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# Knowledge, attitudes, and practices regarding osteoporosis among hormone receptor-positive breast cancer patients: a cross-sectional study

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**Objective:** To investigate the knowledge, attitudes, and practices (KAP) concerning osteoporosis among hormone receptor-positive (HR+) breast cancer patients.

**Methods:** A cross-sectional study was conducted from November, 2023, to March, 2024 among HR+ breast cancer patients to assess their KAP regarding osteoporosis. Structural equation modeling (SEM) was employed to assess the relationships among the KAP dimensions.

**Results:** A total of 758 HR+ breast cancer patients were invited, 610 completed the questionnaire (response/completion rate: 80.5%), and 491 questionnaires were retained for the final analysis after prespecified data cleaning (analytic inclusion rate: 64.8%). HR+ breast cancer patients had insufficient knowledge (mean 9.69, SD 5.93), moderate attitudes (mean 29.50, SD 4.55), and moderate practices (mean 35.85, SD 4.75). SEM showed that knowledge directly influenced attitudes ( $\beta = 0.509, P < 0.001$ ), while both knowledge ( $\beta = 0.585, P < 0.001$ ) and attitudes ( $\beta = 0.402, P < 0.001$ ) had direct effects on practices.

**Conclusions:** HR+ breast cancer patients exhibit insufficient knowledge, positive attitudes, and suboptimal practices regarding osteoporosis.

### KEYWORDS

attitudes, hormone receptor-positive breast cancer, knowledge, osteoporosis, patient, practices

## Introduction

Breast cancer remains a major global health challenge, ranking among the leading causes of cancer-related deaths in women. In 2022, it accounted for 2.3 million new cases and 670,000 deaths worldwide (1). Although the incidence in China is lower than in Western countries, Chinese women still represent 12.2% of global new cases, with an increasing trend among younger individuals that contributes substantially to premature mortality and societal burden (2).

Breast cancer is a heterogeneous disease, broadly classified as hormone receptor-positive (HR+), HER2-positive, or triple-negative (3), with HR+ subtypes comprising approximately 75%–80% of all cases (4, 5). Endocrine therapy, the standard treatment for HR+ breast cancer, includes selective estrogen receptor modulators such as tamoxifen and aromatase inhibitors. Estrogens play a key role in maintaining bone homeostasis by suppressing bone resorption and supporting bone formation, and reduced estrogen signaling can accelerate bone loss. In addition to aromatase inhibitors, selective estrogen receptor degraders (SERDs) further inhibit estrogen receptor signaling and may adversely affect bone health. Tamoxifen exerts bone-protective effects in postmenopausal women but may induce bone loss in premenopausal women (6) whereas aromatase inhibitors reduce estrogen synthesis and cause annual bone losses of 2.2%–2.6% in the lumbar spine and 1.7%–2.1% in the hips (7). Consequently, cancer treatment-induced bone loss (CTIBL) has become one of the most common long-term complications among breast cancer survivors, contributing to fragility fractures, hospitalization, disability, and increased mortality risk (8, 9). In current clinical practice, bone health monitoring is recommended for patients receiving endocrine therapy, including baseline and follow-up bone mineral density assessment (DXA) and evaluation of vitamin D status when appropriate. Preventive or therapeutic strategies typically include patient education, adequate calcium and vitamin D intake, weight-bearing exercise and fall prevention, and pharmacologic interventions such as antiresorptive therapy for patients at elevated fracture risk.

The Knowledge, Attitudes, and Practices (KAP) model suggests that individual behaviors are influenced by one's knowledge and attitudes, which in turn dictate their practices. This framework is particularly valuable in public health for understanding health-related behaviors through KAP surveys, which assess both knowledge and risk perception. This approach is essential for elucidating the complex behaviors associated with health management and promotion (10–12). HR+ breast cancer patients undergoing endocrine therapy face increased risks of bone density loss and fractures due to the unwanted side effects related to treatment. These medications effectively inhibit cancer cell growth but can lead to significant osteoporosis. Additionally, menopausal bone loss further exacerbates the reduction in bone density. Studying the KAP of this demographic can identify knowledge gaps and misconceptions, enabling healthcare professionals to tailor health education and clinical interventions more effectively. Such measures are crucial not only for enhancing disease management efficiency but also for improving patients' quality of life. By reducing the complications associated with osteoporosis, these interventions aim to improve overall treatment outcomes and patient satisfaction. Recently, Ma et al. (13) conducted a study on knowledge, attitudes, and practices regarding osteoporosis, providing valuable insights into this area. However, our study specifically targets HR+ breast cancer patients, a more focused

population, and examines a geographically different cohort in Nantong City, China.

Despite the importance of these therapeutic goals, there is a notable lack of KAP studies focused on osteoporosis prevention and reduction among HR+ breast cancer patients. Therefore, this study aimed to investigate the KAP concerning osteoporosis within this group, addressing the need for targeted research that can lead to more effective health outcomes.

