

The bone health in Sannio rural area: An analysis of free screening

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ABSTRACT

Purpose: Significant gaps persist in osteoporosis prevention and management within rural regions, including limited knowledge, poor access to screening, and inconsistent clinical follow-up. This study investigates risk factors, awareness, personal experiences, and preferences for osteoporosis care among residents of a rural area, with the aim of supporting the development of targeted public health programs.

Methods: A mobile screening project was carried out across the rural Sannio area, excluding the city of Benevento. Adults were invited to participate in a three-phase assessment: (1) free calcaneal quantitative ultrasound (QUS), (2) semi-structured interviews with medical history collection and calculation of the Fracture Risk Assessment Tool (FRAX) score, and (3) blood and urine tests to assess calcium-phosphorus metabolism. Collected data included diagnoses, risk factors, previous management, and knowledge regarding osteoporosis. Quantitative analyses were performed, including linear and logistic regression, to identify variables associated with prevention awareness and satisfaction with the National Health System.

Results: A total of 726 individuals completed the survey. The mean age was 59 years, with a strong female predominance (693 women, 33 men). Overall, 89% had previously undergone osteoporosis screening, and 58.54% reported a diagnosis of osteoporosis. QUS screening identified osteopenia secondary to hypothyroidism in 6% of participants. Among those with a history of gynecological or oncological ablative procedures, 80% were not receiving adequate osteoporosis prophylaxis. Eighteen percent of osteopenia cases were associated with inflammatory bowel disease or celiac disease. Almost all individuals with osteoporosis (90%) underwent screening after a minor fracture. Satisfaction with the initiative was high, with an average 10-year FRAX fracture risk of 14% (± 9.7).

Conclusion: Three principal themes emerged from qualitative interviews: concerns regarding the adequacy of care in rural settings, a desire for locally accessible and tailored services, and interest in a structured osteoporosis prevention program. These insights may guide future public health initiatives in underserved rural areas.

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1. Introduction

Osteoporosis and osteopenia affect more than half of adults over the age of 50. Evidence shows that individuals living outside major Italian cities experience higher rates of hip and fragility fractures, along with reduced access to densi-tometry testing and bone-health specialists ^{1,2}. In rural settings, care gaps include poor awareness of risks, limited availability of screening services, and fragmented management pathways ¹⁻⁴.

The Sannio province covers 2071 km² and had a population of 260,024 as of 2024 ⁵⁻⁷. Located within the southern Apennines, the region is characterized by its basin-like morphology and substantial geographic barriers. Major in-frastructural limitations include:

- no highways
- no rapid long-distance road connections
- a single provincial hospital, with travel times of up to 90 min from some municipalities
- approximately 60% of residents being middle-aged or elderly

This study evaluates risk factors, knowledge, and healthcare experiences regarding osteoporosis among inhabitants of this rural area. The aim is to provide evidence to support future osteoporosis care programs tailored to the specific needs of geographically isolated communities.

2. Materials and methods

This prospective, non-randomized study was conducted within the historical Sannio province, involving adults aged ≥40 years ⁵⁻⁷. Individuals with and without osteoporosis were included, ensuring representation of undiagnosed cases. Exclusion criteria consisted only of age <40 years. Recruitment occurred via local community organizations, social media, and word of mouth.

- A mixed-methods design was employed:
- Phase1:** Free calcaneal quantitative ultrasound (QUS) screening.⁸
 - Phase2:** Semi-structured interviews, collection of medical history, FRAX calculation,⁹ and a satisfaction questionnaire (Yes/No, with reasoning when “No”).
 - Phase3:** Blood and urine testing to assess calcium–phosphorus metabolism ^{10,11}.

Laboratory tests included ESR, PTH, thyroid hormones, fractional protein levels, serum calcium, phosphorus, total and bone alkaline phosphatase, creatinine, 25-OH vitamin D, antigens for celiac disease, and food intolerance screening.¹⁰ Urine measurements included 24-h calciuria and phosphaturia.¹¹

Data were analyzed with descriptive statistics, linear regression, and logistic regression.

