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Original article

Disparities in osteoporosis by race/ethnicity, education, work status, immigrant status, and economic status in the United States

Allen J. Tsai

College of Medicine, Northeast Ohio Medical University, 4209 St. Rt. 44, Rootstown, OH, USA

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ABSTRACT

Aims: Osteoporosis is one of the most common bone health diseases affecting older adults in US. Addressing disparities in osteoporosis will help to enhance the quality of bone care in the nation's bone health programs.
Materials & methods: We used the data of adult participants of the National Health and Nutrition Examination Survey with reported bone mineral density measured during the periods of 2005–2010 and 2013–2014 to examine disparities in osteoporosis based on race/ethnicity, educational attainment, work status, immigrant status, and economic status in US.
Results: Based on educational attainment, the age- and sex-standardized osteoporosis prevalence (SOP) was highest among those with less than a high school education (HSE) (5.1%, 95% CI (CI): 4.3%–5.9%), whereas it was lowest among those with more than HSE (3.2%, CI: 2.7%–3.6%). Based on work status, SOP was highest among unemployed participants (5.4%, CI: 1.9%–8.9%), whereas it was lowest among working participants (2%, CI: 1.6%–2.4%). Based on immigrant status, SOP was highest among non-citizens (6.4%, CI: 5%–7.8%), whereas it was lowest among those born in US (3.4%, CI: 3.1%–3.7%). Based on economic status, SOP was highest among those with poverty-to-income ratio (PIR) < 1 (5.5%, CI: 4.4%–6.5%), whereas it was lowest among those with PIR ≥ 4 (2.4%, CI: 1.9%–2.9%).
Conclusions: Osteoporosis was more prevalent among US adults who were non-citizens, less educated, unemployed, and had lower income. The observed disparities suggest a need for interventions to promote better quality bone care among the socioeconomically disadvantaged groups.

1. Introduction

Osteoporosis is one of the most common bone health diseases affecting older adults in the United States and around the world. Osteoporosis is a skeletal disease characterized by low bone mass and skeletal fragility, resulting in an increased risk of fracture with many associated complications [1,2]. The morbidity and mortality from osteoporosis-related fractures are high, which is associated with high health care costs [3–7]. After a hip fracture, approximately 20% of patients die within the following year, and the risk of premature mortality may remain elevated for > 10 years [8]. Only approximately half of them regain their functional status after fracture. The number of people with osteoporosis is increasing as the population continues to age worldwide. The US National Osteoporosis Foundation estimated that approximately 9 million adults have osteoporosis and > 48 million have low bone mass [9]. By 2030, these numbers are expected to increase to 11.9 million adults with osteoporosis and 64.3 million with low bone mass. Aside from medical concerns, the economic burden of osteoporosis is also significant [4–6,9]. It costs approximately $17 billion annually in US for treating osteoporosis-related fractures, with a projected annual expenditure of $50 billion by the year 2040. This is a major public health and clinical concern as we confront a rapidly aging population [10].

Socioeconomic factors are known to be determinants of disparities in health behaviors and a variety of acute and chronic diseases [11,12]. However, conflicting results exist in the relationship between socioeconomic factors and bone mineral density and osteoporotic fractures [13–19]. Thus, the aim of the study was to examine disparities in osteoporosis by race/ethnicity, education, work status, immigrant status, and economic status using the population data from the National Health and Nutrition Examination Survey in the United States. Addressing disparities in osteoporosis will help to enhance the quality of bone care in the nation's bone health programs.

2. Methods

We used the data of adult participants, aged 18 years and older, of the National Health and Nutrition Examination Survey (NHANES) in

E-mail address: atsai1@neomed.edu.

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the United States from 1999 to 2014. The NHANES is a national representative survey conducted by the National Center for Health Statistics [21], a part of the Centers for Disease Control and Prevention [20]. The survey collected data through interviews, physical examinations, and laboratory tests. The survey samples were designed to be nationally representative of the US non-institutionalized civilian population, which were obtained by using a stratified multistage probability design with planned oversampling of certain age and minority groups. The NHANES survey protocols were approved by a human subjects review board, and written informed consent was obtained from all the participants.

