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ORIGINAL RESEARCH

Construction of Fracture Liaison Service Scheme Under Medical Alliance Framework in China: A Modified Delphi Method Study

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Purpose: To devise an implementation blueprint for the fracture liaison service (FLS) model within the context of a medical consortium. The FLS is an integrated system designed to identify, register, assess, treat, and monitor patients with osteoporotic fractures. The FLS constitutes a structured intervention strategy to administer standardized care to osteoporotic fracture patients. Its efficacy has been validated through extensive implementation across various countries. However, large-scale intervention research on this model within China is lacking. This investigation endeavors to construct a comprehensive FLS framework and to establish its core performance indicators within the Chinese medical alliance structure.

Patients and Methods: The research methodology encompassed focus group interviews and a two-phase Delphi process. An initial inventory of FLS implementation elements was compiled through a systematic literature review and focus group discussions. This was followed by a two-step Delphi survey, wherein experts refined the key indicators. The study calculated metrics such as response rate, composite reliability (CR), coefficient of variation, and the Kendall coefficient of concordance to evaluate the indicators.

Results: The study involved 17 experts who completed 2 rounds of the Delphi consultation, culminating in a consensus on 2 primary and 8 secondary indicators, encompassing 34 specific indicators. The response rate for the first and second round was 100%, with CR values of 0.871 and 0.882, and Kendall's coefficients of 0.161 and 0.179, respectively ($P < 0.05$).

Conclusion: This work delineated a robust set of indicators specifically tailored for the FLS schema under the medical alliance framework in China. The rigorous application of the Delphi technique led to a consensus on 34 pivotal indicators, elucidating their relative significance.

Keywords: osteoporotic fracture, fracture liaison service, Delphi

Introduction

Osteoporotic fractures, also known as fragility fractures, typically occur during everyday activities or after minor trauma in the elderly population. These fractures serve as sentinel events indicating the presence of osteoporosis, and are associated with considerable health risks.[1] The global aging of the population has been accompanied by a surge in the incidence of osteoporosis and osteoporotic fractures among the elderly, leading to heightened rates of long-term disability and mortality, and increased healthcare costs.[2–5] This trend underscores the importance of effective osteoporosis management in minimizing the secondary complications of osteoporotic fractures.[5] Despite this, only a fraction—estimated at around 20%—of elderly patients with osteoporotic fractures are offered post-fracture assessments and treatments for osteoporosis, revealing a critical gap in patient management.[6,7] One solution to close this gap is the fracture liaison service (FLS) model.

The FLS is an integrated system designed to identify, register, assess, treat, and monitor patients with osteoporotic fractures. This model of care offers a systematic approach to intervention and management among elderly patients affected by osteoporotic fractures.[3,8–10] FLS programs have demonstrated success in reducing refracture rates, alleviating

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patient discomfort, reducing healthcare expenditure, and enhancing patients' quality of life in several countries such as the United Kingdom, the United States, Australia, and Singapore.[7,11–14] However, there is a notable lack of large-scale intervention studies and standardized theoretical support for the implementation of an FLS program in China, highlighting the need for interdisciplinary and interdepartmental collaboration.

In China, the medical alliance model integrates the primary, secondary, and tertiary healthcare levels, fostering the system-wide integration of services and presenting an opportunity to establish a comprehensive post-osteoporosis management system. This model has the potential to ensure the seamless management of patients with osteoporotic fractures throughout the disease course, from treatment to rehabilitation.[15–18] In light of this, our study aims to provide a theoretical framework for the scientific management of osteoporotic fractures by constructing an FLS scheme tailored to the Chinese medical alliance context and by defining the core indicators of this framework.

Methods

The study was divided into two phases. Phase 1 consisted of a literature review and focus group interviews to obtain a preliminary list of indicators for the implementation plan of a potential FLS model, while Phase 2 consisted of Delphi expert consultations to reach a consensus on the core indicators of the FLS framework.

Phase 1

Establishment of the Research Team

The research team comprised five orthopedic nursing experts, including one chief nurse (director of nursing, doctoral student), one deputy chief nurse (head nurse of the orthopedic ward), and four charge nurses (two nursing graduate students and two orthopedic specialty nurses). The research team was established to oversee the Delphi consultation process and provide support for consensus building. The research team members took care to avoid influencing the opinions of the panel of experts participating in the Delphi process, and verified that none of the panelists had any conflict of interest. The study protocol was approved by the ethics committee of our hospital.

