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ORIGINAL ARTICLE

The prevalence of radiographic vertebral fractures in Latin American countries: the Latin American Vertebral Osteoporosis Study (LAVOS)

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Abstract
Summary In the first population-based study of vertebral fractures in Latin America, we found a 11.18 (95% CI 9.23–13.4) prevalence of radiographically ascertained vertebral fractures in a random sample of 1,922 women from cities within five different countries. These figures are similar to findings from studies in Beijing, China, some regions of Europe, and slightly lower than those found in the USA using the same standardized methodology.
Introduction We report the first study of radiographic vertebral fractures in Latin America.
Methods An age-stratified random sample of 1,922 women aged 50 years and older from Argentina, Brazil, Colombia, Mexico, and Puerto Rico were included. In all cases a standardized questionnaire and lateral X-rays of the lumbar and thoracic spine were obtained after informed consent.
Results A standardized prevalence of 11.18 (95% CI 9.23–13.4) was found. The prevalence was similar in all five countries, increasing from 6.9% (95% CI 4.6–9.1) in women aged 50–59 years to 27.8% (95% CI 23.1–32.4) in those 80 years and older (p for trend < 0.001). Among different risk factors, self-reported height loss OR=1.63

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(95% CI: 1.18–2.25), and previous history of fracture OR= 1.52 (95% CI: 1.14–2.03) were significantly ($p<0.003$ and $p<0.04$ respectably) associated with the presence of radiographic vertebral fractures in the multivariate analysis. In the bivariate analyses HRT was associated with a 35% lower risk OR=0.65 (95% CI: 0.46–0.93) and physical activity with a 27% lower risk of having a vertebral fracture OR=0.73 (95% CI: 0.55–0.98), but were not statistically significant in multivariate analyses

Conclusion We conclude that radiographically ascertained vertebral fractures are common in Latin America. Health authorities in the region should be aware and consider implementing measures to prevent vertebral fractures.

Keywords Epidemiology · Latin America · Osteoporosis · Prevalence · Vertebral fractures

Introduction

Osteoporosis is a major public health problem and the rates of hip and other fractures are rapidly increasing in developing countries [1–3].

Vertebral fractures, the hallmark of osteoporosis, have been well characterized in developed countries using standardized methodology. Important differences have been found within regions of Europe (European Prevalence Osteoporosis Study, EPOS) [4] and among some regions of the world. These fractures cause substantial back pain and disability. The presence of vertebral fractures indicates an important risk factor for future osteoporotic fractures at the vertebral level as well as other anatomical sites.

In contrast to the knowledge in the developed world, studies on the epidemiology of osteoporotic fractures in Latin America are scarce and have focused only on hip fractures [3, 5]. The epidemiology of vertebral fractures in the Latin American region is unknown. The aim of the Latin American Vertebral Osteoporosis Study (LAVOS) was to determine the prevalence of radiographically ascertained vertebral fractures according to age in five different Latin-American countries within the Latin American region, determine the variation in prevalence by age and country, and identify potential conventional risk factors associated with vertebral fractures previously reported.

Materials and methods

Study design

Five cities within the Latin American region took part in the study. Each center aimed to recruit a random sample of 400 women from population-based listings. Details of the sampling methods differed depending on local circumstances. All countries used the last census available to generate a stratified random sample of 100 women for the following age decades: 50–59, 60–69, 70–79, and ≥ 80 (Puerto Rico recruited women up to 89). The following five cities were selected for this study: Buenos Aires in Argentina, Vitoria, Espiritu Santo in Brazil, Barranquilla in Colombia, Puebla in México, and San Juan in Puerto Rico. A random probability sample was drawn for each selected city using demographic information available from every district and group of household blocks. We used the demographic information and cartography for each site from the Department of Epidemiology at the University of Buenos Aires in Argentina, Instituto Brasileiro de Geografia y Estadistica IBGE in Brazil, National Department of Statistics, DANE in Colombia, the National Institute of Geography and Statistics INEGI in Mexico, and the Census Bureau, Planning Board Office in Puerto Rico.

Before the study began, a training workshop was held with the principal investigators to review the sampling frame, the questionnaire, and survey methods. Additionally, centers were visited early during the survey by a member of the coordinating center team (PC) to standardize the study methods across the participating countries.

