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Development and Validation of an Early Post-Liver Transplant Activity Knowledge, Attitude, and Practice Questionnaire for Intensive Care Unit Nurses: A Multicenter Study

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Study Design A
Data Collection B
Statistical Analysis C
Data Interpretation D
Manuscript Preparation E
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Background: We developed and validated a questionnaire assessing intensive care unit (ICU) nurses' knowledge, attitude, and practice (KAP) regarding early mobilization of patients who are critically ill following liver transplantation.

Material/Methods: Using KAP theory, an initial questionnaire was formed via a literature review, Delphi expert consultation, and pre-survey. In January 2024, ICU nurses from 7 Chinese tertiary hospitals conducting liver transplants were surveyed, yielding 334 valid responses.

Results: The Early Activity Assessment Tools for ICU Nurses after Liver Transplantation Based on the Theory of Knowledge, Attitude, and Practice contains 3 dimensions and 40 entries, including 17 entries in the knowledge dimension, 10 entries in the attitude dimension, and 13 entries in the practice dimension. The content validity index (CVI) of the questionnaire was 0.937, and the CVI of each entry ranged from 0.800 to 1.000. The exploratory factor analysis extracted 3 male factors, accounting for a cumulative variance contribution of 86.852%. The Cronbach's alpha coefficient of the questionnaire was 0.976, the folded half reliability was 0.772, and the retest reliability was 0.784.

Conclusions: The reliability of the Early Activity Assessment Tools for ICU Nurses after Liver Transplantation Based on the Theory of Knowledge, Attitude, and Practice is good, and the tool can support the preliminary verification of the knowledge, attitude, and practice level of ICU nurses on early activities of patients who are critically ill following liver transplantation.

Keywords: Liver Transplantation • Nurse Clinicians • Knowledge • Reproducibility of Results

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Introduction

End-stage liver disease, the final stage of progressive liver disorders, including decompensated cirrhosis and liver failure [1], relies on liver transplantation as the only curative treatment; however, the procedure's complexity and invasiveness pose substantial postoperative complications, threatening the prognosis [2]. Early mobilization (planned, individualized activities such as passive stretching, sitting, and standing initiated postoperatively once stable) is well-established as pivotal for liver transplant recovery. This approach promotes gastrointestinal function, reduces complications (eg, intestinal obstruction, pulmonary infections), mitigates muscle atrophy/joint stiffness, shortens hospital stays, and reduces medical costs [3]. This is further endorsed by the 'Expert Consensus on Enhanced Recovery Management during the Perioperative Period of Liver Transplantation in China', which recommends graded early mobilization to improve patient outcomes [4].

As the primary implementers of early mobilization for patients who are critically ill after transplantation, intensive care unit (ICU) nurses' knowledge and attitude directly determine implementation effectiveness [5]. A systematic review and meta-analysis by Lee et al [6] demonstrated that nurse-involved early mobilization programs significantly decreased ICU length of stay, although the specific roles of nurses in these programmes remained poorly defined. Similarly, Neilson et al [7] surveyed clinicians in an Australian quaternary ICU and found that although 94% of respondents held positive beliefs about early mobilization, awareness of clinical guidelines was low (23%), and persistent system-level barriers (staffing, equipment, time constraints) hindered implementation despite favorable attitudes. These international findings underscore that even when healthcare professionals recognise the value of early mobilization, knowledge gaps and institutional barriers prevent consistent practice [8,9]. However, existing assessment tools focus primarily on patient physiological function [10], lacking 2 key attributes: 1) specificity to ICU nurses' roles in post-liver transplant early mobilization and 2) comprehensive coverage of knowledge, attitude, and practice (KAP) dimensions. This gap prevents the scientific quantification of nurses' competency and the factors influencing early mobilization, leading to fragmented clinical practices and suboptimal patient outcomes [11-13]. Therefore, developing a targeted KAP assessment tool for this specific context is essential.

The primary theoretical foundation for this study is KAP theory. This is one of the classic models for changing health-related behaviors, positing that human behavior evolves through 3 interconnected stages: knowledge acquisition, attitude formation, and behavioral practice [14]. As a foundational framework for analyzing nursing behaviors, the theory's core logic emphasises that 'knowledge is the basis, attitude is the mediator and practice is the outcome', specifically, for ICU nurses caring for patients during early mobilization after liver transplant. Mastering specialized knowledge (eg, indications, contraindications) is a prerequisite for developing a positive attitude and ultimately translating this into standardized, evidence-based practice. Although other theoretical models, such as the Health Belief Model and the Theory of Planned Behavior (TPB), offer valuable complementary perspectives on the barriers and facilitators of behavior change, the development and validation of this assessment tool are strictly guided by the KAP framework to maintain conceptual coherence and a clear focus on the knowledge–attitude–practice continuum.

