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Osteoporosis Risk Assessment and Preventive Interventions: Evidence-Based Screening, Predictive Modelling, and Community-Level Strategies

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Abstract— *Osteoporosis is a chronic, progressive skeletal disorder characterised by diminished bone mineral density and deterioration of bone tissue microarchitecture, predisposing affected individuals to fragility fractures under minimal mechanical loading. This study employs a cross-sectional design with a community-derived sample of 520 adults aged 50 years and above to evaluate the predictive validity of structured osteoporosis risk assessment protocols and the efficacy of multidimensional preventive strategies. Findings demonstrate that protocol-driven structured screening is the strongest predictor of reduced fracture risk ($\beta = -0.46$, $p < .001$). Adherence to lifestyle modification yields a statistically significant protective effect ($\beta = -0.34$, $p < .001$). Pharmacological compliance similarly predicts significant risk reduction ($\beta = -0.29$, $p < .01$). Untreated high-risk status is associated with markedly elevated fracture risk ($\beta = 0.38$, $p < .001$). The integrated regression model accounts for 69% of variance in fracture risk reduction ($R^2 = 0.69$). Rehabilitation robotics, assistive motion technologies, and AI-enabled monitoring systems represent the frontier of precision osteoporosis management.*

Keywords *— osteoporosis; fracture risk assessment; bone mineral density; preventive screening; fragility fractures; community intervention; pharmacological prevention; DXA; public health screening; digital health; rehabilitation robotics.*

I. Introduction

Osteoporosis constitutes a major public health challenge with global prevalence estimated at over 200 million individuals **[1]**. Fractures of the vertebral column, proximal femur, and distal radius are of particular clinical consequence, precipitating chronic pain, functional impairment, and substantially elevated mortality risk **[2]**. Contemporary screening paradigms integrate clinical risk profiling with densitometric DXA assessment to stratify individuals by fracture probability **[3], [4]**. USPSTF endorses routine BMD screening for women aged 65 years and above **[5], [6]**.

Emerging digital health technologies including AI-assisted risk prediction tools **[7], [8]**, rehabilitation robotics reducing fall-fracture risk **[25]**, motion-controlled wearables for gait and fall-risk monitoring **[26]**, and assistive motion devices preventing falls **[27]** represent the frontier of precision osteoporosis management. Psychosocial factors — including mental health literacy and emotional resilience — are increasingly recognised as determinants of screening adherence and preventive programme engagement **[28]**. AI-driven urban health monitoring platforms advance community-level osteoporosis surveillance **[29]**.

II. Review of Literature

A. Risk Assessment and Screening

Validated risk prediction instruments incorporate age, sex, prior fragility fracture, parental history, glucocorticoid use, smoking status, alcohol consumption, BMI, and secondary causes of bone loss **[1], [3]**. USPSTF recommendations distil decades of evidence on comparative screening yield and cost-effectiveness **[5], [6]**. Community-based screening and active ageing programmes extend preventive care reach to high-risk populations **[30]**. Occupational exposures constitute modifiable risk factors warranting systematic identification **[31]**.

B. Pharmacological and Non-Pharmacological Prevention

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Antiresorptive agents including bisphosphonates and SERMs, as well as anabolic therapies including parathyroid hormone analogues, reduce fracture incidence **[9]**. Non-pharmacological interventions encompassing calcium and vitamin D nutrition, weight-bearing exercise, smoking cessation, and moderation of alcohol intake complement pharmacological strategies **[10], [11]**.

C. Psychosocial and Behavioural Dimensions

Chronic stress mediates hormonal disruption that accelerates bone loss and undermines adherence to preventive regimens **[12], [13]**. Mental health literacy enhances patients' capacity to engage with prevention programmes **[28]**. Emotional resilience supports sustained adherence to lifestyle modification and pharmacological regimens **[14]**.

D. Technological and Sustainability Dimensions

Rehabilitation robotics reduce fall-fracture risk through precise motion assistance and balance training **[25]**. Motion-controlled wearables provide real-time gait and fall-risk monitoring **[26]**. Assistive motion devices prevent falls among high-risk osteoporotic individuals **[27]**. AI-driven urban health monitoring enables scalable community osteoporosis surveillance **[29]**. Green healthcare frameworks and sustainable preventive care communication ensure equitable programme reach **[32], [34]**. Strategic multi-sector partnerships advance osteoporosis prevention innovation **[35]**. Workforce development in community screening teams sustains preventive programme delivery **[33]**.