Eligible women participated in a face to face interview in their homes in the case of Mexico, Brazil, and Colombia,

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and in a clinical research center in Argentina and Puerto Rico. In addition to the interview, women were invited for lateral X-rays of the thoracic and lumbar spine. If a woman was unable or refused to participate, she was replaced by the first woman available of the same age strata. The same replacement strategy was used for all countries: making home visits from the houses from the right to the left of the first assigned house in the same block of households until a woman who fulfilled the criteria was found.

The protocol was submitted and approved by each of the Institutional Review Boards in every country and written consent was obtained from all participants before the interview.

Questionnaire

The LAVOS questionnaire was developed based on questionnaires of two large studies, EPOS and SOF [4, 6], and collected self-reported data on demographics, gynecological history, life style factors, and conventional risk factors for osteoporosis [7]. To assess dietary calcium, we included a semiquantitative food questionnaire validated in Spanish for the Mexican population [8]. The Sistema de Nutrimientos (SNUT) program was used to compute dietary calcium in milligrams per day. Commercial calcium supplement intake was calculated according to names and daily doses reported by participants. Alcohol intake was calculated in grams per day using the SNUT program and categorized according to the WHO Audit Program [9] as: never, for the participant who did not report alcohol intake; mild, from 1 to 10 grams per day; moderate, from 11–40 grams per day; and severe, for more than 40 grams per day. The questions assessed the frequency and type of alcoholic beverage consumed during the last year. Physical activity was assessed in minutes per day according to time spent on various activities including walking, dancing, and cycling, among others, and computed for 1 week in the previous year during these activities. Height (centimeters) was determined by means of a stadiometer to the nearest 0.1 cm and weight (kilograms) was assessed with a regularly calibrated scale to the nearest 0.1 kg, in each of the centers. The BMI was computed as weight (kilograms) divided by the square of the height (square meters): normal, defined as a BMI of 19–24.9; overweight, from 25 to 29.9; and obese, > 30. All other risk factors were self-reported during the interview as: information on the maternal history of hip fracture after the age of 50 (yes/no/don't know), personal history of fracture after the age of 40, including the anatomical site and the level of trauma. With regard to height loss, participants were asked: "Do you have the same height you had at the age of 25?" Regarding use of steroids, participants were asked: "Have you ever taken corticosteroid tablets or injections for more than 3 months?" On HRT, participants were asked: "Has your doctor treated you with HRT after the menopause?" Finally, participants were asked about their smoking habits: "Do you smoke cigarettes or any other type of tobacco (currently, in the past or never)?". For smokers, information on time and average number of cigarettes consumed was obtained. The questionnaire was back translated into Portuguese, the only non-Spanish-speaking country included in the study.

During the training session, the questionnaire was reviewed by all PIs in order to clarify terms, country idiosyncrasies, and standardization. A pilot study of this questionnaire was done before the study started in each of the participating cities in order to test its appropriateness and clarity for the local population.

Radiology

Lateral thoracic and lumbar spine radiographs were taken with a 40" tube-to-film distance according to a standard protocol that included details concerning positioning of the participants and the radiographic technique used. Radiographs were taken with the participant in the left lateral position. For the thoracic films, the breathing technique was used. The thoracic film was centered at T7 and the lumbar film at L2. All radiographic studies were collected in our morphometry center in Mexicali, Mexico. A sample of radiographs was sent from each of the participant countries to this center to verify quality assessment and compliance with the protocol.

All study radiographs were digitized using an AccuTab® table, and vertebral dimensions were measured by placement of six points defining the margins of each vertebral body using a cursor with a peripheral device that enters the value of vertebral height into software specially designed to create a database. Six points were marked on each vertebral body from T4 to L4 to define vertebral shape and to describe three vertebral heights: Ha (anterior), Hm (medial), and Hp (posterior) using the same criteria as SOF [10, 11].

The central reader was trained at the San Francisco Coordinating Center (FCM) to ensure that the positioning of the points was similar to that used in the Study of Osteoporotic Fractures and the Beijing Osteoporosis Project [12]. To test the comparability of the method, a random sample of 10% of Mexican radiographs were sent to San Francisco for morphometric measurements. A good degree of agreement (kappa=0.77, 95% CI 0.64–0.90) was found between readers at the San Francisco Coordinating Center at San Francisco and the LAVOS Morphometry Center for identification of normal and abnormal vertebrae.

