Associations between adverse social position and bone mineral density in women aged 50 years or older: Data from the Manitoba Bone Density Program

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MINI ABSTRACT

We examined the independent contribution of income to low bone mineral density in women aged 50 years and older. A significant dose-response association was observed between low income and low BMD, which was not explained by clinical risk factors or osteoporotic treatment in the year prior.

KEYWORDS: bone mineral density, social determinants, income, osteoporosis, disadvantage

ABSTRACT

Background: The association between social disadvantage and osteoporosis is attracting increased attention, however, little is known of the role played by income. We examined associations between income and bone mineral density (BMD) in 51,327 women aged ≥ 50 yrs from Manitoba, Canada.

Methods: Low BMD was defined as a T-score ≥ 2.5 SD (femoral neck or minimum) measured by dual energy x-ray absorptiometry (DXA) 1996-2001. Mean household income was extracted from Canada Census 2006 public use files, and categorized into quintiles. Age, weight and height were recorded at time of DXA. Parental hip fracture was self-reported. Diagnosed comorbidities, including osteoporotic fracture and rheumatoid arthritis, were ascertained from hospital records and physician billing claims. Chronic obstructive pulmonary disease was used as a proxy for smoking, and alcohol abuse as a proxy for high alcohol intake. Corticosteroid use was obtained from the comprehensive provincial pharmacy system. Logistic regression was used to assess relationships between income (highest income quintile held as referent) and BMD, accounting for clinical risk factors.

Results: Compared to quintile 5 the adjusted OR for low BMD at femoral neck for quintiles 1 through 4 were, respectively; OR1.41 (95%CI 1.29-1.55), OR1.32 (95%CI 1.20-1.45), OR1.19 (95%CI 1.08-1.30) and OR1.10 (95%CI 1.00-1.21). Similar associations were observed when further adjustment was made for osteoporotic drug treatment 12 months prior, and when low BMD was defined by minimum T-score.

Conclusions: Lower income was associated with lower BMD, independent of clinical risk factors. Further work should examine whether lower income increases the likelihood of treatment qualification.

INTRODUCTION

It is well documented that an adverse social gradient of health exists for countries with lower income (1). Furthermore, it is becoming more widely recognized that social disparities in health also exist within high income countries, especially where greater inequality exists between the levels of income in the overall population (2). Whilst commonly cited examples of this social gradient are obesity, mental health, and mortality, a social gradient **may** also exist for osteoporotic fracture. Greater fracture risk has been observed for those with lower education (3), lower income (4), those who are unemployed (5), and those who are defined as socially deprived using aggregated measures **or zip codes (6-8) or using proxies for wealth such as having private health insurance (9). However, this association appears controversial, as some studies have reported no association between income and fracture (10), whilst others have reported an increased risk of fracture for those of higher income when measured by cell phone ownership (11).** Whilst the underlying mechanisms for these associations are not yet understood, these associations regarding fracture burden may have important public health implications.

Low bone mineral density (BMD) is a key predisposing factor for increased fracture risk (12). Whilst recent years have seen increasing attention directed toward elucidating the association between social disadvantage and BMD, a 2010 synthesis of available literature highlighted that an extreme paucity of data still existed in this area of enquiry, with only eight papers fulfilling eligibility criteria for review (13). Although an overall consistency in findings was reported, the review was constrained by a limited level of evidence to suggest an association between social disadvantage and BMD. Furthermore, only one of the eight reviewed studies had examined income as the key social parameter of interest: that study reported a positive association between low income and low vertebral BMD in a Spanish population of 1,116 individuals (61.3% female) (14).

The development of the World Health Organization fracture risk assessment (FRAX®) calculator highlights the important role played by clinical risk factors on 10-year fracture

probability (15). Many of the clinical risk factors included in FRAX calibration, such as lifestyle behaviours and family history, have also been associated with social disadvantage. For instance, many studies have shown individuals of greater social disadvantage to have increased body mass index (BMI) (16), smoking (17, 18), and fracture incidence (which affects FRAX calculations as prior fracture) (19). To date, there has been no investigation of whether an association exists between low income and low BMD, and importantly whether any association is sustained once accounting for other clinical risk factors included in FRAX: age, BMI, smoking, alcohol, rheumatoid arthritis, and glucocorticoid use. Thus, we examined the association between quintiles of income and the odds of having an osteoporotic femoral neck BMD T-score or osteoporotic minimum T-score in women aged ≥ 50 years from Manitoba, Canada, who had undergone an initial BMD test between 1996 and 2011.