The objective of this study, therefore, was to develop and validate a reliable and valid KAP questionnaire specifically for ICU nurses regarding early mobilization in patients who are critically ill following liver transplantation. By establishing this instrument, we aim to systematically evaluate ICU nurses' KAP levels in this specific clinical scenario, thereby laying a foundation for subsequent educational interventions, quality improvement initiatives and standardized early mobilization practices for patients undergoing liver transplantation.

Research Hypotheses

1. The developed KAP questionnaire will demonstrate good content validity (content validity index [CVI] ≥0.80) and reliability (Cronbach's alpha [α] coefficient ≥0.70 for each dimension and the total questionnaire), meeting the psychometric requirements of a standardized assessment tool.
2. Exploratory factor analysis (EFA) and confirmatory factor analysis (CFA) will support the three-factor structure (knowledge, attitude, practice) of the questionnaire, consistent with the theoretical framework.

Material and Methods

Questionnaire Development and Methods

Study Design and Validation Framework

This study focused on the initial development and preliminary validation phase of the KAP questionnaire. Although the hypotheses include CFA, the primary objective of this multicenter investigation was to explore the factor structure using EFA in the current sample. Consequently, CFA is not reported in this paper and is planned for future research with an independent sample to confirm the factor structure established here.

Establishment of the Research Team

The team consisted of 15 members, including 4 men and 11 women, aged 34 to 55 years, mainly middle-aged medical staff

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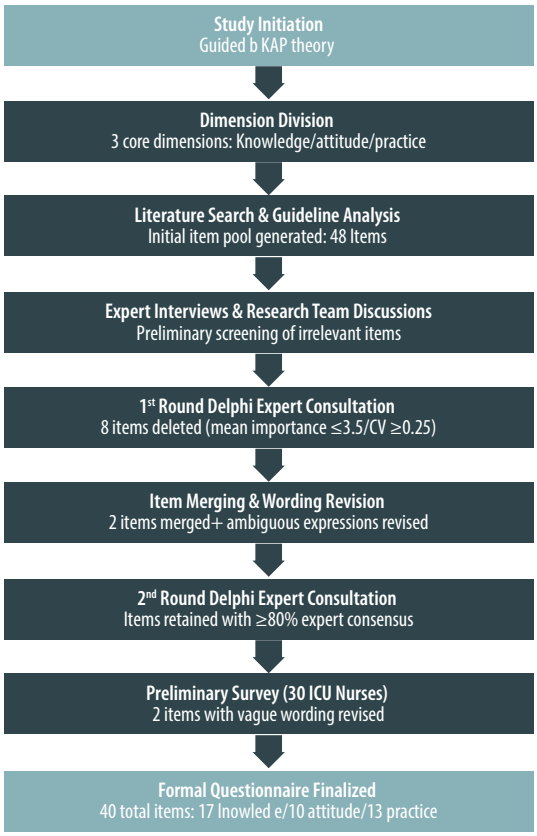

Figure 1. Flow diagram of the generation, optimization, and finalization of questionnaire items for the KAP assessment tool of ICU nurses' early mobilization after liver transplantation.

with extensive experience. In terms of positions, there is 1 deputy director of the nursing department, 1 team-leading director, 1 head nurse of the department, and 2 deputies, with the remainder holding no official position. Regarding professional titles, the team included 2 associate chief physicians, 2 associate chief nurses, 1 attending physician, 2 nurse practitioners, 5 chief physicians, and 1 associate professor. The team covered multidisciplinary backgrounds such as critical care medicine, nursing science, rehabilitation medicine, and clinical medicine, with work experience ranging from 8 to 31 years. Additionally, 4 members served as master's and doctoral supervisors, possessing comprehensive capabilities in clinical practice, teaching, and research supervision, thereby meeting the needs of multidisciplinary collaboration, medical services, and staff training. Team members were assigned clearly defined roles: the ICU director was responsible for clinical pathway review and quality control, the head nurse coordinated resource allocation and nursing practice, ICU specialists provided medical assessments and contraindication guidance, the rehabilitation physician developed mobilization programs and safety assessments, and the 4 ICU specialized nurses were divided into 2 groups for the handling of literature searches, establishment of the items pool, and preliminary surveys. The team adopted a 'phased collaboration-focused discussion' model, holding interdisciplinary meetings every 2 weeks to ensure efficient collaboration throughout the process from literature search and item selection to questionnaire validation. Data analysis was conducted by a doctoral-level statistician using SPSS 26.0 (IBM, Armonk, NY, USA) for item analysis and reliability and validity testing, thus ensuring methodological rigor.

Establishment of the Questionnaire Items

Figure 1 presents a flow chart of the establishment of the questionnaire for this study. The main processes involved are outlined below.

