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Prevalence, awareness, and treatment of osteoporosis among Korean women: The Fourth Korea National Health and Nutrition Examination Survey

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ABSTRACT

Purpose: This study aimed to assess the factors associated with the prevalence, awareness, and treatment of osteoporosis in a representative sample of Korean women.
Methods: Data were obtained from dual energy X-ray absorptiometry measurement of the lumbar vertebrae and femoral neck, and from a standardized questionnaire in 2870 Korean women aged 50 years and older who participated in the Fourth Korea National Health and Nutrition Examination Survey 2008–2009. Osteoporosis was defined by World Health Organization T-score criteria, and awareness and treatment were defined by self-report of an osteoporosis diagnosis and self-report of current anti-osteoporotic medication use, respectively. We assessed the relationship between multiple risk factors and prevalence, awareness, and treatment.
Results: Osteoporosis was reported in 39.1% of Korean women. Among those with osteoporosis, only 37.5% were aware of their diagnosis and 23.5% received pharmacological treatment. Despite higher prevalence among respondents who were older, of lower body weight, calcium intake, physical activity, and education levels, the awareness and treatment rates of these groups were similar or lower than that of the low-risk controls in multivariate logistic regression models. Moreover, easily identifiable risk factors (e.g., history of fracture, falls, height loss, familial osteoporosis) were not associated with awareness and treatment. Participants who had undergone health screening in the previous 2 years exhibited increased awareness and treatment rates independently of other demographic factors.
Conclusions: Osteoporosis was highly prevalent in this Korean study but was underdiagnosed and undertreated. Routine health screenings could be an effective strategy to increase osteoporosis awareness and treatment.

1. Introduction

As the world population continues to age, the prevalence of osteoporosis and the incidence of osteoporosis-related fractures will sharply increase in most developing and developed countries [1]. In addition, Asian baby boomers have continued to age, with osteoporosis and its related fractures already posing a heavy burden [2]. Asian women were reported to have lower bone mass than Caucasians even after the differences between the body sizes of Caucasian and Asian women were taken into account [3]. Unfortunately, despite the availability of published clinical practice guidelines and evidence of the efficacy of a healthy lifestyle and medications for secondary or tertiary prevention and treatment of osteoporotic fracture [4,5], studies have consistently shown that the disease is underdetected and undertreated even in high-risk patients [6–9]. Moreover, compared to Western countries, less is known about the characteristics of osteoporosis in Asian populations [10–14]. Although some differences in gene polymorphisms related to osteoporosis between Asians and Caucasians were reported [15,16], racial and ethnic disparities in osteoporosis care might often reflect demographic, behavioral, and cultural factors, rather than genetic differences [17,18]. Only a few studies have assessed the prevalence, awareness, and treatment of osteoporosis in Asian countries [19–22]. Thus, continuous and multifaceted strategies may be needed to increase awareness about osteoporosis [24], but how to approach and achieve this goal is still being debated among health experts [25–27].

Bone densitometry is readily accessible for a reasonable price in Korea because of the wide coverage of the National Health Service, and state-of-the-art therapeutic modalities are approved for use and subsidized for patients who meet World Health Organization (WHO) criteria, with priority given to those with prevalent fractures. However, to our knowledge, there is no true consensus about whether early

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identification of risk factors for osteoporosis and development of prevention programs in Korea is optimally effective. In the present study, we used data from the Fourth Korean National Health and Nutrition Examination Survey 2008–2009 (KNHANES IV) to assess the osteoporosis prevalence, awareness, and treatment rates in the Korean general population and analyzed the associated risk factors.

2. Material and methods

2.1. Study population

KNHANES IV (2008–2009) was a nationwide survey representing the Korean general population and included comprehensive information on the health status, health behavior, and sociodemographics of 20,277 individuals in 600 national districts. A stratified multistage probability sampling design was used. The health interview survey in KNHANES IV was conducted through face-to-face interviews at participants' homes by trained interviewers. Each participant gave informed consent prior to inclusion in the study.

Initial candidates for this study were 11,064 women who completed both the health interview survey and the health examination survey. We then selected individuals who were aged ≥50 years and had received dual energy X-ray absorptiometry (DXA), gathering 2870 women as the final study population (Fig. 1). As the survey data analyzed are publicly available, this study did not require the ethical approval of our Institutional Review Board.

2.2. Associated factors

From KNHANES IV, we collected information about various factors that could potentially be associated with osteoporosis awareness [23–25]. The variables were divided into 3 groups: (1) demographic status (age, sex, education, marital status, monthly income, and residential area); (2) behavioral risk (smoking, alcohol use, physical activity, body mass index [BMI], and dietary calcium intake); and (3) personal health status and accessibility of care (self-perceived health status, history of fracture, history of falls, height loss of >1 in, family history of osteoporosis, and health screening in the previous 2 years).

The demographic variables were current age (50–59, 60–69, and ≥70 years), highest educational level achieved (elementary school education or less, middle or high school education, and college education or more), household monthly income (<1,000,000 won, 1,010,000–3,000,000 won, and ≥3,000,000 won), marital status (living with or without a spouse), and residential area (urban or rural).