Literature Search and Review

To establish the indicators for the implementation plan of potential FLS models, we conducted an extensive literature search across several databases, including PubMed, Web of Science, China Science and Technology Journal Database, and Wanfang Data. The search encompassed articles published between January 1, 2018, and December 31, 2022. The retrieval strategy, both English and Chinese databases, involved using a combination of free text and subject terms. For instance, in English databases like PubMed, we used search terms such as "fragility fracture*", "osteoporotic fracture*", "fracture liaison service", "fracture*", "osteoporotic", "medical alliance model", and "medical alliance". In Chinese databases such as CNKI, the search query was structured to include terms related to osteoporotic fractures, fragility fractures, osteoporosis, fracture liaison, fracture liaison service, FLS, medical alliance, medical consortium, and regional medical center. After screening the abstracts of the retrieved studies and excluding irrelevant articles, we selected a total of 12 references for an in-depth review (Figure 1).

Focus Group Interviews

Our team used the results of the literature survey to draft an initial list of indicators for the FLS scheme. This list was then modified according to the responses given during the focus group interviews. Focus group interviews are a valuable method for collecting diverse insights and perspectives on topics that may not be well understood or clearly defined. To refine the potential quality indicators, we conducted an expert consultation. We invited 10 experts specializing in hospital nutrition, geriatric medicine, endocrinology, orthopedics, rheumatology and immunology, obstetrics and gynecology, and rehabilitation medicine to participate in focus group interviews. All of these experts were involved in the diagnosis, treatment, and care of osteoporosis patients.

During the interviews in person, the experts were encouraged to share their opinions based on their professional experience and engage in collective deliberation. The participants were given the freedom to express their views, and with their consent, each interview was audio-recorded. The research team then compiled and summarized the expert opinions, which were used to

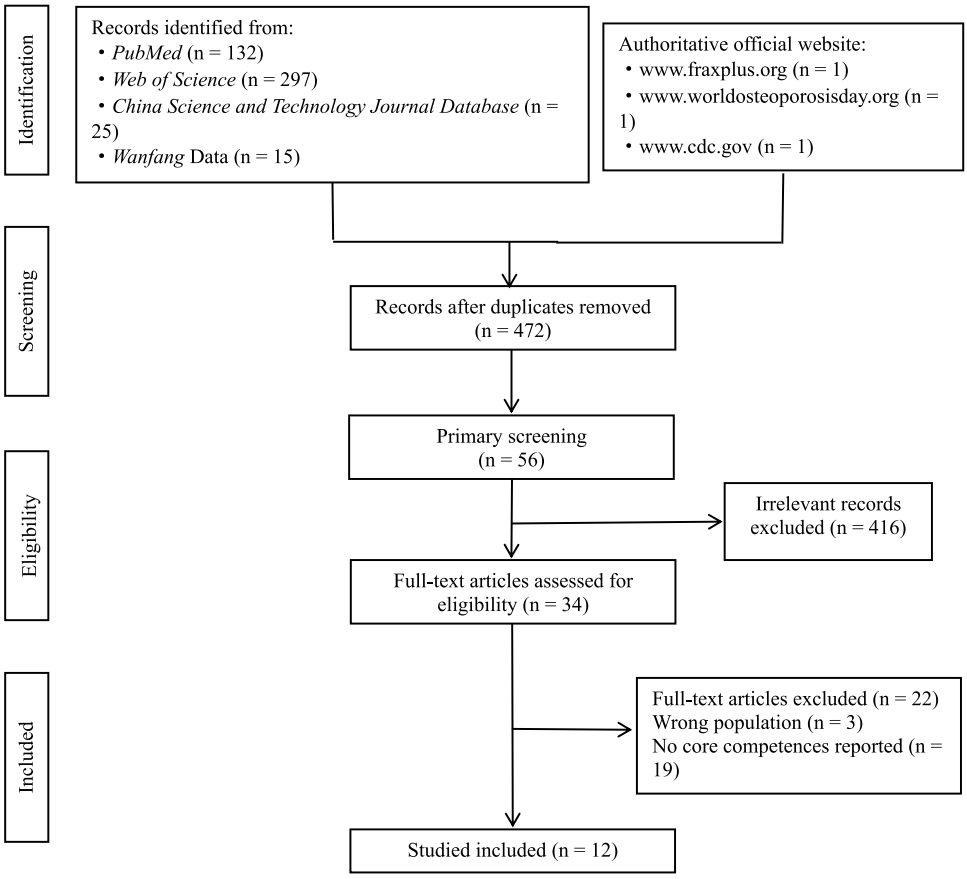

Figure 1 Literature screening process.

modify the proposed FLS scheme through group discussions Among the research team members. As part of the modified Delphi consultation protocol, these experts did not participate in the subsequent Delphi process.[15] Their responses during the focus group interviews were used to refine the indicators of a potential FLS model based on a literature-supported medical alliance framework.[5,13,14,19–21] The focus group interviews resulted in the inclusion of 2 first-level indicators, 8 second-level indicators, and 34 third-level indicators in the proposed FLS scheme (Box 1).

