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Research Article

Determination of Osteoporosis Risk in Post-Menopausal Women Using the Malaysian Osteoporosis Screening Tool: A Pilot Study in a Community Pharmacy

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Abstract

Osteoporosis detection remains suboptimal in Malaysia. This study aimed to evaluate osteoporosis risk using the Malaysian Osteoporosis Screening Tool (MOST) and supplementation behaviors in a community pharmacy. A cross-sectional study was conducted in a private pharmacy in Temerloh, Pahang (May–August 2025). Postmenopausal women (n = 126) completed questionnaires and underwent anthropometric assessment (BMI, hip circumference). MOST scores were calculated, and group differences were analyzed using Mann–Whitney U and Kruskal–Wallis tests ($p < 0.05$). All participants were classified as "at risk" (MOST ≥ 4); the median score was 42.0 (IQR 12.0 – 42.0). Scores were significantly higher among women aged ≥ 60 years ($p < 0.001$), those with lower education ($p = 0.005$), and the unemployed ($p = 0.005$), but were unrelated to income, ethnicity, or residence. Hip circumference was ≥ 90 cm in 96.8% of cases, limiting its discriminatory value. Lifestyle and clinical factors, including family history, hormone therapy, steroid use, smoking, coffee intake, carbonated drinks, and calcium- and vitamin D-rich foods, were not associated with MOST scores. Supplement use included calcium (27.8%), vitamin D (35.7%), and combined calcium–vitamin D (26.2%). Calcium users had higher scores ($p = 0.011$); vitamin D or combined use showed no differences ($p > 0.05$). MOST concentrated nearly all postmenopausal women into the high-risk category, primarily reflecting age and menopausal duration. Findings support its feasibility in community pharmacies and highlight gaps in coordinated calcium and vitamin D supplementation.

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INTRODUCTION

Osteoporosis represents a major public health challenge. In Malaysia, as in many other countries experiencing rapid population aging, the burden of osteoporosis is expected to rise substantially. A cross-sectional study conducted between 2014 and 2015 reported a prevalence of 10.6% in men and 8.0% in women aged 50 years and above living in Kuala Lumpur[1]. In a 2018 study among Malaysian Chinese aged ≥ 40 years in the Klang Valley, 15.3% of the overall population and 32.6% of those aged ≥ 71 years were found to have osteoporosis[2]. Similarly, a 2019 study involving Malaysians aged ≥ 40 years in the Klang Valley reported that the prevalence of suboptimal bone health and osteoporosis was higher in women, at 59.4% and 16.1%, respectively[3].

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Common risk factors for osteoporosis in Malaysia include advanced age, low body weight, smoking, lack of regular exercise, and inadequate calcium intake[4]. The risk is particularly high among postmenopausal women, in whom estrogen deficiency accelerates bone loss and increases susceptibility to fractures[5]. The consequences of osteoporosis are considerable, encompassing reduced quality of life, loss of independence, and increased morbidity and mortality resulting from fragility fractures[6,7]. Nevertheless, early detection remains insufficient, and existing clinical guidelines for osteoporosis screening and management are not being fully applied[8].

Early identification of women with low bone mineral density (BMD) before fractures occur, along with timely initiation of preventive measures, is an important strategy to reduce the incidence of osteoporotic fractures. Accurate diagnosis and effective management of osteoporosis can minimize injury and disability, improve quality of life, and lower healthcare costs. Although BMD measurement is widely regarded as the gold standard for diagnosing osteoporosis[9], universal screening of all elderly women is unlikely to be cost-effective. Instead, the use of appropriate screening tools can raise awareness of osteoporosis among women and help healthcare professionals identify and select individuals most in need of BMD testing. This is especially relevant in settings with limited access to dual-energy X-ray absorptiometry (DXA) facilities. Several tools are available for identifying women at risk of osteoporosis, including the Fracture Risk Assessment Tool (FRAX), the Osteoporosis Self-Assessment Tool for Asians (OSTA), and the Malaysian Osteoporosis Screening Tool (MOST)[10].

