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Original Research Article

Community-based assessment of bone health and associated factors among elderly in an urban slum of Kolkata, West Bengal: a cross-sectional study

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ABSTRACT

Background: Osteoporosis and osteopenia are common metabolic bone disorders among the elderly, increasing fracture risk and disability. Urban slum populations are particularly vulnerable due to poor living conditions, limited health care access, and low awareness. This study aimed to assess bone mineral density (BMD) and its determinants, and to examine awareness and health-seeking behaviour among elderly residents of the Chetla slum, Kolkata, West Bengal.

Methods: A community-based cross-sectional study was conducted from January 2024 to February 2026 among 240 adults aged ≥60 years residing in the Chetla slum for at least one year. Participants were selected using a two-stage cluster sampling method. Data on sociodemographic characteristics, lifestyle, morbidity, and bone health awareness were collected via structured interviews. Anthropometry was measured using standard methods, and BMD was assessed at the calcaneus using a portable quantitative ultrasound densitometer. Osteopenia and osteoporosis were defined according to WHO criteria. Bivariate and multivariable logistic regression analyses identified independent predictors of low BMD.

Results: Mean participant age was 63.6±3.6 years; 67.5% were male. Low BMD was observed in 77.5% of participants. Independent predictors of low BMD included age >63 years (AOR 4.27, 95% CI 1.59-11.50), lower educational attainment (AOR 9.68, 95% CI 3.42-27.35), low physical activity (AOR 4.65, 95% CI 1.29-16.81), and lower socioeconomic status (AOR 2.10, 95% CI 0.96-4.57). Awareness of BMD testing was only 20%, and 35.5% of those with low BMD had not sought treatment.

Conclusions: Elderly residents of the Chetla slum exhibit a high prevalence of low BMD. Community-level interventions including routine BMD screening with portable densitometers, promotion of weight-bearing physical activity, nutritional supplementation, and improved access to geriatric care are recommended to reduce osteoporosis-related morbidity.

Keywords: Bone mineral density, Eastern India, Geriatric health, Osteopenia, Osteoporosis

INTRODUCTION

Bones provide the structural framework of the human body, enabling movement, protecting vital organs, and serving as a reservoir for essential minerals such as calcium and phosphorus required for several physiological functions. Healthy bones are therefore fundamental for maintaining mobility and independence throughout life. Conversely, deterioration in bone

strength can compromise these functions and predispose individuals to fractures and disability.[1,2]

Bone tissue is metabolically active and undergoes continuous structural changes through two physiological processes: modelling and remodelling. Bone modelling refers to the formation and resorption of bone at different sites, resulting in changes in bone shape and size, whereas bone remodelling involves the removal and replacement of bone tissue at the same site through the coordinated activity of osteoclasts and osteoblasts. These processes help maintain skeletal integrity and mineral homeostasis throughout life.[1] Peak bone mass is generally achieved between the ages of 20 and 40 years, after which gradual bone loss occurs. Maintaining adequate bone density during adulthood is therefore essential for preserving skeletal health in later life.[2]

Poor bone health commonly manifests as osteopenia and osteoporosis, which are important metabolic bone disorders. Osteoporosis is characterized by decreased bone mineral density (BMD) and deterioration of bone microarchitecture, resulting in increased bone fragility and susceptibility to fractures.[3] According to the World Health Organization (WHO), osteoporosis is defined as a BMD T-score ≤-2.5 standard deviations below the mean of a young healthy adult population, while osteopenia is defined as a T-score between -1.0 and -2.5.[4] These conditions often remain asymptomatic until a fracture occurs and are therefore frequently referred to as "silent diseases."