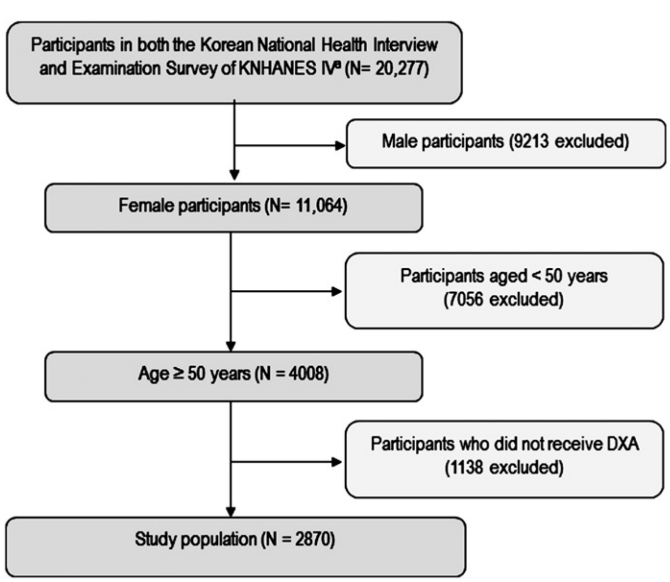

Fig. 1. The study population framework [a]2008–2009 The Fourth Korean National Health and Nutrition Examination Survey.

The health behavioral risk variables included status as a smoker (non, ex-, or current), alcohol consumption (nondrinker, <3 standard drinks (StDs)/occasion, and ≥3 StDs/occasion) [26], and physical activity per week (3 tertiles: <12.0 metabolic equivalent [METs]/week, 12–43.5 METs/week, and >43.5 METs/week) [27]. Body weight and height data were obtained using standard protocols. BMI was calculated in kilograms per square meter and we divided participants into 3 BMI categories (≤20 kg/m^2, >20–24.99 kg/m^2, and ≥25 kg/m^2) [28]. Dietary calcium intake was monitored by 24-h recall and analyzed by CAN-Pro software 3.0 (Korean Nutrition Society, Seoul, Korea), and was divided into 3 tertiles (<231 mg/day, 231–422 mg/day, and >422 mg/day).

Women's health variables include menstrual status (before menarche, during pregnancy, during lactation, normal menstrual status, menopause, and surgical menopause) and we categorized them into 2 levels: menopause (including surgical menopause) or not. Data of age at menarche and menopause of study participants was also collected.

Self-perceived health status was classified into 3 levels according to responses to the question "How do you assess your own health status?": poor, fair, or good. History of fractures was assessed according to location of lumbar, wrist, and hip fractures as diagnosed by a physician. Falls that occurred during the last 12 months before the examination were recorded. Height loss was defined as the difference between the current height and the highest height of the subject's youth.

Family history of osteoporosis was assessed using the question "Have your parents been diagnosed with osteoporosis or fractures due to minimal trauma?" A participant who answered "yes" was defined as having a family history of osteoporosis. Whether or not participants had had a health screening in the previous 2 years was assessed based on self-report.

2.3. Bone mineral density (BMD) measurements and definition of osteoporosis

The KNHANES Osteoporosis survey was a large-scaled BMD survey undertaken by the Korean government, in which the accurate and reliable results were calculated from data gathered by educated and quality controled osteoporosis examination surveyers [29]. The system logics for BMD judgement based on 2007 International Society for Clinical Densitometry (ISCD) Official positrons and guidelines for BMD test with quality control, and interpretation of BMD results was corrected and complemented [30].

The BMD (g/cm^2) measurements of lumbar spines and femoral neck were obtained using DXA (DISCOVERY-W fan-beam densitometer, Hologic Inc., USA). The coefficient of variation (CV) of BMD measurement, based on reproducibility scans, is 1.9% for the L1–4 spine and 2.5% for the femoral neck. We used the L1–4 and femoral neck values for BMD analysis.

The definitions of osteopenia or osteoporosis were made using WHO T-score criteria (−2.5<T-score<−1 and T-score≤−2.5, respectively) and we used the maximum BMD value for Japanese patients [31] as a reference due to the lack of established Korean diagnostic criteria. If a participant has low T-score from one of the BMD of lumbar spine or femoral neck, or both, the participant was classified as having osteoporosis or osteopenia. A past medical history of fracture was not used to define osteoporosis, as KNHANES IV included neither confirmatory imaging tests nor means of distinguishing between low- and high-energy fractures during history taking. In addition, we considered participants who were taking prescription medications for osteoporosis (e.g., bisphosphonate, raloxifene, hormonal agents, etc.) as having osteoporosis because of the possibility that the medication had increased their BMD. During the KNHANES

IV survey, only osteoporosis patients with BMD T-scores < −3.0 or with X-ray-confirmed fractures could receive prescriptions of non-hormonal anti-osteoporotic drugs (e.g., bisphosphonate, raloxifene, PTH, calcitonin, active vitamin D, Vit K/fluride/ipriflavone) under National Health Insurance coverage in Korea [32]. Hormonal agents including estrogen with/without progesterone and tibolone can be prescribed both for the treatment of diagnosed osteoporosis of aforementioned criteria and the prevention of osteoporosis in postmenopausal women under National Health Insurance coverage in Korea [32].

2.4. Definitions of osteoporosis awareness and treatment

Osteoporosis awareness was assessed using the question “Have you been diagnosed with osteoporosis?” A participant who answered “yes” was considered aware of their osteoporosis. Treatment of osteoporosis was defined as self-reported use of a prescription medication for management of osteoporosis at this survey time. In Korea, FDA-approved bone-specific drugs, including bisphosphonate, raloxifene, hormones, parathyroid hormone (PTH), and calcitonin, require doctors' prescriptions and are covered by National Health Insurance in the case of DXA-confirmed osteoporosis [32]. The reimbursement criteria for osteoporosis medication in Korea do not include other risk factors (beside T-score) [33]. In contrast, calcium and vitamin D supplementation are over-the-counter drugs and do not vitally require prescriptions [32].