2.1. Calcaneal quantitative ultrasound (QUS)

The SONOST 3000 device (Osteosys, Korea) was used to determine BQI and QUS T-score for both calcanei. BQI integrates SOS and BUA and reflects bone strength (error <1.5%). SOS correlates with bone structure and BMD; reductions in BMD decrease SOS. BUA reflects bone characteristics; reduced BMD results in lower attenuation. Machine temperature was maintained at 21–25 °C to ensure measurement consistency.⁸

2.2. Semi-structured interviews

Interviews were conducted in 2015 immediately after QUS testing, either in person or at the participant's preference. The opening prompt invited reflections on osteoporosis testing. Conversations flowed naturally into fracture history, concerns about bone health, and expectations for care. Interviews lasted 10–15 min and were transcribed. FRAX scores were calculated and added to clinical documentation.

2.3. Blood and urine tests

The complete panel is listed above and included metabolic, endocrine, renal, and gastrointestinal markers relevant to bone metabolism ^{10,11}.

3. Results

726 participants completed the survey (Table 1).

The mean (SD; range) age of survey participants was 59.8 years (±17.3; 40-101), 693 female (95.46%) and 33 male (4.54%). The gender ratio(F:M) was 21. The most common high school completion was in 423 patients (58.26%).

Valle Caudina (n = 256; 35.27%) and Valle Telesina (n = 224; 30.85%) were most screened (Table 1).

The Former smokers (Table 1) were the most represented class with 327 patients (45.04%).

The Alcohol <1 standard drink (SD) per day intake was the most represented class (Table 1) with 412 patients (56.76%).

The population under examination was predominantly lazy and

Table 1
Demographic details and osteoporosis risk factors of survey participants. N = 726 unless otherwise stated.

Age, years, mean (SD; range)		59.8 (±17.3; 40-101)
Female, n (%)		693(95.46%)
Male, n (%)		33(4.54%)
Gender ratio		21:1
Education, n (%)	Did not complete high school	189(26.03%)
	High school completion	423(58.26%)
	Vocational qualification/diploma	83(11.43%)
	Higher degree	26(3.58%)
	(Master's or PhD)	3(0.42%)
Residential location n (%)	Bachelor degree	2(0.28%)
	Valle Caudina District	256(35.27%)
	Valle Telesina District	224(30.85%)
	Valle Vitulanense District	88(12.12%)
	Alto Tammaro-Fortore District	87(11.98%)
Smoking status n (%)	Benevento's Suburbs	71(9.78%)
	Never	235(32.37%)
	Former	327(45.04%)
Alcohol intake n (%)	Current	164(22.59%)
	None	127(17.49%)
	<1 standard drink (SD) per day	412(56.76%)
	1-2 SD per day	145(19.97%)
Exercise per week n (%) (n = 61)	>2 SD per day	42(5.78%)
	<75min moderate or 35min vigorous	557(76.72%)
	75-150min moderate or 35-75min vigorous	123(16.94%)
	150-300min moderate or 75-150min vigorous	25(3.45%)
	>300min moderate or >150min vigorous	21(2.89%)
Family history ^a n (%)	Yes	327(45.04%)
	No	399(54.96%)
Comorbidities ^b n (%)	0	156(21.49%)
	1	323(44.49%)
	2	158(21.76%)
	≥3	89(12.26%)

^a Family history included presence of parental vertebral or hip fracture or parental diagnosis of osteoporosis.

^b Comorbidities included: coeliac disease, chronic kidney disease, chronic liver disease, hyperthyroidism, hyperparathyroidism, vitamin D deficiency, rheumatoid arthritis, obesity body mass index >30, under-weight body mass index <18.5, epilepsy, diabetes (type 1 or type 2), malabsorption, glucocorticoid use for 3 months or longer, early menopause before age 45 years.

sedentary (Table 1). In fact, the most represented class of the population was that which <75min moderate or 35min vigorous with 557 patients (76.72%).

