 1). Two-sided p-value were used for all analyses and p<0.05 considered to be significant.

Results

97,136 farmers and 3,463,360 individuals with other occupations were followed for over 51.3 million person years. Farmers were older, more often men, had lower income, lower education, lived more in the South and, as expected, in more rural areas compared to individuals with other occupations (p<0.001) (Table 1).

High income were associated with lower risks of hip fracture and hip arthroplasty when adjusted for age for both men and women (p<0.001) (Table 2). High education level was associated with lower risk of hip fracture for women and lower risk of hip arthroplasty for men (p<0.001). For women the risk of hip arthroplasty increased with higher level of education (p<0.001). For men there was no association between education and risk of hip fracture (p>0.30). Northern latitudes were associated with higher risk of both hip outcomes (p<0.001). Discordance was seen when looking at population density; lower density was associated with a reduced risk of hip fracture but a higher risk of hip arthroplasty (p<0.001).

4,027 farmers and 93,109 individuals with other occupations sustained one or more hip fracture during the whole study period (Table 3). The corresponding figures for hip arthroplasty were 2,703 and 32,676. The number of events and incidence by age band and gender for the outcomes of hip fracture and hip arthroplasty are shown in Table 3.

As expected, the incidence rates for both hip fracture and hip arthroplasty increased with age in both men and women, regardless of occupation (p<0.001). In contrast to hip fracture, the rates for hip arthroplasty declined at older ages in both men and women, probably reflecting the elective nature of this procedure compared to acute trauma management in those with hip fracture. Male farmers had a lower risk of hip fracture but a higher risk of hip arthroplasty, adjusted for age and time since baseline (p<0.001) (Table 4), whilst female farmers had only a higher risk of hip arthroplasty (p<0.001). When additionally adjusted for income, education, latitude and population density, the effects of farming were similar or more marked (Table 4). As an example the hip fracture risk per 100,000 for a male farmer aged 70 years, with income in the lowest quintile, having less than 9 years of education, living in the middle-south of Sweden, in a population density of 15000-50000, is 195 (95% CI: 188-203). For a man with another occupation and the same age etc. the hip fracture risk per 100,000 is 325 (95% CI: 318-332).

The age-specific rates of hip fracture and hip arthroplasty increased with time (or calendar year as everyone commenced follow up in 1987), hip fractures increased by 0.5% per year for women (95% CI: 0.2-0.7) and 1.9% per year for men (95% CI: 1.7-2.2) while the respective annual incidences for hip arthroplasty were 2.6% (95% CI: 2.4-2.9) and 2.3% (95% CI: 2.1-2.6). This increase was adjusted for age, income, education, latitude, population density and occupation.

In a sensitivity analysis, the risk of hip fracture was explored when the follow up time was censored additionally at the time for hip arthroplasty. The result of this analysis was almost identical to the results presented in Table 4. In table 4 the HR between farmers and other occupations was 0.60 (0.57-0.63) when fully adjusted. When follow up time for hip fracture was censored at the time for arthroplasty the HR was 0.61 (0.57-0.64).

Interaction with age

Interactions with age were investigated to determine whether the risks of hip fracture or hip replacement were age-dependent (Table 5 and Figure 1). The impact of farming on both hip fracture and hip arthroplasty was age-dependent for men (p<0.001), with greater protection against hip fracture and higher risk of arthroplasty at younger ages. The higher risk of hip arthroplasty associated with farming was also age-dependent in women with higher hazard ratios for younger ages (p<0.001) (Table 5, Figure 1).

Discussion

Our results indicate that farming is associated with a lower risk of hip fracture, and a higher risk of hip arthroplasty, compared to other occupations. For men, there was a 40% lower risk of hip fracture when adjusted for age, income, education, latitude and population density, whereas in women a small protective effect of farming (4%) was not statistically significant. In contrast, the risk of hip arthroplasty for osteoarthritis was approximately doubled (105% increase) in male farmers compared to other occupations, with a lesser but still statistically significant effect in female farmers (40% higher).

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We hypothesized that this pattern of hip fractures and arthroplasty might be observed as it related to high levels of physical activity during farming, which is often included in the heaviest category when describing occupational physical activity [13,15,16,18,24]. The discordance between male and female farmers is consistent with a dose effect, as it is probable that the majority of female farmers were partners of male farmers. Although physically active, it is likely that female farmers in general are not exposed to the same degrees of physical activity as their male partners, though this is poorly documented in developed nations [35]. If true, this might suggest a sigmoid relationship between physical activity and skeletal fragility where extremes have positive or negative effects (e.g. elite athletes and immobilization, respectively) but everyday physical activity has more modest influences [36].