2.5. Statistical analysis

We used a weighted population sample to reflect the sampling method and response rate. We calculated the estimated proportions and standard errors for osteoporosis prevalence, awareness, and treatment for the overall study population as well as for the subgroups in each variable. We also calculated the proportion of participants with osteoporosis who were aware of osteoporosis and people who were taking anti-osteoporotic medications.

We first used logistic regression analysis to explore which demographic status, behavioral risk factors, and health status and accessibility variables were associated with osteoporosis prevalence, awareness, and treatment, adjusting each variable for age only. Next, we performed multivariate logistic regression analysis by adjusting for demographic factors including age, sex, marital status, educational status, monthly income, and residential area. Adjusted odds ratio (aOR) and 95% confidence intervals (95% CI) were calculated to show the strength of each association. A *p*-value of <0.05 was considered significant. All estimates in the analysis were properly weighted to represent the Korean general population. All statistical analyses were performed using STATA 12.0 (Stata Corp., College Station, Texas, USA).

3. Results

3.1. Baseline characteristics of study population

The characteristics of the study participants are summarized in Table 1. Based on WHO criteria, 39.1% of participants were osteoporotic (T-score of the lumbar vertebrae or femoral neck ≤ −2.5, or taking anti-osteoporotic medications), whereas 43.4% of participants in the estimated Korean general female population were osteopenic (−2.5 < T-score of the lumbar vertebrae or femoral neck < −1).

Among the study participants, 7.7% had a BMI <20 kg/m^2. Although the majority of participants were nonsmokers (90.8%), there were 134 current smokers (4.7%) and 129 ex-smokers (4.5%). The percentage of participants who consumed 3 standard drinks and more/day was 14.3%. The mean dietary calcium intake of the study participants was 403.97 ± 19.07 mg/day. The majority (82.9%) of study participants were in the postmenopausal stage.

Table 1
General characteristics of the study population (n = 2870, N = 1.04).

Group	No. (SE)
Total	n = 2870, N = 1.04[a]
Age group (years)	
50–59	44.8 (1.1)
60–69	28.3 (0.9)
≥70	26.9 (0.9)
Height (cm)	153.3 ± 0.2
Weight (kg)	56.9 ± 0.4
BMI	
≥25	37.4 (1.1)
20–24.99	54.9 (1.1)
<20	7.7 (1.1)
Smoking	
None	90.8 (0.6)
Ex-smoker	4.5 (0.5)
Current smoker	4.7 (0.5)
Alcohol[b]	
Nondrinker	54.4 (1.1)
<3 Standard drinks	31.4 (1.0)
≥3 Standard drinks	14.3 (0.8)
Physical activity (METs/week)	45.5 ± 2.9
Dietary calcium intake (mg/day)	403.97 ± 19.07
Education level	
≤Elementary school	63.0 (1.1)
Middle/high school	32.1 (1.1)
≥College	4.9 (0.5)
Monthly income (thousand won)[c]	
≤1000	42.1 (1.1)
1010–3000	35.3 (1.1)
≥3010	22.6 (1.0)
Lumbar spine[d]	
Normal	22.0 (1.0)
Osteopenia	48.4 (1.2)
Osteoporosis	29.6 (1.1)
Femoral neck[d]	
Normal	21.7 (1.0)
Osteopenia	53.7 (1.2)
Osteoporosis	24.6 (1.0)
Taking anti-osteoporotic medications prescribed by a physician	
No	90.8 (0.6)
Yes	9.2 (0.6)
Prevalence[e]	
Normal	17.5 (0.9)
Osteopenia	43.4 (1.1)
Osteoporosis	39.1 (1.1)
Menopause	
No	17.1 (0.8)
Yes	82.9 (0.8)
Age of menarche (years)	15.7 ± 0.8
Age of menopause (years)	48.8 ± 0.3

Data are % (standard error [SE]) or mean ± 2 standard deviations (SD).
Abbreviations: BMI, body mass index; METs, metabolic equivalent.
Data are weighted to the residential population of Korea.
[a] n; unweighted sample size, N; weighted sample size in millions.
[b] High-risk drinking is defined as consuming more than 3 standard drinks per each occasion on average, which has been known to impair bone mineral density.
[c] The exchange rate is approximately 1200 Korean won for 1 US dollar.
[d] The definitions of osteopenia or osteoporosis were made using World Health Organization (WHO) T-score criteria (−2.5 < T-score < −1 or T-score ≤ −2.5).
[e] Prevalence of osteopenia or osteoporosis were calculated using both WHO T-score of the lumbar spine and femoral neck (−2.5 < T-score < −1 or T-score ≤ −2.5), and included those taking anti-osteoporotic medications.

3.2. Prevalence, awareness, and treatment of osteoporosis according to demographic status

Table 2 lists the prevalence, awareness, and treatment rates of osteoporosis by sociodemographic status. The estimated prevalence of osteoporosis increased with older age ($p<0.001$), lower education level ($p<0.001$), lower monthly income ($p<0.001$), and residence in a rural area ($p<0.001$), but did not differ according to marital status ($p = 0.548$). Using multivariate-adjusted logistic regression modeling, the prevalence of osteoporosis increased only with older age and

Table 2
Prevalence, awareness, and treatment of osteoporosis (lumbar spine or femoral neck T-score ≤ −2.5, or taking anti-osteoporotic medications) according to sociodemographic status.