## Materials and methods

### Study design and participants

The current cross-sectional study was conducted from November, 2023, to March, 2024 at Nantong Tumor Hospital in Nantong City, China, focusing on patients receiving endocrine therapy for hormone receptor-positive breast cancer in the maintenance phase, defined as having completed surgery and acute chemotherapy/radiotherapy and continued endocrine therapy for at least 3 months, including both adjuvant therapy and advanced maintenance therapy. During the study period, potentially eligible patients were screened based on clinical records and physician confirmation, and those meeting the inclusion criteria were approached and invited to participate on a voluntary basis. Ethical approval (Approval No: TONGLUNSHENSHI [Keyan] 2022-065) was obtained from the Ethics Committee of the Nantong tumor Hospital, and informed consent was secured from all subjects.

Inclusion criteria encompassed patients with confirmed hormone receptor-positive breast cancer (stage I–IV) who were receiving endocrine therapy in the long-term maintenance phase after completion of initial treatment (e.g., surgery, chemotherapy and/or radiotherapy), individuals with at least primary school education, and patients possessing normal mental capacity, adequate communication skills, and understanding of their medical condition. Only female patients were eligible; male breast cancer patients were excluded to ensure cohort homogeneity, given their low prevalence and different physiological response to endocrine therapy. Because endocrine therapy is also a standard treatment option for some patients with advanced HR+ disease, patients with stable metastatic disease receiving endocrine therapy were eligible for inclusion. A prior diagnosis of osteoporosis was not a reason for exclusion to reflect the real-world clinic population, and osteoporosis status was collected in the baseline questionnaire. Osteoporosis status was self-reported (yes/no/uncertain) and was not systematically confirmed by mandatory DXA testing or by medical record adjudication for all participants in this study. Additionally, voluntary participation was a requisite for inclusion. Exclusion criteria comprised patients with an ECOG performance status > 3 or those receiving end-of-life palliative care who are unable to complete the survey, patients with diagnosed cognitive impairment, dementia, or severe psychiatric disorders (e.g., schizophrenia) that prevent informed consent, patients diagnosed with concurrent malignancies other than breast cancer, and those afflicted with severe degenerative bone or joint disorders.

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**Abbreviations:** CTIBL, cancer treatment-induced bone loss; KAP, knowledge, attitudes, and practices; SD, standard deviations; SEM, structural equation modeling.

## Procedures

The questionnaire underwent multiple revisions, informed by feedback from eight experts in breast cancer treatment. This panel included four medical experts—two internal medicine specialists, one surgeon, and one radiotherapy specialist—and four nursing experts—two nursing management specialists and two clinical nursing specialists. Before the formal survey, a pilot study was conducted with a random sample of 30 patients diagnosed with Hormone Receptor-Positive Breast Cancer Patients. The questionnaire was pre-tested and refined based on results from the pilot study, achieving a reliability coefficient of 0.841.

The final questionnaire, in Chinese, comprised four dimensions. Firstly, participants' demographic information was collected through nine items. Secondly, the knowledge dimension included 13 questions, where correct responses to single-choice questions were awarded 1 point and incorrect or unclear responses received 0 points. Additionally, questions 1, 7, 8, and 11 were multiple-choice items; each correct option was awarded 1 point. Across these four items, there were 16 correct options in total. Therefore, the maximum knowledge score was 25 points (9 single-choice items  $\times$  1 point + 16 correct options across multiple-choice items). Thirdly, the attitudes dimension consisted of nine items, with the first item being open-ended and the remainder utilizing a five-point Likert scale to assess attitudes, yielding scores between 8 and 40 points. Lastly, the practices dimension comprised 10 items covering diet, exercise, and sun exposure, with the first item offering a binary choice ( $A = 1; B/C = 0$ ) and items 2–10 rated on a five-point Likert scale (1–5), leading to scores ranging from 9 to 46 points.

## Score categorization for interpretation

To provide a standardized basis for qualitative descriptions, we categorized KAP scores using the modified Bloom's cut-off points based on the percentage of the maximum possible score: poor/insufficient (<60%), moderate (60%–79%), and good/positive ( $\geq 80\%$ ). Accordingly, for the knowledge scale (0–25), scores <15 were classified as insufficient, 15–19 as moderate, and  $\geq 20$  as good. For the attitudes scale (8–40), scores <24 were classified as poor, 24–31 as moderate, and  $\geq 32$  as good. For the practices scale (9–46), scores <28 were classified as poor, 28–36 as moderate, and  $\geq 37$  as good. These categories were used only to support the narrative qualitative labels, while continuous scores were retained for statistical analyses.

During routine outpatient visits, including waiting for consultation or follow-up appointments for endocrine therapy, eligible patients were approached by trained investigators and invited to participate. The questionnaire was implemented on a digital platform (Questionnaire Star) and accessed via a QR code after informed consent was obtained. Following submission, investigators checked the questionnaire only for completeness (e.g., missing items) and obvious logical inconsistencies. No guidance, prompting, or feedback on item content was provided during completion, and investigators did not intervene in or influence participants' responses. To enhance data accuracy, entries were

double-checked during data entry to minimize potential biases introduced by personnel. To ensure patient confidentiality and informed consent protection, information that directly identified patients (such as names and ID numbers) was separated from the study data immediately after collection. Informed consent was presented on the first page of the questionnaire, and only participants who provided informed consent proceeded to the formal questionnaire content; otherwise, they were automatically redirected out of the survey. We defined the response (completion) rate as the proportion of completed questionnaires among all invited participants, and we reported the analytic inclusion rate as the proportion of invited participants retained after prespecified data cleaning.