This study analyzed data in the cycles of 2005–2010 and 2013–2014 when the dual energy X-ray absorptiometry testing was conducted for a diagnosis of osteoporosis during these cycle years in the survey. Hologic QDR 4500A fan-beam dual-energy x-ray absorptiometry densitometers (Hologic, Inc., Bedford, Massachusetts) were used to assess bone mineral density of the anterior-posterior lumbar spine and proximal femur in the specially equipped mobile examination centers [22]. Certified radiology technologists administered the exams. All the findings of densitometry were reviewed by radiologists to ensure accuracy and consistency [23]. The details of NHANES bone mineral density measurement protocols and quality controls have been published elsewhere [24]. To compare all the participants with the reference standard, T-scores were calculated. Bone mineral density cutoff values to define osteoporosis at the hip and femur were based on 2.5 standard deviation or more below the mean peak bone mass T-scores of young, healthy adults based on the definition by the World Health Organization [25–29].

Race/ethnicity (non-Hispanic white, non-Hispanic black, Hispanic, other race), educational attainment, working status, nativity and citizenship status, and economic status were categorized based on the survey design. Educational attainment was categorized into less than high school, high school and more than high school. Participants were categorized into working and not-working at an outside job or business based on responses to the occupational questionnaire. Working participants were further classified as working part-time (< 35 h/week) vs. full time. Non-working participants were categorized as unemployed, if looking for a job or laid off, and not in the labor force, if neither of these. Nativity and citizenship status were used to define immigration status of participants as U.S. native (U.S. citizen born in U.S.) and U.S. naturalized (U.S. citizen born outside U.S.) and non-citizen. Economic status was measured by the poverty-to-income ratio (P.I.R.) (P.I.R. < 1, 1–1.99, 2–3.99, ≥ 4). P.I.R. is an index of total income assessed in relation to federal poverty thresholds which vary by family size and composition. The numerator in the ratio is the midpoint of the observed family income category in the Family Questionnaire variable HFF19R, and the denominator is the poverty threshold, age of the family reference person, and calendar year, which is based on criteria from the U.S. Census Bureau [30]. Guidelines for calculating the P.I.R. are identical for the 48 contiguous U.S. states and the District of Columbia. In NHANES, the P.I.R. is top-coded and ranges from "0" (no income) to "5" ($\geq$ 5 times the federal poverty level). A ratio of 1.00 is defined as the official federal poverty threshold.

Continuous and categorical data were presented as mean ± standard error or weighted frequency (percentage). All the prevalence estimates were age- and gender-standardized to the 2000 U.S. Census population. Age and gender adjusted prevalence estimates were calculated following the guidelines provided by NHANE [31]. Taylor linearization was used to estimate variances [31]. Estimates with a relative standard error > 30% were considered unreliable and therefore not reported. All analyses were performed using SAS survey procedures (version 9.4, The SAS Institute, Cary, NC), which account for the complex multistage sampling, clustering, and stratification design of NHANES and appropriately weight participants in statistical models. The mobile examination center weights were used in all analyses. Weights for combined cycles were constructed following the NHANES analytic guidelines [32,33]. General linear models were used to determine whether the means of two or more groups differed. Chi-square test was used for comparing categorical variables. The likelihood ratio test was used to assess the significance of interaction term. All estimates were presented with 95% confidence intervals. The reported p values were based on two-sided tests. A P value of < 0.05 was considered statistically significant. The study was granted an exempt status by the institutional review board due to the de-identified quality of the data from the national database.

Table 1
Population characteristics.

Factor	Statistics
Weighted Number	247,649,840
Gender	
Male	119,419,043 (48.2)
Female	128,230,797 (51.8)
Age (years, mean ± sd)	45.2 ± 0.20
Ethnicity	
White (non-Hispanic)	175,136,224 (70.7)
Black (non-Hispanic)	27,726,871 (11.2)
Hispanic	30,279,610 (12.2)
Other race	14,507,135 (5.9)
Education level	
Less than high school	46,683,914 (18.9)
High school	61,273,578 (24.7)
More than high school	139,692,348 (56.4)
Poverty-to-income ratio	
< 1	36,818,163 (14.9)
1.00–1.99	51,241,450 (20.7)
2.00–3.99	72,016,712 (29.1)
4.00+	87,573,515 (35.4)
Immigration status	
US native (born in US)	211,304,641 (85.3)
Naturalized citizen	17,322,727 (7.0)
Non-citizen	19,022,472 (7.7)
Part/Full time work	
Part time	25,037,627 (61.9)
Full time	15,381,351 (38.1)
Working status	
Not in the labor force	79,671,482 (32.2)
Unemployed	8,670,587 (3.5)
Working	159,307,772 (64.3)
Osteoporosis (BMD*)	
No	77,516,402 (96.3)
Yes	2,956,335 (3.7)

Statistics presented as weighted frequency (percent) unless otherwise specified.
* BMD: bone mineral density.

