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The prevalence of low bone mineral density in women aged 55 years or older and the association with socioeconomic factors across the Globe

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Abstract

Background Previous epidemiological studies have reported significant regional variations in the global prevalence of osteoporosis. However, these variations cannot be fully explained by known risk factors.

Aim This study aims to explore the regional variations in the global prevalence of low bone mineral density (LBMD) among women aged 55 years or older and its association of socioeconomic factors.

Methods We used data from the 2019 Global Burden of Disease (GBD 2019) to highlight the regional differences in the prevalence of LBMD among women aged 55 or older worldwide. We then examined the correlations between LBMD in this demographic and four socioeconomic factors: GDP, urbanization ratio, prevalence of undernourishment (sourced from the World Bank), and current health expenditure (CHE) (obtained from the World Health Organization). To investigate the relationships between LBMD in women aged 55 and older and the urbanization ratio, prevalence of undernourishment, and CHE, we utilized linear mixed models.

Results The age-standardized summary exposure value (ASSEV) of LBMD in women aged 55 or older was highest in Western Sub-Saharan Africa (42.88, 95% UI, 33.43–53.04 in 1990 and 39.68, 95% UI, 30.42–49.66 in 2019), followed by Eastern Sub-Saharan Africa, Central Sub-Saharan Africa, and Southeast Asia. The lowest ASSEV was found in Central Asia (20.21, 95% UI, 13.74–27.39 in 1990 and 18.14, 95% UI, 12.03–25.67 in 2019), followed by Western Europe. The ASSEV of LBMD in women aged 55 or older was negatively correlated with CHE (β =-2.39, $P < 0.001$) and positively correlated with the prevalence of undernourishment (β = 1.76, $P < 0.001$). No significant correlation was found between the ASSEV of LBMD in women aged 55 or older and the urbanization ratio.

Conclusions Socioeconomic factors have close relationship with LBMD. The imbalances of socioeconomic development might be the reason for variations of LBMD in women aged 55 or older worldwide. Reduction of undernourishment and enhancement of health expenditure might contribute to preventing LBMD. A limited

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increase in health investment could greatly decrease the prevalence of LBMD, especially in regions with low health expenditure.

Keywords Low bone mineral density, Osteoporosis, GDP, Urbanization, Undernourishment, Health expenditure

Background

Osteoporosis is a systemic skeletal disorder characterized by compromised bone mass and microarchitecture, leading to increased bone fragility and fracture risk [1]. It seriously threatens the health and quality of life of patients [2].

Based on the 2019 Global Burden of Disease (GBD 2019) [3], epidemiological studies revealed an imbalance in the regional prevalence of low bone mineral density (LBMD): LBMD is more prevalent in Sub-Saharan Africa and Southeast Asia, while it is lower in Western Europe and Central Asia [4, 5]. However, this disparity cannot be explained by known risk factors, even when age and gender, the primary contributors to LBMD, are controlled in the analysis. Potential contributors to these regional variations include race, dietary and lifestyle habits, and socioeconomic development levels. While it is known that osteoporosis is more prevalent in Caucasians, this racial group is not t the majority in Sub-Saharan Africa and Southeast Asia. Additionally, specific diet or lifestyle habits in these areas, such as widespread smoking, excessive alcohol intake, or imbalances in phosphorus intake, which could account for the higher prevalence, were not identified. Therefore, it is likely that differences in socioeconomic development may be the most possible factor contributing to the observed disparities in LBMD prevalence.

A previous study found that LBMD is more prevalent in low-income countries, but the authors attributed this to ethnicity, anthropometric variables, and nutrition status [4].However, this explanation may not be entirely convincing. Another study also found similar regional variations in the global distribution of LBMD, but only provided a general explanation based on regional differences in life expectancy, quality of life, and access to healthcare services [5]. These conclusions were drawn from data on the Socio-Demographic Index (SDI) in GBD 2019. However, SDI is generated from three indicators: lag-distributed income per capita, mean education for those 15 years old and older, and the total fertility rate for those younger than 25 years old [3]. These three indicators of SDI may not accurately represent the socioeconomic factors associated with osteoporosis, such as TFR.