Literature Analysis

1) For the literature search and screening, a retrieval strategy combining subject terms and free words was employed, using 'liver transplantation', 'early mobilization', 'critical illness', and 'KAP questionnaire' as search terms in Chinese databases, including China National Knowledge Infrastructure, Wanfang, VIP, and Medlive, as well as English databases such as PubMed and Web of Science. Guided by KAP theory (core logic: knowledge is the basis, attitude is the mediator, and practice is the outcome), we initially divided the questionnaire into 3 dimensions and formed a pool of 48 items through reading the titles, abstracts, and relevant guidelines, with 40 items finalized following expert interviews and group discussions. This included 17, 10, and 13 items in the knowledge, attitude, and practice dimensions, respectively. Specifically, the knowledge dimension was scored using a 3-point Likert scale from 'unaware' to 'aware', with scores of 1 to 3 points; the attitude dimension ranged from 'strongly disagree' to 'strongly agree' and the practice dimension from 'never' to 'always', both using a Likert 5-point scale with scores of 1 to 5 points.

The knowledge dimension focuses on ICU nurses' comprehension of core content such as the definition, indications/contraindications, safety assessment, and emergency response of early mobilization following liver transplantation. The attitude dimension reflects nurses' subjective tendency towards implementing early mobilization for patients who are critically ill after liver transplantation. The practice dimension measures nurses' actual implementation behavior in early mobilization, based on their professional knowledge and attitudes.

2) Item selection followed a four-step principle [15]: content relevance (items with weak relevance to nursing following liver transplantation [eg 'routine postoperative care'] were

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removed); expert scoring threshold (in the first round of the Delphi method, items with a mean importance score ≤3.5, a maximum score ratio ≤20% or a coefficient of variation [CV] ≥0.25 were deleted, resulting in the removal of 8 items); clinical operability (the items 'mobilization assessment content' and 'indications for mobilization initiation' were merged into K6 items); and language conciseness (ambiguous expressions were revised, eg, changing 'mobilization principles need to ensure safety' to 'ensure patient safety and personal safety'). After 2 rounds of discussions within the research team and consultations with Delphi experts, an initial questionnaire containing 40 items was finalized, consisting of 17, 10, and 13 items in the knowledge, attitude, and practice dimensions, respectively.

Expert Consultation

Selection of Consultation Experts

Experts were selected using purposeful sampling to ensure diversity of expertise and relevance to the study topic. A total of 15 experts were selected from relevant fields, such as critical care medicine, nursing management, and rehabilitation related to liver transplantation, for consultation. The inclusion criteria for experts were: (1) at least 10 years of experience in critical care medicine, critical nursing, nursing management, rehabilitation, or related fields concerning liver transplantation; (2) bachelor's degree or higher; (3) intermediate professional title or above; and (4) voluntary participation in this research and active cooperation in completing the expert consultation.

Development of the Expert Consultation Questionnaire

Based on the previously established item pool, a custom-designed expert consultation questionnaire was created, which included 4 parts. (1) Guidance for the consultation questionnaire: This introduced the background, purpose, and significance of the research and a description of the questionnaire. (2) Main body of the questionnaire: This contained the importance evaluation, relevance evaluation, and revision suggestion column for the KAP questionnaire items, with importance and relevance evaluated using a 5-point Likert scale with the following criteria. Importance evaluation: not important=1 point, slightly important=2 points, neutral=3 points, quite important=4 points, very important=5 points. Relevance evaluation: completely irrelevant=1 point, slightly irrelevant=2 points, somewhat relevant=3 points, completely relevant=4 points. Experts were also invited to suggest modifications or additions/deletions of items. (3) Basic information survey for experts: This included gender, age, position, title, institution, professional field, and years of work experience. (4) Self-assessment of expert authority: This was a self-assessment form regarding the basis for judgment and familiarity with the questionnaire content. Items with a mean importance score ≤3.5, a maximum score ratio ≤20%, or a CV ≥0.25 were revised or removed.

Conducting Expert Consultation

The expert consultation was conducted between August and October 2023. In the first round, an electronic questionnaire (in Excel format) containing the research purpose, preliminary item pool, and evaluation criteria (relevance, clarity, and feasibility of each item were rated on a 5-point Likert scale: 1=strongly irrelevant/unclear/unfeasible to 5=strongly relevant/clear/feasible) was sent to 15 experts via email. They were invited to propose suggestions for item modification, addition or deletion, with a 2-week response period, and a reminder email was sent to non-respondents at 1 week. In the second round, items with a CVI <0.33 (low expert recognition) or duplicate items were first deleted based on feedback from the first round, and some items were revised to form a revised questionnaire, which was then re-sent to the same group of experts for re-evaluation. For items with discrepancies, the research team held an online consensus meeting, conducted anonymous voting combined with literature evidence (eg, the 'Expert Consensus on Enhanced Recovery Management during the Perioperative Period of Liver Transplantation in China') and retained items with agreement from ≥80% of experts. For items with significant controversy (eg, 'pain management'), the principal investigator, along with 2 external experts who did not participate in the consultation, served as arbitrators. Subsequently, the expert consultation was conducted again until the coordination coefficient of expert opinions reached ≥0.70 (indicating good consistency), ensuring the clinical applicability and theoretical integrity of the items.