3. Results

A total of 2,956,335 participants (3.7%) in this NHANES cohort were diagnosed with osteoporosis based on the results of bone mineral densitometry. The mean age was 45.2 ± 0.2 years. 48.2% of these participants were men (Table 1). We found differences in the prevalence of osteoporosis by race/ethnicity, educational attainment, work status, immigrant status, and economic status among these participants (Fig. 1). Based on race/ethnicity, the prevalence of osteoporosis was significantly lower among non-Hispanic blacks (1.7%, 95% confidence interval (CI), 1.2%–2.2%) than non-Hispanic whites (3.7%, CI, 3.3%–4.1%, $p < .001$), Hispanic (4.1%, CI, 3.3%–4.9%, $p < .001$), and other races (5.9%, CI, 4.6%–7.2%, $p < .001$). Based on educational attainment, as compared with the prevalence of osteoporosis among the participants with less than a high school education (5.1%, CI, 4.3%–5.9%), the prevalence was significantly lower among those with more than a high school education (3.2%, CI, 2.7%–3.6%, $p < .001$) and those with a high school education (3.4%, CI, 2.8%–4.1%, $p = .002$). Based on work status, as compared with the prevalence of osteoporosis among the participants who were

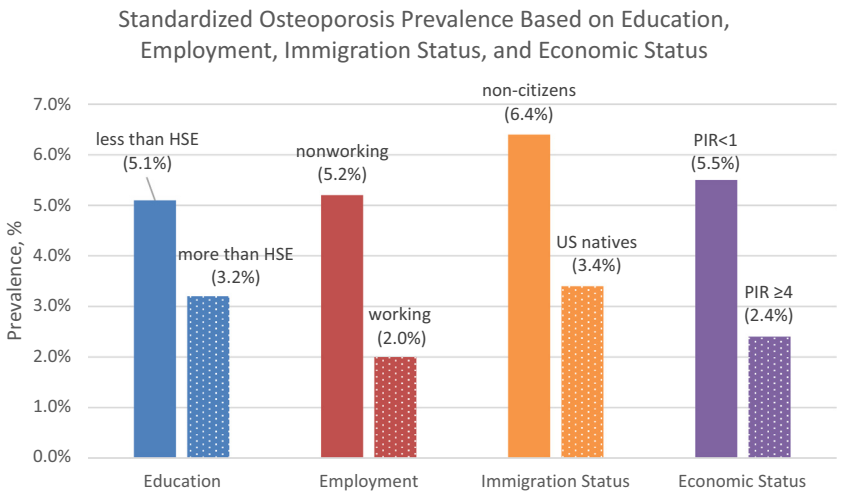

Fig. 1. Standardized osteoporosis prevalence based on education, employment, immigration status, and economic status.

unemployed (5.4%, CI, 1.9%–8.9%) and who were not in labor force (5.2%, CI, 4.9%–5.9%), the prevalence was significantly lower among those who were working (2.0%, CI, 1.6%–2.4%, $p < .001$). Among the working participants, the prevalence of osteoporosis was lower among those who were working full time (2.5%, CI, 1.4%–3.7%) than those who were working part time (4.0%, CI, 3.1%–4.8%, $p = .05$). Based on immigrant status, the prevalence of osteoporosis was significantly lower among the participants who were U.S. citizens (3.4%, CI, 3.1%–3.7%) than the prevalence among those who were non-citizens (6.4%, CI, 5.0%–7.8%, $p < .001$) and those who were naturalized citizens (4.8%, CI, 3.7%–5.9%, $p = .01$). Based on the economic status, the prevalence of osteoporosis was significantly lower among the participants with P.I.R. ≥ 4 (2.4%, CI, 1.9%–2.9%) than the prevalence among those with P.I.R. < 1 (5.5%, CI, 4.4%–6.5%, $p < .001$), those with P.I.R. of 1–1.99 (4.4%, CI, 3.7%–5.1%, $p = .01$), and those with P.I.R. of 2–3.99 (3.5%, CI, 2.9%–4.1%, $p = .004$). We further examined if the associations might vary by gender, and found that there was no significant difference (test of interaction $P > .10$).