According to analysis on the risk factors for osteoporosis listed in the American and Euro guidelines [2, 6], we used four socioeconomic factors sourced from the World Bank (WB) and the World Health Organization (WHO), including gross domestic product (GDP), urbanization ratio, prevalence of undernourishment, and current health expenditure (CHE). There was a total of 17 risk factors listed in the 2020 AACE guidelines and the 2019 ESCEO-IOF guideline [2, 6]. Apart from three unmodifiable risk factors - aging, family history, and race - the negative effects of other risk factors can be reduced to varying degrees through four interventions: timely and effective medical interventions, health education, appropriate nutrition, and access to physical exercise. Global guidelines have confirmed the positive impact of these interventions on improving osteoporosis. In this study, our aim was to explore the socioeconomic indicators that influence the effectiveness of these interventions. We have selected GDP, urbanization rate, undernourishment prevalence, and CHE as the socioeconomic indicators to be examined, based on the characteristics of these interventions. According to the WHO definition, malnutrition encompasses two main aspects: deficiency/imbalance, or excess of nutrient intake. Given the conclusion that low body weight is a risk factor for osteoporosis [2, 6], this discussion will primarily focus on undernutrition.

Furthermore, there is a lack of global epidemiological research focused specifically on older women, particularly those who are postmenopausal. This group has a significantly higher incidence of low bone mineral density (LBMD) compared to men of the same age or younger women [4–9].

The purpose of this study was to explore regional variations in the global distribution of LBMD in women aged 55 or older, and to examine its association with selected socioeconomic factors.

Methods

We conducted an epidemiological study to explore the relationship between the prevalence of LBMD in women aged 55 and older and four socioeconomic factors.

Firstly, we conducted a descriptive analysis of the ASSEV of LBMD in women aged 55 or older, utilizing thermograms. After matching the country names in the different databases, we investigated the correlation between LBMD prevalence and four specific socioeconomic factors with scatter plots, respectively. Finally, we utilized linear mixed-effect models to further examine the relationship between LBMD prevalence and these four socioeconomic factors.

Our research has collected data on the prevalence of LBMD in women aged 55 and older from 1990 to 2019, by countries and regions, using the GBD 2019 dataset. We then collected data from WB websites, including the GDP from 1990 to 2019, urbanization ratio from 1990 to

2019, and prevalence of undernourishment from 2001 to 2019 (this data was unavailable before 2001). CHE data from 2000 to 2019 (unavailable before 2000) were collected from the WHO website.

Outcome variable

Age standardized summary exposure value (ASSEV) of LBMD in women aged 55 or older

The data on osteoporosis used in this study were obtained from the GBD 2019 study (https://vizhub.healthdata.org/gbd-results/), which covers the years 1990 to 2019. In the GBD 2019 report, both osteopenia and osteoporosis were considered as LBMD [3]. The exposure value of LBMD in GBD 2019 does not reflect the actual prevalence of LBMD in a specific country or region. It reflects the relative risk across regions and countries by weighting the relative risk of a region or country relative to the difference between the 99th percentile of age-sex-specific BMD in the National Health and Nutrition Examination Survey (NHANES) study. After adjusting for age, the relative risk value (ASSEV) can be considered a continuous variable. To specifically target postmenopausal women, our study focused on individuals aged 55 years or older.

Exposure variables

GDP

GDP is a continuous variable that measures the total value of all goods and services produced in a country during a specific period. The GDP data from 1990 to 2019 was obtained from the World Bank. Website (https://data.worldbank.org/indicator/NY.GDP.MKTP.CD? view=chart) Current US dollars are used as the statistical unit, with amounts converted from domestic currencies to official exchange rates for the respective year.

Urbanization ratio

The urbanization ratio from the WB website is a continuous variable which refers to the percentage of urban population relative to the total population for a given year. We collected urbanization ratios from 1990 to 2019 for analysis. (https://data.worldbank.org/indicator/SP.URB.TOTL.IN.ZS)

Prevalence of undernourishment

Here the prevalence of undernourishment refers to the percentage of people whose dietary intake is insufficient to maintain a normal, active, and healthy life. It is a continuous variable. This data was obtained from the WB website, with records available from 2001 to 2019. (https://data.worldbank.org/indicator/SN.ITK.DEFC.ZS)

Current health expenditure (CHE) per capita

The WHO has been collecting CHE data from its 190 member states since 2000. Health expenditure includes all expenditures for the provision of health services, family planning activities, nutrition activities and emergency aid designated for health, but excludes the expenditures for drinking water and sanitation. CHE per Capita is a continuous variable measured in US dollars. We have gathered data on CHE from 2000 to 2019 for analysis. (https://apps.who.int/nha/database/Select/Indicators/en)

Statistical analysis

Firstly, we created a thermogram to descriptively analyze the ASSEV of LBMD in women aged 55 or older in a global sample for the years 1990 and 2019. The estimated metrics were accompanied by 95% uncertainty intervals (UIs). These intervals were calculated by drawing 1000 times from the posterior distribution of each quantity and using the 2.5th and 97.5th percentiles of the uncertainty distribution.

Afterwards, we generated scatter trend diagrams to examine the association between the AASEV of LBMD in women aged 55 or older and the four socioeconomic factors.