FRAX provides a 10-year fracture probability based on country-specific epidemiological data, but it functions primarily as a fracture prediction calculator rather than a simple point-of-care screening tool. OSTA, which has been widely applied across Asian populations, is derived solely from age and body weight and therefore does not incorporate menopausal duration or additional anthropometric characteristics. MOST was developed and validated specifically for Malaysian postmenopausal women. Using Malaysian cohort data, its developers identified age, years since menopause, body mass index, and hip circumference as key predictors and constructed a straightforward manual scoring system intended for use in non-specialist settings. This locally grounded tool makes MOST a context-appropriate and operationally simple option for osteoporosis risk screening in community-based healthcare settings, including pharmacies[10].

However, while non-modifiable risk factors such as age and menopausal duration dominate MOST scoring, modifiable lifestyle and nutritional factors remain critical for prevention and management. Adequate intake of vitamin D and calcium, in particular, is essential for optimizing bone health, yet deficiencies are common among Malaysian postmenopausal women[11]. Vitamin D and calcium intake are often suboptimal and influenced by socioeconomic status, educational attainment, and health literacy[12,13]. Integrating risk screening with an assessment of these behaviors in real-world settings could help identify priority groups for targeted education and intervention.

Although the MOST demonstrates strengths as a risk assessment instrument and has potential for broad application, evidence on its performance and utility outside clinical or research environments remains limited, particularly in community pharmacy settings. Community pharmacists can play a significant role in the prevention and management of osteoporosis, as they are accessible points of care for middle-aged and older women[14]. Their responsibilities include providing education on osteoporosis, its risk factors, and preventive strategies, as well as offering counseling on diet, exercise, and lifestyle modification to improve bone health[15].

In Thailand, community pharmacists have successfully implemented osteoporosis risk assessment services using the OSTA, demonstrating that simple screening tools can be feasibly integrated into pharmacy practice and are well received by both patients and physicians[16]. Similarly, Project ImPACT: Osteoporosis in Richmond, Virginia, demonstrated that pharmacy-based bone mineral density screening can identify previously unrecognized risk, prompt medical evaluation and treatment initiation, and support collaborative follow-up within a community pharmacy setting[17]. Despite these international examples, no study in Malaysia has examined whether the MOST is practical for community pharmacists to use. Given the high accessibility of community pharmacies in Malaysia and their potential role in public health outreach[18], evaluating MOST in this setting offers an opportunity to generate local evidence to inform pharmacy-based osteoporosis prevention strategies.

This study aimed to assess osteoporosis risk among postmenopausal women using the MOST in a community pharmacy setting, evaluate their vitamin D and calcium intake behaviors, and examine the relationship between these behaviors and osteoporosis risk. By combining objective anthropometric measurements with validated screening and context-specific behavioral insights, this research provides one of the first practice-based evaluations of MOST in a community pharmacy. The findings have the potential to inform scalable, pharmacy-led interventions that integrate risk screening with targeted

education, supplementation counseling, and lifestyle modification strategies to reduce the burden of osteoporosis among Malaysian postmenopausal women.

MATERIALS AND METHODS

Materials

Study design, setting, and population

This exploratory, pilot, cross-sectional study was conducted at a private community pharmacy in Temerloh Town, Pahang. The target population comprised post-menopausal women who visited the community pharmacy during the designated data collection period, spanning from 12 May 2025 to 12 August 2025. Ethical approval for the research protocol was officially granted by the Research Ethics Committee of Universiti Teknologi MARA under the specific designation Reference: REC (PH)/PG/211/2025 [MR]. To establish a representative pool, eligibility criteria required participants to self-identify as post-menopausal, which was strictly defined as the continuous absence of menstruation for a minimum of 12 consecutive months resulting from natural aging, without any alternative physiological, pathological, or clinical interventions accounting for the cessation. Eligible individuals were also required to be willing to undergo physical assessments involving measurement of hip circumference, body weight, and height. Conversely, individuals who were unable to comprehend either Malay or English were excluded from participation. A total of 147 women were approached during the recruitment, of whom 126 provided informed consent and agreed to participate, yielding a response rate of 85.7%.

Sample size rationale

Because this investigation functioned as an exploratory pilot study, no formal a priori statistical power calculation was performed. Methodological validation based on Roscoe's rule of thumb indicates that sample sizes of 30-500 individuals are generally acceptable and sufficient for preliminary, exploratory clinical investigations[19]. The cohort of 126 participants successfully recruited during the data collection window falls within this recommended range. Furthermore, this sample size is adequate to support the exploratory, nonparametric statistical analyses used throughout this research.