Definition of vertebral deformity

We used the modified Eastell criteria to define vertebral fractures, and we used the same criteria used in SOF to place the six points in each vertebra [13, 14]. This method

Table 1 Prevalence (95% confidence interval) of vertebral fractures in five Latin American countries

Age	LAVOS[a] pooled data, N = 1,902	Argentina, N=420	Brazil, N=415	Colombia[b], N=261	Mexico, N=406	Puerto Rico, N=400	p value
50–59	6.9 (4.6–9.1)	10.4 (4.5–16.4)	6.7 (1.8–11.7)	3.6 (0.48–7.7)	7.7 (2.5–13.0)	5.3 (1.1–9.5)	0.39
60–69	10.2 (7.6–12.8)	13.7 (6.9–20.5)	7.6 (2.4–12.7)	7.9 (2.5–13.2)	13.8 (7.0–20.7)	8.2 (3.0–13.5)	0.32
70–79	18.0 (14.7–21.3)	16.8 (9.9–23.6)	17.7 (10.3–25.1)	22.0 (12.6–31.5)	18.0 (10.6–25.5)	16.8 (9.8–23.8)	0.89
≥ 80	27.8 (23.1–32.4)	24.4 (15.6–33.3)	25.0 (16.3–33.6)	–	38.1 (28.3–47.9)	21.5 (11.2–31.8)	0.06
Overall≤79	11.77 (10.16–13.38)	13.80 (10.03–17.56)	10.79 (7.34–14.23)	10.72 (6.94–14.50)	13.26 (9.46–17.07	10.14 (6.89–13.39)	0.49
Overall ages	14.77 (13.17–16.37)	16.19 (12.65–19.72)	14.21 (10.84–17.59)	–	19.21 (15.36–23.06)	12 (8.8–15.19)	0.03[c]

[a] All women from the five countries combined. Chi squared trend for age, $p<0.001$
[b] Twenty participants excluded aged 80 and over (n=261)
[c] Comparison between countries: Argentina (A), Brazil (B), Mexico (M), Puerto Rico (PR)
A vs B (p = 0.42); A vs M (p = 0.25); A vs PR (p = 0.085); B vs M (p = 0.054); B vs PR (p = 0.34); M vs PR (p = 0.004)

starts by deriving normal values of vertebral dimensions from the study population using the statistical trimming method described by Black [10]. The reference normal values for the Latin American countries participating in this study were derived by a biostatistician (L.P.) at the San Francisco Coordinating Center.

A fracture was diagnosed in a vertebral body based on measurements of vertebral heights. A fracture was defined if a

Table 2 Characteristics of participants

Variable	Argentina	Brazil	Colombia[a]	Mexico	Puerto Rico	Total
Sample size	420	415	281	406	400	1,922
Age (mean ± SD)	68.98±10.58	69.36±11.22	65.47±9.44	69.55±11.87	67.50±10.73	68.36±10.96
Height (mean ± SD)	154.43±6.68	152.78±6.17	154.46±6.29	147.69±6.71	153.81±8.23	152.44±7.37
Weight (mean ± SD)	67.31±12.59	62.69±13.12	62.33±13.00	63.08±12.31	69.06±13.48	65.18±13.17
Maternal history of Fx (%)	10.7	10.6	8.2	6.2	7.3	8.63
Personal history of Fx (%)	25.0	24.3	17.4	20.7	26.0	23.0
Body Mass Index (%)						
Underweight	3.8	7.7	8.5	1.5	3.0	4.7
Normal	21.7	26.5	22.4	20.7	15.0	21.2
Overweight	45.2	42.4	27.4	42.1	47.8	41.9
Obese	29.3	23.4	12.5	35.7	34.3	27.9
Height loss (%)	56.43	35.2	27.76	60.84	37.25	44.59
Calcium≥800 mg (%)	22.4	22.2	5.3	25.9	52.8	26.9
Use of steroids (%)	3.1	3.4	5.3	3.7	1.5	3.3
HRT (%)	13.6	12.0	28.5	19.5	32.8	20.75
Smoking (%)						
Currently smokes	16.0	8.7	8.5	15.3	37.5[b]	17.6
Ever smoked	23.1	18.8	24.6	11.3		28.1
Never smoked	61.0	72.5	66.9	73.4	62.5	54.3
Alcohol intake (%)						
Never	34.5	81.7	75.8	75.1	85.3	69.9
1–10 g/day	63.6	16.6	23.8	23.4	9.3	27.8
10–40 g/day	1.7	1.2	0.0	1.5	4.8	1.9
>40 g/day	0.2	0.5	0.4	0.0	0.8	0.4
Physical activity (%)						
≥ 30 min/day	55.5	25.1	33.5	35.7	21.5	34.4

