Analysis of Osteoporosis Diagnosis and Treatment Capabilities in Shanghai's Community Health Service Institutions: Postprint

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Abstract

Background: The diagnostic and therapeutic capabilities of Shanghai community health service institutions for osteoporosis remain unclear, lacking systematic evaluation and monitoring.

Objective: To understand the current status of diagnosis, treatment, and management of osteoporosis in Shanghai community health service institutions, evaluate their clinical capabilities, and explore existing problems and improvement measures.

Methods: In December 2023, survey questionnaires were distributed to a total of 248 community health service centers and 1,873 general practitioners across 16 districts in Shanghai, investigating the current status, awareness, and capabilities of urban and suburban community health service institutions and general practitioners regarding osteoporosis diagnosis, treatment, and management.

Results: Among the 248 community health service centers in 16 districts of Shanghai, 79 (31.9%) were in urban areas and 169 (68.1%) in suburban areas; among the 1,873 general practitioners, 497 (26.5%) were from urban areas and 1,376 (73.5%) from suburban areas. Regarding the availability of examination and laboratory testing facilities for osteoporosis in Shanghai community health service institutions, the proportions of urban and suburban community health service centers equipped with bone densitometry and bone turnover marker tests were 92.4% vs. 50.9% and 50.6% vs. 12.4%, respectively ($P<0.05$). In terms of osteoporosis medication availability, the proportions of urban and suburban community health service centers equipped with bisphosphonates, active vitamin D and its analogues were 73.4% vs. 45.0% and 69.9% vs. 53.3%, respectively ($P<0.05$). Regarding the implementation of osteoporosis therapeutic modalities, the proportions of urban and suburban community health service

centers offering exercise therapy, physical therapy, and occupational therapy were 73.4% vs. 50.3%, 73.4% vs. 37.9%, and 65.8% vs. 38.5%, respectively (P<0.05). The main difficulties in osteoporosis disease management in community health service centers included insufficient examination equipment and incomplete availability of therapeutic drugs, which were more pronounced in suburban areas (P<0.05). Regarding general practitioners' awareness of osteoporosis high-risk populations and screening in community health service centers, the proportions of urban and suburban general practitioners aware of postmenopausal women were 99.2% vs. 97.8% (P<0.05), and those aware of the Osteoporosis Self-assessment Tool for Asians (OSTA) were 88.3% vs. 84.4% (P<0.05). In terms of awareness of common symptoms and laboratory tests for osteoporosis, the proportions of urban and suburban general practitioners aware of compression fractures were 97.0% vs. 92.2% (P<0.05), and those aware of bone turnover markers were 67.6% vs. 45.2% (P<0.05). Regarding awareness of osteoporosis treatment modalities, the proportions of urban and suburban general practitioners aware of physical therapy and occupational therapy were 89.3% vs. 84.7% and 86.3% vs. 81.2%, respectively (P<0.05). The main difficulties for general practitioners in community health service centers regarding osteoporosis diagnosis and treatment included: insufficient ability to identify high-risk populations, inadequate osteoporosis risk assessment capabilities, lack of diagnostic confidence, and insufficient competence in drug selection and compatibility, which were more pronounced in suburban areas (P<0.05).

Conclusion: Shanghai community health service institutions, particularly suburban community health service centers and general practitioners, need to strengthen the availability of osteoporosis-related examinations and tests such as bone densitometry and bone turnover markers, improve the variety of therapeutic drugs including bisphosphonates, active vitamin D and its analogues, enhance the implementation of relevant appropriate technologies including exercise, physical therapy, and occupational therapy, as well as systematic comprehensive management of osteoporosis. It is recommended to improve relevant information system construction and coordinate and integrate multidisciplinary teams and multi-sectoral resources.

Full Text

Analysis of Osteoporosis Diagnosis and Treatment Capacity in Shanghai Community Health Service Institutions