4. Discussion

There is ample evidence that socioeconomic status affects a wide range of health conditions and outcomes [11,34]. However, studies examining socioeconomic status in relation to osteoporosis have been sparse [13]. Our study used the large nationwide representative data to assess disparities in osteoporosis based on the results of bone mineral densitometry in the United States. Specifically we examined the disparities based on race/ethnicity, education attainment, work status, immigrant status, and economic status, and found that disparities in osteoporosis exist in US. Our findings revealed that socioeconomic factors were related to the prevalence of osteoporosis in the nationally representative sample of adults. Specifically, osteoporosis was more prevalent among the adults who were non-citizens, who were less educated, unemployed, and those who had lower income.

Our findings are consistent with the results of studies in other countries which examined the associations between poverty, osteoporosis, and osteoporotic fractures in Spain [35] and adverse social position and bone mineral density in Canada [36]. In the Spanish study, socioeconomic status, defined by the annual income, was associated with a higher prevalence of densitometric osteoporosis. In the Canadian study, lower household income was associated with lower bone mineral density in a significant dose-response relationship. Low bone mineral density is a key predisposing factor for increased bone fracture risk [1–3]. A study on the association between hip fracture and socioeconomic indicators reported similar findings that older people without health insurance or a high school diploma were more likely to experience an osteoporotic hip fracture [37].

Osteoporosis is often clinically silent and undetected until a sentinel bone fracture event occurs [38,39]. Osteoporosis along with its associated complications have placed a significant financial burden on the US health care system [4,5]. Osteoporosis, although common, is preventable and treatable [40]. The risk of fracture associated with osteoporosis can be substantially mitigated with lifestyle modification and pharmacologic therapies. In US, race/ethnicity is an important factor when examining bone health disparities. In the anatomic and clinical studies, blacks, as compared with other race/ethnicity, were found to have a more favorable skeletal micro-architecture, a higher bone mineral density, greater estimated bone strength, a lower prevalence of osteoporosis, and a lower incidence of bone fracture [41–43]. The lowest prevalence of osteoporosis among blacks was also demonstrated in our study. However, some, but not all, studies reported a higher mortality rate following bone fractures among blacks, which may be multi-factorial, including a lack of access to high-intensity rehabilitation in hospital or post-discharge physical therapy [44]. Although race/ethnicity is not a modifiable factor in assessing the risk of osteoporosis, there are modifiable socioeconomic factors for preventive measures. The higher prevalence of osteoporosis among the less educated and the impoverished underscores a critical need for services, particularly bone examinations. The low frequency of employment among osteoporosis individuals highlights the needs for job training and employment promotion strategies in this at-risk population. Tailored efforts to increase osteoporosis screenings in the non-citizens and immigrant population is suggested by the lack of access to bone care. Prevention efforts may also be needed to target individuals with longer duration of bone loss. Primary prevention of bone loss, including identifying and protecting individuals at risk by increased physical activity, decreased alcohol consumption, smoking cessation, and increased consumption of healthful food [45–48], may also help delay the onset of bone loss, reduce complications of osteoporosis, and thus reduce the associated healthcare costs.

Affordability, sources and continuity of clinical care, and physician advice may determine receipt of needed healthcare service. Education level has been shown to be closely connected to economic status [49]. It has been observed that individuals with lower education levels were less likely to practice sufficient self-care, which may affect their health and increase the risk of osteoporosis [50]. It is possible that participants with lower socioeconomic status in this study might have experienced poverty and food insecurity in adolescence or early childhood and, as a result, achieved lower peak bone mass, which was predisposed to developing osteoporosis later in life. Alternatively, lower socioeconomic

status, poverty, food insecurity, and inadequate nutrition in older adulthood may result in accelerated loss of bone mass and accelerated development of osteoporosis with age. On the other hand, higher income may be an indicator of healthier living habits and more physical activity [51]. Economically active individuals may be more active physically because of their work along with a higher level of social activity and access to healthcare, which may result in a lower risk of osteoporosis. Overall, citizenship, working status, and economic status may be surrogate markers for healthcare axis and better lifestyle. Working individuals, citizens, and individuals with higher economic status were more likely to have better access to healthcare by having health insurance. Individuals with higher socioeconomic status may also have healthier diets. Greater education may provide knowledge which led to a healthier lifestyle.