Hägglund et al [37] studied 532 cases of slipped capital femoral epiphysis treated at three orthopaedic departments in southern Sweden between 1910 and 1982. They found that the incidence of this disease was higher both in boys and in girls living in the countryside, even if the overall incidence was almost doubled in boys. During this period, it is most probable that a number of cases with mild disease never sought medical attention. Slipping of the femoral epiphysis is a risk factor for later development of osteoarthritis, where its etiology frequently is overlooked or not recognized [38] and may contribute to the increased incidence of hip arthroplasty in farmers level of physical activity.

Based on previous literature the evidence for the effect of occupational physical activity to reduce hip fracture risk in women appears inconsistent [12,14–17,19–22,24]. For example, in a recent study investigating 96,676 postmenopausal women from USA, no significant association of occupational physical demand was noted with hip fracture risk [12]. Comparison between studies is complicated by the use of different definitions of occupational physical activity and occasionally taking early life occupational physical demands into account [19,21]. Greater consistency between higher levels of physical activity and lower hip fracture risk has been observed in men, though some studies have found this association is connected to leisure-related rather than to work-related physical activity [24,39]. However, leisure physical activity may cause fracture through accidents rather than skeletal fragility, for example through cycling or other sports that increase the risk of injury [23]. A similar problem may also confound studies of occupational physical activity [21,40], which if true suggests that the protective effect of farming on hip fracture risk due to skeletal fragility may be greater than reported here.

In contrast to hip fracture, an increased risk of hip arthroplasty in farmers has been more consistently observed [6–9,41–44]. The potential dose response illustrated by differential effects between the genders in our study is consistent with previous reports. For example, a hhigher risk for male farmers than for female farmers for the risk of hip arthroplasty was reported in an analysis of the whole Danish working population (217,055 farmers) [6,7]. The hazard ratios, 1.96 in men compared to other occupations and 1.22 for women, are similar to those observed in our study.

The present study has a number of strengths and limitations. The analysis is based on the Swedish Patient Register which has a high degree of accuracy for surgical interventions. By capturing the entire population of Sweden, we avoided a healthy selection bias or non-response bias. An additional strength of this study is that the risk of hip fracture and hip arthroplasty were assessed in the same population in the same time period. Occupation, though self-reported and not independently ascertained, is unlikely to have been subject to recall bias since the occupation was captured before the outcomes of interest occurred. However, the self-reporting meant we could not distinguish between a farmer's wife and a female farmer, which could account for the gender differences in risk associations as discussed above. The results are certainly not applicable to other countries where the gender roles in farming are quite different to those seen in developed countries [21,45] and baseline hip fracture risk is different [46]. Another limitation is that, unlike hip fracture where the occurrence is acute and treatment largely mandatory in this setting, hip arthroplasty is dependent on the referral for surgery and patient choice, both of which may show regional, social and indeed occupational influences. Also, the category of farmers included foresters and professional gardeners, although the numbers may be relatively small and the physical activity exposure similar. Importantly, we could not adjust for BMI, diet and sun exposure, morbidity and several other factors known to affect hip fracture risk and the risk of osteoarthritis-related arthroplasty, though we were able to adjust for a variety of variables, including sex, age, income, education, latitude and population density [4,47]. Innovations in farming technology, particularly mechanisation of many heavy manual duty tasks, over the last 50 years have had two important impacts on farming life. Firstly, there has been a decrease in physical activity exposure, though this is difficult to quantify, but this appears to have been associated with a marked increase in obesity in the farming population [48,35]. For example, in Crete over a 40 year period, the mean weight of middle aged male farmer increased by 20 kg (83 kg vs. 63 kg) leading to an increase of 7 kg/m^2 in mean BMI (22.9 kg/m^2 vs. 29.8 kg/m^2) [35]. Like physical activity, obesity has discordant effects on hip fracture and hip arthroplasty risk. We were unable to determine if there were temporal changes in BMI in our database, but it is unlikely that there were sufficient changes in BMI over the relatively short study timeframe to explain all of the observed findings; this conclusion is also supported by the parallel increases seen in the rates of both events over time.

In summary, the present analysis demonstrates that farming, representing an occupation with high physical activity, is associated with a lower risk of hip fracture for men and higher risk of hip arthroplasty for men and women, compared to other occupations.

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Mini Abstracts

We aimed to study the risk of hip fracture and risk of hip arthroplasty amongst farmers in Sweden. Our results indicate that farming, representing an occupation with high physical activity, in men is associated with a lower risk of hip fracture but an increased risk of hip arthroplasty.