## Data quality control and handling of contradictory responses

To ensure reproducible scoring, we applied pre-specified data-cleaning rules before analysis. Participants were excluded if they were not hormone receptor-positive breast cancer patients based on screening/clinical verification. In addition, for multiple-choice knowledge items, responses were considered logically contradictory if the respondent selected "Uncertain" together with one or more specific answer options within the same item (e.g., in item K8, selecting option "Uncertain" and simultaneously selecting other options). Such responses could not be scored unambiguously under the predefined grading scheme; therefore, these questionnaires were excluded from the analytic dataset.

## Sample size determination

The required sample size was estimated using the formula:

$$n = \frac{z^2 p(1-p)}{d^2}$$

where  $z = 1.96$  corresponds to a 95% confidence level,  $d = 0.05$  represents the permissible margin of error, and  $P = 0.5$  reflects the expected proportion in the target population,  $P = 0.5$  was used because the proportion of HR+ breast cancer patients with adequate osteoporosis-related knowledge in this setting was unknown; therefore,  $P = 0.5$  was chosen to provide the most conservative (largest) sample size estimate. According to this calculation, the minimum sample size needed was 384 participants. Because SEM was also performed, we additionally assessed sample adequacy for SEM using a commonly applied rule-of-thumb of 10–20 participants per observed variable (indicator). The SEM included 31 observed indicators used to estimate the latent constructs, and the final analytic sample size was 491, yielding a case-to-indicator ratio of 15.8:1 (491/31), which falls within the recommended range.

## Statistical analyses

This study was descriptive and exploratory. The outcomes were the Knowledge, Attitudes, and Practices (KAP) dimension scores regarding osteoporosis (and their interrelationships), which together provide an overall profile of health literacy and self-management in HR+ breast cancer patients. Structural equation modeling (SEM) was used to explore the hypothesized relationships among these three dimensions, including the potential mediating role of attitudes between knowledge and practices. Statistical analysis was conducted using R 4.3.2 and Stata 18.0. The distribution of KAP dimension scores was empirically assessed for normality. The scores did not meet normality assumptions; therefore, continuous variables are presented as median (IQR). Group comparisons were performed using the Wilcoxon–Mann–Whitney test for two groups and the Kruskal–Wallis test for three or more groups. Correlations among dimension scores were evaluated using Spearman’s rank correlation. Spearman’s correlation was selected because the KAP scores did not meet normality assumptions. For regression analyses, KAP dimension scores were dichotomized using the median of each dimension as the cutoff, and univariate and multivariate logistic regression analyses were conducted to identify factors associated with KAP. Variables with  $P < 0.10$  in univariate analyses were entered into multivariate models. A two-sided  $P$  value  $< 0.05$  was considered statistically significant. Based on the KAP theoretical framework, SEM was used to examine the mediating role of attitudes between knowledge and practices. Model fit was evaluated using RMSEA, SRMR, TLI, CFI, and  $\chi^2/df$ , with RMSEA  $< 0.08$ , SRMR  $< 0.08$ , and TLI/CFI  $> 0.8$  indicating acceptable fit. Correlated error terms were added between items with similar phrasing within the same dimension to improve model fit, following modification indices.

## Results

### Demographic characteristics and KAP scores

A total of 758 HR+ breast cancer patients were invited to participate in this study, and 610 completed the questionnaire (completion rate 80.5%). Data cleaning led to the exclusion of several cases: 8 for response times exceeding 1,800 s, 67 due to missing informed consent, 24 who were not HR+ breast cancer patients, and 20 due to logically contradictory selections within multiple-choice items (e.g., selecting the option “Uncertain” together with one or more specific answer options in the same item), which prevented unambiguous scoring according to the pre-specified questionnaire grading rules. This process resulted in 491 valid cases included in the final analysis (analytic inclusion rate 64.8%). Key demographic characteristics showed that 38.5% of participants had undergone more than 3 years of endocrine therapy, with the largest age group being 51–60 years (42.6%). Endocrine therapy medications were collected in the questionnaire (Item 1.1: Tamoxifen, anastrozole, letrozole, exemestane, or other). HR+ breast cancer patients had insufficient knowledge (mean 9.69,

SD 5.93), moderate attitudes (mean 29.50, SD 4.55), and moderate practices (mean 35.85, SD 4.75) (Table 1).

### Knowledge, attitudes and practices distribution

Responses to the knowledge dimension showed that 53.4% were unsure whether medications taken by HR+ breast cancer patients would cause osteoporosis (K3), and 67.6% were unsure about the relationship between osteoporosis and breast cancer (K5) and whether they would affect each other (K6). Meanwhile, 69.5% were unsure whether severe osteoporosis could lead to metastasis of breast cancer (K10), and 63.3% were unsure whether estrogen could be used to treat osteoporosis in HR+ breast cancer patients (K12).