Lastly, we employed linear mixed models fitted to maximum likelihood to assess the associations between the ASSEV of LBMD in women aged 55 or older and urbanization ratio, prevalence of undernourishment, and CHE. Because the ASSEV of LBMD in women aged 55 or older was repeatedly measured from 1999 to 2019 and possible inherent differences in disease prevalence among different countries/regions that have not been observed (such as genetic, cultural, environmental factors), we included the three socioeconomic factors as fixed effects and global region and year as random effects into the linear mixed models. It was assumed that there would be a constant correlation between the ASSEV of LBMD in women aged 55 or older and the three socioeconomic factors within a single country. The variability between-region and within-region correlation of ASSEVs of LBMD in women aged 55 or older were taken into account in this model.

All data obtained from three data sources was cross-compared to ensure completeness of the data. The cases with missing data were removed. All data from this study were imported into Excel files and analyzed using the R version 3.5.3 (R Foundation for Statistical Computing, Vienna, Austria). A significance level of $P<0.05$ was used to determine statistical significance.

Results

The ASSEVs for LBMD in women aged 55 or older in total 204 countries and 21 regions from 1990 to 2019 were collected. We collected GDP data for 222 countries from 1990 to 2019, urbanization ratios for 263 countries from 1990 to 2019, and prevalences of undernourishment for 209 countries from 2001 to 2019, from the

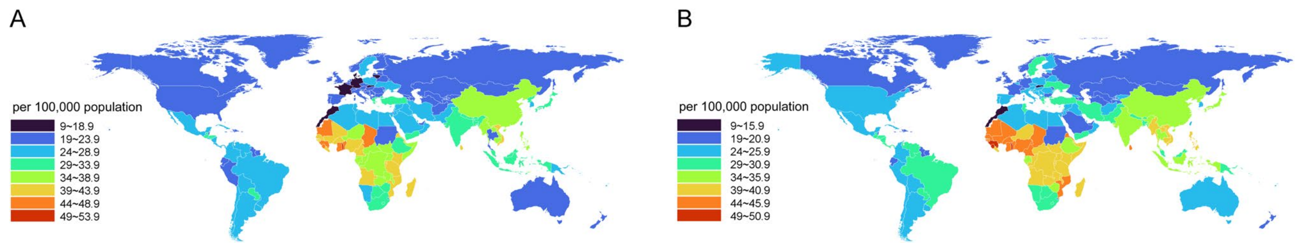

Fig. 1 Global distribution of age-standardized summary exposure values (ASSEVs) for low bone mineral density in women aged 55 or older. **A** 1990. **B** 2019

Table 1 Global distribution of standardized summary exposure value (SEV) for low bone mineral density in women aged 55 or older in 1990 and 2019

GBD region	1990	2019	Difference between 2019 and 1990
Andean Latin America	22.73 (15.44–30.98)	20.63 (13.93–28.43)	−2.11
Australasia	22.44 (17.18–28.75)	20.3 (13.27–28.15)	−2.14
Caribbean	21.99 (16.13–28.45)	19.45 (13.08–26.68)	−2.54
Central Asia	20.21 (13.74–27.39)	18.14 (12.03–25.67)	−2.07
Central Europe	22.81 (16.19-30)	21.42 (15.18–28.23)	−1.39
Central Latin America	25.95 (18.73–33.79)	24.79 (17.79–32.15)	−1.16
Central Sub-Saharan Africa	34.74 (25.13–45.22)	34.93 (25.24–44.83)	0.2
East Asia	35.36 (27.1-44.05)	31.28 (23.82–39.11)	−4.08
Eastern Europe	21.07 (14.67–28.11)	20.19 (14.13–27.34)	−0.88
Eastern Sub-Saharan Africa	36.74 (27.98–46.41)	35.25 (26.56–43.97)	−1.5
High-income Asia Pacific	29.53 (22.07–37.26)	29.66 (23.11–36.56)	0.13
High-income North America	22.75 (16.68–29.56)	24.26 (17.61–31.44)	1.51
North Africa and Middle East	25.25 (18.19–32.96)	23.58 (16.75–30.99)	−1.67
Oceania	26.53 (18.59–35.32)	25.62 (17.95–33.71)	−0.92
South Asia	29.92 (21.82–38.3)	29.06 (21.29–37.6)	−0.86
Southeast Asia	33.64 (25.87–41.99)	33.16 (25.62–40.83)	−0.47
Southern Latin America	26.16 (18.75–34.46)	23.96 (16.98–31.22)	−2.19
Southern Sub-Saharan Africa	30.95 (22.99–39.29)	28.93 (21.33–37.5)	−2.02
Tropical Latin America	28.55 (20.66–37.02)	25.86 (18.45–34.04)	−2.68
Western Europe	20.33 (14.79–26.85)	19.42 (13.62–26.06)	−0.91
Western Sub-Saharan Africa	42.88 (33.43–3.04)	39.68 (30.42–49.66)	−3.2
Overall	27.88 (20.94–35.26)	27.47 (20.37–34.81)	−0.41

WB websites. Additionally, there were CHE data for 182 countries from 2000 to 2019 on obtained from the WHO website. After comparing data from the three resources and removing missing data, a total of 182 cases were included in the statistics.