Box 1 Indicators of the Fracture Liaison Service Model Under the Medical Alliance Framework

Indicator
1) Establishment of a fracture liaison service team under the medical alliance framework
A. Team composition
A1. Fracture liaison service team members include emergency department doctors, orthopedic doctors, and medical professionals specialized in geriatric fragility fracture management (including, but not limited to, endocrinologists, geriatric medicine specialists, cardiologists, respiratory specialists, neurologists, rheumatologists, obstetricians/gynecologists, general practitioners, pharmacists, rehabilitation therapists, nutritionists, internal coordinators, and external coordinators). The team consists of fixed professionals such as doctors and nurses, and has specialized management protocols.
B. Qualifications of team members
B1. Internal coordinator
B2. External coordinator
B3. Doctors in the emergency department, orthopedics, and inpatient wards related to geriatric fragility fractures must possess a master's degree or above, hold a title of associate chief physician or higher, and have over 5 years of specialized work experience.
B4. Rehabilitation therapists and nutritionists should have a bachelor's degree or higher, an intermediate or higher professional title, and at least 5 years of specialized work experience.

(*Continued*)

Box 1 (Continued).

C. Division of labor in the patient diagnosis and treatment process

C1. Pre-hospital transportation: Coordinators from the medical alliance unit are responsible for contacting and transferring fracture patients to tertiary hospitals.

C2. Admission in the emergency department: The emergency department receives patients and consults with orthopedic doctors. Orthopedic doctors use standardized criteria based on age, fracture location, fracture mechanism, and imaging data to identify fragility fracture patients.

C3. Orthopedic inpatient care: Orthopedic doctors conduct comprehensive assessments to determine whether to provide surgical or conservative treatment to patients.

C4. Perioperative care in orthopedics: Fracture liaison service team members conduct comprehensive assessments of patients and intervene in case of any abnormal conditions.

C5. Referral to medical alliance units: The fracture liaison service team develops a comprehensive rehabilitation plan for patients. Internal coordinators contact the medical alliance unit to transfer patients to the corresponding medical alliance institution for post-rehabilitation and osteoporosis treatment. Orthopedic or endocrinology doctors, in collaboration with relevant specialists, formulate anti-osteoporosis treatment plans. Rehabilitation therapists are responsible for developing short-term, medium-term, and long-term rehabilitation plans, while nutritionists are responsible for designing nutritional plans. The medical alliance unit implements the plans accordingly.

C6. Patients returning to an environment with caregivers: Internal/external coordinators assess, track, and provide guidance to patients and caregivers returning home.

C7. Patient follow-up visits: Fracture liaison service team coordinators monitor patients' follow-up visits within the medical alliance units.

2) Specific implementation steps of the fracture liaison service model under the medical alliance framework

A. Inclusion criteria for fragility fracture patients

A1. Specific implementation of fracture liaison service model under the medical alliance framework. The inclusion criteria for patients under the medical alliance model are as follows: patients aged ≥65 years who either (1) have a vertebral or hip fragility fracture, or (2) have a proximal humerus or distal radius fragility fracture along with a dual-energy X-ray absorptiometry T-score ≤ −1.0. The exclusion criterion is patients with high-energy injuries.

B. Assessing osteoporosis and fall risk

B1. Orthopedic doctors collect medical history, laboratory test results, and conduct physical examinations.

B2. Orthopedic doctors assess the fracture risk factors involved in patients.

B3. Orthopedic doctors conduct secondary osteoporosis etiology screening.

B4. Orthopedic doctors perform bone density tests.

B5. Nurses conduct fall risk assessments for patients in recovery.

C. Nurses Initiate measures to prevent recurrent fractures

C1. Orthopedic doctors review the patient's initial fracture situation.

C2. Medication intervention: Treatment plans are developed by orthopedic or endocrinology doctors. After discharge, internal coordinators hand over the treatment plan to the medical alliance units for medication intervention to increase the patient's bone density and reduce the risk of recurrent fractures.

C3. Nutritional intervention: Nutritionists develop feasible nutritional intervention prescriptions based on patient examination indicators and living conditions.

C4. Lifestyle guidance: Patients should quit smoking and avoid excessive drinking.

C5. Exercise rehabilitation guidance: Rehabilitation therapists develop and implement rehabilitation plans. After discharge, community guidance is provided, and family members or caregivers supervise the implementation.

C6. Health education on fall prevention: Internal and external coordinators jointly provide health education on fall prevention.

D. Follow-up and long-term treatment

D1. Internal coordinators inform patients about the follow-up process before discharge, and guide external coordinators in carrying out interventions and follow-up work outside the hospital. During the follow-up period, internal coordinators coordinate with relevant doctors to adjust treatment plans.

D2. Follow-up of adverse drug reactions

D3. Compliance with anti-osteoporosis medications

D4. Follow-up of spine, waist, and lower back pain

D5. Follow-up of quality of life

D6. Tracking endpoint events such as recurrent fractures and falls.

D7. Follow-up period for the is 6 months.

(*Continued*)

Box 1 (Continued).