METHODS

Study design

We performed a cross-sectional study to examine the association between income and an osteoporotic BMD T-score in women aged ≥ 50 years at the time of a first DXA examination. Records of patients who are referred for a BMD test are encrypted with a personal identifier that allows for linkage across data sets and the creation of person-specific longitudinal records of health service utilization. Patient records from the Manitoba Bone Density Program, Canada, were linked to anonymized population-based administrative health records extracted from the data repository housed at the Manitoba Centre for Health Policy at the University of Manitoba, Canada (20, 21). The study was reviewed and approved by the Health Research Ethics Board for the University of Manitoba, and the Health Information Privacy Committee of Manitoba Health.

Data sources

Bone mineral density

Residents of the Province of Manitoba ($n \approx 1.25$ million) have universal access to BMD testing when requested by a health care professional (22). The Manitoba Bone Density

Program is a unique integrated program that has managed all clinical dual energy x-ray absorptiometry (DXA) testing for the province since 1997 (23). Criteria for BMD testing are consistent with most published guidelines (24), DXA testing rates for the Manitoba Bone Density Program have been published, and the program's database has been shown to be over 99% complete and accurate (23). Prior to 2000, BMD was measured by DXA using a pencil-beam instrument (Lunar DPX, GE Lunar, Madison, WI, USA), and post-2000, DXA was performed using a fan-beam instrument (Lunar Prodigy, GE Lunar). All instruments were cross-calibrated using anthropomorphic phantoms and volunteers, as previously reported (25). Low BMD was determined by a T-score at the femoral neck or minimum T-score of ≥ 2.5 SD below the young adult mean. Hip T-scores were calculated using the Third National Health and Nutrition Examination Survey (NHANES III) white female reference values (26). Minimum T-score values were calculated from the combination of femoral neck, total hip and lumbar spine where spine T-scores were calculated using manufacturer reference data for white females.

Adverse social position

Mean household income, based upon area of residence in the year of the DXA test, for dissemination areas (DAs) was extracted from the public use files of Canada Census 2006, and ranked from the lowest to highest. *As of 2001 Census, DAs replace enumeration areas as the basic unit for dissemination, and are the smallest geographic unit for which Census data are released to the public. DAs are composed of one or more neighbouring blocks, and are uniform in population size, ranging from 400 to 700 persons.* Income was categorized into quintiles, with each quintile containing ~20% of the population, as previously described (27, 28). Quintile 1 had the lowest income and quintile 5 had the highest income; quintile 5 was held as the referent category for analyses. *Sensitivity analyses showed similar results whether household income was determined from the 2006 Census data or from Census data for the year that most closely approximated the year of DXA testing (Supplementary File) as both measures of income were highly correlated (Spearman $R > 0.9$); thus, for consistency, we used the single Census year of 2006 for all analyses.*