Global distribution of LBMD in women aged 55 or older

As shown in Fig. 1; Table 1, there were significant regional variations in the global distribution of osteoporosis. The highest ASSEV for LBMD in women aged 55 or older was found in Western Sub-Saharan Africa, with values of 42.88 (95% UI, 33.43, 53.04) in 1990 and 39.68 (95% UI, 30.42, 49.66) in 2019. This was followed by Eastern Sub-Saharan Africa, Central Sub-Saharan Africa and Southeast Asia. In contrast, the lowest ASSEV for LBMD in women aged 55 or older was observed in Central Asia and Western Europe. When comparing the data from 1990, the ASSEVs of LBMD in women aged 55 or older decreased in most regions worldwide in 2019, except for Central Sub-Saharan Africa, High-income Asia Pacific, and High-income North America.

ASSEVs of LBMD in women aged 55 or older and GDP

Figure 2 illustrates scatter trend diagrams for the relationship between the ASSEVs of LBMD in women aged 55 or older and GDPs. In 1990, our study revealed an inverted U-shaped relationship between ASSEVs of LBMD in women aged 55 or older and GDP. Specifically, countries with medium GDP showed higher ASSEVs of LBMD in the group, while those with low or high GDP had lower ASSEVs. This relationship evolved into a sigmoidal pattern in 2019, where ASSEVs to LBMD in women aged 55 or older were higher in the countries with the lowest or medium GDP and lower in the countries with low or very high GPD.

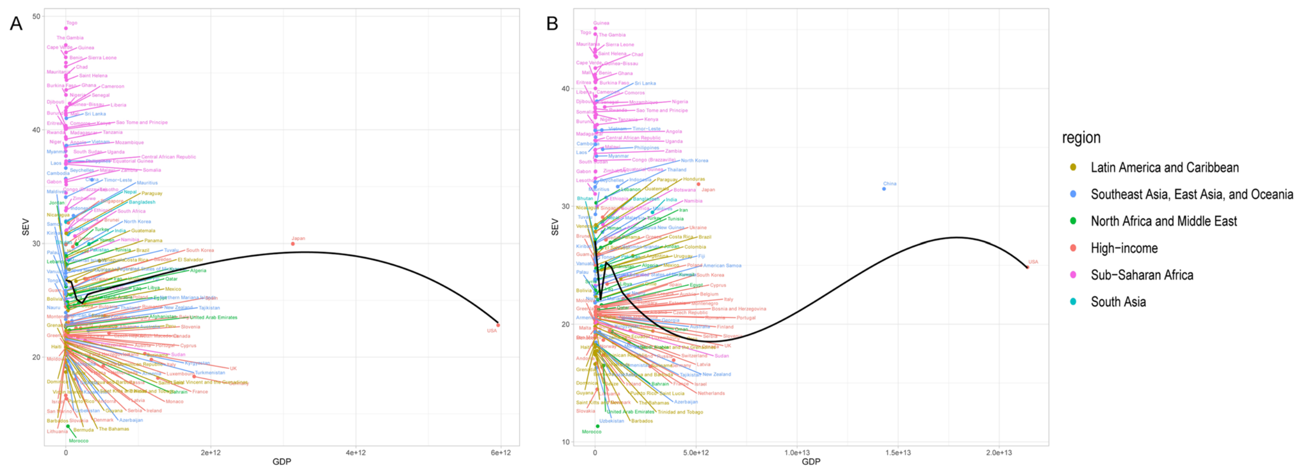

Fig. 2 Scatter trend diagram of the ASSEVs of low bone mineral density in women aged 55 or older and GDP (current UD$) at the country level. **A** 1990. **B** 2019. ASSEV, age standardized summary exposure value