Variables	Prevalence of weighted population (n = 2870, N = 1.04)[a]			Awareness[b] (n = 1215, N = 0.40)[a]			Treatment[b] (n = 1215, N = 0.40)[a]		
	Estimated proportion % (SE)	Age-adjusted OR[c] (95% CI)	Multivariate-adjusted OR[d] (95% CI)	Estimated proportion % (SE)	Age-adjusted OR[c] (95% CI)	Multivariate-adjusted OR[d] (95% CI)	Estimated proportion % (SE)	Age-adjusted OR[c] (95% CI)	Multivariate-adjusted OR[d] (95% CI)
Total	39.1 (1.0)			37.5 (1.6)			23.5 (1.4)		
Age group (years)									
50–59	15.4 (1.3)	1.00	1.00	40.5 (4.5)	1.00	1.00	27.4 (4.1)	1.00	1.00
60–69	44.5 (1.8)	4.38 (3.43–5.59)	3.58 (2.77–4.63)	47.9 (2.7)	1.34 (0.88–2.06)	1.30 (0.83–2.04)	29.2 (2.5)	1.09 (0.68–1.75)	1.11 (0.68–1.79)
≥70	60.9 (1.1)	14.71‡ (11.28–19.19)‡	10.97‡ (8.23–14.63)‡	29.8 (2.1)	0.62 (0.41–0.94)*	0.68 (0.43–1.06)	18.6 (1.8)	0.60 (0.37–0.96)*	0.69 (0.42–1.14)
p for trend	$p^{f}<0.001$	$p<0.001$	$p<0.001$	$p^{f}<0.001$	$p=0.001$	$p=0.007$	$p^{f}=0.003$	$p=0.005$	$p=0.044$
Education									
≥College	22.3 (4.3)	1.00	1.00	42.0 (10.9)	1.00	1.00	35.0 (10.6)	1.00	1.00
Middle/high school	19.7 (1.6)	0.85 (0.47–1.55)	0.86 (0.46–1.59)	41.9 (4.3)	1.03 (0.38–2.76)	1.09 (0.39–3.03)	27.2 (3.9)	0.71 (0.26–1.97)	0.79 (0.27–2.28)
≤Elementary school	50.4 (1.3)	1.63 (0.91–2.89)	1.54 (0.85–2.81)	36.7 (1.8)	1.02 (0.40–2.61)	1.00 (0.37–2.69)	23.7 (1.4)	0.66 (0.25–1.74)	0.70 (0.25–1.97)
p for trend	$p^{f}<0.001$	$p=0.001$	$p<0.001$	$p^{f}=0.497$	$p=0.996$	$p=0.796$	$p^{f}=0.244$	$p=0.450$	$p=0.469$
Marital status									
Not married	39.1 (1.1)	1.00	1.00	37.8 (1.6)	1.00	1.00	23.7 (1.4)	1.00	1.00
Married	34.7 (17.1)	0.62 (0.17–2.28)	0.67 (0.18–2.45)	0.0 (0.0)	N/A	N/A	0.0 (0.0)	N/A	N/A[f]
P	$p^{f}=0.799$	$p=0.481$	$p=0.548$	$p^{f}=0.241$			$p^{f}=0.401$		
Monthly income (thousand won)[e]									
≥3010	26.4 (2.2)	1.00	1.00	36.6 (4.6)	1.00	1.00	24.4 (4.2)	1.00	1.00
1010–3000	31.6 (1.7)	1.19 (0.87–1.62)	1.08 (0.79–1.49)	38.8 (3.1)	1.09 (0.68–1.74)	1.10 (0.68–1.77)	24.6 (2.8)	1.00 (0.59–1.71)	1.03 (0.60–1.77)
≤1000	51.2 (1.6)	1.42 (1.06–1.91)*	1.21 (0.89–1.66)	38.5 (2.1)	1.23 (0.80–1.87)	1.20 (0.77–1.87)	23.6 (1.8)	1.07 (0.66–1.73)	1.10 (0.66–1.81)
p for trend	$p^{f}<0.001$	$p=0.013$	$p=0.179$	$p^{f}=0.911$	$p=0.027$	$p=0.367$	$p^{f,e}=0.951$	$p=0.716$	$p=0.667$
Residential area									
Urban	36.7 (1.3)	1.00	1.00	36.9 (2.1)	1.00	1.00	23.6 (1.8)	1.00	1.00
Rural	45.9 (1.8)	1.16 (0.95–1.42)	1.07 (0.87–1.32)	38.9 (2.5)	1.16 (0.89–1.52)	0.10 (0.83–1.45)	23.4 (2.2)	1.05 (0.77–1.44)	1.04 (0.75–1.44)
P	$p^{f}<0.001$	$p=0.129$	$p=0.475$	$p^{f}=0.545$	$p=0.260$	$p=0.493$	$p^{f}=0.942$	$p=0.736$	$p=0.779$

Abbreviations: SE: standard error; OR: odds ratio; CI: confidence interval; N/A: Not applicable.
All data are weighted to the residential population of Korea.
‡ $p<0.001$.
* $p<0.05$.
[a] n; unweighted sample size, N; weighted sample size in millions.
[b] Among persons with lumbar spine or femoral neck T-score ≤ −2.5, or taking anti-osteoporotic medications.
[c] All variables were adjusted for age.
[d] All variables were adjusted for age, sex, marital status, educational status, monthly income, and residential area.
[e] The exchange rate is approximately 1200 Korean won for 1 US dollar.
[f] *p* values from chi-square test for categorical variables.

Table 3
Prevalence, awareness, and treatment of osteoporosis (lumbar spine or femoral neck T-score ≤ −2.5, or taking anti-osteoporotic medications) according to behavioral risk factors[a].