In terms of related attitudes, 55.4% agreed that they should have a bone density test (A5), 54% agreed that it is more important to prevent osteoporosis caused by breast cancer than to treat it (A9), and 53% agreed that osteoporosis needs to be examined and treated in a hospital (A8). When it comes to whether or not they have developed osteoporosis (A1), 56.2% of the respondents’ attitudes fluctuated. In addition, 13.2% did not think that osteoporosis would promote the development of breast cancer (A2) (Supplementary Table S2).

Responses to the practices items showed that only 30.1% were certain that they have had a bone density test (P 1). Results also showed that a combined 24.5% of participants were concerned about bumping or falling, leading them to refuse exercise (P5). On the other hand, 38.5% did not take the initiative to learn about the relevant knowledge related to their condition (Supplementary Table S3).

### Correlation analysis

In the correlation analysis (Spearman’s rank correlation), knowledge was moderately and positively correlated with attitudes ( $r = 0.421$ ,  $P < 0.001$ ) and practices ( $r = 0.572$ ,  $P < 0.001$ ), and attitudes were moderately and positively correlated with practices ( $r = 0.483$ ,  $P < 0.001$ ) (Table 2). Given the cross-sectional design, these correlations should be interpreted as associations rather than evidence of directionality or causality.

### Multivariate logistic regression analysis

Supplementary Table S4 shows the cut values. Multivariate logistic regression revealed that duration of endocrine therapy  $> 3$  years (OR = 0.22, 95% CI: 0.06–0.77,  $P = 0.018$ ), undergraduate or college education (OR = 11.49, 95% CI: 3.75–35.16,  $P < 0.001$ ), homemaker (OR = 2.16, 95% CI: 1.03–4.52,  $P = 0.041$ ), retirement (OR = 4.11, 95% CI: 2.14–7.88,  $P < 0.001$ ), other occupations (OR = 8.69, 95% CI: 3.23–23.40,  $P < 0.001$ ), and self-reported undiagnosed or uncertain osteoporosis status (OR = 0.30, 95% CI: 0.15–0.60,  $P = 0.001$ ; OR = 0.25, 95% CI: 0.13–0.48,  $P < 0.001$ ) were independently associated with knowledge (Supplementary Table S5).

TABLE 1 Baseline table.

<i>N</i> = 491	<i>N</i> (%)	Knowledge median[IQR]	<i>P</i>	Attitudes median[IQR]	<i>P</i>	Practices median[IQR]	<i>P</i>
<b>Total score</b>	491 (100.0)	10.00 [4.00, 14.50]		30.00 [26.00, 32.00]		36.00 [32.50, 39.00]	
<b>Duration of endocrine therapy</b>							
Within 1 month	12(2.4)	10.00 [8.50, 13.25]	<0.001	28.00 [23.50, 34.25]	0.085	34.50 [30.50, 38.25]	<0.001
1-6 months	47(9.6)	6.00 [3.00, 11.00]		28.00 [24.50, 31.50]		34.00 [30.00, 36.50]	
6 months–1 year	99(20.2)	8.00 [3.00, 13.00]		30.00 [25.00, 32.00]		35.00 [31.00, 38.00]	
1 year–3 years	144(29.3)	9.00 [4.00, 14.25]		31.00 [27.75, 32.25]		36.00 [33.75, 39.00]	
Above 3 years	189(38.5)	12.00 [7.00, 15.00]		29.00 [26.00, 32.00]		37.00 [34.00, 40.00]	
<b>Age</b>							
Below 40 years old	48 (9.8)	11.00 [8.00, 16.00]	<0.001	30.00 [26.75, 32.00]	0.028	37.00 [34.00, 39.25]	<0.001
41–50 years old	90 (18.3)	10.00 [5.00, 15.00]		30.00 [25.00, 32.75]		36.00 [31.25, 38.75]	
51–60 years old	209 (42.6)	10.00 [4.00, 15.00]		29.00 [25.00, 32.00]		37.00 [34.00, 39.00]	
61–70 years old	104 (21.2)	10.00 [6.00, 14.00]		31.00 [28.00, 32.25]		37.00 [33.00, 40.00]	
Above 71 years old	40 (8.1)	4.00 [1.00, 9.00]		27.50 [25.00, 32.00]		33.00 [29.00, 35.25]	
<b>Marital status</b>							
Single	10 (2.0)	13.50 [5.75, 17.00]	0.416	31.00 [28.00, 37.50]	0.570	39.50 [35.00, 41.50]	0.262
Married	468 (95.3)	10.00 [4.00, 14.00]		30.00 [26.00, 32.00]		36.00 [32.00, 39.00]	
Divorced/widowed	13 (2.7)	12.00 [7.00, 15.00]		28.00 [26.00, 33.00]		36.00 [33.00, 39.00]	
<b>Education</b>							
Primary school and below	81 (16.5)	5.00 [2.00, 11.00]	<0.001	30.00 [26.00, 32.00]	0.135	33.00 [31.00, 36.00]	<0.001
Junior high school	188 (38.3)	9.00 [4.00, 13.00]		30.00 [25.00, 32.00]		36.00 [33.00, 38.00]	
High school/technical school	158 (32.2)	10.00 [5.00, 15.75]		29.00 [25.00, 32.00]		37.00 [32.25, 40.00]	
Bachelor's degree/college	64 (13.0)	14.00 [11.00, 18.00]		31.00 [27.00, 34.00]		38.00 [35.00, 41.00]	
<b>Type of occupation</b>							
Regular company employee	133 (27.1)	9.00 [3.00, 14.00]	<0.001	29.00 [24.00, 32.00]	0.238	36.00 [31.00, 39.00]	0.004
Manual labor-intensive work	74 (15.1)	6.00 [3.00, 10.00]		30.00 [27.25, 32.75]		35.00 [33.00, 38.00]	
Homemaker	78 (15.9)	8.00 [4.00, 13.00]		30.00 [27.00, 32.00]		34.50 [31.00, 37.75]	
Retired	167 (34.0)	12.00 [7.00, 15.50]		29.00 [26.00, 32.00]		37.00 [34.00, 40.00]	
Other	39 (7.9)	14.00 [10.00, 16.00]		31.00 [26.00, 32.00]		36.00 [33.50, 39.00]	
<b>Have you experienced breast cancer metastasis</b>							
Yes	176(35.8)	9.00 [4.00, 14.00]	0.014	31.00 [28.00, 33.00]	<0.001	37.00 [34.00, 39.00]	<0.001
No	250(50.9)	11.00 [6.00, 15.00]		29.00 [25.00, 32.00]		37.00 [33.00, 40.00]	
Uncertain	65(13.2)	8.00 [2.00, 13.00]		27.00 [24.00, 32.00]		33.00 [30.00, 37.00]	
<b>Have you been diagnosed with osteoporosis</b>							
Yes	77(15.7)	13.00 [10.00, 16.00]	<0.001	31.00 [28.00, 34.00]	0.013	38.00 [35.00, 40.00]	<0.001
No	166(33.8)	10.50 [7.00, 15.00]		29.00 [26.00, 32.00]		37.00 [34.00, 40.00]	
Uncertain	248(50.5)	7.00 [2.75, 12.25]		30.00 [25.00, 32.00]		35.00 [31.00, 38.00]	
<b>Demographic variables - multiple choice questions</b>						<b>Options</b>	
<b>1.1 Currently, what medication are you receiving for endocrine therapy?</b>							
a. Tamoxifen						87 (17.7%)	
b. Anastrozole						79 (16.1%)	
c. Letrozole						172 (35%)	