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Abstract

Background: The diagnostic and treatment capabilities for osteoporosis in Shanghai community health service institutions remain unclear, with systematic evaluation and monitoring lacking. **Objective:** To understand the current status of osteoporosis diagnosis and management in Shanghai community health services, evaluate their treatment capacity, and explore existing problems and improvement measures. **Methods:** In December 2023, questionnaires were distributed to 248 community health service centers and 1,873 general practitioners (GPs) across 16 administrative districts of Shanghai, investigating the current status, knowledge, and competencies regarding osteoporosis diagnosis and management in urban and suburban community institutions. **Results:** Among the 248 community health centers, 79 (31.9%) were in urban areas and 169 (68.1%) in suburban areas. Among the 1,873 GPs, 497 (26.5%) were in urban areas and 1,376 (73.5%) in suburban areas. Regarding examination and testing equipment, the availability rates of bone mineral density (BMD) testing and bone turnover marker tests were 92.4% vs. 50.9% and 50.6% vs. 12.4% in urban versus suburban centers, respectively ($P<0.05$). For medication availability, urban and suburban centers showed significant differences in bisphosphonates (73.4% vs. 45.0%) and active vitamin D analogues (69.9% vs. 53.3%) ($P<0.05$). In terms of non-pharmacological treatments, urban centers had higher implementation rates for exercise therapy (73.4% vs. 50.3%), physical factor therapy (73.4% vs. 37.9%), and occupational therapy (65.8% vs. 38.5%) compared to suburban centers ($P<0.05$). Major management challenges included insufficient examination equipment and incomplete medication supplies, particularly pronounced in suburban areas ($P<0.05$). Regarding GP knowledge of high-risk populations and screening tools, urban GPs showed higher awareness of postmenopausal women (99.2% vs. 97.8%) and the Osteoporosis Self-assessment Tool for Asians (OSTA) (88.3% vs. 84.4%) ($P<0.05$). For symptom recognition, urban GPs demonstrated better awareness of compression fractures (97.0% vs. 92.2%) and bone turnover markers (67.6% vs. 45.2%) ($P<0.05$). For treatment modalities,

urban GPs had higher awareness of physical factor therapy (89.3% vs. 84.7%) and occupational therapy (86.3% vs. 81.2%) ($P<0.05$). Primary diagnostic and treatment difficulties included inadequate ability to identify high-risk populations, insufficient osteoporosis risk assessment capacity, lack of diagnostic confidence, and limited medication selection and combination skills, with suburban GPs reporting more significant challenges ($P<0.05$). **Conclusion:** Shanghai community health service institutions, particularly those in suburban areas, need to strengthen the availability of osteoporosis-related examinations (BMD, bone turnover markers) and therapeutic medications (bisphosphonates, active vitamin D analogues), expand non-pharmacological interventions including exercise therapy, physiotherapy, and occupational therapy, and implement systematic comprehensive management approaches. Recommendations include enhancing information system construction and coordinating multidisciplinary teams and resources.

Keywords: Osteoporosis; Community health centers; Practice management, medical; Diagnosis and treatment standard; Quality of care; Shanghai

Introduction

Osteoporosis is a systemic skeletal disease characterized by low bone mass, deterioration of bone microarchitecture, increased bone fragility, and susceptibility to fracture, which can occur in any age group but is most common in postmenopausal women and elderly men. With China's aging population, the incidence of osteoporosis has been rising annually. Surveys indicate that among osteoporosis patients in mainland China, the 10-year growth rates are approximately 15% for men and 20% for women, with an overall prevalence of 24.62% in individuals over 40 years old, affecting up to 140 million people. Early-stage osteoporosis often presents with subtle symptoms that are easily overlooked, yet it can lead to serious complications such as fractures, compromising patient prognosis and quality of life. Therefore, early prevention and standardized management of osteoporosis are particularly critical. However, systematic evaluation and monitoring of community health service institutions' capabilities remain lacking, leaving their diagnostic and treatment capacities for osteoporosis unclear. This study employed a multi-center, cross-sectional survey method to investigate the current status of osteoporosis-related diagnosis, treatment, and management capabilities among Shanghai community health service centers and their GPs. The aim was to understand the current diagnostic and treatment landscape, identify problems, and propose improvement measures to enhance primary care service capacity and improve patient outcomes and quality of life.

Methods

1.1 Survey Subjects

In December 2023, GPs from 248 community health service centers across Shanghai's 16 administrative districts were selected as survey subjects. Based on the number of practicing GPs and their professional structure at each center, a stratified simple random sampling method was employed, selecting 25% from each professional rank (resident, attending, associate chief, and chief physician). A total of 1,873 GPs were identified as questionnaire respondents. Inclusion criteria were: (1) currently practicing community GPs, and (2) informed consent and willingness to participate. Exclusion criteria were: non-cooperation or incomplete questionnaire responses. This study was approved by the Ethics Committee of Tongji University Affiliated Yangpu Hospital (Approval No.: LL-2023-LW-020).