Variables	Prevalence of weighted population (n = 2870, N = 1.04)[a]			Awareness[b] (n = 1215, N = 0.40)[a]			Treatment[b] (n = 1215, N = 0.40)[a]		
	Estimated proportion % (SE)	Age-adjusted OR[c] (95% CI)	Multivariate-adjusted OR[d] (95% CI)	Estimated proportion % (SE)	Age-adjusted OR[c] (95% CI)	Multivariate-adjusted OR[d] (95% CI)	Estimated proportion % (SE)	Age-adjusted OR[c] (95% CI)	Multivariate-adjusted OR[d] (95% CI)
Smoking									
None	37.9 (1.1)	1.00	1.00	39.6 (2.7)	1.00	1.00	25.2 (1.5)	1.00	1.00
Ex-smoker	57.9 (5.2)	1.47 (0.93–2.33)	1.43 (0.89–2.30)	28.7 (5.6)	0.66 (0.38–1.17)	0.64 (0.36–1.14)	15.2 (4.5)	0.57 (0.28–1.16)	0.55 (0.27–1.13)
Current smoker	44.4 (4.9)	0.95 (0.60–1.49)	0.89 (0.56–1.42)	15.8 (4.6)	0.31 (0.15–0.61)[e]	0.28 (0.14–0.58)[e]	7.8 (3.1)	0.27 (0.11–0.65)[f]	0.29 (0.12–0.70)[f]
p for trend	*p*[g] < 0.001	*p* = 0.623	*p* = 0.821	*p*[g] < 0.001	*p* < 0.001	*p* < 0.001	*p*[g] = 0.002	*p* = 0.001	*p* = 0.002
Alcohol[h]									
Nondrinker	47.8 (1.5)	1.00	1.00	35.2 (1.9)	1.00	1.00	21.5 (1.7)	1.00	1.00
<3 standard drinks	32.0 (1.8)	0.68 (0.55–0.86)	0.71(0.56–0.89)[f]	44.3 (3.3)	1.37 (1.00–1.88)[i]	1.38 (1.01–1.90)[i]	31.4 (3.1)	1.56 (1.10–2.22)[i]	1.57 (1.10–2.24)[i]
≥3 standard drinks	21.8 (2.5)	0.55[e] (0.40–0.76)[e]	0.55 (0.40–0.76)[e]	36.7 (6.2)	0.95 (0.55–1.63)	1.03 (0.59–1.77)	16.2 (4.1)	0.63 (0.33–1.18)	0.67 (0.35–1.26)
p for trend	*p*[g] < 0.001	*p* < 0.001	*p* < 0.001	*p*[g] = 0.064	*p* = 0.356	*p* = 0.238	*p*[g] = 0.002	*p* = 0.663	*p* = 0.543
Physical activity[j]									
3rd tertile	29.2 (1.7)	1.00	1.00	40.0 (3.1)	1.00	1.00	27.0 (2.8)	1.00	1.00
2nd tertile	43.5 (1.9)	1.49 (1.16–1.92)[f]	1.51 (1.16–1.95)[f]	38.7 (2.7)	0.98 (0.69–1.40)	1.03 (0.72–1.47)	25.0 (2.4)	0.93 (0.63–1.38)	0.96 (0.64–1.42)
1st tertile	43.9 (1.9)	1.29 (1.00–1.65)[i]	1.26 (0.98–1.61)	35.6 (2.6)	0.91 (0.64–1.30)	0.94 (0.66–1.34)	20.2 (2.2)	0.74 (0.49–1.12)	0.75 (0.50–1.13)
p for trend	*p*[g] < 0.001	*p* = 0.049	*p* = 0.069	*p*[g] = 0.527	*p* = 0.601	*p* = 0.707	*p*[g] = 0.140	*p* = 0.147	*p* = 0.162
Body mass index									
≥25	31.3 (1.6)	1.00	1.00	40.7 (3.0)	1.00	1.00	28.2 (2.7)	1.00	1.00
>20–24.99	40.1 (1.5)	1.91 (1.54–2.37)[e]	2.03 (1.63–2.53)[e]	36.4 (2.1)	0.78 (0.57–1.06)	0.80 (0.59–1.09)	22.3 (1.8)	0.68 (0.49–0.96)[i]	0.67 (0.47–0.95)[i]
≤20	68.3 (3.6)	5.31 (3.52–8.00)[e]	5.61 (3.64–8.67)[e]	34.8 (4.3)	0.77 (0.49–1.20)	0.81 (0.51–1.27)	17.5 (3.4)	0.53 (0.30–0.92)[i]	0.53 (0.31–0.93)[i]
p for trend	*p*[g] < 0.001	*p* < 0.001	*p* < 0.001	*p*[g] = 0.392	*p* = 0.152	*p* = 0.236	*p*[g] = 0.046	*p* = 0.011	*p* = 0.010
Calcium intake[k]									
3rd tertile	30.4 (1.8)	1.00	1.00	47.8 (3.5)	1.00	1.00	34.0 (3.4)	1.00	1.00
2nd tertile	39.1 (1.9)	1.28 (0.98–1.66)	1.22 (0.93–1.60)	33.6 (2.8)	0.56 (0.38–0.81)[f]	0.56 (0.38–0.82)[f]	20.4 (2.4)	0.50 (0.33–0.76)[e]	0.52 (0.34–0.79)[f]
1st tertile	50.3 (1.9)	1.46 (1.13–1.87)[f]	1.35 (1.05–1.75)[i]	35.4 (2.4)	0.66 (0.46–0.94)[i]	0.64 (0.45–0.92)[i]	20.7 (2.0)	0.55 (0.37–0.80)[f]	0.55 (0.38–0.82)[f]
p for trend	*p*[g] < 0.001	*p* = 0.003	*p* = 0.020	*p*[g] = 0.002	*p* = 0.045	*p* = 0.033	*p*[g] < 0.001	*p* = 0.005	*p* = 0.006