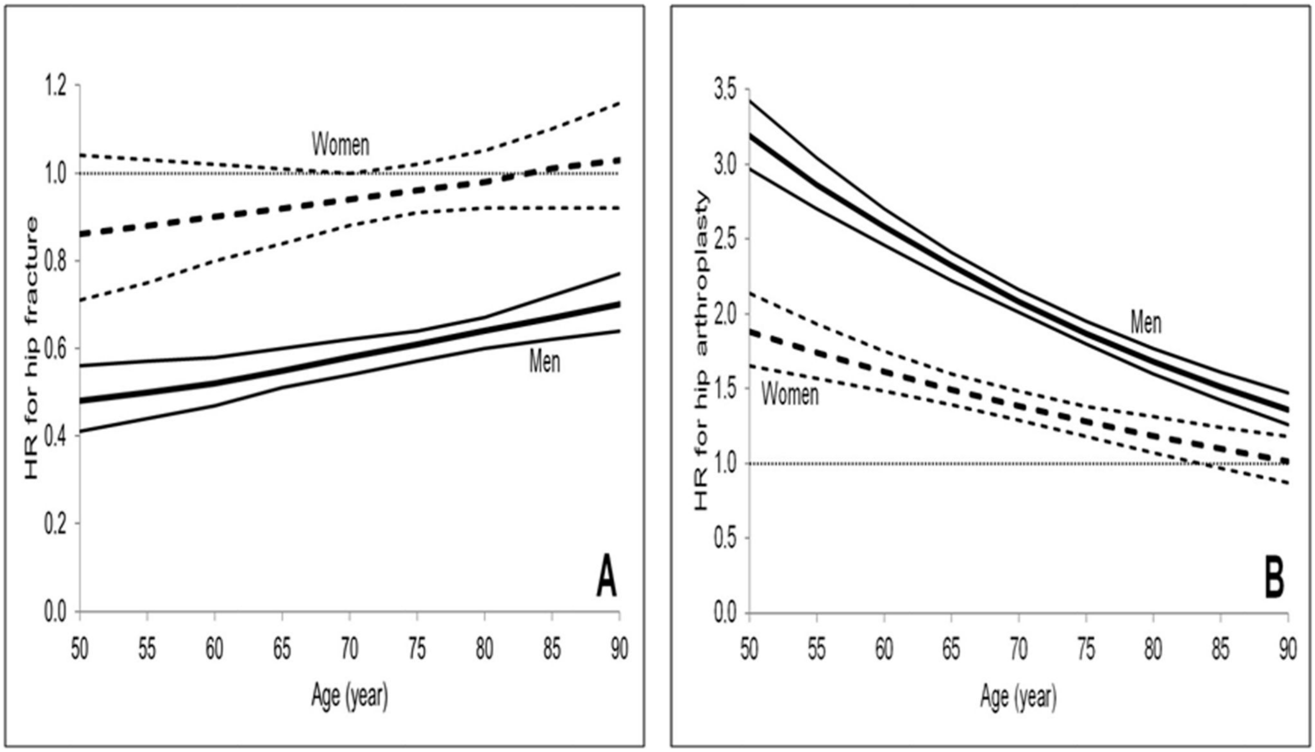

Figure 1.

Risk of hip fracture and hip arthroplasty for farmers according to age for hip fracture on left panel (A) and hip arthroplasty on right panel (B). HR and 95% confidence interval adjusted for age, time since baseline, income, education, latitude and population density. Black lines denotes men and dotted lines denotes women. The horizontal dotted line is y=1. If HR is 1 there is no effect of risk factors for risk of endpoint.

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Table 1

Baseline characteristics for farmers and individuals with other occupation

	Farmers n = 97,136	Other occupations n = 3,463,360	Two sided p-value Farmers vs other occupation
Men	75%	53%	<0.001
Age (years)	58.3±12.2	51.8±12.1	<0.001
Income			
lowest quintile	39%	13%	<0.001
2nd quintile	26%	19%	
3rd quintile	17%	22%	
4th quintile	11%	23%	
highest quintile	7%	24%	
Education			
≤ 9 years	67%	43%	<0.001
10-12 years	29%	37%	
University	4%	20%	
Latitude			
South	32%	20%	<0.001
Middle-south	42%	53%	
Middle-north	15%	17%	
North	11%	11%	
Population density (000)			
>200	0.6%	16%	<0.001
50-200.	21%	33%	
15-50	47%	35%	
<15	31%	16%	

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Table 2

Hazard ratio (HR) per 1-unit step and 95% confidence interval (CI) in the whole population (both farmers and other occupation) adjusted for age and time since baseline. Sex-specific model used.