1.2 Questionnaire Design and Distribution

1.2.1 Questionnaire Design The research team developed the questionnaire based on osteoporosis community diagnosis and management guidelines. The survey consisted of two parts: (1) **Institution questionnaire (Questionnaire 1)**: A baseline survey of community health centers regarding osteoporosis diagnosis and management quality, covering: (a) availability of osteoporosis-related examinations, tests, and medications; (b) implemented treatment technologies; (c) current disease management status and challenges; and (d) existing training methods. This was completed by quality control officers at each community health center. (2) **GP questionnaire (Questionnaire 2)**: Assessing GPs' knowledge of osteoporosis, including high-risk populations, screening tools, common symptoms, fracture risk, medication types and treatment methods, patient referral criteria, and diagnostic and management challenges.

1.2.2 Questionnaire Distribution Through the quality control network of Shanghai General Practice Clinical Quality Control Center, the questionnaire was distributed and collected via point-to-point contact between quality control secretaries and liaison officers at each community health center, ensuring high response rates and quality control. The survey was conducted in two rounds through an online questionnaire platform. Both questionnaires achieved a 100% response rate.

1.3 Statistical Analysis

Questionnaire data were analyzed using SPSS 23.0 software. Normally distributed continuous variables were expressed as mean ± standard deviation ($\bar{x}\pm s$). Categorical data were expressed as frequencies and percentages, with between-group comparisons using chi-square tests or Fisher's exact test. Statistical significance was set at $P<0.05$.

Results

2.1 Basic Information of Shanghai Community Health Centers and GPs

A total of 1,873 GPs from 248 community health centers participated in the survey. Centers were categorized by location: 79 (31.9%) urban and 169 (68.1%) suburban. Among GPs, 497 (26.5%) practiced in urban areas and 1,376 (73.5%) in suburban areas. The GP cohort included 574 males (30.7%) and 1,299 females (69.4%), with a mean age of 38.94$\pm$7.78*yearsandaverageworkexperienceof*15.54$\pm$9.13 years. Additionally, 58.8% (1,102/1,873) had completed standardized residency training in general practice. Detailed distributions by location, professional title, and education level are presented in Table 1 .

2.2 Osteoporosis Diagnosis and Management in Community Health Centers

2.2.1 Availability of Osteoporosis Examination Equipment The availability of X-ray, MRI, and nuclear medicine examinations did not differ significantly between urban and suburban community health centers (P>0.05). However, urban centers had lower CT availability but higher dual-energy X-ray absorptiometry (DXA) bone density testing availability compared to suburban centers, with statistically significant differences (P<0.05) .

2.2.2 Availability of Osteoporosis Laboratory Tests The availability of urinary calcium/phosphorus/creatinine tests showed no significant difference between urban and suburban centers (P>0.05). Urban centers demonstrated significantly higher availability of bone turnover markers and serum calcium/phosphorus tests compared to suburban centers (P<0.05) .

2.2.3 Availability of Osteoporosis Medications Overall, 94.4% (234/248) of community health centers stocked at least one anti-osteoporosis medication, while 10.9% (27/248) carried only traditional Chinese patent medicines. Regarding specific medications, urban centers showed significantly higher availability of active vitamin D analogues (69.6% vs. 53.3%) and bisphosphonates (73.4% vs. 45.0%) compared to suburban centers (P<0.05). No significant differences were observed for calcitonin, RANKL monoclonal antibody (denosumab), sclerostin monoclonal antibody (romosozumab), parathyroid hormone analogues, estrogen, selective estrogen receptor modulators, vitamin K2, calcium receptor modulators, or traditional Chinese patent medicines (P>0.05) .

2.2.4 Implementation of Osteoporosis Treatments No significant difference was observed in the implementation rates of traditional Chinese medicine appropriate technologies between urban and suburban centers (P>0.05). However, urban centers showed significantly higher implementation rates for exercise

therapy (73.4% vs. 50.3%), physical factor therapy (73.4% vs. 37.9%), and occupational therapy (65.8% vs. 38.5%) compared to suburban centers (P<0.05) .