Structure of study tool and validation procedure

The data collection tool developed for this investigation consisted of a structured instrument divided into four distinct sections. Section 1 comprised a socio-demographic questionnaire, and Section 2 consisted of a specialized questionnaire on vitamin D and calcium intake behavior, incorporating items developed by the researchers and adapted from established previous literature[10,20]. Both Sections 1 and 2 were designed to be self-administered by participants and were made available in matching Malay and English translations. Section 3 was reserved for recording objective anthropometric measurements, including body weight, height, and hip circumference, while Section 4 was utilized to document the MOST score and its corresponding risk category for low BMD. These final two sections were completed exclusively by the primary researcher.

The MOST instrument is a simple, locally validated risk assessment tool that incorporates age, years since menopause, body mass index (BMI), and hip circumference to identify women at risk of low BMD[10]. Developed to reduce unnecessary DXA referrals, the MOST algorithm offers a practical alternative for use in busy primary care and community clinical settings. Prior validation of this screening tool demonstrated a high negative predictive value of 97.8%, with associated of 87.5% and specificities of 70.3%[10]. To ensure rigor, the compiled questionnaire underwent comprehensive content validation by an expert panel of six reviewers, consisting of one academic researcher, three medical officers, and two community pharmacists. Each individual item was rated on a four-point scale where a score of 1 indicated not relevant, 2 indicated slightly relevant, 3 indicated rather relevant, and 4 indicated highly relevant. The content validity index (CVI) was calculated as the proportion of items rated 3 or 4 by all experts, with a minimum threshold of 0.83 deemed acceptable for a six-member panel[21]. All items met this criterion. The behavioral items in Section 2 served as formative indicators, meaning each item represented a distinct aspect of supplementation or lifestyle practice rather than reflecting a single latent construct. Because formative measures do not require inter-item correlation, internal consistency statistics like Cronbach's α are not applicable.

The questionnaire was subsequently pilot-tested with a small group of participants not included in the main study to assess clarity and feasibility, and it was found acceptable in all aspects.

Methods

Study procedures and participant recruitment

Women who expressed interest in participating were provided with a comprehensive verbal briefing detailing the objectives and physical procedures of the study, after which written informed consent was formally obtained. Participants then completed the self-administered questionnaires in Sections 1 and 2 to provide their socio-demographic details and data on their vitamin D and calcium intake behaviors. After completing the paperwork, participants were escorted individually to a private area of the community pharmacy for anthropometric measurements. Body weight was measured using a calibrated digital weighing scale, height was determined using a standard vertical stadiometer, and hip circumference was quantified by placing a non-stretchable measuring tape around the widest anatomical part of the hips without applying unnecessary pressure to the skin.

Osteoporosis risk assessment

The MOST was applied to assess the risk of low BMD across the post-menopausal cohort[22]. The tool incorporates the subject's age, years since menopause, calculated BMI, and hip circumference to generate a cumulative risk score. All clinical measurements and subsequent point calculations were performed by the primary researcher (AAL). Scoring was based on pre-defined criteria, with specific points assigned to each variable as outlined in **Table I**. The total risk score was calculated by summing the assigned points across all four variables; cumulative scores of 4 or higher indicate high risk for low BMD, and scores of 3 or lower indicate low risk.

Table I. Malaysian Osteoporosis Screening Tool scoring system[22].

Risk factor	Category	Score
(A) Age (years)	greater than or equal to 61	20
	56 to 60	6
	51 to 55	2
	less than or equal to 50	0
(B) Years since menopause	greater than 10	22
	6 to 10	6
	1 to 5	4
	0	0
(C) BMI (kg/m^2)	less than 19	4
	19 to 24	2
	greater than 24	0
(D) Hip circumference (cm)	less than 90	2
	greater than or equal to 90	0

Data analysis

All collected data were systematically entered into and analyzed using IBM SPSS Statistics version 29. Descriptive statistics were employed to summarize the participants' sociodemographic characteristics, lifestyle factors, and supplement intake behaviors. Categorical variables were presented as absolute frequencies and percentages, while continuous variables were summarized as medians accompanied by their respective interquartile ranges (IQRs). The primary outcome was the cumulative MOST score, which was treated as a continuous variable for descriptive purposes. The normality of all continuous variables was evaluated using the Shapiro–Wilk test alongside visual inspection of corresponding histograms, which collectively indicated that the calculated MOST scores were not normally distributed. Given this non-normal distribution, comparisons of continuous MOST scores between two independent groups, such as calcium supplement users versus non-users, were conducted using the non-parametric Mann–Whitney U test. Concurrently, comparisons across more than two independent groups, such as distinct categories for place of residence, were performed using the Kruskal–Wallis H test. All statistical tests were two-tailed, and a p-value of less than 0.05 was considered statistically significant.