Clinical risk factors

Age, weight and height were recorded at the time of DXA. Prior to 2000 weight and height was by self-report, however, post-2000 weight was assessed without shoes using a standard floor scale, and height was assessed with a wall-mounted stadiometer. BMI was calculated as weight (kg)/divided by height (m)² (kg/m²). Self-reported parental hip fracture data at the time of DXA was available from 2005 onwards. Medically diagnosed conditions prior to BMD testing were ascertained through a combination of hospital discharge abstracts (coded using the International Classification of Diseases, 9th Revision, Clinical Modification [ICD-9-CM] prior to 2004 and the 10th revision, Canadian version [ICD-10-CA] thereafter) and physician billing claims (coded using ICD-9-CM) (20). Rheumatoid arthritis was defined using one hospitalization or at least two physician visits in the preceding three-year period. Chronic obstructive pulmonary disease (COPD) was used as a proxy for smoking status, and a diagnosis of alcohol abuse was used as a proxy for high alcohol intake. Prior major osteoporotic fracture (hip, spine, wrist or humerus) was ascertained through the combined use of hospital discharge records and physician billing claims since 1987. Prolonged corticosteroid use (>90 days dispensed in the year prior to DXA testing) was obtained from the comprehensive provincial pharmacy system. Osteoporotic drug treatment dispensed in the year prior to DXA testing, defined with and without hormone therapy, was used to calculate the medication possession ratio (MPR) (29) categorised as none, <0.5, 0.5-0.8, or >0.8. To account for the possibility that prevalent diseases may mediate the association between income and BMD, we employed the Johns Hopkins Adjusted Clinical Groups® Case-Mix System version 10. Ambulatory diagnostic groups (ADGs) represent 32 comorbidity clusters of every ICD-9-CM/ICD-10-CA diagnostic code. Depending upon the variety of codes an individual receives over the prior year, the number of ADGs can range from 0 to 32 (30-32). Our study population was then categorized as having fewer than 3 (referent), 3-5, or ≥6 ADGs as previously described (33)

Statistical analyses

Descriptive characteristics of the study population are presented across income quintiles using means, standard deviations, frequencies and percentages, and linear trends were

examined using χ^2 analysis for categorical data, ANOVA for normally distributed continuous data, or Kruskal-Wallis for non-parametric continuous data. Logistic regression models assessed the relationship between income quintiles (holding the highest income quintile as referent) and an osteoporotic BMD T-score of ≥ 2.5 SD below the young adult mean at the femoral neck and minimum BMD T-score. These models were initially adjusted for age alone, and then for additional clinical risk factors of age, BMI, COPD, alcohol, rheumatoid arthritis, and glucocorticoid use. Given that osteoporotic drug treatment may confound the association between income and BMD, logistic models were rerun with further adjustment for osteoporotic drug treatment in the 12 months prior, and sensitivity analyses were performed whereby results were stratified by current osteoporosis treatment. Some women with BMD ≥ 1.5 SD below the young adult mean may benefit from treatment, therefore sensitivity analyses were performed to examine the alternate cut-points of BMD T-score ≥ 2.0 and ≥ 1.5 SD below the young adult mean. Sensitivity analyses were performed to examine the role played by prevalent diseases in associations between income and BMD, whereby ADGs replaced rheumatoid arthritis, COPD and alcohol abuse in the models. Model fit was assessed using the Aikake Information Criterion (AIC). Significance was set at $p \leq 0.05$, and statistical analyses were performed using MINITAB (Version 16.0; Minitab, State College, PA) software.

RESULTS

Table 1 presents characteristics of the study population (n=51,327) across quintiles of household income. The mean femoral neck T-score was -1.47 (± 0.97) and mean minimum T-score was -1.91 (± 1.12). Lower household income was significantly associated with increasing age and BMI, and a greater likelihood of prior fracture, COPD, glucocorticoid use and an osteoporotic T-score at the femoral neck or for the minimum site (all $p < 0.001$); these associations were approximately linear across the income quintiles. A positive association was seen for increasing income and the increased likelihood of a parental hip fracture ($p < 0.001$), and a linear trend was also seen across income quintiles for rheumatoid arthritis ($p = 0.045$).

Table 2 presents the association between income quintiles and osteoporosis defined by a BMD T-score at the femoral neck of ≥ 2.5 SD below the young adult mean. Similar trends were observed for the lumbar spine and total hip as were seen for the femoral neck (Supplementary File). For all age-adjusted and multivariable logistic regression models, income quintiles showed a significant dose-response association with the likelihood of having an osteoporotic T-score at the femoral neck (overall p for linear trend <0.001). After adjustment for all clinical risk factors (Model 1), compared to quintile 5 (referent), the OR for quintile 1 was 1.41 (95%CI 1.29-1.55), for quintile 2 was 1.32 (95%CI 1.20-1.45), for quintile 3 was 1.19 (95%CI 1.08-1.30) and quintile 4 was 1.10 (95%CI 1.00-1.21). With the exception of parental hip fracture, all clinical risk factors showed significant independent associations in the model (alcohol abuse $p=0.045$, all others all $p<0.001$). Associations between income and an osteoporotic T-score were unaffected by further adjustment for osteoporotic drug treatment in the 12 months prior (Model 2, Table 2). Sensitivity analyses whereby cut-points were defined by T-scores ≥ 2.0 SD and ≥ 1.5 SD below the young adult mean showed similar results; significant associations between income quintiles and osteoporotic T-scores were sustained (data not shown). Results were similar when the number of ADGs replaced rheumatoid arthritis, COPD and alcohol abuse in the models, and when stratified by osteoporosis treatment (Supplementary File).