	HR per 1 unit step (95% CI)	
	Men	**Women**
Hip fracture		
Income (1-5, 5:highest income)[a]	0.80 (0.79-0.81) *	0.96 (0.95-0.97) *
Education (1-7, 7:highest education)[a]	1.00 (0.99-1.01)	0.89 (0.89-0.90) *
Latitude (1-4, 4: most north)[a]	1.07 (1.05-1.08) *	1.06 (1.05-1.07) *
Population density (1-6, 6: most rural)[a]	0.94 (0.94-0.95) *	0.97 (0.96-0.97) *
Hip arthroplasty		
Income[a]	0.95 (0.94-0.93) *	0.98 (0.97-0.99) *
Education[a]	0.93 (0.92-0.94) *	1.02 (1.01-1.02) *
Latitude[a]	1.03 (1.02-1.04) *	1.07 (1.05-1.08) *
Population density[a]	1.10 (1.10-1.11) *	1.06 (1.05-1.07) *

* Two-sided p-value <0.05

[a] As defined in Table 1 and method section

Table 3

Incidence per 100,000 person years (95% confidence interval, CI) of hip fracture and hip arthroplasty, by age and gender.

	Farmers			Other occupations		
Age interval	**Number of outcomes**	**Outcome incidence (per 100,000 years) (95% CI)**		**Number of outcomes**	**Outcome incidence (per 100,000 years) (95% CI)**	
Men			*Hip fracture*			
35-39	2	7	(1-27)	87	8	(6-9)
40-49	15	9	(5-15)	1045	16	(15-17)
50-59	58	22	(17-29)	2779	37	(36-39)
60-69	288	88	(78-98)	6145	109	(106-112)
70-79	1054	325	(305-345)	15015	389	(383-395)
80-89	1219	1112	(1050-1176)	11356	1303	(1280-1328)
90-99	107	2384	(1952-2879)	533	3020	(2769-3288)
Women						
35-39	0	0	(0-39)	40	4	(3-5)
40-49	5	7	(2-17)	591	10	(9-11)
50-59	64	51	(39-65)	3312	47	(46-49)
60-69	210	150	(130-172)	9261	169	(166-173)
70-79	553	642	(589-698)	24014	664	(655-672)
80-89	429	2238	(2031-2460)	18078	2204	(2172-2236)
90-99	23	3585	(2272-5381)	853	4950	(4624-5294)
Men			*Hip arthroplasty*			
35-39	0	0	(0-14)	12	1	(1-2)
40-49	33	20	(14-28)	783	12	(11-13)
50-59	420	164	(148-180)	5017	67	(65-69)
60-69	1559	483	(459-507)	10932	194	(191-198)
70-79	1893	601	(574-629)	11665	304	(299-310)
80-89	390	361	(326-398)	2114	241	(231-251)
90-99	3	65	(13-189)	12	63	(33-111)
Women						
35-39	0	0	(0-39)	14	1	(1-2)
40-49	12	18	(9-31)	626	10	(10-11)
50-59	150	120	(102-141)	4898	70	(68-72)
60-69	421	303	(275-333)	11494	211	(207-214)
70-79	404	471	(426-519)	13423	369	(363-376)
80-89	64	315	(243-402)	2465	284	(273-295)
90-99	0	0	(0-469)	18	85	(51-135)

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Table 4

Hazard ratio (HR) and 95% confidence interval (CI) for farmers versus other occupations.

Outcome	HR (95% CI)	
	Adjusted for age and time since baseline	**Adjusted for age, time since baseline, income, education, latitude and population density**
Men		
Hip fracture	0.80 (0.77-0.84)*	0.60 (0.57-0.63)*
Hip arthroplasty	2.04 (1.97-2.11)*	2.05 (1.98-2.13)*
Women		
Hip fracture	0.96 (0.91-1.01)	0.96 (0.90-1.02)
Hip arthroplasty	1.44 (1.35-1.53)*	1.40 (1.31-1.49)*

*Two-sided p-value <0.05

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Table 5

Risk of hip fracture and hip arthroplasty for farmers according to age. HR and 95% confidence interval adjusted for age, time since baseline, income, education, latitude and population density.

Outcome	HR (95% CI)		p-value[a]
	At the age of 60 years	At the age of 80 years	
Men			
Hip fracture	0.51 (0.45-0.56)	0.62 (0.60-0.65)	<0.001
Hip arthroplasty	2.58 (2.46-2.70)	1.68 (1.60-1.77)	<0.001
Women			
Hip fracture	0.90 (0.79-1.02)	0.98 (0.91-1.05)	0.24
Hip arthroplasty	1.61 (1.48-1.75)	1.18 (1.07-1.31)	<0.001

[a]Two-sided p-value for the interaction between farming and age. Age was used as a continuous variable and examples are shown at the ages of 60 and 80 years.