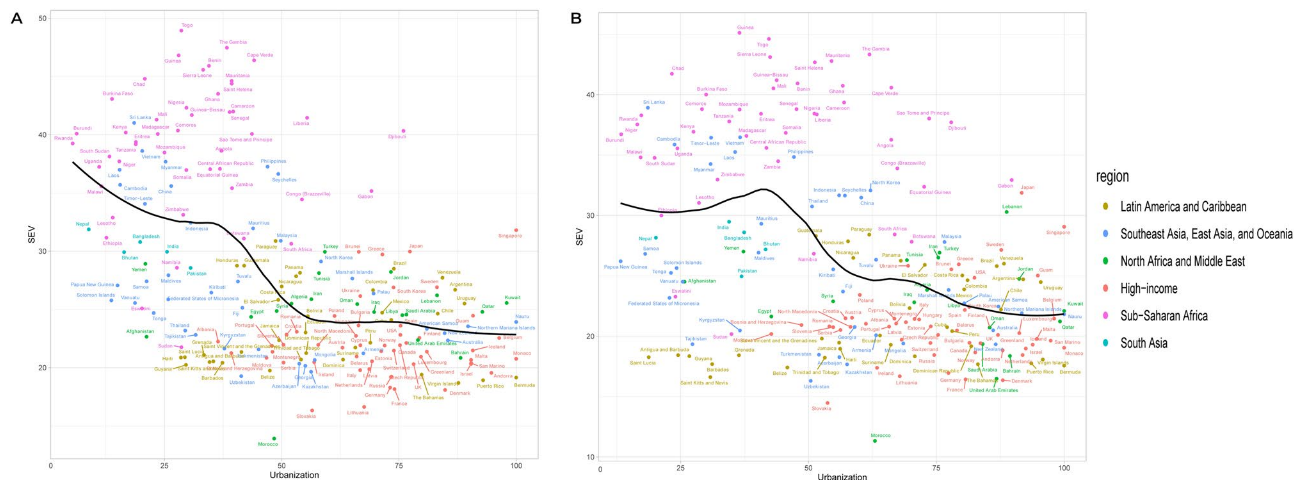

Fig. 3 Scatter trend diagram of the ASSEVs of low bone mineral density in women aged 55 or older and ratios of urbanization (% of total population) in country level. **A** 1990. **B** in 2019. ASSEV, age standardized summary exposure value

ASSEVs of LBMD in women aged 55 or older and urbanization ratio

Figure 3 shows that the ratio of urbanization was negatively correlated with the ASSEVs of LBMD in women aged 55 or older, indicating that women aged 55 or older had lower ASSEVs of LBMD in countries with high ratios of urbanization. This trend was similar in 1990 and 2019.

ASSEVs of LBMD in women aged 55 or older and prevalence of undernourishment

Figure 4 demonstrates the trend line for ASSEVs of LBMD in women aged 55 or older and the prevalence of undernourishment. A logarithmic curve was observed in 2001, indicating that the ASSEVs in women aged 55 or older were lower in countries with lower prevalence of undernourishment. This relationship became more pronounced in 2019.

ASSEVs of LBMD in women aged 55 or older and current health expenditure per capita (CHE)

A "L"-shaped relationship was found between the ASSEVs of LBMD in women aged 55 or older and CHEs in both 2000 and 2019 (see Fig. 5). In 2000, the ASSEVs to LBMD in women aged 55 or older were significantly higher in countries with CHEs less than 200 USD. However, they decreased sharply and remained at a low level when CHEs exceeded 200 USD. This trend was also observed in 2019, as the ASSEVs of LBMD in women aged 55 or older were relatively low in countries with CHEs of 350 USD or higher.

Linear mixed model analysis

We performed linear mixed models to examine the relationships between the ASSEVs of LBMD in women aged 55 or older and urbanization ratio, prevalence of undernourishment, and CHE. Model 1 did not adjust any