Globally, osteoporosis is a major public health problem affecting approximately 200 million individuals and contributing substantially to morbidity among the elderly population.[3] With increasing life expectancy, the burden of osteoporosis and related fractures is expected to rise significantly. It has been projected that the number of hip fractures worldwide may increase from about 1.7 million in 1990 to over 6 million by 2050.[5] Nearly half of these fractures are expected to occur in Asia due to rapid demographic ageing.[6,7] In India, osteoporosis is increasingly recognized as a significant health concern, particularly among older adults. Population-based data suggest that nearly one in five adults may have osteoporosis and almost half may have osteopenia, with prevalence increasing markedly among the elderly.[8]

Several factors contribute to poor bone health, including advancing age, hormonal changes, low body mass index, inadequate calcium intake, reduced sunlight exposure, smoking, and physical inactivity.[1,2] These modifiable risk factors provide opportunities for preventive interventions. The most serious complication of osteoporosis is fragility fracture, commonly affecting the hip, spine, and wrist, which may lead to chronic pain, reduced mobility, loss of independence, and increased mortality.[9,10]

Bone mineral density measurement is an important tool for early detection of osteoporosis and prediction of fracture risk. Techniques such as quantitative ultrasound and dual-energy X-ray absorptiometry are widely used for assessing BMD in clinical and community settings.[11,12] Early identification of individuals with low bone density allows timely implementation of preventive measures including lifestyle modification, nutritional supplementation, and medical management.

Evidence from India indicates a growing interest in community-based assessment of bone health. For instance, a community-based study conducted in rural West Bengal reported a high prevalence of low BMD among women aged 40 years and above and identified several associated factors including vitamin D deficiency, poor diet, and comorbidities.[11] However, most available studies in India have focused on postmenopausal women or general adult populations and many are hospital-based. A study conducted in an urban slum of Mumbai reported a high prevalence of osteopenia and osteoporosis among postmenopausal women and identified several lifestyle determinants of bone mineral density.[13]

Elderly individuals residing in urban slums constitute a particularly vulnerable population due to poor living conditions, limited access to health services, inadequate nutrition, and low awareness regarding preventive health practices. Despite the growing burden of osteoporosis in India, community-based data focusing specifically on elderly populations living in urban slums remain limited, particularly in eastern India. Moreover, information regarding their awareness and health-seeking behaviour related to bone health is scarce. Understanding these aspects is important for identifying gaps in early detection and preventive care.

Therefore, the present study was undertaken to assess bone health status using bone mineral density measurement and to identify its associated factors among elderly residents of an urban slum in Kolkata, West Bengal. In addition, the study aimed to examine their awareness and health-seeking behaviour regarding poor bone health. The findings of this study may help identify modifiable determinants and gaps in health-care utilization, thereby informing community-based strategies for the prevention and early detection of osteoporosis in vulnerable urban populations.

METHODS

Study design and setting

A community-based cross-sectional study was conducted among elderly individuals residing in an urban slum located in the field practice area of the Urban Health Unit and Training Centre (UHU&TC), Chetla, under the All-India Institute of Hygiene and Public Health (AIIH&PH), Kolkata, India. The study area covers wards 74 and 82 of the Kolkata Municipal Corporation. The UHU&TC provides primary health-care services to the local population through clinic-based and outreach activities

and serves as a field training site for postgraduate public health students. The study was conducted between January 2024 and February 2026.

Study participants and sample size

Elderly individuals aged 60 years and above who had been residing in the study area for at least one year were eligible to participate. Individuals who were critically ill, unable to comprehend the interview, or unwilling to provide informed consent were excluded. The required sample size was calculated using Cochran's formula for cross-sectional studies ($n=Z^2pq/L^2$), assuming a prevalence of poor bone health of 35.1% from a previous community-based study, with a 95% confidence level and an absolute precision of 7% (14). After applying a design effect of 1.3 to account for cluster sampling, the minimum sample size was 233, which was rounded to 240 participants.

Sampling technique

A two-stage cluster sampling technique was used. The study area comprised 27 lanes, considered natural geographic units and served as clusters. In the first stage, 15 clusters were selected using probability proportional to population size based on the estimated elderly population in each lane. In the second stage, 16 elderly individuals were selected from each cluster through simple random sampling after preparing a household listing of eligible participants with the assistance of field health workers. In households with more than one eligible elderly individual, the eldest member was included.