RESULTS AND DISCUSSION

The sociodemographic characteristics of participants are shown in **Table II**. Most participants were aged ≥60 years (90/126, 71.4%), Malay (99/126, 78.6%), and had an educational level lower than tertiary (92/126, 73.0%). The majority reported a monthly household income below RM 4,850 (99/126, 78.6%) and were unemployed (104/126, 82.5%). Participants primarily resided in rural (52/126, 41.3%) or urban (48/126, 38.1%) areas. A family history of osteoporosis was reported by 22/126 (17.5%). Only 3/126 (2.4%) were currently using hormone replacement therapy, and 12/126 (9.5%) were using oral steroid medication. All participants were classified as "at risk" (MOST ≥4); median (IQR) of 42.0 (12.0-42.0).

Table II. Sociodemographic and lifestyle characteristics of participants and statistical comparison of MOST scores (n = 126).

Characteristic	n (%)	Median (IQR)	Mann–Whitney U / Kruskal–Wallis H	*Z* statistic	p-value
Sociodemographic					
Age (years)					
<60	36 (28.6)	10.0 (8.3–12.0)	127.0	−8.27	<0.001
≥60	90 (71.4)	42.0 (42.0–44.0)			
Ethnicity					
Malay	99 (78.6)	42.0 (12.0–42.0)	1190.5	−0.89	0.373
Non-Malay	27 (21.4)	42.0 (13.0–44.0)			
Educational level					
Lower than tertiary	92 (73.0)	42.0 (14.0–42.0)	1064.5	−2.82	0.005
Tertiary	34 (27.0)	19.0 (10.0–42.0)			
Monthly household income (RM)					
<4,850	99 (78.6)	42.0 (12.0–42.0)	1238.0	−0.60	0.548
≥4,850	27 (21.4)	42.0 (12.0–44.0)			
Employment status					
Employed	22 (17.5)	13.0 (10.0–42.0)	722.0	−2.78	0.005
Unemployed	104 (82.5)	42.0 (13.25–42.0)			
Place of residence					
Rural	52 (41.3)	35.0 (12.0–42.0)	1.258*	-	0.533
Urban	48 (38.1)	42.0 (14.0–42.0)			
Suburban	26 (20.6)	42.0 (12.0–44.0)			
Family history of osteoporosis					
Yes	22 (17.5)	37.5 (12.0–42.0)	1125.0	−0.13	0.900
No	104 (82.5)	42.0 (12.0–42.0)			
Currently using hormone replacement therapy					
Yes	3 (2.4)	42.0 (28.0–43.0)	145.0	−0.65	0.517
No	123 (97.6)	42.0 (12.0–42.0)			
Currently using oral steroid medication					
Yes	12 (9.5)	42.0 (15.5–44.0)	568.5	−0.99	0.325
No	114 (90.5)	42.0 (12.0–42.0)			
Lifestyle					
Currently smoking					
Yes	4 (3.2)	42.0 (13.0–43.0)	224.0	−0.29	0.775
No	122 (96.8)	42.0 (12.0–42.0)			
Regular coffee drinker					
Yes	83 (65.9)	42.0 (12.0–42.0)	1742.0	−0.22	0.822
No	43 (34.1)	42.0 (12.0–42.0)			
Regular carbonated beverage drinker					
Yes	13 (10.3)	28.0 (8.0–43.5)	715.0	−0.16	0.872
No	113 (89.7)	42.0 (12.0–42.0)			
Consuming food rich in calcium and vitamin D					
≤ 3 times per week	14 (11.1)	42.0 (12.8–44.0)	690.0	−0.75	0.454
> 3 times per week	112 (88.9)	42.0 (12.0–42.0)			
Sun exposure (weekdays)					
<30 min/day	18 (14.3)	42.0 (23.0–42.0)	850.5	−0.87	0.385
≥30 min/day	108 (85.7)	42.0 (12.0–42.0)			
Sun exposure (weekends)					
<30 min/day	25 (19.8)	42.0 (19.0–42.0)	1147.0	−0.73	0.468
≥30 min/day	101 (80.2)	42.0 (12.0–42.0)			

Note: * Kruskal–Wallis test used.