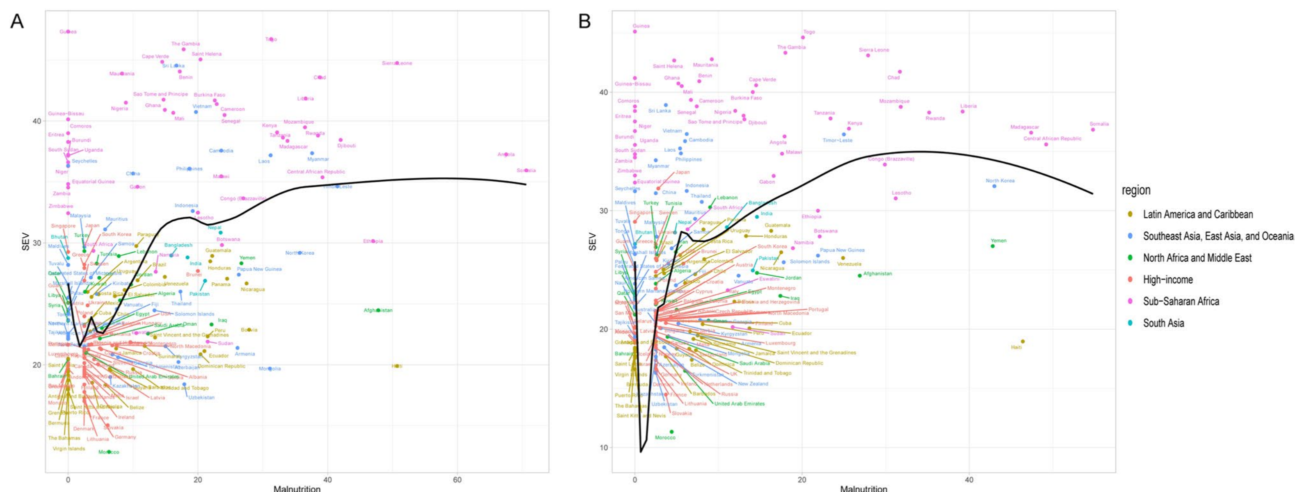

Fig. 4 Scatter trend diagram on the ASSEVs of low bone mineral density in women aged 55 or older and prevalences of undernourishment (% of population) at the country level. **A** 2001. **B** 2019. ASSEV, age standardized summary exposure value

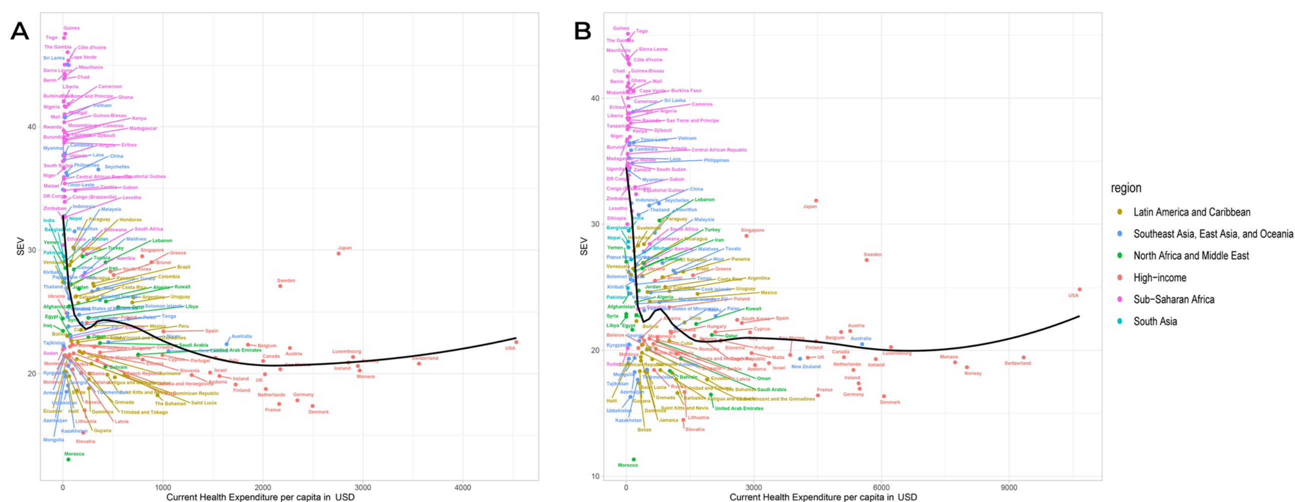

Fig. 5 Scatter trend diagram of the ASSEVs of low bone mineral density in women aged 55 or older and CHE per Capita (UD$) at the country level. **A** 2000. **B** 2019. ASSEV, age standardized summary exposure value

Table 2 Linear mixed model the relationships between the age standardized summary exposure value of low bone mineral density in women aged 55 or older and socioeconomic factors

	Model 1		**Model2**		**Model3**	
	Estimate (95%CI)	***P* value**	**Estimate (95%CI)**	***P* value**	**Estimate (95%CI)**	***P* value**
Urbanization ratio	0.33 (−0.33-1.00)	0.324	0.36 (−0.31- 1.02)	0.296	0.35 (−0.31-1.02)	0.297
Prevalence of undernourishment	1.76 (1.38–2.14)	< 0.001	1.77 (1.38–2.15)	< 0.001	1.76 (1.37–2.16)	< 0.001
CHE	−2.37 (−2.60–2.13)	< 0.001	−2.39 (−2.63- −2.16)	< 0.001	−2.39 (−2.63- −2.15)	< 0.001

Model 1: no covariates were adjusted

Model 2: calendar year was adjusted

Model 3: regional data in GBD 2019 was adjusted additionally

CHE Current health expenditure per capita (UD$)

covariates; Model 2 adjusted for calendar year data; and Model 3 additionally adjusted for reginal data in GBD 2019. The results from all three models consistently showed trends for the three socioeconomic factors (see Table 2).