Data collection tools and techniques

Data were collected through face-to-face interviews during household visits using a predesigned and pretested structured interview schedule. The schedule included information on socio-demographic characteristics, socioeconomic status, behavioural factors, dietary habits, sunlight exposure, morbidity profile, history of fractures, reproductive history among female participants, awareness regarding osteoporosis, and health-seeking behaviour. The schedule was developed in English, translated into Bengali and Hindi, and back-translated to ensure semantic equivalence. Pre-testing was conducted among 30 elderly individuals residing in a different slum area, and necessary modifications were made prior to data collection.

Anthropometric measurements were recorded following standard procedures using a calibrated digital weighing scale for body weight and a non-stretchable measuring tape for height. Body mass index (BMI) was calculated as weight in kilograms divided by the square of height in meters and categorized according to World Health Organization criteria (15). Bone mineral density (BMD) was assessed using calcaneal quantitative ultrasonography with a portable bone densitometer. BMD status was categorized based on T-scores according to World Health Organization criteria: normal (≥-1), osteopenia (-1 to -2.5), and osteoporosis (≤-2.5). For analytical purposes, osteopenia and osteoporosis were considered as low BMD.

Study variables

Socio-demographic and socioeconomic factors

Socio-demographic characteristics included age (in completed years), sex, education (no formal education, primary, middle school, secondary, higher secondary, graduate and above), occupation (skilled, semi-skilled, unskilled, homemaker), family type (nuclear/joint), number of family members, and marital status. Socioeconomic status (SES) was classified according to the modified BG Prasad classification 2025 based on per capita monthly income in Indian Rupees.[16]

Reproductive history

Among female participants, reproductive history included age at menarche, age at menopause, and total number of children.

Behavioural factors

Physical activity was defined as any bodily movement produced by skeletal muscles that requires energy expenditure and was assessed using the International Physical Activity Questionnaire (IPAQ). Participants were categorized into low, moderate, and high physical activity levels based on the standard IPAQ scoring protocol.[17] Substance use was recorded as ever or current use of smoking tobacco (bidi, cigarettes), smokeless tobacco (gutkha, snuff), and alcohol, including duration of use in months.

Dietary habits

Dietary habits were categorized as vegetarian or non-vegetarian. Minimum dietary diversity, a proxy indicator for micronutrient adequacy, was defined as consuming at least five of ten food groups, categorized as achieved (5-10) or not achieved (0-4).

Sunlight exposure

Sun exposure per day was defined as the average number of hours an individual was exposed to direct sunlight between 08:00 and 16:00 hours during routine daily activities, recorded in hours based on participant self-report.[3,18] Body parts exposed to sunlight referred to areas of the body usually uncovered during outdoor activities. The exposed body surface area was estimated using the Lund and Browder chart.[19] Exposed areas included neck, shoulders, hands, thighs, knees, feet, and other exposed parts.

Morbidity and drug intake

Morbidity profile included presence of chronic non-communicable diseases such as diabetes, hypertension, hypothyroidism, arthritis or low back pain, and renal disease. Co-morbidity was recorded when two or more chronic conditions were present. History of previous osteoporotic fracture and parental hip fracture was also noted. Recent drug intake included use of steroids, aluminium antacids, phenytoin, anti-tubercular drugs, anti-diabetic, and anti-hypertensive medications.

Statistical analysis

Data were entered into Microsoft Excel and analysed using Jamovi version 2.6.26. Descriptive statistics such as mean, standard deviation, median, interquartile range, frequency, and percentage were used to summarize the study variables. Associations between categorical variables were assessed using Pearson's chi-square test. Variables that were statistically significant in univariate analysis or considered epidemiologically relevant were included in multivariable logistic regression to identify independent predictors of low BMD. Results were expressed as odds ratios with 95% confidence intervals, and a p value <0.05 was considered statistically significant.

Ethical considerations

The study protocol was reviewed and approved by the Institutional Ethics Committee of the All-India Institute of Hygiene and Public Health, Kolkata. Written informed consent was obtained from all participants prior to data collection. Confidentiality and anonymity of participants were maintained throughout the study.