2.2.5 Implementation of Osteoporosis Management Programs Only 36 centers (14.5%) had established osteoporosis management information systems, with just 7 achieving interoperability with regional hospital information systems (HIS). Of these 36 centers, 13 were urban (16.5%) and 23 were suburban (13.6%), with no significant difference in proportion (P>0.05). Urban centers demonstrated significantly higher implementation rates for routine chronic disease management (including regular intervention and follow-up), screening, rehabilitation, standardized medical record documentation, specialized clinics, patient self-management groups, and community health education compared to suburban centers (P<0.05) .

2.2.6 Challenges in Osteoporosis Management Community health centers identified insufficient examination equipment, incomplete medication supplies, and limited physician diagnostic capacity as primary management challenges, with suburban centers reporting significantly higher rates for equipment and medication shortages (86.4% and 90.5% vs. 72.2% and 78.5%, respectively) (P<0.05). No significant differences were observed regarding difficulties with two-way referral pathways or expert guidance (P>0.05) .

2.2.7 Training Methods for Osteoporosis No significant differences were found in the utilization of in-house lectures or absence of training between urban and suburban centers (P>0.05). However, urban centers reported significantly higher rates of self-study and organized participation in academic conferences or training programs (P<0.05) .

2.3 GP Knowledge of Osteoporosis Diagnosis and Treatment

2.3.1 Knowledge of High-Risk Populations No significant differences were observed between urban and suburban GPs in recognizing most high-risk factors, including advanced age, family history of fragility fractures, unhealthy lifestyle, diseases affecting bone metabolism, and medications affecting bone metabolism (P>0.05). However, urban GPs showed significantly higher awareness of postmenopausal women as a high-risk group (99.2% vs. 97.8%) (P<0.05) .

2.3.2 Knowledge of Screening Tools No significant differences were found in awareness of the International Osteoporosis Foundation (IOF) One-Minute Osteoporosis Risk Test or the Fracture Risk Assessment Tool (FRAX®) between urban and suburban GPs (P>0.05). Urban GPs demonstrated significantly higher awareness of the Osteoporosis Self-assessment Tool for Asians (OSTA) compared to suburban GPs (88.3% vs. 84.4%) (P<0.05) .

2.3.3 Knowledge of Clinical Symptoms No significant differences were observed in awareness of back pain, height loss/kyphosis, or spinal deformity between urban and suburban GPs (P>0.05). However, urban GPs showed significantly higher awareness of compression fractures (97.0% vs. 92.2%) (P<0.05) .

2.3.4 Knowledge of Fracture Risk Factors No significant differences were found in awareness of recent fragility fractures (particularly within 24 months), fractures during anti-osteoporosis treatment, multiple fragility fractures, high-dose glucocorticoid use ($ $7.5 mg/d prednisolone for >3 months), high fall risk, or FRAX-calculated 10-year major osteoporotic fracture risk >30% or hip fracture risk >4.5% (P>0.05). Urban GPs showed significantly higher awareness of DXA-measured bone density (T<-3.0) as a risk factor (P<0.05) .

2.3.5 Knowledge of Diagnostic Examinations and Tests No significant differences were observed in awareness of X-ray, nuclear medicine, or ultrasound bone density between urban and suburban GPs (P>0.05). Urban GPs demonstrated significantly higher awareness of bone density testing, bone turnover markers, serum calcium/phosphorus, urinary calcium/phosphorus, and blood/urine routine tests, but lower awareness of CT and MRI compared to suburban GPs (P<0.05) .

2.3.6 Knowledge of Therapeutic Medications No significant differences were found in awareness of active vitamin D analogues, parathyroid hormone analogues, estrogen, selective estrogen receptor modulators, or vitamin K2 between urban and suburban GPs (P>0.05). Urban GPs showed significantly higher awareness of bisphosphonates, calcitonin, RANKL monoclonal antibody (denosumab), sclerostin monoclonal antibody (romosozumab), and traditional Chinese patent medicines compared to suburban GPs (P<0.05) .

2.3.7 Knowledge of Treatment Modalities No significant differences were observed in awareness of exercise therapy or rehabilitation engineering between urban and suburban GPs (P>0.05). Urban GPs demonstrated significantly higher awareness of physical factor therapy and occupational therapy compared to suburban GPs (P<0.05) .

2.3.8 Knowledge of Patient Referral Criteria No significant differences were found in referral criteria including patients with pain or fractures requiring diagnosis, severe complications, lack of examination capabilities, adverse drug reactions, or absence of therapeutic medications (P>0.05) .