Considering the multicollinearity between GDP with urbanization ratio, prevalence of undernourishment, and health expenditure [10–12], and tested VIF ≥ 5, GDP was not included in the linear mixed modelling analysis.

The ASSEVs to LBMD in women aged 55 or older were negatively correlated with CHE ($P < 0.001$). Conversely, the ASSEVs of LBMD in women aged 55 or older were positively correlated with the prevalence of undernourishment ($P < 0.001$). No statistically significant correlation was found between the ASSEVs to LBMD in women aged 55 or older and urbanization ratio. The sensitivity analysis showed that the relationships were robust.

Sensitive analysis

We performed multiple imputation for cases with missing data and discarded in the initial step. They were then included in a linear mixed model for sensitivity analysis. And similar results were produced in sensitivity analysis.

Discussion

The distribution of LBMD in women aged 55 or older worldwide in our study were consistent with the results of other studies based on the GBD 2019 data [4, 5]. We found that the highest ASSEVs of LBMD in women aged 55 or older were in Western Sub-Saharan Africa, followed by Eastern Sub-Saharan Africa, Central Sub-Saharan Africa, and Southeast Asia. The lowest ASSEVs to LBMD in women aged 55 and older were found in Central Asia and Western Europe. Dong et al. (2022) studied women of all age groups and found that the highest ASSEVs of LBMD were present in Western Sub-Saharan Africa. This trend was consistent with regional rankings in Eastern Sub-Saharan Africa, Central Sub-Saharan Africa, and Southeast Asia [4]. They found the lowest ASSEVs of LBMD in Western Europe, followed by Central Asia and Australasia. Similar results were also reported by Panahi et al. (2023) [5].

Our scatter trend diagrams revealed that the LBMD in women aged 55 or older was higher in developing countries, but lower in both underdeveloped and developed countries, except for those with extremely underdeveloped economies. Our findings could not be directly compared with previous studies on the relationship between GDP and both osteoporosis and other chronic diseases, as there was a limited amount of research on this topic. We speculated that an extremely low GDP may could potentially contribute to the development of LBMD as an indirect risk factor. While a higher GDP may suggest a better food supply, its effects on health investment, medical security, and social welfare are still uncertain. One study showed that GDP growth only accounted for 43% of the growth in health expenditure [10]. From our study, we can draw two main conclusions. Firstly, there is an overall negative correlation between GDP and LBMD in women aged 55 or older. This is in line with the results of other studies that have used the SDI of GBD as a reference index [4, 5]. Secondly, LBMD in women aged 55 or older appears more severe in countries with medium and high GDP. This may be attributed to the fast-paced lifestyle and in heightened work pressure that often accompany economic development. A large-scale study showed that in 2016, the prevalence of insufficient physical activity in high-income countries was more than twice that in low-income countries [13]. Another study revealed that inadequate physical activity is a significant issue in high-income and middle-income countries, particularly those with income inequalities [14].

There was no significant correlation found between the ASSEVs of LBMD in women aged 55 or older and urbanization globally. Previous researches on this topic yielded inconsistent results across different countries. For example, studies conducted in China, India, South Korea, and Spain have shown a higher prevalence of LBMD in rural areas compared to urban areas [15–18], whereas studies in the UK, Greece, and Canada have reported the opposite [19–21]. These conflicting results may indicate that physical activity has a greater impact in developed countries, where medical services and health education are more evenly distributed between rural and urban areas. However, in developing countries, limited access to improved medical services and health education in rural areas are likely the primary factors affecting LBMD. Therefore, the impact of urbanization on risk factors related to osteoporosis is complex and can result in different effects under different conditions, making it difficult to form a consistent conclusion.

We discovered a positive correlation between the ASSEVs of LBMD in women aged 55 or older and undernourishment. The prevalence of LBMD were significantly lower in countries with lower undernourishment ratios compared to those with higher ratios. Previous research and guidelines have consistently emphasized the role of balanced nutrition in preventing LBMD at all stages of life. Adequate nutrition from early childhood plays a crucial role for achieving peak BMD and reducing the risk of LBMD later in life [22]. Furthermore, maintaining a balanced diet is also considered a key factor in preventing postmenopausal LBMD, as supported by multiple studies [2, 23, 24].