Abbreviations: SE: standard error; OR: odds ratio; CI: confidence interval, METs: metabolic equivalent.
All data are weighted to the residential population of Korea.
[a] n; unweighted sample size, N; weighted sample size in millions.
[b] Among persons with lumbar spine or femoral neck T-score ≤ −2.5, or taking anti-osteoporotic medications.
[c] All variables were adjusted for age.
[d] All variables were adjusted for age, sex, marital status, educational status, monthly income, and residential area.
[e] $p < 0.001$.
[f] $p < 0.01$.
[g] *p* values from chi-square test for categorical variables.
[h] High-risk drinking is defined as consuming more than 3 standard drinks (= 30 g of pure alcohol) per occasion on average.
[i] $p < 0.05$.
[j] Physical activity per week was divided into 3 tertiles (<12.0 METs/week, 12–43.5 METs/week, and >43.5 METs/week).
[k] Dietary calcium intake was divided into 3 tertiles (<231 mg/day, 231–422 mg/day, and >422 mg/day).

lower education. The differences for other factors were not statistically significant.

Among the osteoporotic participants, only 37.5% were aware of their diagnosis and 23.5% were under treatment. Awareness and treatment rates among high-risk groups (low education, low income, residence in rural areas) did not differ from those among low-risk groups. Moreover, the rates of awareness and treatment decreased as age increased ($p=0.007$ and $p=0.044$, respectively).

3.3. Prevalence, awareness, and treatment of osteoporosis according to behavioral risk factors

Table 3 lists the osteoporosis prevalence, awareness, and treatment rates by behavioral risk factors. The prevalence of osteoporosis was increased in clinical risk factor groups such as ex- and current smokers (57.9% and 44.4%, respectively), and those with lower physical activity (43.9%), lower BMI (<20 kg/m^2, 68.3%), and lower calcium intake (50.3%). However, except for BMI associations and calcium intake, these associations were not significant after multivariate adjustment for sociodemographic factors.

On the other hand, drinkers had a significantly lower prevalence of osteoporosis than nondrinkers did ($p<0.001$). These associations persisted even after multivariate logistic regression analysis ($p<0.001$).

Among osteoporotic participants, awareness and treatment rates were significantly lower in current smokers ($p<0.001$ and $p=0.002$, respectively), and these correlations persisted after multivariate logistic regression analysis ($p<0.001$ and $p=0.002$, respectively).

3.4. Prevalence, awareness, and treatment rates of osteoporosis according to health status and accessibility

Table 4 states the estimated prevalence, awareness, and treatment rates of osteoporosis by health status and accessibility. The prevalence of osteoporosis was significantly different according to self-perceived heath status ($p<0.001$), but this association was not significant after multivariate adjustment for sociodemographic factors ($p=0.261$). Participants with a poor/very poor subjective health status exhibited higher rates of awareness and treatment than participants with good/very good subjective health statuses did (aOR = 1.90, 95% CI = 1.34–2.68 for awareness; aOR = 1.58, 95% CI = 1.07–2.33 for treatment).

Participants with a history of fractures had higher treatment rates than participants without fractures ($p<0.001$). Participants with easily perceivable risk factors did not demonstrate any association with osteoporosis treatment. Participants with a height loss of >1 in and a family history of osteoporosis did not demonstrate a significant association with awareness or treatment. Only participants who had a history of falls in the recent 1 year exhibited better awareness ($p=0.045$), but did not exhibit better treatment rates ($p=0.968$).

Participants who had a health screening in the previous 2 years had a higher awareness of osteoporosis (46.6% versus 27.3%), and this association remained significant after adjustment for demographic covariates (aOR = 2.05; 95% CI = 1.54–2.72). This group also had a higher treatment rate than the control group (30.3% versus 16.0%), and this association remained significant after adjustment for demographic covariates (aOR = 2.07; 95% CI = 1.50–2.86).

4. Discussion

In the estimated Korean general female population aged ≥50 years, 39.1% had osteoporosis while 43.4% had osteopenia. The age-specific prevalence of osteoporosis in the present study is consistent with that of a previous Korean population-based study [13]. Among the population with osteoporosis, 37.5% were aware of their diagnosis and only 23.5% were under treatment for osteoporosis. Despite the fact that the prevalence of osteoporosis was higher among participants of older age, low education, low income, residence in rural areas, and who were current smokers, the awareness and treatment rates of these high-risk groups did not differ from the low-risk groups, nor were they lower. Participants who had easily perceivable osteoporosis risk factors did not demonstrate better awareness or treatment of osteoporosis. Participants who had undergone a health screening in the previous 2 years demonstrated higher rates of awareness and treatment than the controls.

Osteoporosis is often not detected until fracture presentation and is hence considered a "silent epidemic" with a need for early diagnosis [34]. The results of the present study appear to agree with previous studies that dealt with the osteoporosis care gap as an international phenomenon [35], with only 21.6% of osteoporotic women over the age of 65 receiving treatment in the USA in 2001–2003 [36], and 5.2–37.5% of osteoporotic women in Canada receiving treatment in 1966–2003 [37]. Likewise, despite the reasonable prices and accessibility of anti-osteoporotic medication and DXA, and the relatively wide coverage of National Health Insurance in Korea [33], the osteoporosis treatment rate (23.5%) is similar to or even lower than those of the aforementioned countries. Moreover, the treatment rate in Korea (23.5%) is far lower than that in France, where insurance covers 70% of screening and treatment costs [38]. It is particularly disappointing that the Korean treatment rate is as low as that of countries where insurance does not cover bone densitometry and anti-osteoporotic treatment [36].