2.3.9 Challenges in Osteoporosis Diagnosis and Treatment No significant differences were observed regarding insufficient experience with newer medications or inability to establish treatment control targets (P>0.05). However, suburban GPs reported significantly higher rates of insufficient ability to identify

high-risk populations, inadequate osteoporosis risk assessment capacity, lack of diagnostic confidence, and limited medication selection and combination skills compared to urban GPs ($P<0.05$) .

2.3.10 Challenges in Osteoporosis Management No significant differences were found regarding poor patient compliance or limited consultation time ($P>0.05$). Suburban GPs reported significantly higher rates of insufficient health education capacity, lack of examination equipment, incomplete medication supplies, lack of expert guidance, and absence of two-way referral pathways compared to urban GPs ($P<0.05$) .

Discussion

3.1 System-Based Analysis of Community Osteoporosis Care

Community health centers face significant deficiencies in osteoporosis examination and testing capabilities, with suburban areas particularly disadvantaged. For diagnostic equipment, urban centers achieved availability rates of 92.4% for DXA bone density testing, 50.6% for bone turnover markers, and 91.1% for serum calcium/phosphorus tests—substantially higher than suburban rates of 50.9%, 12.4%, and 65.1%, respectively. While X-ray availability showed no significant urban-suburban difference (88.6% vs. 87.6%), DXA bone density testing is crucial for early detection and diagnosis of osteoporosis. X-ray imaging, though capable of showing trabecular bone sparsity, is subjectively interpreted and only becomes positive after more than 30% bone loss, making early detection difficult. Bone turnover markers and serum calcium/phosphorus tests, while not diagnostic for osteoporosis, play important roles in differential diagnosis of bone diseases, fracture risk prediction, treatment adherence monitoring, and therapeutic efficacy assessment. These findings indicate substantial objective limitations in community-level osteoporosis diagnosis and assessment, particularly the critically low availability of bone density testing and bone turnover marker tests in suburban areas.

Notably, CT availability was higher in suburban centers (45.6%) than urban centers, while MRI and nuclear medicine examinations were available in only about 1% of centers in both regions. Although these modalities are valuable for detecting subtle fractures and differential diagnosis of bone diseases, research suggests CT is less effective than X-ray for early osteoporosis diagnosis, providing diagnostic value only when patients have obvious osteoporosis or compression fractures. This suggests communities need to better utilize and integrate existing resources according to disease characteristics and equipment features to improve osteoporosis care quality.

Regarding medication availability, 94.4% of community health centers stocked at least one anti-osteoporosis drug, primarily including active vitamin D analogues, bisphosphonates, and traditional Chinese patent medicines. Urban centers

showed significantly higher availability of bisphosphonates (73.4% vs. 45.0%) and active vitamin D analogues (69.6% vs. 53.3%) compared to suburban centers. Additionally, 10.9% of centers carried only traditional Chinese patent medicines for osteoporosis treatment. Studies on medication consumption patterns in community settings have shown that while calcium supplements consistently rank first, consumption of alendronate sodium is increasing while some traditional Chinese patent medicines are declining. This indicates a need for improved availability of essential anti-osteoporosis medications, particularly in suburban areas.

For non-pharmacological treatments, traditional Chinese medicine appropriate technologies were similarly implemented in urban and suburban centers (79.7% vs. 80.5%). However, urban centers showed higher implementation rates for exercise therapy (73.4% vs. 50.3%), physical factor therapy (73.4% vs. 37.9%), and occupational therapy (65.8% vs. 38.5%). Osteoporosis management requires comprehensive approaches, and guidelines recommend multiple rehabilitation modalities including exercise, physiotherapy, and occupational therapy. Literature has documented the effectiveness of combined traditional Chinese medicine and exercise interventions, as well as anti-osteoporosis medications combined with physiotherapy, in improving symptoms, reducing pain, regulating bone metabolism, and increasing bone density. This suggests substantial potential for expanding non-pharmacological interventions, particularly in suburban community health centers.

In chronic disease management, routine chronic disease management for osteoporosis was notably insufficient, with only 35.4% of urban centers and 16.6% of suburban centers implementing such programs. Urban centers demonstrated higher implementation rates for rehabilitation services (64.6% vs. 28.4%) and specialized clinics (41.8% vs. 14.2%), as well as screening (26.4% vs. 24.9%) and health education (70.9% vs. 55.6%). Community surveys have shown that 90.12% of residents desire osteoporosis-related training and prefer obtaining information through online platforms or community health activities. This highlights the need for communities to strengthen systematic chronic disease management while emphasizing health education tailored to residents' needs for better prevention and early intervention. Regarding information systems, only 36 centers had established osteoporosis-related information platforms, with no significant urban-suburban difference. Research has demonstrated that information-based management integrating multidisciplinary teams improves pain symptoms, quality of life, and health literacy among chronic disease patients. This underscores the importance of enhancing information system construction for effective chronic disease management.