[a] The 20 participants aged 80 and over from Colombia were included in the risk factors analysis
[b] Puerto Rico asked current and ever in the same category

reduction of 3 SD or more from the normal mean for the vertebral level of anterior-to-posterior or middle-to-posterior heights ratios were found. In addition, a vertebral body was defined as a fracture if the ratios of posterior-to-adjacent posterior and the anterior heights-to-adjacent anterior were reduced by 3 SD or more compared with normal values.

Analysis

The prevalence of asymptomatic vertebral fractures was calculated for each age strata with a 95% confidence interval. A woman with at least one vertebral deformity was considered a case of vertebral fracture. Also, the prevalence of the different risk factors was estimated in each city. To compare the prevalence of vertebral fracture among cities for each age group, the Chi-squared test statistic was used. Since no significant difference was found among the countries, all data were pooled to evaluate the association of the different risk factors and the presence of vertebral fractures. We use a bivariate analysis to estimate the odds ratio and 95% confidence interval, followed by a logistic regression (full model and stepwise). Additionally, prevalence ratios adjusted for the different risk factors with 95% confidence intervals were estimated using the Cox regression model with constant time at risk, as suggested by Barros and Hirakata [15]. Finally, the

Table 3 Risk factors for vertebral fracture in Latin America

Variable[a]	*N* = 1,922	Percentage	Bivariate OR (CI 95%)	*P* value	Multivariate OR (CI 95%)	*P* value
Maternal history of fractures						
No	261/1,756	14.9	1.00		1.00	
Yes	21/166	12.7	0.83 (0.50–1.36)	0.83	0.91 (0.55–1.49)	0.71
History of fracture						
No	190/1,479	12.8	1.00		1.00	
Yes	92/443	20.8	1.78 (1.34–2.36)	0.001	1.52 (1.14–2.03)	0.04
Body mass index[b]						
Underweight	18/90	20.0	1.00		1.00	
Normal	56/408	13.7	0.64 (0.34–1.20)	0.18	0.70 (0.37–1.30)	0.26
Overweight	129/805	16.0	0.76 (0.43–1.37)	0.41	0.82 (0.45–1.47)	0.51
Obese	73/537	13.6	0.63 (0.34–1.16)	0.15	0.70 (0.38–1.30)	0.26
Height loss[c]						
No	70/709	9.9	1.00		1.00	
Yes	165/857	19.3	2.18 (1.60–2.97)	0.001	1.63 (1.18–2.25)	0.003
Calcium dietary						
< 800 mg	205/1,405	14.6	1.00		1.00	
≥ 800 mg	77/517	14.9	1.02 (0.76–1.37)	0.9	1.05 (0.77–1.43)	0.74
Use of steroids						
No	271/1,859	14.6	1.00		1.00	
Yes	11/63	17.5	1.24 (0.60–2.49)	0.64	1.13 (0.56–2.28)	0.72
HRT						
No fracture group	239/1,525	15.7	1.00		1.00	
Fracture group	43/397	10.8	0.65 (0.46–0.93)	0.02	0.73 (0.50–1.04)	0.08
Smoking						
Never	191/1,293	14.8	1.00		1.00	
Ever	65/440	14.8	1 (0.72–1.31)	0.99	1.21 (0.88–1.68)	0.23
Current	26/189	13.8	0.91 (0.56–1.44)	0.66	1.07 (0.67–1.72)	0.75
Alcohol intake g/day						
Never	187/1,343	13.9	1.00		1.00	
1–10	85/535	15,9	1.17 (0.81–1.50)	0.56	1.11 (0.80–1.53)	0.52
11–40	8/37	21.6	1.71 (0.71–3.97)	0.17	1.74 (0.75–4.04)	0.19
> 40	2/7	28.6	2.47 (0.33–14.42)	0.47	2.63 (0.48–14.39)	0.26
Physical activity						
0–29 min/day	201/1,260	16.0	1.00		1.00	
≥ 30 min/day	81/662	12.2	0.73 (0.55–0.98)	0.03	0.79 (0.58–1.07)	0.14