The most significant finding of our study is the correlation between the ASSEVs of LBMD in women aged 55 or older and CHE. As CHEs increased, the ASSEVs of LBMD in women aged 55 or older showed a significant decrease, but only when CHEs were below a certain threshold (approximately 350 USD in 2019). Once CHE exceeded this level, the ASSEVs of LBMD in women aged 55 or older remained consistently low. The overall relationship between them can be described as a 'L'-shape. This discovery suggests that the ASSEVs of LBMD in countries with limited access to healthcare could be greatly affected by health expenditures. A slight increase in healthcare investment has the potential to significantly

enhance LBMD outcomes within this particular population, especially in areas with very low health expenditure. The impact of health expenditure can be attributed to two factors: improved medical services and health education. Firstly, enhanced healthcare facilities offer medications for both the prevention and treatment of osteoporosis [2, 25, 26]. Effective treatment also delays the progression of chronic diseases, such as chronic kidney disease and tumor, thereby preventing the development of osteoporosis as a complication [27–31]. Secondly, improved health education assists individuals in decreasing their likelihood of smoking and excessive drinking, both of which can lead to the development of LBMD [32–35]. Additionally, effective health education helps individuals adopt healthy lifestyle and dietary habits, while also increasing their awareness of disease prevention [36, 37].[36,37] Numerous studies have demonstrated that regular physical exercise, a balanced diet, and adequate intake of calcium and vitamin D play a crucial role in achieving peak bone mineral density in adulthood, which is essential in LBMD prevention [38–43]. Based on our findings, it is clear that increasing CHE has a more significant impact on preventing LBMD in low-income countries. Taking into account our previous results on urbanization and undernourishment, in low-income countries, increasing investment in CHE should focus on improving access to healthcare services (such as bone health screenings) and health education, as well as improving nutrition supply, as these are more effective means of reducing LBMD. This would guide more efficient investments in terms of enhancing health expenditure.

In summary, we have acknowledged that the causal pathway is complex in terms of how socioeconomic development affects the development of LBMD. Various factors would play significant roles through different intermediate links at different stages of socioeconomic development. Based on our findings regarding LBMD and CHE, there are several questions that still need to be addressed. Firstly, what is the inflection point for increasing health expenditure? Additionally, which factor plays a more significant role in enhancing health expenditure: medical services or nutrition? Lastly, what types of medical services are most effective in preventing LBMD: medicines, health education, or others? It is significantly valuable for LBMD prevention to make these topics clear.

There were several limitations in our study. Firstly, we relied on data from the GBD 2019 study. This may have introduced bias due to limited access to bone mineral density screening in certain countries, potentially affecting the accuracy of our results. Meanwhile, there may be a similar bias present in the statistics for GBP, urbanization ratio, prevalence of undernourishment, and CHE. Additionally, the definition of LBMD used in the GBD 2019 study did not align with clinical diagnosis criteria for osteopenia and osteoporosis [44, 45]. This could lead to discrepancies between our findings and those of national epidemiological investigations. Lastly, as an exploratory study, we did not consider other socioeconomic factors that may impact LBMD. Our findings suggest that socioeconomic factors play a significant role in preventing LBMD, and further research in this area is necessary.

Conclusion

Socioeconomic factors have close relationship with LBMD. The imbalances of socioeconomic development might be the reason for variations of LBMD in women aged 55 or older worldwide. Reducing undernourishment and increasing health expenditure may help prevent LBMD. A limited increase in health investment could greatly decrease the prevalence of LBMD, especially in regions with low health expenditure.

Authors' contributions

Yibiao Zhou and Jun Jiang designed the study. Jinyi Wu analyzed the data. Jun Jiang drafted the manuscript. Jun Jiang, Jinyi Wu, Yue Chen, and Yibiao Zhou contributed to the interpretation of the data and revision of the manuscript. All authors have read and agreed to the published version of the manuscript.

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Data availability

(1) Age standardized summary exposure value (ASSEV) of LBMD in women 55+: disease data from 1990 to 2019 used in this study were obtained from GBD 2019 study (https://vizhub.healthdata.org/gbd-results/). (2) GDP: this data from 1990 to 2019 were chosen as the basic economic indicator (https://data.worldbank.org/indicator/NY.GDP.MKTP.CD? view=chart). (3) Urbanization ratio: we collected urbanization ratios from 1990 to 2019 for analysis (https://data.worldbank.org/indicator/SP.URB.TOTL.IN.ZS). (4) Prevalence of undernourishment: this data were obtained from the World Bank website, with available records spanning from 2001 to 2019 (https://data.worldbank.org/indicator/SN.ITK.DEFC.ZS). (5) Current Health Expenditure (CHE): we collected CHE data from 2000 to 2019 for analysis (https://apps.who.int/nha/database/Select/Indicators/en).

Declarations

Ethics approval and consent to participate

Not applicable.

Consent for publication

Not applicable.

Competing interests

The authors declare no competing interests.

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