The study has several strengths. The diagnosis of osteoporosis was made based on bone mineral densitometry testing rather than self-reported information, which has prevented ascertainment biases, as osteoporosis was generally under-diagnosed and its prevalence tended to be underestimated in the United States [1–5]. These are randomly selected samples from representative national datasets through standardized methods of data collection. The results therefore can be extrapolated to the general population. In addition, these large samples allow for analyses with sufficient power across various race/ethnicity and socioeconomic strata. However, there are limitations in this study. This is an observational retrospective study susceptible to potential biases. The economic status was assessed by using the official federal poverty threshold, but income assessment among retired senior participants could be difficult [52]. The data cannot provide a causal relationship between the exposure of interest and osteoporosis, and cannot provide information of chronic diseases and medication use in association with osteoporosis or information of longitudinal changes of modifiable socioeconomic factors in this cohort during the survey years. Nonetheless, the findings of the representative national data analyses provide important information for targeted interventions among the at-risk population groups in the United States.

Prevention of disease, elimination of health disparities, and reduction of preventable clinical complications have been a major focus of recent US health care reform. The observed disparities in our study suggest a need for interventions to promote better quality bone care among the socioeconomically disadvantaged population groups. Communities and health care systems should increase the awareness of the social vulnerabilities and the awareness about the importance of bone health for all Americans. The results from this report should be able to help with future screening and surveillance activities and to guide public health priorities and policies.

Declarations of interest

None.