Preliminary Survey

The preliminary survey was conducted using convenience sampling, with 30 ICU nurses selected from a tertiary hospital in Beijing in November 2023. Notably, this hospital performs over 100 liver transplant surgeries annually, and the ICU nursing team has extensive experience in postoperative management, with the educational background of the nurses (85% with bachelor's degrees) and their work experience (40% with 5 to 10 years' experience) closely aligning with the characteristics of national multicenter samples, ensuring extrapolation of the preliminary survey results. The evaluation assessed whether the language of the questionnaire items was clear and understandable and whether the number of items was reasonable. The inclusion criteria were: (1) registered nurses currently working in the ICU; (2) directly involved in the care of patients who are critically ill following liver transplantation; (3) having at least 1 year of working experience and at least 6 months of working in the ICU; and (4) voluntary participation in this study and signing the informed consent form. The exclusion

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criteria were: (1) intern nurses, visiting nurses, and nurses in standardized training, and (2) nurses who have been away from their positions in the ICU for 3 consecutive months or more due to various reasons (eg, sick leave, maternity leave, out-of-town education).

Formal Survey

ICU nurses from 7 tertiary general hospitals across China that perform liver transplant surgeries were selected in January 2024 for a validity and reliability test using convenience sampling. Among the survey participants, 30 nurses were selected to complete a second questionnaire 2 weeks after the first survey to assess test–retest reliability, with the same inclusion and exclusion criteria as in the preliminary survey. The questionnaire in this study included 40 items, and the estimated sample size was 200 to 400, following the principle that the sample size required for the reliability and validity tests of the questionnaire should be at least 5 to 10 times the number of questionnaire items [15]. The survey was distributed through the Questionnaire Star platform and consisted of 3 parts: informed consent, general information, and the KAP questionnaire for ICU nurses regarding early mobilization of patients who are critically ill after liver transplantation. A total of 348 questionnaires were collected, and those with a short completion time were excluded, resulting in 334 valid questionnaires, with a valid response rate of 95.98%. This study was approved by the hospital's ethics committee (approval no. 2022-P2-032-01).

Statistical Methods

Data analysis was performed using IBM SPSS Statistics software (version 26.0). Frequency and percentage were used to describe the categorical variables; means±standard deviation or median (P25-75) were used to describe the continuous variables.

Evaluation of Expert Consultation

The expert consultation process was quantitatively evaluated using several key metrics: experts' familiarity (Cs) with the topic, the theoretical and practical basis (Ca) for their judgments, and the authority coefficient (Cr), which is the arithmetic mean of Cs and Ca. The degree of consensus among experts was assessed using Kendall's coefficient of concordance (W) and the CV. A CV <0.25 and a significant Kendall's W (P<0.05) were considered indicative of a satisfactory level of consensus.

Item Analysis

Item analysis was conducted to refine the initial item pool. The critical ratio (CR) method was used to compare the total scores of the highest and lowest 27% of respondents (independent samples t test). Items with a non-significant CR (P≥0.05) were considered for removal. Additionally, the corrected item–total correlation was calculated by correlating each item's score with the total score of its respective dimension, excluding that item. Items with a correlation coefficient <0.4 were deemed to have poor discriminative power and were eliminated.

Reliability Testing

The reliability of the final questionnaire was evaluated primarily through internal consistency, measured by Cronbach's α coefficient for the entire scale and for each dimension. A split-half reliability coefficient (using the Spearman-Brown formula) was also computed to further assess scale stability.

Validity Testing

The validity of the questionnaire was examined from 2 perspectives. Content validity was quantified using the CVI, which included the item-level CVI (I-CVI), and the scale-level CVI (S-CVI), calculated as the proportion of experts who rated items 3 or 4 on a 4-point relevance scale. Structural validity was assessed using EFA. The suitability of data for EFA was confirmed via the Kaiser-Meyer-Olkin (KMO) measure (values >0.80) and Bartlett's test of sphericity (P<0.001). Principal component analysis (PCA) with varimax rotation was used to extract factors. Factors with eigenvalues >1 were retained to reduce the data and maximize the variance explained in the observed variables, thus providing a clear and concise summary of the underlying structure during the initial exploratory phase of scale development.

For all statistical tests, a two-tailed P value <0.05 was considered statistically significant. To test the research hypotheses, a series of predefined analyses was conducted. First, to address Hypothesis 1 regarding content validity and reliability, we calculated the CVI based on expert ratings and assessed internal consistency (Cronbach's α), split-half reliability, and test–retest reliability. Second, to address Hypothesis 2 regarding the three-factor structure, EFA was performed to determine whether the empirical data aligned with the theoretical KAP dimensions.