RESULTS

Participant characteristics

A total of 240 elderly individuals residing in the urban slum participated in the study. The mean age of participants was 63.6±3.6 years, with the majority belonging to the 60-64 years age group (68.8%). Most participants were male (67.5%) and Hindu (81.7%). Regarding caste distribution, 37.5% belonged to the unreserved category and 36.3% to other backward classes. The majority lived in joint families (93.3%), with a mean family size of 4.25 members. Most participants were currently married (60.4%), while 31.6% were widowed. In terms of education, 40% had completed primary education, whereas 27.5% had no formal education. Nearly 63.7% were not currently working, and among those employed, unskilled work was the most common occupation (53.3%). More than half of the participants belonged to the lower-middle socioeconomic class (53.3%), with a mean per capita monthly income of ₹2723±554.

Table 1: Sociodemographic characteristics of study participants (n=240).

Variables	Category	Number (%)
Age group (years)	60-64	165 (68.8)
	65-69	56 (23.3)
	≥70	19 (7.9)
Gender	Male	162 (67.5)
	Female	78 (32.5)
Religion	Hindu	196 (81.7)
	Muslim	37 (15.4)
	Others	7 (2.9)
Caste	Unreserved	90 (37.5)
	OBC	87 (36.3)
	SC	59 (24.5)
	ST	4 (1.7)
Family type	Nuclear	16 (6.7)
	Joint	224 (93.3)
Family size	2-4 members	148 (61.7)
	5-6 members	92 (38.3)
Marital status	Currently married	145 (60.4)
	Widow/widower	76 (31.6)
	Separated	10 (4.2)
	Never married	9 (3.8)
Educational status	No formal education	66 (27.5)
	Primary	96 (40.0)
	Middle school	48 (20.0)
	Secondary	20 (8.3)
	Higher secondary	8 (3.3)
	Graduate and above	2 (0.9)
Currently working	Yes	87 (36.3)
	No	153 (63.7)
Occupation	Skilled	2 (0.9)
	Semi-skilled	68 (28.3)
	Unskilled	128 (53.3)
	Homemaker	42 (17.5)
Socio-economic status*	Middle class	112 (46.7)
	Lower-middle class	128 (53.3)

*According to modified BG Prasad classification 2025

Behavioural and health-related characteristics

Regarding lifestyle factors, 62.5% of participants reported moderate physical activity, while 29.2% had low physical activity levels. Nearly 63% reported no addiction, whereas 18.8% were current tobacco smokers, 16.6% used smokeless tobacco, and 2.1% consumed alcohol.

Most participants followed a non-vegetarian diet (92.9%). Based on body mass index, 74.1% had normal BMI, 22.1% were overweight or obese, and 3.8% were underweight. A majority of participants reported at least one morbidity (78.8%), most commonly low back pain, hypertension, and diabetes mellitus. Only 10% reported a

history of fracture, while 64.2% reported less than one hour of daily sun exposure (Table 2).

Table 2: Behavioural and health-related characteristics of study participants (n=240).

Variables	Category	Number (%)
Current addiction	None	150 (62.5)
	Tobacco smoking	45 (18.8)
	Smokeless tobacco	40 (16.6)
	Alcohol	5 (2.1)
Physical activity	Low	70 (29.2)
	Moderate	150 (62.5)
	High	20 (8.3)
Dietary habit	Non-vegetarian	223 (92.9)
	Vegetarian	17 (7.1)
BMI	Underweight	9 (3.8)
	Normal	178 (74.1)
	Overweight/obese	53 (22.1)
Morbidities	Present	189 (78.8)
	Absent	51 (21.2)
History of fracture	Yes	24 (10.0)
	No	216 (90.0)
Sun exposure in hour/day	<1	154 (64.2)
	1-2	47 (19.5)
	≥2	39 (16.3)

Bone health status of study participants

Bone mineral density assessment revealed that 63.7% of participants had osteopenia and 13.8% had osteoporosis, while 22.5% had normal bone mineral density. Thus, 77.5% of participants had low BMD (T-score < -1). The mean (SD) T-score was -1.44 (0.57) and the median (IQR) was -1.3 (-1.7 to -1.2) (Table 3).

Table 3: Distribution of study participants according to bone health status (n=240).