(Continued)

TABLE 1 (Continued)

Demographic variables - multiple choice questions	Options
d. Exemestane	160 (32.6%)
e. Other	183 (37.3%)
<b>6. Who usually takes care of you?</b>	
a. Spouse	410 (83.5%)
b. Children	146 (29.7%)
c. Parents	50 (10.2%)
d. Other relatives	7 (1.4%)
e. Live alone	12 (2.4%)
f. Other (please specify)	2 (0.4%)
<b>7. How do you pay for your medical expenses?</b>	
a. Urban and rural residents' medical insurance	184 (37.5%)
b. Urban employee basic medical insurance	305 (62.1%)
c. Other (please specify)	6 (1.2%)

TABLE 2 Spearman correlation analysis.

	Knowledge	Attitudes	Practices
Knowledge	1.000		
Attitudes	0.421 ( $P < 0.001$ )	1.000	
Practices	0.572 ( $P < 0.001$ )	0.483 ( $P < 0.001$ )	1.000

For attitudes, higher knowledge score (OR = 1.13, 95% CI: 1.09–1.17,  $P < 0.001$ ), absence or uncertainty of breast cancer metastasis (OR = 0.41, 95% CI: 0.27–0.63,  $P < 0.001$ ; OR = 0.31, 95% CI: 0.16–0.58,  $P < 0.001$ ), and self-reported undiagnosed osteoporosis status (OR = 0.53, 95% CI: 0.30–0.96,  $P = 0.037$ ) showed significant associations (Supplementary Table S6).

Regarding practices, higher knowledge (OR = 1.13, 95% CI: 1.08–1.19,  $P < 0.001$ ) and attitudes scores (OR = 1.21, 95% CI: 1.14–1.29,  $P < 0.001$ ), as well as higher education levels—junior high school (OR = 3.81, 95% CI: 1.75–8.33,  $P = 0.001$ ), high school or technical school (OR = 5.10, 95% CI: 2.01–12.93,  $P = 0.001$ ), and undergraduate or college (OR = 4.83, 95% CI: 1.47–15.93,  $P = 0.010$ )—were independently associated with proactive practices (Supplementary Table S7).

## Structural equation modeling

The outcomes of the analysis on direct and indirect effects revealed that knowledge exerted a direct influence on attitudes ( $\beta = 0.509$ ,  $P < 0.001$ ), while both knowledge ( $\beta = 0.585$ ,  $P < 0.001$ ) and attitudes ( $\beta = 0.402$ ,  $P < 0.001$ ) directly impacted practices. The SEM demonstrated acceptable fit (RMSEA = 0.074, SRMR = 0.079, TLI = 0.813, CFI = 0.833; Supplementary Table S8). Additionally, knowledge indirectly affected practices through its influence on attitudes ( $\beta = 0.205$ ,  $P < 0.001$ ) (Table 3, Figure 1).