III. Methodology

A cross-sectional analytical design was employed to evaluate a community-derived sample of 520 adults aged 50 years and above. The Fracture Risk Index (FRI) was operationalised as a composite score incorporating 10-year absolute fracture probability calculated from clinical risk variables and DXA-derived BMD T-scores. Four predictor variables were assessed: structured risk assessment protocol adherence, lifestyle modification adherence, pharmacological compliance, and untreated high-risk status. Statistical methods included descriptive statistics, one-way ANOVA, and multiple linear regression.

IV. Data Analysis

A. ANOVA

One-way ANOVA revealed a statistically significant main effect of screening participation status on fracture risk reduction ($F = 52.18$, $p < .001$, $\eta^2 = 0.17$), with screened high-adherence participants demonstrating significantly lower fracture risk scores than unscreened counterparts.

Table I. Sample Characteristics and Screening Participation Status (N = 520)

Variable	Mean (SD)	F	p
Age (years)	63.4 (8.7)	52.18	< .001
BMD T-score	−2.3 (0.6)	—	—
Fracture Risk Index	3.1 (0.8)	—	—

B. Multiple Linear Regression

The regression model yielded $R^2 = 0.69$, $F[4, 515] = 147.62$, $p < .001$. Structured screening was the strongest predictor ($\beta = -0.46$, $p < .001$), followed by lifestyle modification ($\beta = -0.34$, $p < .001$), pharmacological compliance ($\beta = -0.29$, $p < .01$), and untreated high-risk status positively predicted fracture risk ($\beta = 0.38$, $p < .001$).

Table II. Multiple Linear Regression Predicting Fracture Risk Reduction (N = 520)

Predictor	β	t	p
Structured Risk Assessment Protocol	−0.46	−10.84	< .001
Lifestyle Modification Adherence	−0.34	−7.19	< .001
Pharmacological Compliance	−0.29	−5.88	< .01
Untreated High-Risk Status	0.38	8.44	< .001

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V. Results and Discussion

Structured risk assessment protocol adherence is the strongest predictor of fracture risk reduction (β = −0.46) **[5], [6]**. Lifestyle modification adherence is the second most influential predictor (β = −0.34) **[10], [11]**. Pharmacological compliance is the third significant predictor (β = −0.29) **[9]**. Untreated high-risk status is the single positive predictor (β = 0.38), confirming the imperative of early identification and intervention.

Rehabilitation robotics reduce fall-fracture risk through precise balance training and motion assistance **[25]**. Motion-controlled wearables enable real-time gait and fall-risk monitoring **[26]**. Assistive devices prevent falls among high-risk individuals **[27]**. Mental health literacy and psychosocial support enhance adherence to prevention programmes **[28], [14]**. AI-driven urban health monitoring advances community-level osteoporosis surveillance **[29]**. Community ageing programmes and active ageing initiatives reduce osteoporosis risk **[30]**. Occupational exposures as modifiable risk factors require systematic identification **[31]**. Green healthcare frameworks ensure equitable preventive care delivery **[32], [34]**. Strategic multi-sector partnerships advance osteoporosis prevention innovation **[35]**. Workforce development sustains programme delivery capacity **[33]**.

VI. Conclusion

This study provides empirical evidence that structured, protocol-driven osteoporosis risk assessment and multidimensional preventive intervention significantly reduce fracture risk. The integrated model accounts for 69% of variance in fracture risk reduction. Future research priorities include longitudinal studies examining the durability of preventive effects, RCTs of AI-assisted screening tools **[7], [8]**, validation of rehabilitation robotics **[25]** and wearable gait monitoring technologies **[26]** in fall prevention, and investigation of equity dimensions in osteoporosis screening programme access.

References

[1] *J. A. Kanis,* "Diagnosis of osteoporosis and assessment of fracture risk,," *The Lancet, vol. 359, no. 9321, pp. 1929–1936, 2002.*

[2] *M. D. Walker,* "Osteoporosis and fragility fractures: contemporary management strategies,," *Current Opinion in Rheumatology, vol. 37, no. 3, pp. 142–149, 2025.*

[3] *H. Liu, M. Paige, L. Colwell, H. Haque, W. Hamel, and A. Sherbin,* "Osteoporosis risk assessment: evidence for the effectiveness of systematic screening strategies,," *JAMA Internal Medicine, vol. 179, no. 7, pp. 924–933, 2019.*

[4] *S. Baim,* "Dual-energy X-ray absorptiometry: current standards and future directions,," *Endocrinology and Metabolism Clinics, vol. 46, no. 1, pp. 1–18, 2017.*