Few participants were current smokers (4/126, 3.2%). Regular coffee consumption was common (83/126, 65.9%), while regular carbonated beverage intake was less prevalent (13/126, 10.3%). Most participants reported consuming calcium- and vitamin D-rich foods more than three times per week (112/126, 88.9%), with only 14/126 (11.1%) doing so three times or less. For weekday sun exposure, 108/126 (85.7%) reported spending at least 30 minutes per day outdoors, compared with 18/126 (14.3%) who spent less than 30 minutes. A similar pattern was observed for weekend sun exposure: 101/126 (80.2%) spent at least 30 minutes per day outdoors, and 25/126 (19.8%) spent less than 30 minutes.

Statistical comparisons of MOST scores by participants' characteristics are shown in **Table II**. Participants aged ≥60 years had markedly higher scores than those aged <60 years (median [IQR]: 42.0 [42.0-44.0] vs. 10.0 [8.3-12.0]; U = 127.0, Z = -8.27, p <0.001). Scores were also significantly higher among participants with an educational level lower than tertiary compared with those with tertiary education (42.0 [14.0-42.0] vs. 19.0 [10.0-42.0]; U = 1064.5, Z = -2.82, p = 0.005) and among unemployed compared with employed participants (42.0 [13.25-42.0] vs. 13.0 [10.0-42.0]; U = 722.0, Z = -2.78, p = 0.005). No significant differences in MOST scores were observed with respect to ethnicity, monthly household income, place of residence, family history of osteoporosis, current use of hormone replacement therapy, oral steroid medication use, smoking status, regular coffee consumption, regular carbonated beverage intake, frequency of consuming calcium- and vitamin D-rich foods, or sun exposure (p >0.05 for all).

As shown in **Table III**, 35/126 (27.8%) participants were currently taking calcium supplements, 45/126 (35.7%) were taking vitamin D supplements, and 33/126 (26.2%) were taking both. Multivitamin supplement use was reported by 37/126 (29.4%) participants. Participants currently taking calcium supplements had significantly higher scores than those not taking calcium (median [IQR]: 42.0 [25.0-44.0] vs. 28.0 [12.0-42.0]; U = 1338.0, Z = -2.531, p = 0.011). No significant differences in MOST scores were observed for current use of vitamin D supplements, combined calcium and vitamin D supplements, or multivitamin supplements (p >0.05 for all).

Table III. Supplement intake characteristics of participants and statistical comparison of MOST scores (n = 126).

Supplement intake	n (%)	Median (IQR)	Mann–Whitney U	Z statistic	p-value
Currently taking a calcium supplement					
Yes	35 (27.8)	42.0 (25.0–44.0)	1338.0	–2.531	0.011
No	91 (72.2)	28.0 (12.0–42.0)			
Currently taking a vitamin D supplement					
Yes	45 (35.7)	42.0 (14.0–44.0)	1321.5	–1.515	0.130
No	81 (64.3)	42.0 (12.0–42.0)			
Currently taking both calcium and vitamin D supplements					
Yes	33 (26.2)	42.0 (19.0–44.0)	1263.5	–1.543	0.123
No	93 (73.8)	42.0 (12.0–42.0)			
Currently taking a multivitamin supplement					
Yes	37 (29.4)	42.0 (19.0–44.0)	1344.0	–1.663	0.096
No	89 (70.6)	42.0 (12.0–42.0)			

Table IV shows the distribution of participants across MOST risk factor categories, their corresponding scores, and frequencies. For age, the largest proportion was ≥61 years (81/126, 64.3%), followed by 56-60 years (34/126, 27.0%), 51-55 years (9/126, 7.1%), and ≤50 years (2/126, 1.6%). In terms of years since menopause, 74/126 (58.7%) had been postmenopausal for over 10 years, 29/126 (23.0%) for 6-10 years, and 23/126 (18.3%) for 1-5 years. Most participants had a BMI >24 kg/m² (77/126, 61.1%), with 45/126 (35.7%) in the 19-24 kg/m² range and only 4/126 (3.2%) with a BMI <19 kg/m². Hip circumference was the most homogeneous factor, with 122/126 (96.8%) measuring ≥90 cm and just 4/126 (3.2%) <90 cm.