## Discussion

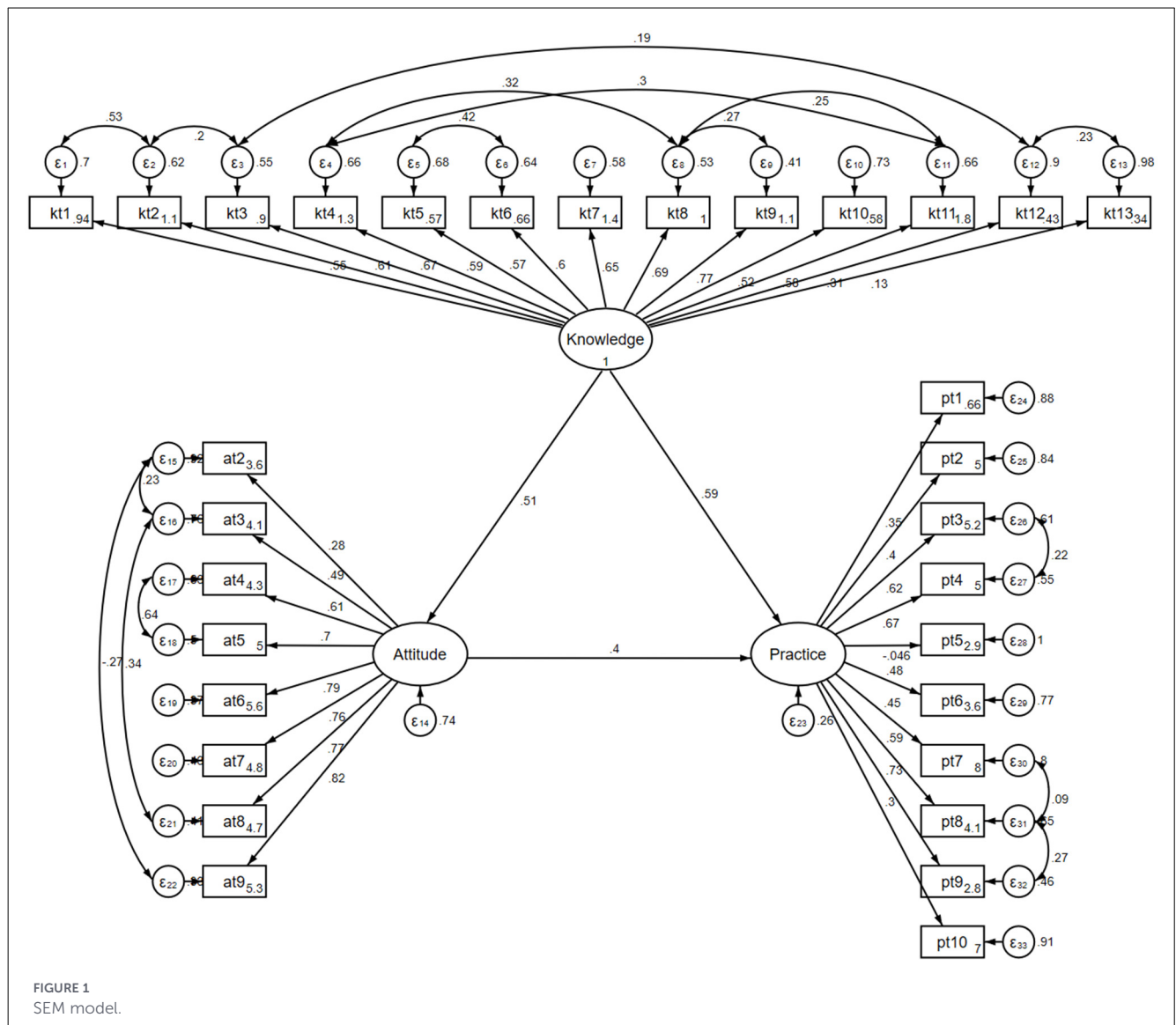
HR+ breast cancer patients exhibit insufficient knowledge and moderate attitudes and practices concerning osteoporosis. Our findings suggest that targeted education may be particularly relevant for patients with lower educational attainment and for those with longer endocrine therapy duration, although the effectiveness of such approaches needs to be evaluated in future studies.

The study's findings regarding significant differences in knowledge, attitudes, and practices among HR+ breast cancer patients present valuable insights into factors influencing osteoporosis management. Participants with longer durations of endocrine therapy exhibited higher knowledge, attitudes, and practices scores concerning osteoporosis management. This pattern is in line with prior reports showing that longer treatment duration is associated with higher health-related knowledge and self-management behaviors in other clinical settings (14). These findings align with the recent study by Ma et al. (13), which similarly identified education level and treatment duration as significant factors influencing osteoporosis-related knowledge and practices. However, our study extends these findings by specifically focusing on HR+ breast cancer patients and demonstrating the mediating role of attitudes in the knowledge-practices relationship through structural equation modeling. The geographical and cultural context of our Nantong City cohort provides additional insights into how regional factors may influence patient behaviors and attitudes toward osteoporosis management.