Community health centers identified insufficient examination equipment, incomplete medication supplies, and limited physician diagnostic capacity as primary management challenges, with suburban centers reporting significantly higher rates of equipment and medication shortages (86.4% and 90.5% vs. 72.2% and 78.5%, respectively). While urban centers had higher availability of key di-

agnostic tools (bone density testing) and medications (bisphosphonates and active vitamin D analogues) but lower CT availability, this suggests communities need not only to strengthen equipment and medication supplies but also make rational priority selections based on their characteristics. Regarding limited physician capacity, urban centers reported 79.7% vs. 82.8% in suburban centers, with no significant statistical difference. Notably, only 1.3% of urban centers reported no training activities compared to 6.5% of suburban centers, indicating that current training still falls short of meeting community needs for osteoporosis diagnosis and management.

3.2 Individual Capacity and Standardization in Community Osteoporosis Care

In screening and assessment, GPs generally demonstrated high awareness of high-risk populations, with suburban GPs showing slightly lower but still substantial awareness of postmenopausal women (97.8% vs. 99.2%). Postmenopausal women represent the primary at-risk population, and systematic reviews have confirmed that postmenopausal osteoporosis and fragility fractures reduce health-related quality of life (HRQoL), with bone density positively correlated and fracture severity negatively correlated with HRQoL. This suggests suburban GPs need to enhance disease assessment and prevention awareness for this population.

For screening tools, urban GPs showed higher awareness of OSTA (88.3% vs. 84.4%). While OSTA has limited specificity and is primarily used for postmenopausal women, it is intuitive and convenient, with positive results indicating the need for bone density testing and providing predictive value for fracture risk. This indicates that community GPs need to strengthen awareness of OSTA and screening for at-risk populations.

Regarding clinical symptoms, suburban GPs showed lower awareness of compression fractures (92.2% vs. 97.0%). For fracture risk assessment, awareness of "DXA-measured bone density (T<-3.0)" and "high fall risk or chronic disease-related fall history" was below 90% in both groups, while awareness of "FRAX-calculated 10-year major osteoporotic fracture risk >30% or hip fracture risk >4.5%" was below 80%. Bone density values and FRAX are important risk assessment tools and indicators for osteoporotic fractures. Reports indicate that in Chinese populations over 40 years, the prevalence of osteoporosis is 5.0% in men and 20.6% in women, with vertebral fracture rates of 10.5% in men and 9.7% in women. This highlights the need for community GPs to strengthen fracture risk assessment capabilities.

For diagnostic examinations, urban GPs showed higher awareness of bone density testing (97.2% vs. 92.1%) but lower awareness of CT and MRI compared to suburban GPs (66.2% vs. 70.6% and 27.4% vs. 34.9%, respectively). Combined with equipment availability patterns, this suggests community GPs' diagnostic capabilities are limited by equipment conditions, while also indicating poten-

tial for utilizing existing X-ray, CT, and MRI resources to enhance differential diagnosis and fracture assessment.

For laboratory tests, urban GPs demonstrated higher awareness of bone turnover markers (67.6% vs. 45.2%), serum calcium/phosphorus (92.6% vs. 87.0%), and urinary calcium/phosphorus (53.9% vs. 46.9%), suggesting GPs need to strengthen utilization of these tests for disease assessment. Notably, awareness of blood/urine routine tests was 44.9% in urban vs. 39.2% in suburban GPs, while liver and kidney function test awareness was 52.3% vs. 47.5%, respectively. Reports have linked anti-osteoporosis drug adverse reactions to patients' 25-hydroxyvitamin D levels, indicating the need for enhanced monitoring.