E. Operation process within the medical alliance framework

E1. Patients are referred from tertiary hospitals to medical consortium units: After discharge, the orthopedic doctor provides a treatment plan for osteoporosis. The department reports to the medical affairs office, which assigns a specific person to contact the medical consortium unit for the patient's bidirectional referral, to carry out subsequent rehabilitation and osteoporosis treatment.

E2. Patients returning to an environment with caregivers: Internal/external coordinators assess, track, and provide guidance to patients and caregivers returning home.

E3. Patient follow-up visits: Patients have follow-up visits in medical alliance units, and fracture liaison service team coordinators track their progress.

Phase 2

In phase 2, we used the Delphi method, which is widely adopted to reach a consensus on a topic among a panel of experts. The entire process of conducting the Delphi study followed the Conducting and Reporting of Delphi Studies guidelines proposed by Jünger and associates.[16]

Selection of Delphi Panel

For the Delphi study, experts were selected based on specific inclusion criteria to ensure a high level of expertise and relevance to the research topic. The criteria for inclusion were as follows: (1) experts from the fields of nutrition, geriatric medicine, endocrinology, orthopedic surgery, rheumatology and immunology, obstetrics and gynecology, or rehabilitation medicine, who were engaged in the treatment or care of patients with osteoporosis or osteoporotic fractures and had a minimum of 10 years of professional experience; (2) experts who held a senior professional title or above (for those with over 20 years of work experience, a mid-level professional title was considered acceptable); and (3) experts who possessed a bachelor's degree or higher educational level.

The purpose, methodology, and potential risks and benefits of the Delphi expert consultation were communicated to the potential participants via email. Experts who met the criteria were encouraged to suggest other professionals who could contribute valuable insights to the study. After obtaining written informed consent from all the experts, we distributed questionnaires to the experts between February and March 2023. The research team successfully recruited 17 experts for each round of Delphi consultations, ensuring a diverse group with extensive knowledge in the relevant field.

Round 1 of the Delphi Survey

The first round of the Delphi survey was initiated by sending online questionnaires to the experts via their private Email addresses to maintain confidentiality. The materials provided included the preliminary list of indicators for the FLS implementation plan, along with sections for revision comments and the addition of new indices.[17]

The expert consultation questionnaire was organized into four sections: (1) Introduction: This section offered a comprehensive explanation of the research objectives, significance, main content, and instructions for completing the questionnaire. (2) Basic Information Survey: This section gathered essential information from the experts, such as their full name, institutional affiliation, age, position, professional title, highest educational qualification, field of work, and years of experience in their relevant areas. (3) Main Questionnaire: This section contained specific items grouped under 2 primary indicators, 8 secondary indicators, and 34 tertiary indicators. The importance of each indicator was evaluated using a five-point Likert scale. A column for suggested modifications was included, allowing experts to propose changes, additions, or deletions to the indicator content, and provide their rationale for the suggested revisions. (4) Expert Self-Assessment Form: This section included the experts' judgment criteria and level of familiarity with the subject matter. In the Delphi method, the basis for expert judgments includes their individual expertise, experience in relevant fields, and available scientific research and data.

For core indicator items, a consensus was considered to have been reached if its mean score on the Likert scale was greater than 4.0 (indicating its importance), and its coefficient of variation was less than 0.25.[22,23] The core indicator

items for which a consensus was not reached in the first round were entered into the second round to give the experts an opportunity to possibly amend their answers based on other experts' opinions.

Round 2 of the Delphi Survey

Following the completion of the first round of the Delphi survey, the research team collected the questionnaires from the experts, and meticulously compiled and summarized the experts' feedback. Two members of the team independently assessed all comments for similarity, and any discrepancies between them were resolved through discussion with the full research team. These findings, along with the results of the statistical analysis, informed the team's deliberations regarding potential modifications to the indicators.

In the second round, the experts received a revised list of core indicators, accompanied by the original questionnaire. To enhance the response rate for the second round and to reduce potential expert fatigue from responding to repeated items, the questionnaire was designed to be user-friendly, with a clear and consistent layout. It began with items for which a consensus had not yet been achieved in the first round, in order to prioritize these for discussion.

The final outcomes of the Delphi study were thoroughly reviewed and discussed by the entire research team to ensure the validity and reliability of the consensus reached.

Data Analysis

Data management and entry were performed using Microsoft Excel 2019, which was also used to proofread the collected data and ensure data accuracy. Statistical analysis was conducted using SPSS 25.0 (IBM Corporation, 2017). Composite reliability (CR) values were used to quantify the authority of the expert opinions. The concordance among the expert opinions was assessed by calculating the coefficient of variation and the Kendall coefficient of concordance (Kendall W). These statistical measures provided a robust framework for evaluating the consensus as well as the reliability of the expert panel's recommendations.

Results

Demographics of the Expert Panel

A total of 17 experts from the fields of trauma and orthopedic nursing, rheumatology and immunology, endocrinology, and community management participated in two rounds of expert consultations. The basic information of these experts is presented in Table 1.