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References

[1] Golob AL, Laya MB. Osteoporosis: screening, prevention, and management. Med Clin North Am May, 2015;99(3):587–606.
[2] Nelson HD, Haney EM, Dana T, Bougatsos C, Chou R. Screening for osteoporosis: an update for the U.S. Preventive Services Task Force. Ann Intern Med Jul 20, 2010;153(2):99–111.
[3] Wright NC, Looker AC, Saag KG, Curtis JR, Delzell ES, Randall S, et al. The recent prevalence of osteoporosis and low bone mass in the United States based on bone mineral density at the femoral neck or lumbar spine. J Bone Miner Res 2014;29(11):2520–6. Nov.
[4] Burge R, Dawson-Hughes B, Solomon DH, Wong JB, King A, Tosteson A. Incidence and economic burden of osteoporosis-related fractures in the United States, 2005-2025. J Bone Miner Res 2007;22(3):465–75. Mar.
[5] Jha S, Bhattacharyya T. Utilization and cost of anti-osteoporosis therapy among US Medicare beneficiaries. Arch Osteoporos Dec, 2016;11(1):28.
[6] Ström O, Borgström F, Kanis JA, Compston J, Cooper C, et al. Osteoporosis: burden, health care provision and opportunities in the EU: a report prepared in collaboration with the International Osteoporosis Foundation (IOF) and the European Federation of Pharmaceutical Industry Associations (EFPIA). Arch Osteoporos 2011;6:59–155.
[7] Binkley N, Blank RD, Leslie WD, Lewiecki EM, Eisman JA, Bilezikian JP. Osteoporosis in crisis: It's time to focus on fracture. J Bone Miner Res 2017;32(7):1391–4.
[8] Papadimitriou N, Tsilidis KK, Orfanos P, Benetou V, Ntzani EE, et al. Burden of hip fracture using disability-adjusted life-years: a pooled analysis of prospective cohorts in the CHANCES consortium. Lancet Public Health 2017;2(5):e239–46.
[9] National Osteoporosis Foundation (NOF). NOF's clinician's guide to prevention and treatment of osteoporosis. Washington, DC: NOF; 2013 [Available at]. http://www.nof.org/hcp/clinicians-guide.
[10] Khosla S, Farr JN, Kirkland JL. Inhibiting cellular senescence: a new therapeutic paradigm for age-related osteoporosis. J Clin Endocrinol Metab 2018;103(4):1282–90.
[11] Pathirana TI, Jackson CA. Socioeconomic status and multimorbidity: a systematic review and meta-analysis. Aust N Z J Public Health 2018;42(2):186–94.
[12] Bowman SA. Socioeconomic characteristics, dietary and lifestyle patterns, and health and weight status of older adults in NHANES, 1999-2002: a comparison of Caucasians and African Americans. J Nutr Elder 2009;28(1):30–46.
[13] Brennan SL, Pasco JA, Urquhart DM, Oldenburg B, Wang Y, Wluka AE. Association between socioeconomic status and bone mineral density in adults: a systematic review. Osteoporos Int 2011;22(2):517–27.
[14] Du Y, Zhao LJ, Xu Q, Wu KH, Deng HW. Socioeconomic status and bone mineral density in adults by race/ethnicity and gender: the Louisiana osteoporosis study. Osteoporos Int 2017;28(5):1699–709.
[15] Lyles CR, Schafer AL, Seligman HK. Income, food insecurity, and osteoporosis among older adults in the 2007-2008 National Health and Nutrition Examination Survey (NHANES). J Health Care Poor Underserved 2014;25(4):1530–41.
[16] Gillespie CW, Morin PE. Trends and disparities in osteoporosis screening among women in the United States, 2008-2014. Am J Med 2017;130(3):306–16.
[17] Myong JP, Kim HR, Choi SE, Koo JW. The effect of socioeconomic position on bone health among Koreans by gender and menopausal status. Calcif Tissue Int 2012;90(6):488–95.
[18] Brennan SL, Winzenberg TM, Pasco JA, Wluka AE, Dobbins AG, Jones G. Social disadvantage, bone mineral density and vertebral wedge deformities in the Tasmanian older adult cohort. Osteoporos Int 2013;24(6):1909–16.
[19] Elliot JR, Gilchrist NL, Wells JE. The effect of socioeconomic status on bone density in a male Caucasian population. Bone 1996;18(4):371–3.
[20] Centers for Disease Control and Prevention. About the National Health and nutrition examination survey. http://www.cdc.gov.ezp.welch.jhmi.edu/nchs/nhanes/about_nhanes.htm.
[21] National Center for Health Statistics. Dual energy x-ray absorptiometry - femur. Atlanta, GA: CDC; 2013 Available at http://www.cdc.gov.ezp.welch.jhmi.edu/nchs/nhanes/nhanes2007-2008/DXXFEM_E.htm.
[22] Wahner HW, Looker A, Dunn WL, Walters LC, Hauser MF, Novak C. Quality control of bone densitometry in a national health survey (NHANES III) using three mobile examination centers. J Bone Miner Res 1994;9:951–60.
[23] Centers for Disease Control and Prevention. National Health and nutrition examination survey (NHANES). Dual energy X-ray absorptiometry (DXA) procedures manual. http://www.cdc.gov.ezp.welch.jhmi.edu/nchs/data/nhanes/nhanes_07_08/manual_dexa.pdf; 2019.
[24] Centers for Disease Control and Prevention. National Health and Nutrition Examination Survey (NHANES). Body composition procedures manual. http://www.cdc.gov.ezp.welch.jhmi.edu/nchs/data/nhanes/nhanes_13_14/2013_Body_Composition_DXA.pdf; 2019.
[25] Kanis JA, McCloskey EV, Johansson H, et al. A reference standard for the description of osteoporosis. Bone 2008;42(3):467–75.
[26] Looker AC, Wahner HW, Dunn WL, et al. Updated data on proximal femur bone mineral levels of US adults. Osteoporos Int 1998;8(5):468–89.
[27] Kanis JA, Melton LJIII, Christiansen C, et al. The diagnosis of osteoporosis. J Bone Miner Res 1994;9(8):1137–41.
[28] Edwards MH, Dennison EM, Aihie Sayer A, Fielding R, Cooper C. Osteoporosis and sarcopenia in older age. Bone 2015;80:126–30.
[29] World Health Organization. Assessment of fracture risk and application to screening for postmenopausal osteoporosis. Geneva, Switzerland: World Health Organization; 1994.
[30] DeNavas-Walt C, Proctor BD, Mills RJ. Income, poverty and health insurance coverage in the United States: 2003. US Census Bureau, current population reports. Washington, DC: US Government Printing Office; 2004. p. 60–226.
[31] How to generate age-adjusted prevalence rates and means using SAS 9.2 survey procedure. https://www.cdc.gov/nchs/tutorials/NHANES/NHANESAnalyses/AgeStandardization/Task1b_SAS92.htm.
[32] National Health and Nutrition Examination Survey. Analytic guidelines. http://www.cdc.gov/nchs/data/nhanes/analytic_guidelines_11_12.pdf; 2011-2012.
[33] National Health and nutrition examination survey: Analytic guidelines. http://