Bone health status	Number (%)
Normal (T score ≥ -1)	54 (22.5)
Osteopenia (-2.5 <T score <-1)	153 (63.7)
Osteoporosis (T score ≤ -2.5)	33 (13.8)
Total	240 (100)

Factors associated with low bone mineral density

Bivariate analysis revealed that low bone mineral density (BMD) was significantly associated with age, gender, caste, education, socioeconomic status, physical activity, current working status, comorbidities, and long-term medication use ($p<0.05$). Specifically, socio-economic status ($\chi^2=15.7$, df=1, $p<0.001$), comorbidities ($\chi^2=108$, df=1, $p<0.001$), long-term medication use ($\chi^2=108$, df=1, $p<0.001$), education ($\chi^2=57.7$, df=1, $p<0.001$), physical activity ($\chi^2=18.8$, df=1, $p<0.001$), caste ($\chi^2=7.81$, df=1, $p=0.005$), and gender ($\chi^2=12.1$, df=1, $p<0.001$) demonstrated highly significant associations with low BMD. In contrast, religion, family size, and nutritional status did not show a statistically significant association ($p>0.05$) (Table 4).

Table 4: Distribution of study participants according to their bone mineral density (BMD) T score value (n=240).

Bone mineral density (BMD T score value)	Number (%)
Normal BMD (T score ≥ -1.0)	54 (22.5)
Low BMD (T score < -1.0)	186 (77.5)
Total	240 (100)

Multivariable analysis

Variables that were statistically significant in bivariate analysis or considered epidemiologically relevant were included in a multivariable logistic regression model. After adjustment, increasing age, lower educational status, low physical activity, and lower socioeconomic status remained independently associated with low bone mineral density (BMD). Participants aged more than 63 years had significantly higher odds of having low BMD compared with younger participants. Similarly, individuals with lower educational attainment and low physical activity levels had significantly greater odds of low BMD. Multivariable logistic regression was conducted using six variables: age, religion, caste, education, physical activity, and socioeconomic status. In this model, four variables emerged as significant independent predictors of low BMD: age >63 years (adjusted odds ratio [AOR] 4.27, 95% CI 1.59-11.50), lower socioeconomic status (AOR 2.10, 95% CI 0.96-4.57), lower educational level (AOR 9.68, 95% CI 3.42-27.35), and low physical activity (AOR 4.65, 95% CI 1.29-16.81) (Table 5).

The multivariable logistic regression model explained 29.1-44.4% of the variance in low bone mineral density (Cox & Snell $R^2=0.291$; Nagelkerke $R^2=0.444$), and adjusted odds ratios with 95% confidence intervals were estimated to identify independent predictors.

Awareness and health-seeking behaviour

All participants reported awareness that bone weakness can occur with increasing age. However, only 20% were aware of bone mineral density testing.

Among participants with low BMD (n=186), the majority preferred allopathic treatment (83.3%), while 75.2% preferred government health facilities for seeking care. Approximately 64.5% reported currently receiving treatment, whereas 35.5% had not sought treatment for their condition.

Table 5: Association of demographic, socioeconomic, behavioral and health related factors with bone health status (BMD value) among elderly slum dwellers (n=240).

Characteristics	Category (total)	BMD Normal, N (%)	BMD Low, N (%)	χ^2 (df)	P value
Age group*(in completed years)	≤ 63 (n=140)	48(34.3)	92 (65.7)	26.8 (1)	<0.001
	>64 (n=100)	6 (6)	94 (94)		
Gender	Male (162)	47 (29)	115 (71)	12.1 (1)	<0.001
	Female (78)	7 (9)	71 (91)		
Religion[§]	Hindu (196)	41 (20.9)	155 (79.1)	1.53 (1)	0.216
	Others (44)	13 (29.5)	31 (70.5)		
Caste[@]	Unreserved (90)	29 (32.2)	61 (67.8)	7.81 (1)	0.005
	Other castes (150)	25 (16.7)	125 (83.3)		
Education[#]	Up to middle school (210)	31 (14.8)	179 (85.2)	57.7 (1)	<0.001
	Secondary and above (30)	23 (76.7)	7 (23.3)		
Socio-economic status^	Below middle class (128)	16 (12.5)	112 (87.5)	15.7 (1)	<0.001
	Middle class and above (112)	38 (33.9)	74 (66.1)		
Family member	>4 (92)	21 (22.8)	71 (77.2)	0.009 (1)	0.924
	≤4 (148)	33 (22.2)	115 (77.8)		
Activity	Low activity (70)	3 (4.3)	67 (95.7)	18.8 (1)	<0.001
	Moderate to high (170)	51 (30)	119 (70)		
Currently working	Yes (87)	46 (52.8)	41 (47.2)	72.2 (1)	<0.001
	No (153)	8 (5.2)	145 (94.8)		
Nutritional status	Normal& underweight (187)	42 (22.4)	145 (77.6)	7.81 (1)	0.978
	Overweight and obese (53)	12 (22.6)	41 (77.4)		
Co-morbidities	Yes (189)	15 (7.9)	174 (92.1)	10.8 (1)	<0.001
	No (51)	39 (76.4)	12 (23.6)		
Long term medication +	Yes (189)	15 (7.9)	174 (92.1)	10.8 (1)	<0.001
	No (51)	39 (76.4)	12 (23.6)		