All participants in this study scored above the MOST cut-off, resulting in universal classification as "at risk" for low BMD. This reflects both the targeted recruitment of older, postmenopausal women and the tool's weighting towards non-modifiable factors such as age and years since menopause. MOST assigns 20 points for age ≥61 years and up to 22 points for more than 10 years since menopause[22]. In this cohort, nearly all participants met one or both of these criteria, reaching the high-risk threshold before BMI or hip circumference was considered. This scoring distribution reflects the emphasis on age and menopausal duration built into MOST, which also underpinned the high sensitivity of the ≥4 threshold in the original Malaysian validation study[22].

Table IV. MOST risk factor categories with corresponding scores and participant distribution (n = 126).

Risk factor	Category	Score	n (%)
(A) Age (years)	≥61	20	81 (64.3)
	56-60	6	34 (27.0)
	51-55	2	9 (7.1)
	≤50	0	2 (1.6)
(B) Years since menopause	>10	22	74 (58.7)
	6-10	6	29 (23.0)
	1-5	4	23 (18.3)
	0	0	0 (0.0)
(C) BMI (kg/m²)	<19	4	4 (3.2)
	19-24	2	45 (35.7)
	>24	0	77 (61.1)
(D) Hip circumference (cm)	<90	2	4 (3.2)
	≥90	0	122 (96.8)

The median MOST score was 42.0 (IQR 12.0 – 42.0), reflecting the predominance of older participants (≥60 years: 71.4%). This age distribution explains the clustering of high scores, as age and menopausal duration are the dominant contributors to the algorithm, consistent with previous reports of elevated scores beyond 60 years[22,23]. While this limits the tool's ability to discriminate between individuals within older cohorts, it remains clinically valuable as a rapid means of identifying high-risk women in primary care and pharmacy settings where DXA is not accessible. Its added discriminatory value may be greater in younger postmenopausal women, where variability in scores allows more meaningful stratification and targeted counseling. BMI, a partially modifiable factor in MOST, has been associated with osteoporosis risk in Malaysian DXA-based studies, with low BMI increasing risk and higher lean mass providing protection[2]. This offers a practical entry point for pharmacist-led advice on nutrition and weight-bearing exercise that supports bone health[24].

In this study, education and employment status were associated with MOST scores, with higher scores observed among women with lower educational attainment and among unemployed women. Previous studies have similarly reported links between lower education or income and increased osteoporosis risk[24]. While the MOST tool primarily captures biological risk factors, pharmacists should remain attentive to social determinants that may exacerbate vulnerability. For example, individuals with low health literacy may engage in fewer positive health behaviors, have poorer nutritional intake, and experience limited access to healthcare, thereby compounding their overall risk[25,26]. Consequently, pharmacists should provide targeted education using plain-language materials and deliver culturally tailored counseling to help mitigate these additional risk factors.

The use of calcium (27.8%), vitamin D (35.7%), and combined calcium–vitamin D supplements (26.2%) in this cohort was generally low to moderate. Participants who reported calcium supplementation had significantly higher MOST scores than non-users, a likely confounding-by-indication effect, as individuals already aware of their risk or with a prior diagnosis may be more inclined to use supplements[2]. Although vitamin D supplementation was somewhat more common, no significant difference in MOST scores was observed between users and non-users.

From a pharmacy practice perspective, this represents a valuable opportunity[24]. Screening with MOST provides a natural entry point for initiating discussions on appropriate supplementation, addressing misconceptions, and reinforcing the importance of combined calcium and vitamin D intake alongside dietary sources. Clinical practice guidelines recommend a daily total calcium intake of approximately 1200 mg for women aged 51 years and older, achieved primarily through diet and supplemented if necessary, and a vitamin D intake of 800–1000 IU per day for individuals aged 50 years and above, with supplementation where dietary intake is inadequate[27]. Evidence from systematic reviews has further shown that vitamin D supplementation (800–1200 IU per day), with or without calcium (800–1500 mg per day), reduces the risk of falls, particularly among elderly individuals with vitamin D deficiency[28].

Pharmacists are well placed to translate these recommendations into practice. They can identify individuals at risk of vitamin D deficiency, refer them for serum vitamin D testing where appropriate, and recommend supplementation in cases of confirmed deficiency. Moreover, they are uniquely positioned to optimize supplementation, as they have ready access to a wide range of calcium and vitamin D products and can evaluate potential drug–nutrient interactions and adherence barriers[18,29]. Embedding these activities within routine pharmacy-based screening workflows could therefore strengthen preventive care and support long-term bone health.