Results

Expert Consultation Results

A total of 15 experts aged 34 to 55 years (mean age: 43.6±6.22 years) from Beijing, Zhejiang, Chongqing, Shanghai, Gansu, and Sichuan were invited. The average work experience of the experts was 21.27 years, and the Cr was 0.96 (Ca: 0.95, Cs: 0.97), indicating a high level of professionalism in their opinions. Among the experts, 8 held bachelor's degrees, 3 had master's degrees, 3 had PhDs, and 1 was a postdoctoral researcher, with

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Table 1. Demographic characteristics of ICU nurses in the survey.

Demographic characteristics	Category	M±SD, N(%)
Gender	Male	66 (19.8)
	Female	268 (80.2)
Age	Mean±SD (years)	31.4±5.7
Educational background	Associate degree	58 (17.4)
	Bachelor's degree	271 (81.1)
	Master's degree or higher	5 (1.5)
Professional titles	Junior titles	242 (72.5)
	Intermediate titles	87 (26.1)
	Senior titles	5 (1.5)
Years of ICU work experience	0-5 years	80 (24.0)
	5-10 years	89 (26.7)
	10-15 years	97 (29.0)
	Over 15 years	68 (20.4)
ICU work category	General ICU nurses	243 (72.8)
	Specialized ICU nurses	91 (27.2)

4, 5, and 5 experts holding intermediate, associate senior, and senior professional titles, respectively. The response rate for the first round of consultation was 93.75% (15/16), with familiarity level, judgment basis, and authority coefficients being 0.97, 0.95, and 0.96, respectively. Kendall's W was 0.298 (χ^2=210.255, P<0.001), suggesting low coordination in the initial opinions of the experts, possibly due to vague item descriptions or differences in professional understanding. The research team conducted anonymous voting on controversial items, resulting in the deletion of 8 items with CV ≥0.25. In the second round, the response rate was 100% (15/15), and Kendall's W significantly improved to 0.512 (χ^2=299.322, P<0.001), with CV <0.25 for all items, indicating high consistency in expert opinions following item revisions (eg, adding 'nutritionist' to K5, specifying 'activities of daily living training' in K8, and including 'transfer training' in K9). This change reflects the effectiveness of the Delphi method in integrating multidisciplinary perspectives and enhancing the scientific rigor of the items. Ultimately, the KAP questionnaire for ICU nurses regarding early mobilization in patients who are critically ill after liver transplantation was finalized, consisting of 3 dimensions and 40 items.

Preliminary Survey Results

The preliminary survey included 30 ICU nurses, with an effective response rate of 93.3% (28/30). Feedback from nurses regarding their understanding of the items resulted in the original item 'changes in consciousness' being revised to 'abnormal consciousness' due to vague wording (some nurses mistakenly thought it included 'emotional changes'). Another item, 'safety risks include unplanned extubation', was revised to 'common safety risks mainly include unplanned extubation' because it did not specify 'common' risks. Following these modifications, the factor loadings for the revised items in the formal survey were 0.872 (K14) and 0.890 (K12), both exceeding the critical value of 0.4, and nurses reported that "the revised items are more aligned with clinical scenarios." Additionally, the average completion time for the preliminary survey decreased from 18 to 12 min, along with reduced redundancy of items, indicating that simplified items effectively enhanced the operability of the questionnaire.

General Information of Survey Participants

A total of 348 questionnaires were collected in this study, with 334 valid questionnaires, resulting in an effective response rate of 95.98%. As shown in **Table 1**, regarding the demographic characteristics of the respondents, there were 268 women (80.24%), and the age range was 21 to 52 years (mean age: 31.41±5.73 years). In terms of educational background, the proportion of those with a bachelor's degree was the highest, accounting for 81.14%. Regarding professional titles, junior titles were the most dominant, accounting for 72.46%. For years of ICU work experience, the group with 10 to 15 years of experience accounted for the highest percentage (29.04%). In terms of work category, general ICU nurses constituted the largest proportion, accounting for 72.75%.

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Table 2. Results of exploratory factor analysis of KAP Questionnaire for ICU Nurses on early mobilization in critically ill patients after liver transplantation (n=334).