Table 3 presents the associations between income quintiles and osteoporosis defined by a minimum T-score ≥ 2.5 SD below the young adult mean. For all age-adjusted and multivariable logistic regression models, income quintiles showed a significant dose-response association with the likelihood of having osteoporosis defined by a minimum T-score (overall p for linear trend <0.001). After adjustment for all clinical risk factors (Model 1), income quintiles showed a significant dose-response association with the likelihood of having osteoporosis defined by minimum T-score; compared to quintile 5 (referent), the OR for quintile 1 was 1.46 (95%CI 1.36-1.56), for quintile 2 was 1.33 (95%CI 1.25-1.43), for quintile 3 was 1.20 (95%CI 1.12-1.28) and quintile 4 was 1.15 (95%CI 1.08-1.23). These associations were not appreciably attenuated by further adjustment for osteoporotic treatment in the 12 months prior (Model 2). Results were

sustained when cut-points for osteoporosis using minimum T-scores were defined as $\geq 2.0SD$ and $\geq 1.5SD$ below the young adult mean (data not shown). Results were virtually identical when the number of ADGs replaced rheumatoid arthritis, COPD and alcohol abuse in the model (Supplementary File).

DISCUSSION

We found a strong dose-response association between lower income and an osteoporotic BMD T-score. These findings were consistent when using different cut-points and skeletal measurement sites to define osteoporosis, and were not explained by clinical risk factors or osteoporotic drug treatment.

To date, the association between income and osteoporotic BMD T-scores has been little understood due to a paucity of data. Without an evidence-base, it has also been unknown whether accounting for clinical risk factors may mediate any relationship between income and BMD. Educational attainment, as an alternative parameter of social disadvantage, has shown a dose-response association with BMD in studies from the USA (17), Italy (34), and Turkey (35). However, those studies did not account for the role played by clinical risk factors on poorer bone health.

Given we showed associations between income and BMD to remain unexplained by clinical risk factors or osteoporotic drug treatment, it is plausible that factors other than those seen in the clinical setting are potential barriers or enhancers to good bone health. Other unmeasured factors that may impact on BMD and are associated with lower income may include higher levels of physical inactivity (18), lower dietary calcium intake and increased likelihood of smoking (17), poorer mental health status (36, 37) (increased use of selective serotonin reuptake inhibitors (SSRIs) reduces BMD (38)), determinants during childhood or adolescence (39), or environmental factors such as water supply, lead exposure, and sun exposure. Furthermore, the accumulative impact of disadvantage over the life-course would be greater in those of lower income compared to greater income. Another explanation may be that those of lower income are more likely

to have multiple co-morbidities and associated pharmacotherapy treatments, which may impact negatively on bone.

Our results have implications in the public health setting. First, these data highlight that osteoporosis is no exception to the theory of a social gradient of health. Second, the differences in having an osteoporotic BMD T-score across income quintiles are substantial. Even small differences in BMD between income quintiles will impact on social disparities in fracture incidence in the broader population; indeed a decrease of $\sim 1/4$ SD in BMD has been suggested as increasing hip fracture risk by $\sim 27\%$ (40-42). Our data showed a difference in BMD T-score of 0.3SD between women in the lowest income group compared to their counterparts in the highest income group. Disparities in BMD across the income continuum have high potential to translate into a disproportionate burden of disease, fracture risk, direct and indirect health care costs, and reduced time to mortality post-fracture. The strong dose-response association we observed between income and BMD suggest that there are systemic obstacles to ‘good’ bone health that are conflated with lower income. Whilst complex relationships exist between health and biology, complexity also exists between health and lifestyle behaviours, health services, the physical environment, discrimination, exclusion, literacy levels, and health and social policies.