Awareness of osteoporosis may affect health-related behaviors, and increased knowledge about osteoporosis may be the most effective strategy for prevention of osteoporotic fracture [39]. Furthermore, it is known that raising awareness of osteoporosis increased treatment and treatment compliance rates [40]. In the present study, osteoporotic Korean women exhibited a lower rate of awareness of their condition: only 37.5% were aware of it at the time of their participation. This rate was lower than that of osteoporotic Turkish women between 2001 and 2002 (44%) [41]. The Korean awareness rate in 2003 was 27.9% [42], and there has not been much improvement since then.

Most previous studies have demonstrated that socioeconomic status is inversely associated with awareness, knowledge, and adherence to treatment [24,41]. Our study suggests that osteoporosis was highly prevalent in groups with advanced age, lower education, lower income, and residence in rural communities, but the osteoporosis awareness and treatment rates of such groups were not different from control groups. Osteoporotic Korean women generally had lower awareness and treatment rates irrespective of their sociodemographic status than women in other countries did.

There was a higher prevalence of osteoporosis in current smokers than in controls, but their diagnosis awareness was significantly lower than that of controls. Participants with a low BMI (<20 kg/m^2) exhibited higher risks of osteoporosis (aOR = 13.70, 95% CI = 6.35–29.53), but their awareness and treatment rates were significantly lower than those of the controls were. A better-targeted intervention to increase awareness in this population may be needed. There was a lower prevalence of osteoporosis among those who consumed alcohol in the present study, and this finding is contrast to previous results [26]. In this study population, at-risk drinkers who consumed more than 3 StDs (approximately ≥30 g) in one occasion was 14.3%, and only 1.13% consumed alcohol more than once a week. Therefore, in terms of alcohol dose, most of the drinkers in this study were moderate drinkers. Some studies suggested that moderate alcohol consumption is not harmful and may even be beneficial to bone health [43–45]. However, the dose of moderate alcohol consumption on bone health may need further investigation, especially among Asians, who are known to be more susceptible to alcohol-related diseases due to genetic differences in alcohol dehydrogenase (*ALD*) and aldehyde dehydrogenase (*ALDH*) [46,47]. On the other hand, light-to-moderate drinkers in the present study demonstrated better awareness and treatment.

Table 4
Prevalence, awareness, and treatment of osteoporosis (lumbar spine or femoral neck T-score ≤ −2.5, or taking anti-osteoporotic medications) according to Health Status and Accessibility[a].

Variables	Prevalence of weighted population (n = 2870, N = 1.04)[a]			Awareness[b] (n = 1215, N = 0.40)[a]			Treatment[b] (n = 1215, N = 0.40)[a]		
	Estimated proportion % (SE)	Age- and sex-adjusted OR[c] (95% CI)	Multivariate- adjusted OR[d] (95% CI)	Estimated proportion % (SE)	Age-adjusted OR[c] (95% CI)	Multivariate- adjusted OR[d] (95% CI)	Estimated proportion % (SE)	Age-adjusted OR[c] (95% CI)	Multivariate- adjusted OR[d] (95% CI)
Self-perceived health status									
Good/very good	35.9 (1.9)	1.00	1.00	28.9 (2.9)	1.00	1.00	19.7 (2.6)	1.00	1.00
Fair	33.6 (2.0)	0.98 (0.75–1.28)	0.98 (0.75–1.30)	36.7 (3.3)	1.41 (0.95–2.10)	1.35 (0.91–2.02)	20.8 (2.7)	1.06 (0.67–1.67)	1.04 (0.66–1.64)
Poor/very poor	46.0 (1.7)	1.21 (0.96–1.54)	1.14 (0.75–1.30)	43.9 (2.3)	2.03 (1.45–2.85)‡	1.90 (1.34–2.68)‡	27.8 (2.1)	1.64 (1.12–2.41)*	1.58 (1.07–2.33)*
p for trend	*p*[f] < 0.001	*p* = 0.090	*p* = 0.261	*p*[f] < 0.001	*p* < 0.001	*p* < 0.001	*p*[f] = 0.030	*p* = 0.007	*p* = 0.014
History of fracture									
No	38.0 (1.1)	1.00	1.00	33.8 (1.6)	1.00	1.00	21.2 (1.4)	1.00	1.00
Yes	89.1 (4.0)	9.15 (3.61–23.14)‡	8.41 (3.29–21.48)*	100.0 (0.0)	N/A	N/A	65.6 (6.8)	7.70 (4.11–14.43)‡	7.20 (3.81–13.59)‡
p	*p*[f] < 0.001	*p* < 0.001	*p* < 0.001	*p*[f] < 0.001			*p*[f] < 0.001	*p* < 0.001	*p* < 0.001
History of falls in recent 1 year									
No	38.6 (1.2)	1.00	1.00	36.5 (1.8)	1.00	1.00	23.9 (1.6)	1.00	1.00
Yes	41.6 (2.5)	0.96 (0.74–1.25)	0.90 (0.69–1.18)	42.3 (3.8)	1.34 (0.95–1.90)	1.43 (1.00–2.04)*	22.4 (3.2)	0.96 (0.64–1.43)†	1.00 (0.67–1.51)
p	*p*[f] = 0.287	*p* = 0.467	*p* = 0.472	*p*[f] = 0.163	*p* = 0.091	*p* = 0.045	*p*[f] = 0.667	*p* = 0.843	*p* = 0.968
Height loss (inches)[e]									
<1	25.1 (1.5)	1.00	1.00	39.4 (3.3)	1.00	1.00	27.5 (3.0)	1.00	1.00
≥1	39.9 (1.9)	1.25 (0.97–1.59)	1.17 (0.91–1.51)	43.9 (3.0)	1.32 (0.91–1.92)	1.29 (0.89–1.88)	25.5 (2.6)	0.96 (0.64–1.45)	0.94 (0.62–1.43)
p	*p*[f] < 0.001	*p* = 0.074	*p* = 0.208	*p*[f] = 0.306	*p* = 0.136	*p* = 0.175	*p*[f] = 0.619	*p* = 0.878	*p* = 0.802
Family history of osteoporosis or fracture									
No	39.3 (1.2)	1.00	1.00	36.1 (1.7)	1.00	1.00	23.3 (1.5)	1.00	1.00
Yes	38.6 (2.6)	1.32 (1.01–1.73)*	1.35 (1.03–1.78)*	44.7 (4.2)	1.35 (0.93–1.95)	1.36 (0.93–1.99)	24.9 (3.6)	1.02 (0.61–1.57)	1.06 (0.69–1.62)
p for trend	*p*[f] = 0.810	*p* = 0.040	*p* = 0.030	*p*[f] = 0.054	*p* = 0.110	*p* = 0.105	*p*[f] = 0.675	*p* = 0.897	*p* = 0.783
Health screening in the past 2 years									
No	43.5 (1.7)	1.00	1.00	27.3 (2.2)	1.00	1.00	16.0 (1.7)	1.00	1.00
Yes	36.1 (1.3)	1.05 (0.85–1.29)	1.11 (0.90–1.37)	46.6 (2.2)	2.17 (1.63–2.88)‡	2.05 (1.54–2.72)‡	30.3 (2.1)	2.14 (1.56–2.95)‡	2.07 (1.50–2.86)‡
p	*p*[f] < 0.001	*p* = 0.619	*p* = 0.310	*p*[f] < 0.001	*p* < 0.001	*p* < 0.001	*p*[f] < 0.001	*p* < 0.001	*p* < 0.001