*Median age of study participants was 63 years; [@]'Others' refers to SC, ST and OBC castes; [$]'Others' refers to Muslim, Sikh, Christan; [#]'Up to middle school' refers to educational status of illiterate, literate with no formal education and primary and middle school and 'secondary and above' refers to secondary and further higher educational status; [^]'Below middle class' refers to lower middle and lower socio-economic class and 'middle class and above' refers to middle, upper middle and upper socio-economic class; [+]Long term medication was more than 6months; df: degree of freedom; CI: confidence interval

Table 6: Multivariable logistic regression analysis showing factors associated with poor bone health status (low BMD) among elderly slum dwellers (N=240).

Characteristics	Category (Total)	BMD normal, N (%)	Low, N (%)	AOR (95% CI)	Adjusted p value
Age group (in completed years)	≤ 63 (n=140)	48 (34.3)	92 (65.7)	Reference	0.004
	>64 (n=100)	6 (6)	94 (94)	4.27 (1.59-11.50)	
Religion	Hindu (196)	41 (20.9)	155 (79.1)	Reference	0.154
	Others (44)	13 (29.5)	31 (70.5)	2.08 (0.75-5.72)	
Caste	Unreserved (90)	29 (32.2)	61 (67.8)	Reference	0.124
	Other castes (150)	25 (16.7)	125 (83.3)	2.56 (1.13-5.78)	
Education	Up to middle school (210)	31 (14.8)	179 (85.2)	Reference	<0.001
	Secondary and above (30)	23 (76.7)	7 (23.3)	9.68(3.42-27.35)	
Socio-economic status	Below middle class (128)	16 (12.5)	112 (87.5)	Reference	0.05
	Middle class and above (112)	38 (33.9)	74 (66.1)	2.10 (0.96-4.57)	
Activity	Low activity (70)	3 (4.3)	67 (95.7)	Reference	0.019
	Moderate to high (170)	51 (30)	119 (70)	4.65(1.29-16.81)	

DISCUSSION

This community-based study among 240 elderly slum dwellers in Chetla, Kolkata, revealed a high prevalence of poor bone health, with 63.7% of participants having osteopenia and 13.8% having osteoporosis. Overall, 77.5% had low bone mineral density (BMD), highlighting the significant burden of age-related skeletal fragility in socioeconomically vulnerable populations. Mean T-score (-1.44±0.57) further underscores the widespread risk of

osteoporosis and related fractures in this cohort. These findings are consistent with previous Indian studies reporting osteopenia prevalence of 62-64% and osteoporosis prevalence of 10-15% in older adults.[11,20,21] Globally, systematic reviews report osteoporosis prevalence of 9-35% among older adults, confirming that the current study aligns with international patterns.[22]

Advancing age emerged as a strong predictor of low BMD. Participants aged >63 years had 4.27 times higher odds of low BMD compared with younger participants, consistent with the well-established biological mechanism of age-related bone loss due to imbalance in bone remodelling and reduced calcium absorption.[1,2,4] Similar associations with age were reported in Chandigarh, Mumbai, and nationwide assessments in India.[20,13,21] Global studies also confirm age as a major determinant of osteoporosis, particularly among postmenopausal women.[22]