Whilst little can be done in the clinical setting to address disparities in income (and indeed addressing social disparities in health requires multidimensional approaches rather than attention toward one factor alone (43)), a practical consequence of these data should be focused attention directed toward those who are socially disadvantaged in recognition of the increased susceptibility they have toward lower BMD, above and beyond the commonly considered clinical risk factors. That a social gradient exists in BMD, independently of known clinical risk factors for fracture, again points to the complexity of this issue, and the important role that the clinical setting plays in multidimensional approaches to eliminating disparities in osteoporosis. Without the combined efforts of those in the fields of medicine, public and preventive health, social and health policy, and research, amongst others, efforts to eliminate social disparities in osteoporosis will have

limited impact. It is plausible that the increased odds for an osteoporotic T-score will translate into greater numbers of individuals with lower income qualifying for treatment. However, it is not known whether the observed association between income and BMD translates into an increased likelihood of qualification for treatment for 10-year fracture probability in those of lower income.

This study has unique strengths. Our study size provided significant power to account for the differences in clinical risk factors across the income continuum, differences that may otherwise mask the effect of income on BMD. The dose-response strength of association between income and low BMD was consistent in all analyses. Our study also has some limitations. Our study was performed using a clinical referral population. However, if income had no role to play in BMD, we would be less likely to see an association in a clinical referral population. We were unable to account for ethnicity in these analyses as the study cohort was almost exclusively White (97-98% for each income quintile). Complex ethnic variations exist in BMD, and it has been suggested that differences in BMD are more likely to vary within rather than between ethnicities (44). Given the cross-sectional nature of our study design, we are unable to comment on cause and effect, and it is possible that the generalizability of our findings may not encompass other populations. Our sample showed a bias toward greater numbers in the higher income quintiles compared to the lowest income quintile. Furthermore, there were no available income data measured at the individual-level, and we were unable to verify household income data. It is possible that some DAs may straddle health region boundaries, and thus the physical legal boundaries of provinces may result in split dissemination blocks. Finally, as our discussion indicates, we do not suggest that the observed associations between income and BMD are independent of other social parameters.

In conclusion, we report strong associations between lower income and lower BMD that are independent of known clinical risk factors, amounted to almost 40% greater odds for those with lowest income compared to the highest income. Given these disparities, and the potential for increased fracture risk associated with lower BMD, increased attention should be directed towards individuals of lower income in the clinical setting. However,

future work should confirm whether these associations are reflected in an increased likelihood of qualification for treatment for fracture probability in those with lower income.

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Disclosures/Competing Interests

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Table 1: Characteristics of the study population across quintiles of household income, presented as mean ($\pm$ SD), median (IQR range), or number (% weighted to the population in each quintile).