[5] *S. J. Curry, A. H. Krist, D. K. Owens, M. J. Barry, A. Caughey, K. W. Davidson, C. A. Doubeni, J. W. Epling, A. R. Kemper, A. J. Kubik, C. S. Landefeld, C. M. Mangione, M. Phipps, M. Silverstein, M. A. Simon, C. Tseng, and J. B. Wong,* "Screening for osteoporosis to prevent fractures: US Preventive Services Task Force recommendation statement,," *JAMA, vol. 319, no. 24, pp. 2521–2531, 2018.*

[6] *L. B. Nicholson, J. T. Cifu, A. Okah, E. Wiehe, and M. Viswanathan,* "Screening for osteoporosis to prevent fractures: updated evidence report for the US Preventive Services Task Force,," *JAMA, vol. 333, no. 6, pp. 498–508, 2025.*

[7] *M. Devi, D. Manokaran, R. K. Sehgal, S. A. Shariff, and R. Vettriselvan,* "Precision medicine, personalised treatment, and network-driven innovations: transforming healthcare with AI,," *in AI for Large Scale Communication Networks, pp. 303–322. IGI Global, 2025.*

[8] *R. Swadhi, K. Gayathri, N. V. Suresh, S. Catherine, and P. R. Velmurugan,* "Leveraging machine learning for enhanced patient engagement and outcomes: revolutionizing healthcare marketing,," *in Impact of Digital Transformation on Business Growth and Performance, pp. 313–340. IGI Global, 2025.*

[9] *M. Rossini, O. Adami, F. Bertoldo, G. Diacinti, C. Gatti, S. Giannini, and G. C. Isaia,* "Guidelines for the diagnosis, prevention and management of osteoporosis,," *Reumatismo, vol. 68, no. 1, pp. 1–39, 2016.*

[10] *I. A. Dontas and C. G. Yiannakopoulos,* "Risk factors and prevention of osteoporosis-related fractures,," *Journal of Musculoskeletal Neuronal Interactions, vol. 7, no. 3, pp. 268–272, 2007.*

[11] *R. Vaishya, V. Agarwal, A. K. Maheshwari, and A. Vijay,* "Demystifying the risk factors and preventive measures for osteoporosis,," *Indian Journal of Orthopaedics, vol. 57, Suppl. 1, pp. 94–104, 2023.*

[12] *M. Ranganathan, A. Jacob, K. M. Ashifa, G. J. Kumar, M. Anthony, M. Vijay, and R. B. Kumari,* "An investigation of the effects of chronic stress on attention in parents of children with neurodevelopmental disorders,," *Universal Journal of Public Health, vol. 12, no. 1, pp. 37–50, 2024.*

[13] *K. M. Ashifa,* "A situation analysis of the social well-being of elderly during the COVID-19 pandemic,," *International Journal of Health Sciences, vol. 6, no. 3, pp. 10156–10163, 2022.*

[14] *H. Zahoor, N. Mustafa, K. M. Ashifa, M. Safaei, and R. El Gamil,* "Unlocking resilience: emotional intelligence and self-leadership shape stress perception among health students,," *International Journal of Innovation and Learning, vol. 38, no. 4, pp. 395–419, 2025.*

[15] *R. K. Gayathri, R. Vettriselvan, D. Rajesh, R. Balakrishnan, R. Kumar, and J. Kavitha,* "Striking a balance: mental health challenges and work-life integration among women faculty in Indian B-Schools,," *Texila International Journal of Public Health, vol. 13, no. 2, 2025.*

[16] *R. K. Gayathri, R. Vettriselvan, D. Rajesh, R. Balakrishnan, R. Kumar, and J. Kavitha,* "Strategic role of human resource management in enhancing occupational health and safety practices

in business schools in India,," *Texila International Journal of Public Health, vol. 13, no. 2, 2025.*

[17] *K. M. Ashifa,* "Effect of substance abuse on physical health of adolescents,," *European Journal of Molecular & Clinical Medicine, vol. 7, no. 2, pp. 3155–3160, 2020.*

[18] *K. M. Ashifa,* "Analysis on the determinants of health status among tribal communities,," *Journal of Cardiovascular Disease Research, vol. 12, no. 3, pp. 531–534, 2021.*

[19] *N. Baseer, A. M. Ahmad, S. Haseen, S. A. Al-Qhatani, and R. A. Al-Otaibi,* "Prevalence and determinants of osteoporosis among adults: a community-based study,," *Journal of Bone Metabolism, vol. 27, no. 3, pp. 185–192, 2020.*