Item	Knowledge	Attitude	Practice
K1: Concept of early mobilization in critically ill patients after liver transplantation	0.834	0.066	0.246
K2: Indications and contraindications for early mobilization in critically ill patients after liver transplantation	0.834	0.056	0.268
K3: Critically ill patients after liver transplantation should engage in early passive or active limb mobilization despite having various monitoring lines	0.860	0.128	0.265
K4: The principles of early mobilization in critically ill patients after liver transplantation are to ensure patient safety and personal safety, improve functional impairment, and prioritize tasks, with the main goals of lung function recovery, sitting, and standing for conscious patients, and prevention of complications (eg, lung infections, pressure injuries, deep vein thrombosis, joint contractures, and muscle atrophy) for unconscious patients	0.879	0.152	0.251
K5: The professional team implementing early mobilization in critically ill patients after liver transplantation includes doctors, nurses, rehabilitation therapists, and nutritionists, with comprehensive management through multidisciplinary collaboration	0.845	0.112	0.239
K6: Consensus recommends that daily assessments of consciousness, muscle strength, and cooperation ability be conducted for critically ill patients after liver transplantation, along with the formulation of goals and plans for individualized activity to achieve the goal of daily activity	0.854	0.103	0.257
K7: The indications for early mobilization initiation in critically ill patients after liver transplantation include stable cardiovascular, neurological, and respiratory systems, with patent drainage tubes in place	0.888	0.119	0.243
K8: Early mobilization in critically ill patients after liver transplantation focuses on exercises for respiratory function, limb muscle strength, joint mobility, and activities of daily living (ADL)	0.885	0.117	0.257
K9: The mobilization plan for critically ill patients after liver transplantation should be progressive, including supine training, transfer training, sitting training, standing training, and walking training	0.885	0.077	0.243
K10: Pain management after liver transplantation is divided into preventive and multimodal analgesia, with personalized pain relief based on individual differences and a focus on post-treatment pain assessment to create conditions for implementing early mobilization	0.885	0.070	0.265
K11: Safety risk assessment indicators during early mobilization in critically ill patients after liver transplantation: monitoring basic vital signs (eg, heart rate, respiration, blood pressure, and blood oxygen saturation), assessing surgical-related complications (eg, wound bleeding, abdominal bleeding, and bile leakage), closely monitoring drainage fluid color, blood routine, liver function, coagulation routine, biochemical indicators, and subjective feelings of patients	0.911	0.094	0.240
K12: Common safety risks during early mobilization in critically ill patients after liver transplantation: unplanned extubation, falls, falling off bed, pressure injuries, and hemodynamic changes	0.890	0.101	0.251
K13: Emergency plans for common safety risks during early mobilization in critically ill patients after liver transplantation: risk assessment, safety measures, and personnel arrangements	0.880	0.089	0.215
K14: Indications for early mobilization suspension in critically ill patients after liver transplantation: hemodynamic instability, abnormal respiratory rhythm and frequency, changes in symptoms, abnormal consciousness, and patient intolerance	0.872	0.098	0.234
K15: Outcome indicators for critically ill patients after liver transplantation: the incidence of complications, physical function (eg, muscle strength), hospital stays, ICU stays, duration of mechanical ventilation, and ADL scores	0.878	0.064	0.247

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Table 2 continued. Results of exploratory factor analysis of KAP Questionnaire for ICU Nurses on early mobilization in critically ill patients after liver transplantation (n=334).

Item	Knowledge	Attitude	Practice
K16: Main surgical methods for liver transplantation: classic orthotopic liver transplantation, classic piggyback liver transplantation, split liver transplantation, and assisted liver transplantation. Main postoperative complications: intra-abdominal bleeding, bile leakage, bile duct obstruction, infection, liver graft dysfunction, vascular complications, rejection reactions, and metabolic complications	0.848	0.060	0.252
K17: Prolonged bed rest for critically ill patients after liver transplantation increases the risks of lung function impairment, inadequate tissue oxygenation, and lower limb venous thrombosis, with a higher incidence of complications and longer ICU and hospital stays	0.901	0.078	0.256
A1: I am willing to assist critically ill patients after liver transplantation in engaging in early mobilization	0.149	0.911	0.151
A2: I believe it is crucial for ICU nurses to master the relevant knowledge of early mobilization in critically ill patients after liver transplantation	0.123	0.944	0.205
A3: I think ICU nurses should master postoperative pain management methods and the effectiveness assessments for critically ill patients after liver transplantation	0.083	0.943	0.234
A4: I believe that common safety risks during early mobilization in critically ill patients after liver transplantation can be prevented through medical efforts	0.111	0.929	0.198
A5: I think ICU nurses should conduct emergency drills for common emergencies during early mobilization in critically ill patients after liver transplantation	0.092	0.933	0.220
A6: I believe ICU nurses should master the content and methods for assessing the effectiveness of early mobilization in critically ill patients after liver transplantation	0.078	0.947	0.229
A7: I think the benefits of early mobilization after liver transplantation outweigh the risks and can help restore gastrointestinal motility, improve postoperative tolerance, reduce pulmonary complications, and prevent postoperative atelectasis	0.085	0.943	0.219
A8: I believe early mobilization in critically ill patients after liver transplantation is of great significance and value	0.099	0.953	0.227
A9: I think that planned and purposeful early mobilization in critically ill patients after liver transplantation is safe and effective	0.087	0.952	0.223
A10: I believe ICU nurses should make scientific, prudent, and effective nursing decisions following evidence-based guidance to care for and guide rehabilitation for critically ill patients after liver transplantation	0.094	0.956	0.223
P1: I will proactively learn about early mobilization-related knowledge for critically ill patients after liver transplantation and accept relevant training	0.302	0.172	0.733
P2: I will assess the vital signs, consciousness, muscle strength, cooperation ability, and catheterization of each tube for critically ill patients after liver transplantation daily as needed	0.328	0.226	0.833
P3: I will continuously monitor the graft function status of critically ill patients after liver transplantation	0.283	0.235	0.831
P4: I will actively communicate with critically ill patients after liver transplantation to provide psychological support and help them build confidence	0.290	0.290	0.859
P5: I will proactively educate critically ill patients after liver transplantation and their family members and actively implement early mobilization after obtaining their informed consent	0.270	0.255	0.872
P6: I will assist other medical staff in the professional team to develop individualized mobilization plans based on each patient's characteristics	0.269	0.215	0.840
P7: I will make adequate preparations for early mobilization, including auxiliary equipment, rescue devices, and medications	0.247	0.232	0.886