Table 1 Basic Information of the Experts Participating in the Delphi Consultation

Demographic characteristic		Frequency	Percentage
Age (years)	30–39	3	18%
	40–49	10	59%
	≥50	4	23%
Sex	Male	7	41%
	Female	10	59%
Educational level	PhD	5	29%
	Master's degree	5	29%
	Bachelor's degree	7	42%
Professional titles	Senior professional	6	35%
	Associate senior professional	8	47%
	Mid-level professional	3	18%
Years of experience	10–19	6	35%
	20–29	9	52%
	≥30	2	13%

Positivity and Authority of Experts, and Degree of Coordination Among Expert Opinions

Each of the two rounds of the Delphi survey involved the distribution and return of 17 questionnaires, yielding a valid response rate of 100%, which signified an effective consultation process and a high level of positivity among the experts. The voluntary completion of the questionnaires by the experts ensured that their opinions were free from conflicts of interest or researcher influence. To maintain confidentiality and anonymity, the consultation forms and the experts' personal information forms were kept separate, with the former not indicating the experts' names or showing any identifying marks. This ensured that the experts' opinions remained anonymous throughout the data-analysis process.

In the first round, modifications to the proposed FLS framework were suggested by 10 of the 17 experts, representing 58.82% of the total expert panel. In the second round, a total of 6 experts recommended further changes to the FLS framework, constituting 35.29% of the panel. The authority of the experts was measured using CR values, with CR $\geq$ 0.7 generally considered indicative of reliable expert opinion. This measure was calculated using the formula CR = (Ca + Cs)/2, where Ca represents the experts' self-assessment of their judgment criteria, and Cs represents the experts' familiarity with the indices. In this study, the CR values of both rounds of expert consultation were above 0.70; specifically, the CR value was 0.871 (Ca = 0.912, Cs = 0.829) in the first round, and 0.882 (Ca = 0.924, Cs = 0.840) in the second round.

The degree of coordination among the experts' opinions was assessed using the coefficient of variation and Kendall's W coefficient. The coefficients of variation for both rounds of consultation were below 0.25, indicating a low degree of variability and thus a high level of agreement among the experts. The Kendall W values for the first and second round of consultation were 0.161 and 0.179, respectively, with *P*-values of less than 0.05, indicating a statistically significant level of coordination among the constructed core competencies. Therefore, the experts' opinions were deemed to be consistent and well-coordinated (Table 2).

Round 1 of the Delphi Consultation

In the first round of consultation, the experts primarily suggested modifications to the tertiary indicators (ie, specific indicator details). There were no objections or concerns raised regarding the primary and secondary indicators.

In regards to Part A of the proposed FLS model, five experts suggested modifications to the composition of the FLS team. Among them, two experts recommended adding "the intensive care medicine and clinical support departments" to the list of relevant medical professionals. One expert proposed including "general practice medicine" in the FLS team. Another expert suggested referring to the FLS team as "medical professionals specialized in geriatric fragility fracture management". One expert recommended including a "community family physician" in the FLS team, while another expert suggested adding a "pharmacist" to the team. Considering the practical needs and feasibility of the work, five experts suggested that there should not be excessive requirements for the professional titles and educational qualifications of the FLS team members.

Based on the above suggestions, the contents of A1-1 were modified as follows: "Medical professionals specialized in geriatric fragility fracture management (including, but not limited to, the mentioned departments)". Since community general practitioners are already included in the role of external coordinators, they do not need to be separately listed as internal medical professionals. Part A2-3 of the proposed FLS scheme was revised to "Emergency department, orthopedic, and inpatient doctors in wards specializing in geriatric fragility fractures should have a bachelor's degree or higher, with a minimum of 5 years of specialized work experience and a professional title of senior resident or higher".

Table 2 Degree of Expert Opinion Consensus

Indicator	First Round			Second Round		
	Kendall W	x^2 Value	*P*-value	Kendall W	X^2Value	*P*-value
Primary	0.235	4.000	0.046	0.294	5.000	0.025
Secondary	0.222	26.385	0.000	0.237	28.230	0.000
Tertiary	0.152	85.162	0.000	0.170	95.456	0.000
All indicators	0.161	117.855	0.000	0.179	130.788	0.000

Regarding Part B of the proposed FLS scheme, three experts suggested adding an environmental assessment for home falls. Hence, B2-5 was modified as follows: "Nurses conduct fall risk assessment and environmental assessment for home falls for patients in rehabilitation".

Three experts recommended enhancing the content of lifestyle guidance, such as increasing sunlight exposure, avoiding or reducing the use of medications that affect bone metabolism, and moderately increasing daily activity levels. Hence, B3-4 was revised to: "Lifestyle guidance: Provide guidance to patients on smoking cessation, alcohol avoidance, increasing sunlight exposure, avoiding or reducing the use of medications that affect bone metabolism, and moderately increasing daily activity levels".