Moreover, individuals with higher education levels demonstrated better knowledge, attitudes, and practices related to osteoporosis. Notably, patients aged >71 years showed substantially lower knowledge in the univariate analysis, which may relate to lower digital health literacy, age-related cognitive decline, or a greater focus on immediate cancer survivorship concerns rather than long-term bone health management. This aligns with existing literature highlighting the positive correlation

TABLE 3 Analysis of direct and indirect effects.

Model paths		Total effects		Direct effect		Indirect effect	
		$\beta$ (95% CI)	<i>P</i>	$\beta$ (95% CI)	<i>P</i>	$\beta$ (95% CI)	<i>P</i>
Total attitudes score	Total knowledge score	0.509 (0.429, 0.590)	<0.001	0.509 (0.429, 0.590)	<0.001		
Total practices score	Total attitudes score	0.402 (0.310, 0.494)	<0.001	0.402 (0.310, 0.494)	<0.001		
	Total knowledge score	0.790 (0.729, 0.851)	<0.001	0.585 (0.497, 0.674)	<0.001	0.205 (0.152, 0.257)	<0.001



between education level and health literacy across various populations (15–17). Multivariate logistic regression reinforces this association, indicating that individuals with a undergraduate or college education are significantly more likely to possess adequate knowledge. Additionally, a history of breast cancer metastasis was associated with lower knowledge and attitudes scores. Because our survey did not capture detailed clinical, psychosocial, or health-system factors, the specific reasons for this difference cannot be determined. One possible interpretation is that in metastatic care, immediate priorities related to cancer control and symptom management may reduce attention to long-term bone health education and self-management. Future studies incorporating

qualitative assessments may help identify barriers specific to this subgroup. Furthermore, patients diagnosed with osteoporosis showed higher knowledge scores than those without or uncertain about an osteoporosis diagnosis. A plausible explanation is that a confirmed diagnosis often triggers physician-initiated counseling, and treatment discussions, which may improve osteoporosis-related knowledge and awareness. By contrast, patients without a diagnosis or those uncertain about their osteoporosis status may have had fewer opportunities for targeted communication and follow-up, which could contribute to lower knowledge. However, osteoporosis status in this study was self-reported and was not verified by medical record review or mandatory DXA assessment;

therefore, these comparisons should be interpreted cautiously and should not be taken to indicate the presence or absence of osteoporosis, which is multifactorial. Osteoporosis status was self-reported rather than clinically adjudicated for all participants; therefore, misclassification of osteoporosis status is possible and should be considered when interpreting these comparisons.

The correlation analysis and SEM further elucidated the interplay between knowledge, attitudes, and practices. Significant positive correlations were observed between knowledge and attitudes, knowledge and practices, and attitudes and practices, indicating a cohesive relationship between these components. The SEM revealed that knowledge directly influenced attitudes and practices, with attitudes serving as a mediator between knowledge and practices. These findings are compatible with the KAP framework, in which knowledge and attitudes are related to health practices; however, the cross-sectional design does not allow inference about temporal order or causality (18, 19).

The distribution of responses in the knowledge dimension reveals varied levels of awareness and understanding among HR+ breast cancer patients regarding osteoporosis-related concepts. While a substantial proportion of participants correctly identified factors such as the association between menopause and osteoporosis, the increased risk of osteoporosis in breast cancer patients, and the potential impact of certain medications on bone health, there were still notable gaps in knowledge. For instance, a significant number of participants were uncertain about the relationship between osteoporosis and breast cancer or were unaware of symptoms indicative of osteoporosis. These findings suggest a need for targeted educational interventions to enhance awareness and knowledge regarding osteoporosis among HR+ breast cancer patients. Recommendations for improvement may include developing educational materials tailored to the specific information needs of this population, disseminating information through multiple channels such as healthcare providers, patient support groups, and social media platforms, and incorporating interactive elements to facilitate learning and retention of key concepts (20–22).

In the attitudes dimension, participants exhibited a range of perspectives regarding their beliefs and perceptions related to osteoporosis and its management. While many participants expressed concerns about the potential impact of osteoporosis on their daily lives and the progression of breast cancer, there were also notable areas of uncertainty or disagreement. For example, a considerable proportion of participants were unsure about the necessity of undergoing bone density testing, or believed that osteoporosis treatment required more expensive medical examination and hospital-based treatment. These findings underscore the importance of addressing misconceptions and uncertainties surrounding osteoporosis management among HR+ breast cancer patients. To address these gaps, interventions could focus on providing clear and accurate information about the importance of preventative measures, promoting positive attitudes toward screening and treatment, and addressing fears or misconceptions that may act as barriers to proactive health behaviors (23–25).

In the practices dimension, participants demonstrated varying levels of engagement in behaviors aimed at preventing or

managing osteoporosis. While a significant number of participants reported undergoing bone density testing and adhering to recommended treatments, there were also areas where practices could be improved. For instance, a notable proportion of participants reported uncertainty or reluctance regarding dietary adjustments, regular exercise, or calcium supplementation, which are key components of osteoporosis management. Additionally, concerns about the potential risks associated with exercise highlight the need for targeted interventions to address fears and misconceptions that may hinder engagement in physical activity. Practical recommendations may include providing tailored guidance on diet and exercise, offering resources or support for behavior change, and emphasizing the importance of a proactive approach to bone health within the context of breast cancer survivorship care (26–28). In our sample, only 30.1% of participants reported having undergone bone density testing. While physicians play a central role in initiating screening and counseling, shared decision-making also requires that patients recognize the value of these recommendations; insufficient knowledge or low perceived necessity may reduce follow-through even when testing is suggested.