Regarding therapeutic medications, urban GPs showed higher awareness of bisphosphonates, calcitonin, RANKL monoclonal antibody (denosumab), sclerostin monoclonal antibody (romosozumab), and traditional Chinese patent medicines. Awareness of bisphosphonates reached 95.4% among urban GPs, correlating with 73.4% availability in urban centers, suggesting GP prescribing patterns are constrained by existing resources. Awareness of active vitamin D analogues and traditional Chinese patent medicines was 64.6% and 43.9% in urban GPs vs. 60.6% and 32.8% in suburban GPs, respectively. As active vitamin D analogues are essential for bone health and traditional Chinese patent medicines are commonly used in community settings, GP knowledge and application of these agents require strengthening.

For non-pharmacological treatments, awareness of exercise therapy, physical factor therapy, occupational therapy, and rehabilitation engineering exceeded 85% among community GPs, yet implementation rates remained below 80%, indicating substantial potential for expanding these interventions.

Regarding patient referral, awareness of adverse drug reactions and absence of therapeutic medications as referral indications showed no urban-suburban difference, both below 80%. Studies have shown that a two-way referral model based on hierarchical diagnosis and treatment systems improves bone metabolism, bone density, and quality of life in elderly osteoporosis patients. This highlights the need for community GPs to strengthen awareness of medication indications, contraindications, and adverse reactions, while enhancing two-way referral protocols.

Regarding diagnostic challenges, the most frequently cited difficulty was "insufficient experience with newer medications," reported by 85.3% of urban and 82.8% of suburban GPs. Other challenges including "limited medication selection and combination skills," "insufficient osteoporosis risk assessment capacity," "inadequate high-risk population identification," and "inability to establish treatment control targets" were more pronounced among suburban GPs. For management challenges, suburban GPs reported higher rates of insufficient examination equipment (84.2%) and lack of expert guidance (76.6%). These findings indicate that improving osteoporosis care requires simultaneous enhancement

of GP diagnostic capacity and community support for essential equipment and resources. Additionally, both urban and suburban GPs cited poor patient compliance (79.7% and 80.3%, respectively) as a management challenge. Studies have reported individual variations in osteoporosis patients based on gender, education, family history, comorbidities, and immune function, suggesting that disease management optimization should emphasize individualized patient education and health literacy.

3.3 Strategies to Improve Community Osteoporosis Care Quality

Based on survey findings regarding community health centers and GPs, the following strategies are proposed to improve osteoporosis diagnosis and management quality:

1. **Strengthen essential equipment and medication availability** at primary care institutions, focusing on bone density testing, bone turnover markers, active vitamin D analogues, and bisphosphonates. Community health centers should also expand non-pharmacological interventions such as exercise therapy, physical factor therapy, occupational therapy, and traditional Chinese medicine appropriate technologies based on their existing resources and infrastructure.

2. **Tailor GP training programs** to address specific needs and disease characteristics, emphasizing practical skills including rational selection and application of examinations and tests, as well as detailed knowledge of medication contraindications, indications, dosing, and administration to enhance diagnostic confidence and treatment competence.

3. **Implement systematic comprehensive management** approaches given current equipment and expertise limitations. This includes enhancing information system construction, establishing integrated service processes encompassing community education, screening, specialized diagnosis and treatment, standardized documentation, and patient self-management, while coordinating multidisciplinary teams and resources, such as strengthening specialist-GP collaboration for osteoporosis care.

4. **Prioritize health education and patient engagement** strategies, recognizing that poor compliance affects nearly 80% of patients. Management approaches should incorporate individualized education based on patient demographics, comorbidities, and treatment responses.

Community health centers currently face inadequate diagnostic and treatment conditions for osteoporosis, particularly in suburban areas, with insufficient essential equipment (bone density, bone turnover markers), limited availability of key medications (bisphosphonates, active vitamin D analogues), and underutilization of non-pharmacological interventions. Management systems lack comprehensive health education, screening programs, and information-based disease management platforms. Community GPs, especially in suburban centers,

demonstrate insufficient diagnostic and management experience, with notable gaps in health education capacity, knowledge of specific examination and medication applications, and fracture risk assessment. Beyond addressing equipment and medication shortages and enhancing training, improving information systems and integrating multidisciplinary resources are essential for systematic comprehensive disease management.

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Author Contributions

Zhang Hanzhi was responsible for questionnaire design, results analysis, manuscript writing, and revision. Jin Hua and Ma Le contributed to questionnaire revision, distribution, and data collection. Shi Ling, Chen Chen, and Huan Hongmei participated in questionnaire revision and research design. Yu Dehua conceived the research idea, designed the overall study, and took responsibility for the manuscript.

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Note: Figure translations are in progress. See original paper for figures.