Four experts proposed improvements to the referral process within the medical alliance model. According to their suggestions, departments should follow the established referral process, and relevant departments should handle the coordination, eliminating the need for each patient to contact the medical affairs office. Based on these recommendations, B5-1 was modified as follows: "Referral of patients from tertiary hospitals to medical alliance units: After discharge, orthopedic doctors provide osteoporosis treatment plans. Hospitals or departments establish referral processes, register and record referral patients, assign dedicated personnel for coordination, facilitate two-way referrals, and provide post-rehabilitation and osteoporosis treatment".

Round 2 of the Delphi Consultation

In the second round, the altered core competency items after the first round were presented to the experts. In the second round of the Delphi process, the modified core competency items that resulted from the first round of expert feedback were presented to the experts once again. Based on the expert recommendations obtained in the second round, the following modifications were made to the contents of four third-level indicators. The specific changes included:

One expert suggested that fall risk assessment and environmental assessment should be conducted during the patient's hospitalization rather than waiting until the rehabilitation period. Considering the feasibility of the implementation, we revised B2-5 from "Nurses conduct fall risk assessment and environmental assessment for home falls for patients in rehabilitation" to "Nurses conduct fall risk assessment and environmental assessment for home falls for patients during their hospitalization".

To ensure practicality, one expert proposed that the personnel responsible for lifestyle guidance in B3-4 should be explicitly defined as "coordinators". Two experts believed that the ultimate evaluation criteria for FLS are the osteoporosis treatment rate and the rate of recurrent fractures. Therefore, in B4-6, "adverse events" was modified to "endpoint events".

Considering the specific feasibility of the approach, two experts suggested that the osteoporosis treatment plan should be developed by orthopedic doctors or endocrinologists. As a result, B5-1, which initially stated "After discharge, orthopedic doctors provide osteoporosis treatment plans", was revised to "After discharge, orthopedic doctors or endocrinologists provide osteoporosis treatment plans".

After the second round of consultation, 2 first-level indicators and 8 second-level specific competencies with 34 third-level indicators were unanimously agreed upon by the expert panel (Table 3).

Table 3 Indicators of the Fracture Liaison Service Model Under the Medical Alliance Framework

Indicator	Importance Score (x ± s)	Coefficient of Variation
1) Establishment of fracture liaison service team under the medical alliance framework	4.941 ± 0.243	0.049
A. Team composition	5.000 ± 0.000	0.000
A1. Fracture liaison service team members include emergency department doctors, orthopedic doctors, and medical professionals specialized in geriatric fragility fracture management (including, but not limited to, endocrinologists, geriatric medicine specialists, cardiologists, respiratory specialists, neurologists, rheumatologists, obstetricians/gynecologists, general practitioners, pharmacists, rehabilitation therapists, nutritionists, internal coordinators, and external coordinators). The team consists of fixed professionals such as doctors and nurses, and has specialized management protocols.	4.941 ± 0.243	0.049

(*Continued*)

Table 3 (Continued).