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Table 2 continued. Results of exploratory factor analysis of KAP Questionnaire for ICU Nurses on early mobilization in critically ill patients after liver transplantation (n=334).

Item	Knowledge	Attitude	Practice
P8: I will help critically ill patients after liver transplantation engage in activities during early mobilization using professional assistance facilities	0.271	0.250	0.895
P9: I will gradually implement early mobilization, starting with passive bedside exercise and transitioning to active bedside exercise, 1 to 2 times a day for 5 to 10 min each time while fully considering the patient's tolerance and making personalized adjustments based on daily goals	0.330	0.185	0.849
P10: I will closely monitor vital signs, catheter patency, pain levels, and drainage fluid status during early mobilization and report any abnormalities to doctors in a timely manner	0.319	0.209	0.854
P11: I will proactively assess the wound, subjective feelings, and effects of early mobilization for patients after implementing early mobilization	0.313	0.203	0.860
P12: I will proactively learn about the surgical methods for liver transplantation in critically ill patients and promptly identify complications related to surgery and early mobilization	0.313	0.170	0.874
P13: I am able to correctly implement emergency measures for unexpected events	0.305	0.181	0.854
Characteristic value	22.280	4.278	8.183
Variance contribution (%)	35.477	24.108	27.267
Cumulative variance contribution (%)	35.477	59.585	86.852

Item Analysis Results

(1) Critical ratio method: Based on the overall score of the questionnaire, the top 27% were categorized as the high-score group and the bottom 27% as the low-score group. An independent samples *t* test revealed statistically significant differences between each item in the high- and low-score groups ($P<0.001$), indicating good discriminative ability for all items, which were retained. (2) Homogeneity test method: The correlation of each item with the corresponding dimension total score and the overall questionnaire score was calculated using Pearson's correlation analysis. The results showed a correlation coefficient of $r=0.875$-0.945 for knowledge-related items corresponding to the overall knowledge score, $r=0.933$-0.986 for attitude-related items corresponding to the overall knowledge score, $r=0.819$-0.965 for practice-related items corresponding to overall knowledge score and $r=0.657$-0.852 for all items corresponding to the overall questionnaire score. All correlation coefficients were >0.4 ($P<0.01$), indicating good correlations of each item with their corresponding dimensions and the overall questionnaire score, leading to the retention of all items.

Reliability and Validity Analysis

The questionnaire's psychometric properties were systematically evaluated through content validity, structural validity, and reliability tests, with the results as follows. Content validity was assessed via the second round of expert consultation, yielding an I-CVI ranging from 0.800 to 1.000. The mean CVI values for the knowledge, attitude and practice dimensions were 0.918, 0.940, and 0.959, respectively, with an S-CVI of 0.937, indicating good content relevance. For structural validity, EFA confirmed data suitability (KMO=0.956; Bartlett's test of sphericity: $\chi^2=26{,}348.889$, $P<0.001$). Using PCA with varimax rotation, 3 factors with eigenvalues >1 were extracted, explaining 86.852% of the total variance. All item factor loadings exceeded 0.70 (range: 0.733-0.956), indicating a well-defined structure (see **Table 2** for the rotated factor matrix).

As detailed in **Table 3**, the questionnaire demonstrated excellent internal consistency (Cronbach's $\alpha=0.976$ overall; dimension-specific α: 0.987-0.993) and split-half reliability (0.772 overall; dimension-specific: 0.956-0.987), all exceeding the recommended threshold of 0.80 [16]. Test–retest reliability was evaluated by reassessing 30 ICU nurses after a 2-week interval (inclusion criteria excluded nurses in rotational shifts or continuing training to ensure population consistency), yielding an overall coefficient of 0.784 (knowledge=0.856, attitude=0.867, practice=0.866), which meets the psychometric requirement of >0.70 [12]. Notably, the questionnaire's overall test–retest reliability (0.856) outperformed the pediatric ICU (PICU) nurse KAP questionnaire reported by Luo (2023) (0.742) [17], potentially due to the clarity and clinical relevance of the revised items.