Abbreviations: SE: standard error; OR: odds ratio; CI: confidence interval; N/A: Not applicable.
All data are weighted to the residential population of Korea.
* $p < 0.05$.
† $p < 0.01$.
‡ $p < 0.001$.
[a] n; unweighted sample size, N; weighted sample size in millions.
[b] Among persons with lumbar spine or femoral neck T-score ≤ −2.5, or taking anti-osteoporotic medications.
[c] All variables were adjusted for age.
[d] All variables were adjusted for age, sex, marital status, educational status, monthly income, and residential area.
[e] Height loss was defined as the calculated difference between the current stature and the highest statures in participants' youth.
[f] *p* values from chi-square test for categorical variables.

In addition, there was an inverse relationship between dietary calcium intake and the prevalence of osteoporosis. In a previous study, postmenopausal Asian women consuming less than the recommended dietary calcium intake were shown to be at greater risk than Caucasian women with the same intake [48]. In the present study, the mean dietary calcium intake of osteoporotic Korean women was 403.97 ± 19.07 mg/day, which was far below the recommended intake (1200 mg/day). Moreover, the group with the lowest calcium intake in this study had lower awareness and treatment of osteoporosis.

Ironically, participants with good self-perceived health status were less likely to be aware of their osteoporotic status. Furthermore, participants with good self-perceived health status were less likely to receive treatment. Our results suggest that a change in health belief may be needed to promote bone health in this population.

Easily identifiable osteoporosis risk factors (history of falls, height loss of >1 in, and a family history of osteoporosis) were not related with treatment of osteoporosis. Only participants who reported a history of falls in the recent 1 year exhibited better awareness. Those factors are known as independent risk factors for fractures [25,49,50], and our study suggests that a tailored education to increase awareness in this population may be needed.

We also determined that undergoing a medical checkup in the previous 2 years was significantly associated with increased osteoporosis awareness. This suggests that screening for osteoporosis may be an effective way to reinforce osteoporosis detection and management among subgroups with lower osteoporosis awareness. There are no studies of the cost-effectiveness of DXA screening in postmenopausal Korean women, but low-cost DXA screening was cost-effective for preventing osteoporotic fractures and increasing adherence to treatment in some developed countries [51,52]. In addition, DXA screening was highly effective in increasing awareness of osteoporosis and prompting treatment of osteoporosis [53]. The appropriate use of regular DXA screening for osteoporotic Korean women should be considered to increase the awareness and treatment rates of osteoporosis.

Our study has some limitations. First, the cross-sectional nature of our study design indicates that only limited causal associations can be made. Second, several pieces of information were collected from the self-reported questionnaires, so reporting bias cannot be excluded. Third, it was unfortunate that we could not assess which kind of osteoporosis medication the study participants received. Fourth, the present study was limited by a lack of information regarding the participants' health providers, participants' knowledge of and attitudes toward osteoporosis, and provider–patient relationships, all of which are factors potentially associated with osteoporosis awareness and treatment.

5. Conclusions

We found that the rates of awareness and treatment of osteoporosis among osteoporotic Korean women are not optimal, and that a higher osteoporotic prevalence rate within a particular group was not accompanied by higher rates of awareness and treatment within that group. These findings indicate that more targeted interventions to improve the osteoporosis screening process are needed. We recommend that such factors be considered when educating healthcare professionals and organizing healthcare programs. Furthermore, emphasis should be placed on routine health screening to be an effective strategy to increase osteoporosis awareness and treatment.

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