Indicator	Importance Score (x ± s)	Coefficient of Variation
B. Qualifications of team members	5.000 ± 0.000	0.000
B1. Internal coordinator	4.706 ± 0.470	0.100
B2. External coordinator	4.706 ± 0.588	0.125
B3. Emergency department, orthopedic, and geriatric fragility fracture-related inpatient doctors should have a master's degree or higher, a bachelor's degree or higher, senior resident or higher professional title, and at least 5 years of specialized work experience.	4.647 ± 0.606	0.130
B4. Rehabilitation therapists and nutritionists should have a bachelor's degree or higher, intermediate or higher professional title, and at least 5 years of specialized work experience.	4.765 ± 0.437	0.092
C. Division of labor in the patient diagnosis and treatment process	4.765 ± 0.437	0.092
C1. Pre-hospital transportation: Coordinators from the medical alliance unit are responsible for contacting and transferring fracture patients to tertiary hospitals.	4.824 ± 0.393	0.081
C2. Admission to the emergency department: The emergency department receives patients and consults with orthopedic doctors. Orthopedic doctors use standardized criteria based on age, fracture location, fracture mechanism, and imaging data to identify fragility fracture patients.	4.706 ± 0.588	0.125
C3. Orthopedic inpatient care: Orthopedic doctors conduct comprehensive assessments to determine whether to provide surgical or conservative treatment to patients.	4.882 ± 0.332	0.068
C4. Perioperative care in orthopedics: Fracture liaison service team members conduct comprehensive assessments of patients and intervene in case of any abnormal conditions.	4.706 ± 0.588	0.125
C5. Referral to medical alliance units: The fracture liaison service team develops a comprehensive rehabilitation plan for patients. Internal coordinators contact the medical alliance unit to transfer patients to the corresponding medical alliance institution for post-rehabilitation and osteoporosis treatment. Orthopedic or endocrinology doctors, in collaboration with relevant specialists, formulate anti-osteoporosis treatment plans. Rehabilitation therapists are responsible for developing short-term, medium-term, and long-term rehabilitation plans, while nutritionists are responsible for designing nutritional plans. The medical alliance unit implements the plans accordingly.	4.588 ± 0.618	0.135
C6. Patients returning to an environment with caregivers: Internal/external coordinators assess, track, and provide guidance to patients and caregivers returning home.	4.647 ± 0.493	0.106
C7. Patient follow-up visits: Fracture liaison service team coordinators monitor patients' follow-up visits within the medical alliance units.	4.588 ± 0.618	0.135
2) Specific implementation steps of the fracture liaison service model under the medical alliance framework	4.647 ± 0.493	0.106
A. Inclusion criteria for fragility fracture patients	4.588 ± 0.618	0.135
A1. Specific implementation of fracture liaison service model under the medical alliance framework. The inclusion criteria for patients under the medical alliance model are as follows: patients aged ≥65 years who either (1) have a vertebral or hip fragility fracture, or (2) have a proximal humerus or distal radius fragility fracture with a dual-energy X-ray absorptiometry T-score ≤ −1.0. The exclusion criterion is patients with high-energy injuries.	4.882 ± 0.332	0.068
B. Assessing osteoporosis and fall risk	4.706 ± 0.470	0.100
B1. Orthopedic doctors collect medical history, laboratory test results, and conduct physical examinations.	4.706 ± 0.470	0.100
B2. Orthopedic doctors assess the fracture risk factors involved in patients.	4.941 ± 0.243	0.049
B3. Orthopedic doctors conduct secondary osteoporosis etiology screening.	4.588 ± 0.618	0.135
B4. Orthopedic doctors Perform bone density tests.	5.000 ± 0.000	0.000
B5. Nurses assess fall risk and home fall environment during the patient's hospitalization.	4.529 ± 0.624	0.138

(*Continued*)

Table 3 (Continued).

Indicator	Importance Score (x ± s)	Coefficient of Variation
C. Nurses Initiate measures to prevent recurrent fractures	5.000 ± 0.000	0.000
C1. Orthopedic doctors review the patient's initial fracture situation.	5.000 ± 0.000	0.000
C2. Medication intervention: Treatment plans are developed by orthopedic or endocrinology doctors. After discharge, internal coordinators hand over the treatment plan to the medical alliance units for medication intervention to increase the patient's bone density and reduce the risk of recurrent fractures.	4.765 ± 0.437	0.092
C3. Nutritional intervention: Nutritionists develop feasible nutritional intervention prescriptions based on patient examination indicators and living conditions.	4.882 ± 0.332	0.068
C4. Lifestyle guidance: Coordinators guide patients to quit smoking, avoid excessive alcohol consumption, increase sunlight exposure, avoid or minimize the use of medications that affect bone metabolism, and moderately increase daily activity levels.	4.941 ± 0.243	0.049
C5. Exercise rehabilitation guidance: Rehabilitation therapists develop and implement rehabilitation plans. After discharge, community guidance is provided, and family members or caregivers supervise the implementation.	4.765 ± 0.562	0.118
C6. Health education on fall prevention: Internal and external coordinators jointly provide health education on fall prevention.	4.706 ± 0.588	0.125
D. Follow-up and long-term treatment	4.765 ± 0.562	0.118
D1. Internal coordinators inform patients about the follow-up process before discharge, and guide external coordinators in carrying out intervention and follow-up work outside the hospital. During the follow-up period, internal coordinators coordinate with relevant doctors to adjust treatment plans.	4.882 ± 0.332	0.068
D2. Follow-up of adverse drug reactions	4.882 ± 0.332	0.068
D3. Compliance with anti-osteoporosis medications	5.000 ± 0.000	0.000
D4. Follow-up of spine, waist, and lower back pain	4.824 ± 0.393	0.081
D5. Follow-up of quality of life	4.941 ± 0.243	0.049
D6. Tracking endpoint events such as recurrent fractures and falls.	4.882 ± 0.332	0.068
D7. Follow-up period for is 6 months.	4.941 ± 0.243	0.049
E. Operation process within the medical alliance	4.765 ± 0.437	0.092
E1. Referral of patients from tertiary hospitals to medical alliance units: After discharge, orthopedic or endocrinology doctors provide osteoporosis treatment plans. Hospitals or departments establish referral processes, register and record referral patients, assign dedicated personnel for coordination, facilitate two-way referrals, and provide post-rehabilitation and osteoporosis treatment.	4.647 ± 0.606	0.130
E2. Patients returning to an environment with caregivers: Internal/external coordinators assess, track, and provide guidance to patients and caregivers returning home.	4.647 ± 0.606	0.130
E3. Patient follow-up visits: Patients have follow-up visits in medical alliance units, and fracture liaison service team coordinators track their progress.	4.765 ± 0.437	0.092