Patients with a family history of osteoporosis or hip or vertebral fracture (Table 1) were 327(45.04%).

Most patients 323(44.49%) had 1 disease or comorbidity predisposing to osteoporosis (Tab.1).

88.98%(n = 642) had a screening test for osteoporosis, and 425 (58.54%) had a diagnosis of osteoporosis. 11.02%(n = 80) of participants did the screening because it was free without any clinical indication.

Results details of calcaneal quantitative ultrasound(Table 2): normal in 80 patients (11.02%) the Average T-Score was $-0.82(\pm 0.32; 1.9; -1)$ and Average Z-Score was $-0.77(\pm 0.42; 1.8; -1)$; osteopenia in patients 221(30.44%) the Average T-Score was $-2.1(\pm 1.24; -1.1; -2.5)$ and Average Z-Score was $-1.9(\pm 1.34; -1.1; -2.5)$; Osteoporosis in 425 patients(58.54%); the Average T-Score was $-3.3(\pm 1.24; -1.1; -4.6)$ and Average Z-Score was $-3.4(\pm 0.87; -0.7; -4.7)$.

Bisphosphonate and Vitamin D therapy was the most prescribed (Table 2) in 276(38.02%) patients.

The average 10-year fracture risk percentage according to FRAX (Fig. 1) was 14% (± 9.7 ; 3-24): in normal 3%(± 2.6 ; 0-6); in osteopenia 15% (± 3.2 ; 10-19); 24% (± 8.7 ; 19-65).

Screening showed that 6.33% of patients(n = 14) had osteopenia due to hypoparathyroidism. 80% of patients who had had gynecological or oncological ablative operations did not have adequate protective therapy for osteoporosis. 18.1%(n = 40) of osteopenia were due to inflammatory bowel diseases or diseases such as celiac disease. 90.18%(n = 393) of osteoporotic patients had undergone screening after a minor fracture, as in 70.18%(n = 298) of the wrist fractures.

Patients were very satisfied with the initiative (Fig. 2). 704 patients (96.96%) were satisfied.

Of the twenty-two patients (3.03%) who were not satisfied. Most conflicted with the bureaucracy for the prescription of drugs, tests and specialist visits for further information and control.

4. Discussion

The following discussion provides an analysis of the outcomes derived from our screening initiative within the Sannio rural population, situating them within the existing international scientific literature on osteoporosis and bone fragility.

Table 2
Results details of calcaneal quantitative ultrasound screening and therapy after the screening.

		n (%)	Average T-Score (SD; range)	Average Z-Score (SD; range)
Results of MOC	Normal	80 (11.02%)	$-0.82(\pm 0.32; 1.9; -1)$	$-0.77(\pm 0.42; 1.8; -1)$
	Osteopenia	221 (30.44%)	$-2.1(\pm 1.24; -1.1; -2.5)$	$-1.9(\pm 1.34; -1.1; -2.5)$
	Osteoporosis	425 (58.54%)	$-3.3(\pm 1.24; -1.1; -4.6)$	$-3.4(\pm 0.87; -0.7; -4.7)$
Patients in Therapy after the screening				
None		80 (11.02%)		
Vitamine D		221 (30.44%)		
Biphosphonate + Vit.D		276 (38.02%)		
Denosumab + Vit.D		100 (13.77%)		
Romosuzumab + Vit.D		49 (6.75%)		

4.1. Disease prevalence and demographic factors

Our findings indicate that the prevalence of osteoporosis in rural areas (10.33%) is higher than the rate documented in urban populations (5.52%), a pattern reported in cross-sectional studies from regions such as China.¹² This difference suggests a potential inequity in access to healthcare or diagnostic screening across geographical boundaries. The observed gender distribution aligns with global trends, where males exhibit a markedly lower prevalence of osteoporosis compared to females (2.68% vs. 13.82%).¹² Consistent with the hormone-related origin of the condition, postmenopausal women showed the highest prevalence (30.34%) relative to premenopausal women (4.78%).¹²