Female gender was significantly associated with low BMD, reflecting postmenopausal estrogen deficiency that accelerates bone resorption.[3] Comparable findings have been reported in India and internationally.[20-23] Educational attainment was independently associated with BMD, with participants having lower education showing 9.68 times higher odds of low BMD. Lower literacy likely limits awareness of bone health, dietary adequacy, and preventive behaviors.[11,13,24]

Socioeconomic status and physical activity were also significant determinants. Low socioeconomic status nearly doubled the odds of low BMD, reflecting nutritional constraints, limited healthcare access, and higher prevalence of comorbidities.[16,20] Low physical activity increased the odds of low BMD by 4.65 times, consistent with mechanical loading's role in maintaining bone strength.[11,17] Similar trends were reported in South India and Northern India, where physically inactive and economically disadvantaged older adults had higher osteoporosis prevalence.[20,24]

Comorbidities and long-term medication were strongly associated with low BMD. In our study, 78.8% had at least one chronic disease, which is known to disrupt bone metabolism through inflammatory pathways and prolonged drug exposure, including glucocorticoids.[1,2,20,25] Despite universal awareness about age-related bone weakness, 80% had no knowledge about BMD testing, and treatment-seeking behaviors were suboptimal, indicating a critical gap between awareness and actionable prevention. Most participants preferred allopathic treatment in government facilities, consistent with prior studies on healthcare utilization in low-income Indian communities.[23]

These findings highlight the need for community-level interventions, including regular BMD screening, education on calcium and vitamin D supplementation, promotion of weight-bearing physical activity, and strengthening geriatric services under national programs. Targeted strategies focusing on women, older age groups, and socioeconomically disadvantaged populations are imperative to mitigate the growing burden of osteoporosis and fractures in India.[2,11,21,25]

The high prevalence of low BMD observed in this study may partly be attributed to inadequate vitamin D status due to limited sun exposure and suboptimal dietary calcium intake, consistent with previous community-based studies in India.[2,11,18,21] Public health interventions promoting calcium-rich diets and vitamin D supplementation, along with lifestyle modifications, are essential to prevent osteoporosis in this vulnerable population.

Despite these findings, certain limitations should be considered. The cross-sectional design precludes causal inference, and self-reported data on health behaviours and substance use may be affected by response bias. Additionally, the study was conducted in a single urban slum in Kolkata, limiting generalizability, and recall bias may have influenced information on sun exposure, physical activity, and health history. Nevertheless, the high prevalence of low bone mineral density observed in this population underscores the urgent need for community-based interventions, including awareness campaigns, promotion of weight-bearing physical activity, and strategies to improve dietary calcium and vitamin D intake. Targeted programs for women, older adults, and socioeconomically disadvantaged groups are essential to reduce the burden of osteoporosis and related fractures in India. Future longitudinal studies incorporating clinical, nutritional, and genetic assessments are warranted to better understand risk factors and inform public health strategies.

CONCLUSION

This study provides the first comprehensive assessment of bone health among elderly residents of an urban slum in Kolkata, revealing a high prevalence of osteopenia and osteoporosis in this vulnerable population. Notably, modifiable lifestyle factors, including low physical activity, limited sun exposure, and poor nutritional awareness, emerged as significant predictors of low bone mineral density, alongside non-modifiable factors such as advancing age and female gender. The study also highlights a clear socioeconomic gradient, with lower educational attainment and socioeconomic status associated with poorer bone health. These findings underscore that urban slum populations, often overlooked in national surveys, bear a disproportionate burden of osteoporosis and fracture risk.

From a public health perspective, these results point to actionable interventions. Community-level strategies, such as routine bone health screening, promotion of weight-bearing physical activity, education on calcium and vitamin D intake, and integration of geriatric bone

health services into existing urban primary care programs, are urgently needed. Targeted efforts focusing on women, older adults, and socioeconomically disadvantaged groups could mitigate the growing burden of osteoporosis. By identifying population-specific risk factors in a resource-limited urban setting, this study provides critical evidence to inform policy and program planning for bone health promotion in India.

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