Discussion

The Framework Indicators of the FLS Model Under the Medical Alliance Framework, Constructed in This Study, are Scientifically Sound and Reliable

The Delphi method conducted in this study has good reliability, and the selection of the expert panel is based on three principles.[24,25] After conducting two rounds of Delphi consultations, we reviewed, added, deleted, and modified the indicators to form a formal framework for the FLS model under the medical alliance framework.[22] This framework was developed with good scientific rigor. First, regarding representativeness, the 17 selected experts have extensive experience in the management of osteoporotic fractures, including treatment, nursing, rehabilitation, and management. Among them, 10 experts hold a master's degree or higher, 6 experts have senior professional titles, and 8 experts have associate senior professional titles. The extensive experience and excellent credentials of the experts ensure that the established evaluation indicators have good representativeness in the field. Second, expert positivity is generally required to be

greater than 50% in the Delphi method.[24–26] In this study, the valid response rate for each of the two rounds of consultation was 100%. The suggestion rates of 58.82% and 35.29% in the first and second round, respectively, indicate that the experts had a good level of enthusiasm and engagement in providing their opinions. These rates show that a significant proportion of the experts actively participated and shared their insights, which is beneficial for ensuring a comprehensive and well-rounded evaluation of the indicators. The expert authority coefficient is a quantitative evaluation index for the degree of representativeness and authority of the expert in their given field. A CR value of greater than 0.7 signifies a good degree of trustworthiness, while CR values exceeding 0.8 indicate that the expert possesses a great degree of certainty.[24–26] The CR values of the two rounds of consultation were 0.853 and 0.873, indicating high expert authority and reliable results. In addition, the Kendall W values for the two rounds were 0.161 and 0.179 ($P < 0.05$), which means that a basic agreement among the experts was reached.

The Framework Indicators of the FLS Model Under the Medical Alliance Framework Demonstrate Good Practicality, Comprehensiveness, and Alignment with the National Context

The FLS is a multidisciplinary collaborative intervention model for fragility fractures, with a key focus on utilizing nurses as coordinators to facilitate effective teamwork within the FLS team. This comprehensive management approach involves patient monitoring, education, intervention, and follow-up at multiple levels.[13,14] This study explores the construction of the FLS model under the medical alliance framework in the context of the national tiered diagnosis and treatment system. Under the medical alliance framework, the FLS integrates multi-level optimized collaborative care, interdisciplinary intervention, and the addition of coordinators to enhance team collaboration efficiency. Compared to conventional nursing care, FLS offers advantages in terms of multi-level and comprehensive care. This provides a reference for exploring an elderly fragility fracture intervention model that is tailored to the specific characteristics of China.

The Construction of the Framework for the FLS Model Under the Medical Alliance Framework Holds Significant Importance

FLS has been widely implemented globally, and is considered one of the most effective models for managing fragility fractures. While there are several FLS models in existence, the details may vary between countries and institutions. When implementing FLS projects in China, it is important to consider the current nurse-to-patient ratio and tailor the approach to make the best use of existing healthcare resources. To leverage the strengths of nursing professionals, it is crucial to scientifically and reasonably design region-specific FLS programs that take into account local conditions. Utilizing the medical alliance framework as a foundation to implement systematic and comprehensive intervention measures for fragility fracture patients can facilitate the widespread clinical adoption of the FLS framework and contribute to the dissemination and improvement of management techniques within the medical alliance. This approach is of great significance in improving the overall level of integrated diagnosis and treatment within the medical alliance and represents a further exploration of chronic disease management programs in China.[26] A 6-year study has indicated that an FLS program can improve the bone health of elderly osteoporosis patients who visit trauma services due to vertebral compression fractures, thereby reducing the subsequent re-fracture rate.[27] This study primarily focuses on elderly patients with vertebral compression fractures, a population whose range and intensity of activities are somewhat limited, which is often related to factors such as the availability of a personal caregiver after surgery. It is suggested that future studies should extend the intervention time and conduct large-sample randomized controlled trials to further observe the impact of the FLS model on the re-fracture rate among elderly fracture patients.

Conclusion

In our study, by strictly following the Delphi method, we reached a good consensus on 34 indicators, and ascertained the relative importance of each, which provides theoretical support for the management of patients with osteoporotic fractures. Our future research will center on the practice/implementation of the FLS scheme and its impact on refracture rates, pain levels, quality of life, and medication adherence. Additionally, we should continue to improve the FLS scheme

construction, strengthen the outcomes of the FLS model, and explore modalities for implementing a comprehensive framework for the management of patients with osteoporotic fractures under the medical alliance framework.

Ethics Approval and Informed Consent

The study protocol was approved by the ethics committee of Aerospace Center Hospital.

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Disclosure

The authors declare that there is no conflicts of interest in this work.

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