Globally, advanced age, female sex, and a reduced Body Mass Index (BMI) are consistently recognized as independent risk factors for the disease.¹² Furthermore, in both urban and rural cohorts, additional risk factors identified include hypertension, smoking, a familial history of osteoporosis, and dyslipidemia.¹²

4.2. Osteosarcopenia and specific rural vulnerabilities

The concurrent decline in bone and muscle health, termed osteosarcopenia, constitutes an evolving syndrome that significantly contributes to functional impairment.¹³ Research conducted by Bhat et al. demonstrated that osteosarcopenia was substantially more prevalent in rural women (13.9%) compared to their urban counterparts (1.6%).¹³ Key risk factors identified in this cohort included older age, low BMI, tobacco use, inadequate protein intake, and lower socioeconomic status.¹³ The study emphasized that women with sarcopenia faced an almost six-fold higher risk of developing osteoporosis (OR = 6.2).¹³ These results highlight the importance of targeting modifiable risks to mitigate negative, frailty-related consequences in rural communities.¹³ Additionally, investigations into the Dietary Inflammatory Index (DII) and osteosarcopenia suggest that a healthy, low-inflammatory diet may be pivotal in preserving musculoskeletal health among the elderly.¹⁴

4.3. Integrated care and clinical pathway optimization

The imperative for a more comprehensive and tailored preventive and therapeutic strategy is clear.¹⁵ The HOPE (*Healthy Longevity and Ageing in Place*) trial assessed the effectiveness of multicomponent integrated interventions (MIC) among older adults residing in rural settings.¹⁵ The MIC group, which encompassed pharmacological treatment for osteoporosis, pharmaceutical care, nutritional support, and physical exercise, exhibited a greater enhancement in intrinsic capacity (IC) and a lesser degree of reduction in happiness scores, compared to treatment for osteoporosis alone or usual care.¹⁵ This underscores the critical role of integrated approaches in promoting healthy aging within rural communities.¹⁵

The enhancement of the clinical care pathway is also vital. The adoption of a co-management protocol with internal medicine for hip fracture patients in Spain was shown to improve clinical outcomes, specifically reducing 30-day mortality post-discharge and elevating the rate of prescribed osteoporosis treatment.¹⁶

4.4. Bone density status and fracture risk assessment

A study focusing on bone mineral density (BMD) status in Spain found that peak bone mass is typically attained between 20 and 39 years of age in both sexes.¹⁷ BMD was positively correlated with height, BMI, and physical activity, while being negatively correlated with smoking.¹⁷ In postmenopausal women and men aged ≥ 50 years, 54.4% were found to have osteopenia, and 10.7% had osteoporosis, with the prevalence being higher in women (18.6% vs. 2.6%) and increasing with age.¹⁷ Separately, an analysis of patients with **Osteoporosis Vertebral Fractures (OVCF)** in China indicated that the age of onset is rising annually.¹⁸ Furthermore, gender influences characteristics such as the