This study had limitations. In our clinical setting, adjuvant bisphosphonates (e.g., zoledronic acid) are part of standard care for postmenopausal patients or those at high fracture risk. This routine clinical management and related counseling may increase bone health awareness and could have influenced the KAP scores observed. Firstly, the cross-sectional design of the study limits the ability to establish causality between variables, as it only captures a snapshot of the participants' KAP at a specific point in time. Secondly, the study was conducted at a single oncology hospital in Nantong City, potentially limiting the generalizability of the findings to broader populations of HR+ breast cancer patients. In addition, because only female patients were included, the findings may not be generalizable to male breast cancer patients. Furthermore, the use of convenience sampling and QR code-based data collection may have introduced selection bias, potentially favoring younger, more highly educated, or more tech-savvy participants who were able to complete a smartphone-based questionnaire, which may affect the representativeness of the sample. In addition, higher educational attainment is often associated with greater health literacy, which may introduce reporting bias because more educated participants may better understand and complete a structured questionnaire; therefore, their scores may partly reflect questionnaire comprehension rather than only true osteoporosis-related knowledge. Although these exclusions were based on prespecified, scoring-related criteria, we acknowledge that contradictory responses may be more common among participants with lower comprehension, which could slightly affect representativeness. Lastly, reliance on self-reported data through questionnaires may introduce recall bias and social desirability bias, impacting the accuracy and reliability of the reported KAP scores. In addition, osteoporosis diagnosis status was self-reported and not systematically confirmed by DXA or medical record review for all participants, which may have introduced misclassification. Additionally, the self-developed questionnaire, while showing good reliability (Cronbach's  $\alpha = 0.841$ ), may benefit from more extensive psychometric testing

including construct validity and factor analysis in future studies. Cultural, social, and economic factors specific to the Nantong City context may limit the generalizability of findings to other populations with different backgrounds.

Based on our findings, healthcare providers should consider implementing targeted educational interventions in clinical settings. These interventions should be tailored according to patients' education levels, with simplified materials for those with lower educational attainment and more comprehensive resources for highly educated patients. For patients with longer treatment durations, educational programs should focus on maintaining engagement and updating knowledge about evolving treatment protocols. Clinical pathways should incorporate regular assessment of patients' knowledge, attitudes, and practices regarding osteoporosis, with personalized education plans developed based on individual assessment results. Additionally, healthcare teams should address specific misconceptions identified in our study, such as the relationship between osteoporosis and breast cancer progression, and provide clear guidance on safe exercise practices to overcome fears of physical activity.

In conclusion, HR+ breast cancer patients exhibit insufficient knowledge, positive attitudes, and suboptimal practices regarding osteoporosis. Given the significant associations identified between education levels and KAP scores, tailored educational interventions should be implemented targeting HR+ breast cancer patients, especially those with lower education levels, to improve their knowledge, attitudes, and practices concerning osteoporosis.

## Data availability statement

The original contributions presented in the study are included in the article/[Supplementary material](#), further inquiries can be directed to the corresponding authors.

## Ethics statement

The studies involving humans were approved by Oncology Hospital in Nantong City from November 8, 2023, to March 22, 2024 (Approval No: TONGLUNSHENSHI [Keyan] 2022-065). The studies were conducted in accordance with the local legislation and institutional requirements. The participants provided their written informed consent to participate in this study.

## Author contributions

XC: Data curation, Project administration, Formal analysis, Validation, Conceptualization, Writing – original draft, Writing – review & editing, Resources. RX: Writing – original draft, Funding acquisition, Visualization, Formal analysis, Resources, Conceptualization, Supervision, Writing – review & editing, Investigation. XS: Conceptualization, Methodology, Validation, Resources, Writing – review & editing, Formal analysis, Visualization, Writing – original draft. XH: Formal analysis, Conceptualization, Project administration, Writing – original draft,

Data curation, Writing – review & editing, Supervision, Validation. LC: Visualization, Formal analysis, Project administration, Methodology, Writing – review & editing, Supervision, Software, Writing – original draft. JL: Resources, Visualization, Writing – review & editing, Writing – original draft, Validation, Conceptualization, Formal analysis, Software, Methodology. XL: Investigation, Supervision, Writing – review & editing, Writing – original draft, Data curation, Software, Visualization, Methodology, Resources. LP: Visualization, Software, Writing – review & editing, Writing – original draft, Funding acquisition, Methodology, Formal analysis, Supervision. YC: Data curation, Methodology, Supervision, Conceptualization, Writing – review & editing, Visualization, Writing – original draft, Project administration.

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## Conflict of interest

The author(s) declared that this work was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

## Generative AI statement

The author(s) declared that generative AI was not used in the creation of this manuscript.

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## Supplementary material

The Supplementary Material for this article can be found online at: <https://www.frontiersin.org/articles/10.3389/fpubh.2026.1741278/full#supplementary-material>

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