www.cdc.gov/nchs/data/series/sr_02/sr02_161.pdf; 1999–2010.
[34] Smith GD. Life-course approaches to inequalities in adult chronic disease risk. Proc Nutr Soc 2007;66(2):216–36.
[35] Navarro MC, Sosa M, Saavedra P, et al. Poverty is a risk factor for osteoporotic fractures. Osteoporos Int 2009;20(3):393–8.
[36] Brennan SL, Leslie WD, Lix LM. Associations between adverse social position and bone mineral density in women aged 50 years or older: data from the Manitoba bone density program. Osteoporos Int 2013;24(9):2405–12.
[37] Wilson RT, Chase GA, Chrischilles EA, et al. Hip fracture risk among community-dwelling elderly people in the United States: a prospective study of physical, cognitive, and socioeconomic indicators. Am J Public Health 2006;96(7):1210–8.
[38] Harrington JT, Broy SB, Derosa AM, Licata AA, Shewmon DA. Hip fracture patients are not treated for osteoporosis: a call to action. Arthritis Rheum 2002;47(6):651–4.
[39] Ballane G, Cauley JA, Luckey MM, El-Hajj Fuleihan G. Worldwide prevalence and incidence of osteoporotic vertebral fractures. Osteoporos Int 2017;28(5):1531–42.
[40] Harrington JT. A decade of system- and population-based osteoporosis care improvement. Osteoporos Int 2011;22(Suppl. 3):483–6.
[41] Popp KL, Hughes JM, Martinez-Betancourt A, Scott M, Turkington V, et al. Bone mass, microarchitecture and strength are influenced by race/ethnicity in young adult men and women. Bone 2017;103:200–8.
[42] Putman MS, Yu EW, Lee H, Neer RM, Schindler E, et al. Differences in skeletal microarchitecture and strength in African-American and white women. J Bone Miner Res 2013;28(10):2177–85.
[43] Munhoz L, Aoki EM, Cortes ARG, de Freitas CF, Arita ES. Osteoporotic alterations in a group of different ethnicity Brazilian postmenopausal women: an observational study. Gerodontology 2018;35(2):101–9.
[44] Sterling RS. Gender and race/ethnicity differences in hip fracture incidence, morbidity, mortality, and function. Clin Orthop Relat Res 2011;469(7):1913–8.
[45] Julián C, Huybrechts I, Gracia-Marco L, González-Gil EM, Gutiérrez Á, et al. Mediterranean diet, diet quality, and bone mineral content in adolescents: the HELENA study. Osteoporos Int 2018;29(6):1329–40.
[46] Mazidi M, Shivappa N, Wirth MD, Hebert JR, Vatanparast H, Kengne AP. The association between dietary inflammatory properties and bone mineral density and risk of fracture in US adults. Eur J Clin Nutr 2017;71(11):1273–7.
[47] Christianson MS, Shen W. Osteoporosis prevention and management: non-pharmacologic and lifestyle options. Clin Obstet Gynecol 2013;56(4):703–10.
[48] Cooper CM, Ballard JE. Bone mineral density in Hispanic women: a review of the literature with implications for promoting culturally relevant osteoporosis education. J Health Care Poor Underserved 2011;22(2):450–68.
[49] Krieger N, Williams DR, Moss NE. Measuring social class in US public health research: concepts, methodologies, and guidelines. Annu Rev Public Health 1997;18:341–78.
[50] Speake DL, Cowart ME, Pellet K. Health perceptions and lifestyles of the elderly. Res Nurs Health 1989;12:93–100.
[51] Crespo CJ, Smit E, Andersen RE, et al. Race/ethnicity, social class and their relation to physical inactivity during leisure time: results from the third National Health and nutrition examination survey 1988-1994. Am J Prev Med 2000;18:46–53.
[52] National Council on Aging. Economic security for seniors 2012. Washington, DC: NCOA; 2013 [Available at:]. http://www.ncoa.org/press-room/fact-sheets/economic-security-for.html.