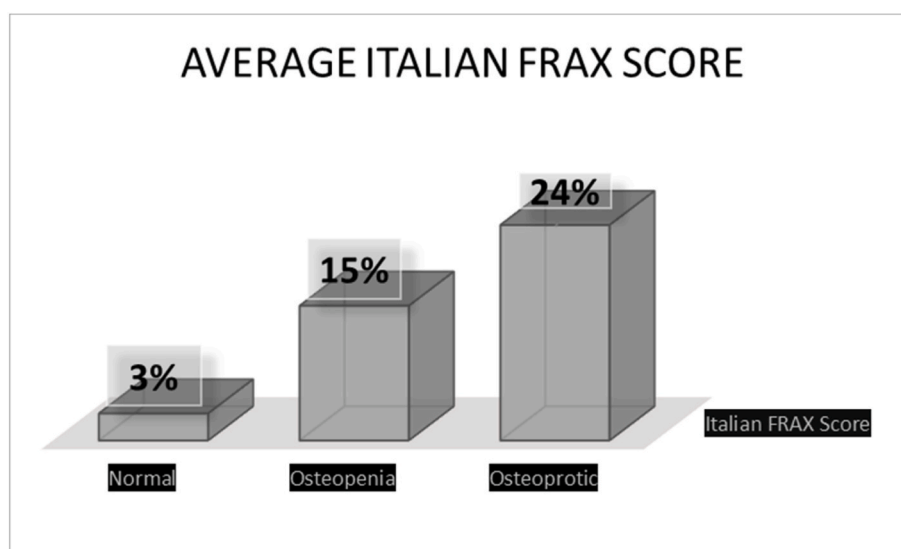


Fig. 1. The average 10-year fracture risk percentage according to FRAX was 14% (± 9.7 ; 3-24).

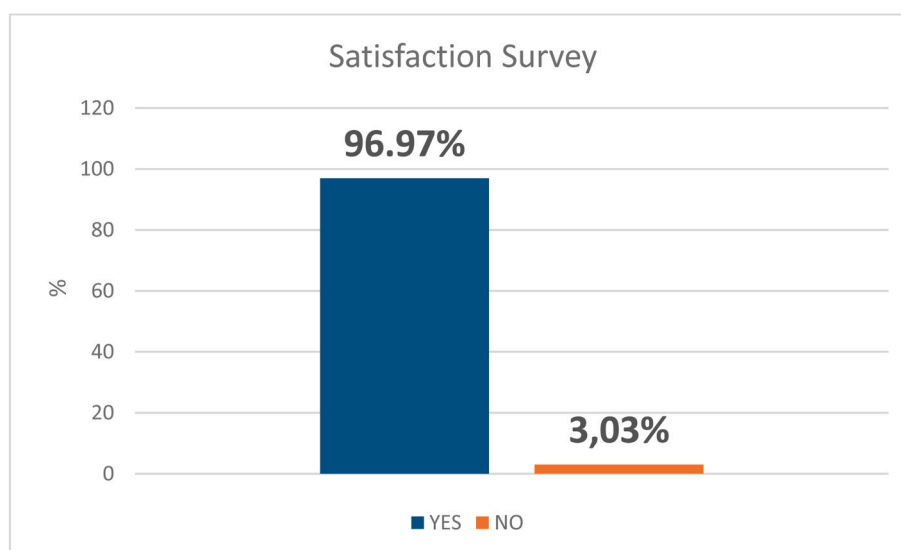


Fig. 2. Patients were very satisfied with the initiative.

number of fractured vertebrae, occupational distribution, BMI, and hypertension/blood lipid levels.¹⁸ The occurrence of OVCF is predominantly located in the thoracolumbar region, and female sex, older age, and lower BMI were confirmed as independent risk factors for osteoporosis.¹⁸

4.5. Guidelines and prophylactic screening

The 2024 guideline from the *Royal Australian College of General Practitioners* and *Healthy Bones Australia* encourages the early identification of poor bone health using clinical risk factors and the use of an absolute fracture risk assessment tool, particularly FRAX.¹⁸ However, widespread population-based osteoporosis screening is not recommended in Australia due to a lack of supporting evidence.¹⁸ It is paramount to recognize patients at "imminent" or "very high" fracture risk as a cohort for whom early osteoanabolic therapy should be considered.¹⁸ Moreover, the guideline stresses that calcium and Vitamin D supplementation are most effective in reducing fracture risk when administered to individuals with a documented deficiency, not to healthy,

non-institutionalized persons.¹⁸

To improve identification and care, a nurse-led BMD self-referral program in a primary health care setting demonstrated an increased rate of BMD testing compared to control centers.¹⁹ Critically, this type of program identified a higher number of men aged 65 years and older who were at risk for osteoporosis and bone fractures^{12,19-21}.

In conclusion, the data from the Sannio project, which showed high patient satisfaction with the mobile screening model (Fig. 2), reinforces the evidence supporting accessible and integrated programs to improve bone health outcomes in underserved rural communities.