	Total (n=51,327)	Quintile 1* (n=8,699)	Quintile 2 (n=10,370)	Quintile 3 (n=11,219)	Quintile 4 (n=10,679)	Quintile 5 (n=10,360)	p for trend
<i>Clinical risk factors</i>							
Age (yr)	65.3 (57.7-73.2)	68.6 (60.0-76.7)	66.7 (59.0-74.5)	65.8 (58.3-73.3)	64.0 (57.2-71.2)	61.9 (55.7-69.8)	<0.001
BMI (kg/m ²)	27.0 ($\pm$ 5.4)	27.3 ($\pm$ 5.8)	27.3 ($\pm$ 5.5)	27.0 ($\pm$ 5.4)	27.0 ($\pm$ 5.3)	26.5 ($\pm$ 5.1)	<0.001
Prior fracture	4,412 (8.6%)	913 (10.5%)	879 (8.5%)	889 (7.9%)	778 (7.3%)	683 (6.6%)	<0.001
Parental hip fracture	2,848 (5.5%)	430 (4.9%)	513 (4.9%)	619 (5.5%)	665 (6.2%)	621 (6.0%)	<0.001
COPD	4,232 (8.4%)	1,014 (11.7%)	990 (9.5%)	890 (7.9%)	744 (7.0%)	594 (5.7%)	<0.001
Glucocorticoid use	2,056 (4.0%)	446 (5.1%)	442 (4.3%)	456 (4.1%)	370 (3.5%)	342 (3.3%)	<0.001
Rheumatoid arthritis	1,759 (3.4%)	332 (3.8%)	377 (3.6%)	347 (3.1%)	352 (3.3%)	351 (3.4%)	0.045
Alcohol abuse	951 (1.9%)	227 (2.6%)	210 (2.0%)	202 (1.8%)	150 (1.4%)	162 (1.6%)	<0.001
<i>Any osteoporotic treatment</i>							
None	37,107 (72.3%)	6,389 (73.5%)	7,656 (73.8%)	8,151 (72.7%)	7,646 (71.6%)	7,265 (70.1%)	
MPR <0.5	5,330 (10.4%)	963 (11.1%)	1,089 (10.5%)	1,164 (10.4%)	1,054 (9.9%)	1,060 (10.2%)	
MPR 0.5-0.8	2,909 (5.7%)	436 (5.0%)	521 (5.0%)	656 (5.9%)	667 (6.3%)	629 (6.1%)	
MPR $\geq$ 0.8	5,981 (11.7%)	911 (10.5%)	1,104 (10.7%)	1,248 (11.1%)	1,312 (12.3%)	1,406 (13.6%)	
<i>Osteoporotic treatment excluding HT</i>	5,588 (10.9%)	1,191 (13.7%)	1,183 (11.4%)	1,177 (10.5%)	1,068 (10.0%)	969 (9.4%)	<0.001
Femoral neck T-score	-1.47 ($\pm$ 0.97)	-1.63 ($\pm$ 0.98)	-1.52 ($\pm$ 0.98)	-1.47 ($\pm$ 0.96)	-1.39 ($\pm$ 0.94)	-1.33 ($\pm$ 0.96)	<0.001
Minimum T-score	-1.91 ($\pm$ 1.12)	-2.10 ($\pm$ 1.14)	-1.98 ($\pm$ 1.13)	-1.92 ($\pm$ 1.11)	-1.82 ($\pm$ 1.09)	-1.75 ($\pm$ 1.09)	<0.001
<i>Osteoporotic T-score[†]</i>							
Femoral neck	6,936 (13.5%)	1,612 (18.5%)	1,575 (15.2%)	1,507 (13.4%)	1,194 (11.2%)	1,048 (10.1%)	<0.001
Minimum T-score	15,346 (29.9%)	3,213 (36.9%)	3,369 (32.5%)	3,354 (29.9%)	2,884 (27.0%)	2,526 (24.4%)	<0.001

*lowest income

[†] $\geq$ 2.5SD below young adult mean

MPR=medication possession ratio, HT= hormone therapy

Table 2: Age-adjusted and multivariable logistic regression models presenting the associations between adverse social position and osteoporosis (defined by BMD at the femoral neck ≥ 2.5 SD below young adult mean)