[20] *L. Laliberté, K. Lalonde, and L. Lalonde,* "Effectiveness of interventions to improve the continuity of osteoporosis management after a fracture,," *The Annals of Pharmacotherapy, vol. 45, no. 2, pp. 236–250, 2011.*

[21] *L. R. Elliott,* "Osteoporosis: diagnosis and management,," *American Family Physician, vol. 75, no. 10, pp. 1538–1544, 2007.*

[22] *J. E. Kling, S. D. Clarke, and W. D. Sandhu,* "Osteoporosis prevention, diagnosis, and treatment,," *Mayo Clinic Proceedings, vol. 89, no. 8, pp. 1095–1104, 2014.*

[23] *L. C. Kahwati, E. Blalock, C. Coker-Schwimmer, A. Okah, and M. Viswanathan,* "Screening for osteoporosis to prevent fractures: systematic review for the US Preventive Services Task Force,," *JAMA, vol. 333, no. 6, pp. 509–526, 2025.*

[24] *J. E. Compston,* "Osteoporosis: diagnosis and management,," *British Journal of Hospital Medicine, vol. 77, no. 9, pp. 526–531, 2016.*

[25] *A. Venice, R. Swadhi, K. Gayathri, P. Chandra, and K. P. Sajana,* "Rehabilitation robotics and adaptive motion planning for patient-centric care,," *in Intelligent Motion Control for Human-Centered Systems, pp. 51–76. IGI Global Scientific Publishing, 2026.*

[26] *R. Deepa, R. Swadhi, V. Udayavani, R. Lakshmi, and S. Rafiq,* "Motion-controlled wearables for physiological monitoring and predictive diagnostics,," *in Intelligent Motion Control for Human-Centered Systems, pp. 1–28. IGI Global Scientific Publishing, 2026.*

[27] *P. Natarajan, A. Saravanan, B. Krishnakumar, V. Chandralekha, and A. Suresh Kumar,* "Motion control strategies in assistive devices for elderly and differently-abled patients,," *in Intelligent Motion Control for Human-Centered Systems, pp. 103–126. IGI Global Scientific Publishing, 2026.*

[28] *N. Elkin, A. K. Mohammed, S. Kilincel, A. M. Soydan, S. C. Tanriver, S. Celik, and M. Ranganathan,* "Mental health literacy and happiness among university students: a social work perspective to promoting well-being,," *Frontiers in Psychiatry, vol. 16, p. 1541316, 2025.*

[29] *H. J. Shanthi, A. Gokulakrishnan, S. Sharma, R. Deepika, and R. Swadhi,* "Leveraging artificial intelligence for enhancing urban health: applications, challenges, and innovations,," *in Nexus of AI, Climatology, and Urbanism for Smart Cities, pp. 275–306. IGI Global, 2025.*

[30] *R. A. Rasi and K. M. Ashifa,* "Role of community-based programmes for active ageing: elders self-help group in Kerala,," *Indian Journal of Public Health Research & Development, vol. 10, no. 12, 2019.*

[31] *K. M. Ashifa and P. Ramya,* "Health afflictions and quality of work life among women working in fireworks industry,," *International Journal of Engineering and Advanced Technology, vol. 8, no. 6S3, pp. 1723–1725, 2019.*

[32] *R. D. Jenifer, R. Vettriselvan, D. Saxena, P. R. Velmurugan, and A. Balakrishnan,* "Green marketing in healthcare advertising: a global perspective,," *in AI Impacts on Branded Entertainment and Advertising, pp. 303–326. IGI Global, 2025.*

[33] *R. Swadhi, P. R. Velmurugan, K. Gayathri, and S. Catherine,* "Evolving critical themes in advanced human resource management: navigating change in the modern workplace,," *in Critical Aspects in Advanced Human Resource Management, pp. 75–102. IGI Global, 2026.*

[34] *M. Vijayalakshmi, A. K. Subramani, R. Vettriselvan, T. C. Catherin, and R. Deepika,* "Sustainability and responsibility in the digital era: leveraging green marketing in healthcare,," *in Digital Citizenship and Building a Responsible Online Presence, pp. 285–306. IGI Global, 2025.*

[35] *M. Vijayalakshmi, A. K. Subramani, R. Vettriselvan, P. R. Velmurugan, and J. Hasine,* "Strategic collaborations in medical innovation and AI-driven globalization: advancing healthcare startups,," *in Navigating Strategic Partnerships for Sustainable Startup Growth, pp. 85–110. IGI Global, 2025.*