5. Conclusions

The strengths of this study are (Fig. 3):

This mobile screening initiative revealed significant unmet needs in bone health prevention across the rural Sannio area. High participation rates and overwhelmingly positive feedback highlight both interest and necessity for structured, ongoing programs. Findings support the establishment of comprehensive primary-care-based pathways for early

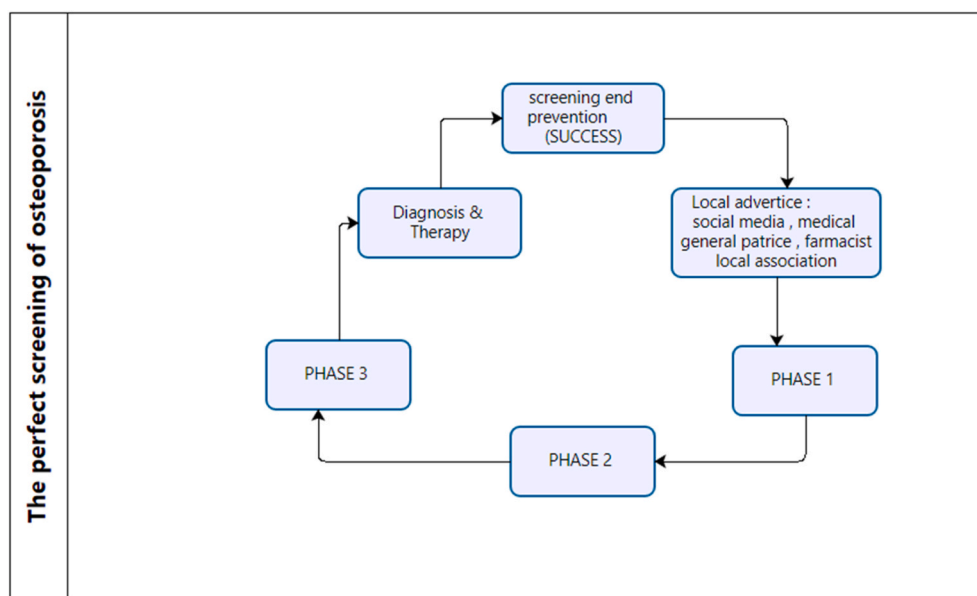


Fig. 3. Flowchart. *The perfect circle about rural osteoporosis screening and therapy.*

detection, secondary prevention, and long-term management of osteoporosis in underserved rural communities.

Author contributions

“Conceptualization, L.M., G.C., M.L. M., M.R., G.R., J.C.; methodology, L.M., J.C.; software, L.M.; validation, G.R., A.F., F.B., L.M., M.L. M.; formal analysis, L.M., M.R. writing, L.M., J.C. All authors have read and agreed to the published version of the manuscript.”

Institutional review board statement

The study was conducted in accordance with the Declaration of Helsinki, Clinical trial number: not applicable.

Human ethics and consent to participate declarations

Not applicable. Every human participant should provide their consent. Approval Committee or the Internal Review Board (IRB): Approved by Internal Committee AO San Pio Hospital.

Data availability statement

That the data can be requested from the corresponding author and will be given within a reasonable time.

Ethical statement

All authors agree that:

This research presents an accurate account of the work performed, all data presented are accurate and methodologies detailed enough to permit others to replicate the work.

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All authors have been personally and actively involved in substantive work leading to the manuscript and will hold themselves jointly and individually responsible for its content.

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Abbreviations

QUS	calcaneal quantitative ultrasound
FRAX	fracture risk assessment tool
BMI	Body Mass Index
IC	intrinsic capacity
HOPE	Healthy Longevity and Ageing in Place
DII	Dietary Inflammatory Index
OVCF	Osteoporosis Vertebral Fractures
MDPI	Multidisciplinary Digital Publishing Institute
DOAJ	Directory of open access journals
TLA	Three letter acronym
LD	Linear dichroism

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