	Age-adjusted		Model 1		Model 2	
	OR (95%CI)	p value	OR (95%CI)	p value	OR (95%CI)	p value
<i>Household income</i>						
Quintile 1*	1.33 (1.22-1.46)	<0.001	1.41 (1.29-1.55)	<0.001	1.37 (1.25-1.51)	<0.001
Quintile 2	1.21 (1.11-1.32)	<0.001	1.32 (1.20-1.45)	<0.001	1.27 (1.16-1.39)	<0.001
Quintile 3	1.12 (1.02-1.22)	0.01	1.19 (1.08-1.30)	<0.001	1.15 (1.05-1.26)	0.003
Quintile 4	1.03 (0.94-1.13)	0.50	1.10 (1.00-1.21)	0.06	1.09 (0.99-1.20)	0.09
Quintile 5 (referent)	-	-	-	-	-	-
Overall p for linear trend		<0.001		<0.001		<0.001
<i>Clinical Risk Factors</i>						
Age, continuous (yr)	1.09 (1.09-1.09)	<0.001	1.09 (1.09-1.09)	<0.001	1.09 (1.09-1.09)	<0.001
BMI, continuous (kg/m ²)	-	-	0.84 (0.84-0.85)	<0.001	0.84 (0.84-0.85)	<0.001
Prior fracture	-	-	2.40 (2.22-2.61)	<0.001	2.17 (2.02-2.32)	<0.001
Parental hip fracture	-	-	0.99 (0.87-1.13)	0.91	0.72 (0.68-0.77)	<0.001
COPD	-	-	1.37 (1.25-1.50)	<0.001	1.34 (1.23-1.47)	<0.001
Glucocorticoid use	-	-	1.43 (1.25-1.63)	<0.001	1.46 (1.28-1.67)	<0.001
Rheumatoid arthritis	-	-	1.60 (1.39-1.84)	<0.001	1.62 (1.41-1.87)	<0.001
Alcohol abuse	-	-	1.32 (1.00-1.74)	0.05	1.22 (1.00-1.49)	0.05
<i>Osteoporotic treatment[†]</i>						
None	-	-	-	-	-	-
<0.5	-	-	-	-	1.04 (0.96-1.14)	0.33
0.5-0.8	-	-	-	-	0.71 (0.62-0.81)	<0.001
>0.8	-	-	-	-	0.65 (0.59-0.71)	<0.001

*lowest income

[†]in previous 12 months, including hormone therapy

Table 3: Age-adjusted and multivariable logistic regression models presenting the associations between adverse social position and osteoporosis (defined by minimum T score ≥ 2.5 SD below young adult mean)

	Age-adjusted		Model 1		Model 2	
	OR (95%CI)	p value	OR (95%CI)	p value	OR (95%CI)	p value
<i>Household income</i>						
Quintile 1*	1.33 (1.25-1.43)	<0.001	1.46 (1.36-1.56)	<0.001	1.44 (1.34-1.54)	<0.001
Quintile 2	1.21 (1.13-1.29)	<0.001	1.33 (1.25-1.43)	<0.001	1.32 (1.23-1.41)	<0.001
Quintile 3	1.05 (1.20-1.20)	<0.001	1.20 (1.12-1.28)	<0.001	1.19 (1.11-1.27)	<0.001
Quintile 4	1.07 (1.00-1.43)	0.03	1.15 (1.08-1.23)	<0.001	1.15 (1.07-1.23)	<0.001
Quintile 5 (referent)	-	-	-	-	-	-
Overall p for trend		<0.001		<0.001		<0.001
<i>Clinical Risk Factors</i>						
Age, continuous (yr)	1.07 (1.07-1.07)	<0.001	1.07 (1.07-1.07)	<0.001	1.07 (1.07-1.07)	<0.001
BMI, continuous (kg/m ²)	-	-	0.86 (0.86-0.87)	<0.001	0.86 (0.85-0.86)	<0.001
Prior fracture	-	-	2.11 (1.97-2.27)	<0.001	2.18 (2.03-2.35)	<0.001
Parental hip fracture	-	-	1.00 (0.91-1.10)	0.98	0.97 (0.89-1.07)	0.58
COPD	-	-	1.35 (1.26-1.46)	<0.001	1.37 (1.27-1.47)	<0.001
Glucocorticoid use	-	-	1.42 (1.28-1.58)	<0.001	1.51 (1.35-1.68)	<0.001
Rheumatoid arthritis	-	-	1.34 (1.20-1.51)	0.001	1.36 (1.21-1.52)	<0.001
Alcohol abuse	-	-	1.27 (1.02-1.59)	0.04	1.28 (1.02-1.60)	0.03
<i>Osteoporotic treatment, MPR[†]</i>						
None	-	-	-	-	-	-
<0.5	-	-	-	-	0.96 (0.90-1.03)	0.24
0.5-0.8	-	-	-	-	0.60 (0.54-0.66)	<0.001
>0.8	-	-	-	-	0.53 (0.49-0.57)	<0.001

*lowest income

[†]in previous 12 months, including hormone therapy; MPR = medication possession ratio

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