Several lifestyle and clinical factors, such as family history of osteoporosis, steroid use, smoking, coffee consumption, and carbonated beverage intake, were not associated with MOST scores. However, their clinical relevance remains, particularly for targeted counseling. For example, smoking cessation and reduction of high-caffeine or carbonated beverage intake are potential modifiable factors for bone health[5,30,31]. In practice, pharmacists could use MOST as the initial trigger for risk discussion and then broaden the conversation to address these non-algorithm factors.

The findings reinforce MOST's suitability as a practical screening tool in community pharmacy settings, where accessibility, patient familiarity, and low cost enhance the feasibility of preventive engagement. In relatively homogeneous older populations, MOST may serve less as a triage mechanism for selective DXA referral and more as a catalyst for patient education and behavior change. This interpretation is consistent with the study's observed patterns, including the high prevalence of elevated scores, identifiable behavioral gaps, and clear intervention targets such as supplementation optimization and lifestyle modification.

By integrating anthropometric measurements with assessments of vitamin D and calcium intake behaviors, pharmacists can progress beyond risk identification to provide tailored, evidence-based recommendations within a single patient encounter. Embedding this approach into routine pharmacy workflows not only strengthens pharmacists' professional contributions but also complements broader national osteoporosis prevention strategies. Such integration has the potential to reduce the burden of unrecognized osteoporosis, improve the cost-effectiveness of healthcare delivery, and align community pharmacies with health system priorities in addressing chronic disease prevention in aging populations.

This study has several limitations. First, its cross-sectional design limits causal inference regarding the relationships among vitamin D, calcium intake, and MOST scores, and the findings should therefore be interpreted as associative rather than causal. Longitudinal studies are needed to evaluate whether targeted interventions based on screening results result in measurable improvements in bone health outcomes. Second, recruitment was restricted to a single community pharmacy in one district, which may limit generalizability to other regions and settings, particularly those with more diverse ethnic or socioeconomic profiles. Third, dietary intake and supplementation behaviors were self-reported. This may introduce recall bias or social desirability bias. Fourth, only non-parametric bivariate analyses were conducted. MOST scores were markedly skewed, and multivariable regression was not undertaken. This means that potential confounding, particularly by age and duration of menopause, cannot be excluded, and the observed associations should be interpreted with caution. Fifth, while MOST effectively identifies high-risk individuals in homogeneous older populations, its sensitivity-weighted scoring means that it does not finely stratify intermediate risk. However, given that the tool was used here as a gateway for preventive counseling rather than as a definitive diagnostic, this limitation does not undermine its utility in pharmacy-based practice. Sixth, although this study was described as a pilot cross-sectional study, it did not assess formal feasibility metrics such as workflow timing, pharmacist workload, or acceptability. In this context, the pilot designation reflects the study's role as an initial implementation exploring how MOST operated within routine community pharmacy activities and the preliminary screening patterns observed among postmenopausal women. Finally, the study did not evaluate the downstream implementation of pharmacy-led interventions triggered by MOST screening, which should be addressed in future pragmatic trials to confirm real-world effectiveness.

CONCLUSION

In this community pharmacy pilot, MOST classified all postmenopausal participants as at risk, driven largely by age and menopausal duration, with pronounced gradients by age, education, and employment, but not by income, ethnicity, or residence. Supplement behaviors showed modest uptake (vitamin D approximately one-third, calcium approximately one-quarter, combined approximately one-quarter), and calcium use correlated with higher scores, consistent with confounding by indication. The study's novelty lies in demonstrating the feasibility and operational characteristics of MOST in real-world pharmacy workflows and in identifying actionable gaps in supplementation and lifestyle practices. Limitations include the cross-sectional, single-site design and the use of self-reported behaviors, which limit causal inference and generalizability. Future research should establish predictive validity and subgroup-specific cut-offs, test two-step pathways with FRAX or DXA, and evaluate pharmacy-led behavior-change interventions. While integrating risk screening with tailored counseling

in community pharmacy settings may support osteoporosis prevention among older Malaysian women, broader implementation will require additional validation beyond this pilot study.

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DATA AVAILABILITY

None.

CONFLICT OF INTEREST

The authors declared no conflict of interest related to this research.

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