[a] Age and race not presented but also were included and adjusted in the model
[b] Missing 82 participants
[c] Missing 356 participants

Table 4 Standardized rates of asymptomatic vertebral fractures using the 2006 Mexican and USA population age distribution

Age	LAVOS[c] pooled data	Argentina	Brazil	Colombia	Mexico	Puerto Rico
Mexican[a] population	11.18 (9.23–13.14)	13.51 (11.39–15.63)	10.20 (8.33–12.08)	7.90 (6.23–9.57)	13.56 (11.44–15.68)	9.27 (7.47–11.06)
USA[b] population	12.69 (10.63–14.76)	14.52 (12.34–16.71)	11.69 (9.70–13.68)	8.36 (6.65–10.08)	15.67 (13.42–17.92)	10.57 (8.66–12.47)

[a] 2006 Mexican age distribution population
[b] 2006 USA age distribution population
[c] All women from the five countries combined

prevalence of vertebral fractures was age standardized with the direct method against Mexican and US populations for comparison [16, 17]. Statistical analyses were performed using the SPSS Program (12th edition).

Results

Seventy-one percent of the randomly selected women agreed to participate in the study. Because of financial limitations only 281 women were enrolled at Barranquitas (Colombia). A total sample of 1,922 women was included for the LAVOS study with a mean age of 68.4 years. Although radiographs were obtained in all women, X-rays for 20 (1.8%) of them were not evaluated due to inadequate positioning or technical errors in obtaining the radiographs. The present analysis is based on 1,902 women who had morphometric measurements of their spine radiographs.

Table 1 shows the prevalence of asymptomatic vertebral fractures by age stratum and country. As expected, the prevalence of asymptomatic vertebral fractures steadily increased from ages 50–59 years to over 80 years. Although modest differences in the prevalence of asymptomatic vertebral fractures were observed in the different countries, by age strata, these were not statistically significant. The higher prevalence of asymptomatic vertebral fractures were found in Mexican women 80 years and older ($p=0.06$). A significant difference was observed. In the overall prevalence when we included all women from the five countries, probably related to the imbalance of the sample in this older group since different cut-off points were set for some countries. The combined figures from the five countries showed that the prevalence increased from 6.9% among those aged 50 to 59 to 27.8% in those aged 80 and over ($p=0.001$) .The prevalence of potential risk factors for fracture in each country is shown in Table 2. Modest differences were found in some of these factors across the countries such as HRT and dietary calcium, which appears to be higher in Puerto Rico, and the highest self-report of height loss is in Mexicans. The other characteristics seem to be similar in all countries. When we analyzed fractures for all countries combined, in the bivariate analysis significant associations ($p<0.001$) were observed for history of fracture after age 50 (OR=1.78; 95% CI: 1.34–2.36) and height loss (OR=2.18; 95% CI: 1.60–2.97). Hormone replacement therapy was associated with 35% lower odds of having a vertebral fracture (OR=0.65; 95% CI: 0.46–0.93), as well as physical activity, with 27% lower odds of having a vertebral fracture (OR=0.73; 95% CI: 0.55–0.98). In the multivariate analysis (stepwise and full model), only two factors remained significant: history of fracture (OR=1.52; 95% CI: 1.14–2.03) and height loss (OR=1.63; 95% CI: 1.18–2.25) (Table 3). Using the Cox regression model for prevalence ratios the results were very similar; the same variables reached significance: history of fracture (PR=1.37; 95% CI: 1.06–1.77) and height loss (PR=1.57; 95% CI: 1.18–2.10). Standardized rates using the age distribution from the Mexican and USA populations for the year 2006 are presented in Table 4 for comparison with other international studies.

Table 5 Prevalence of asymptomatic vertebral fractures in different studies that used a similar method of assessing vertebral fractures

Age	SOF White	Beijing	LAVOS
50–59	–	4.1 (0.6–7.7)	6.9 (4.6–9.1)
60–69	14.5[a] (13.4–15.5)	12.6 (7.0–16.2)	10.2 (7.6–12.8)
70–79	22.0 (20.8–23.3)	17.5 (10.7–24.3)	18.0 (14.7–21.3)
> 80	33.9 (30.9–36.9)	27.1 (15.8–38.5)	27.8 (22.1–31.0)

[a] The Study of Osteoporotic Fractures (SOF) included women aged 65 years or over

Discussion

This is the first study on the prevalence of asymptomatic vertebral fractures in the Latin American population of women aged 50 years and over. Five cities from five countries of Latin America were included in the study, including the two most populated countries within the region, which comprise a little over 60% of the Latin American population (Brazil and Mexico)[18, 19]. We found that the prevalence of vertebral fractures was similar in these countries and, when pooled, increased from 6.9% in women aged 50 to 59 to 27.8% in women over 80.

There appeared to be modest variation of the prevalence between the different cities, Puebla (Mexico) estimates were the highest within the region in almost all age strata, and San Juan (Puerto Rico) the lowest. Although no differences were found when analyzed by age strata in an overall sample of women aged up to 79 years, a significant difference was found when all ages were included. We think that this could be an spurious association reflecting the variability due to the disparity of the sample in the sample of women aged 80 or over.

Our study demonstrates that the prevalence of radiographically ascertained vertebral fractures in Latin American women is similar to the prevalence of vertebral fractures that have been reported using the same methodology in other studies and slightly lower than in US whites, as shown in Table 5. Regional variations in the prevalence of vertebral fractures have been previously reported in multicenter studies in Europe where a 3-fold range difference was found. The European Prevalence Osteoporosis Study (EPOS) reported a higher prevalence in Scandinavian countries (Norway 23.7 and Sweden 27.8) and lower rates for some cities of Southern Europe (Madrid 14.9), Mediterranean countries (Turkey, 15.9), and Russia (12.7) [4].

Included in our questionnaire were several clinical risk factors known to be associated with osteoporosis and fractures. With the exception of a higher proportion of calcium intake (52.8% reported 800 mg/day) and women with HRT (32.8%) in San Juan (Puerto Rico), and a higher proportion of women in Buenos Aires (Argentina) reporting physical activity of 30 min or more (55.5%) the prevalence of the majority of risk factors was similar across the countries, and this fact might explain the similar prevalence of rates in the region.

Additionally, other factors associated with vertebral fractures in our population were: history of fracture and self-report of height loss. Hormone therapy and physical activity apparently protect women against vertebral fractures, although the associations with these two variables did not remain statistically significant in the multivariate analysis.

The study has several strengths. The results are based on random samples of major cities and there was a relatively high rate of participation. All of the countries followed standardized approaches to recruiting participants, obtaining X-rays, assessing potential risk factors and all of the films were assessed centrally using the same methods that have been employed in studies in the US and China. In addition, vertebral fractures were based on normal values for each of the five countries derived from the same studies.

Our study also had limitations. It was not specifically designed to characterize the risk factors for vertebral fracture; therefore, we had limited power to find significant associations for some of the risk factors that were uncommon in the population. As a cross-sectional study, we were not able to determine how many fractures caused significant pain or disability. And since no uniform definition of vertebral deformity due to osteoporosis fractures has been accepted, they might be a chance that not all radiographic fractures found in this sample can be attributed to osteoporosis. However, this limitation is found in almost all studies of this type.

In conclusion, vertebral fractures in Latin American women are common. The prevalence is only slightly lower than that found in white women in the USA and similar to that found in Chinese women from Beijing using similar methodology, and although different definitions were used, the rate in Latin America appears to be similar to rates reported for southern Europe and the Mediterranean. These results reinforce the view that the prevalence of vertebral fractures has been more similar across regions than that seen for hip fractures [20].

It is important to recognize this health problem in older Latin American women since vertebral fractures may cause substantial disability and a negative impact on quality of life that has not previously been recognized. In the light of these results, doctors and health authorities in the Latin American region should recognize that radiographically confirmed vertebral fractures are common in Latin American women and measures should be implemented to identify women at risk of vertebral fractures and provide public health advice and, where appropriate, medical treatment to reduce that risk.

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Conflicts of interest None.

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