Guided by KAP theory, the questionnaire was developed via 2 rounds of Delphi consultation (expert authority coefficient=0.96)

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Table 3. Reliability of knowledge, attitude, and practice dimensions.

Item	Cronbach's α coefficient	Split-half reliability	Retest reliability
Knowledge	0.987	0.956	0.856
Attitude	0.993	0.987	0.867
Practice	0.985	0.959	0.866
Overall questionnaire	0.976	0.772	0.784

and pre-survey optimization, with improved expert opinion consistency (Kendall's W=0.298-0.512). Key psychometric tests confirmed its excellent reliability (Cronbach's α=0.976, test–retest reliability=0.856) and validity (S-CVI=0.937; EFA extracted 3 KAP-consistent factors, cumulative variance=86.852%).

Discussion

High Scientific Validity and Reliability of the Questionnaire

This study presents preliminary evidence for the psychometric properties of a newly developed KAP questionnaire for ICU nurses regarding early mobilization following liver transplantation. Guided by KAP theory, the questionnaire was developed through literature analysis, 2 rounds of Delphi expert consultation, and pre-survey optimization. Expert opinions showed increasing consistency, with all items having a CV <0.25. Reliability and validity tests confirmed the questionnaire's excellent psychometric properties: Cronbach's α coefficient=0.976, split-half reliability=0.772, and test–retest reliability=0.856. For validity, the I-CVI ranged from 0.800 to 1.000, with an S-CVI of 0.937. The EFA extracted 3 common factors (consistent with the KAP framework) with a cumulative variance contribution rate of 86.852%, and all item factor loadings ranged from 0.733 to 0.956 (>0.4). Although these initial findings are promising and confirm the tool's scientific reliability in this sample, they should be considered preliminary findings pending further validation in independent cohorts using CFA.

Notably, the overall Cronbach's α coefficient of the questionnaire reached 0.976, and the α coefficients of each dimension were as high as 0.987 to 0.993, which not only fully demonstrated strong internal consistency of the scale and high correlation between items in the same dimension but also may indicate a certain degree of item redundancy. The high item correlation may be due to the fact that some items in the knowledge and practice dimensions were designed with overlapping connotations in the process of combining clinical guidelines and expert opinions, such as the correlation between items related to 'mobilization safety risk assessment' and 'mobilization suspension indications' in the knowledge dimension. Although all items were retained following item analysis due to good discriminative ability and homogeneity, the possible item redundancy needs to be further optimized in follow-up research, such as merging items with highly overlapping connotations or deleting repetitive items on the premise of ensuring the comprehensiveness of the scale content.

Unique Advantages and Significance of the Questionnaire

The primary contribution of this study lies in addressing a significant gap in the existing literature. Although previous studies have developed KAP questionnaires for early mobilization targeting general ICU patients [18] or specific populations, such as patients with trauma or those undergoing cardiac surgery [19,20], a validated tool specifically for liver transplant recipients has been notably absent. This gap is critical because the postoperative recovery trajectory of patients undergoing liver transplant is unique, involving specific risks and considerations. Our research methods and results align with the rigorous standards established in prior studies for developing disease-specific KAP questionnaires. For example, the high content validity achieved through the Delphi expert consultation method is consistent with the validation process reported in Mahaptra's study on developing and validating a KAP questionnaire for relevant clinical scenarios [21]. This consistency underscores the importance of expert consensus-based methods in ensuring the relevance and comprehensiveness of the tool for the target clinical context, be it delirium assessment or early mobilization following liver transplantation.

Following liver transplantation, patients face various complications and recovery challenges in ICUs. In recent years, early mobilization has been gaining increasing attention as an effective nursing intervention [22,23]. The KAP theory concludes that knowledge, attitude, and practice are part of a continuously developing process, where human behavior is based on specific knowledge and attitude; the more knowledge the individual possesses, the stronger their beliefs are, and the more likely the individual is to form behavioral habits [24,25]. In this regard, the KAP of nurses when implementing nursing measures significantly impacts patient recovery outcomes [5]. Currently, despite some available assessment tools targeting ICU nurses or patients in early mobilization, their design concepts and applicability involve certain limitations. For example,

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the assessment tool for early mobilization participation developed by Knutsen et al (2024) focuses on the subjective experiences and physiological function indicators of patients, without addressing the knowledge reserves and behavioral practices of nursing staff [10]. Although the KAP questionnaire for PICU nurses compiled by Luo includes knowledge, attitude, and practice dimensions, its item design mainly focuses on pediatric patients who are critically ill, lacking specificity for the complex pathological characteristics and multidisciplinary collaboration needs of patients after liver transplantation [16]. Additionally, the KAP scale for deep vein thrombosis prevention developed by the Chinese scholar Wang is framed within KAP theory but focuses on managing a single complication, without systematically covering the entire assessment process of early mobilization [26].

In contrast, the questionnaire in this study offers several distinct advantages. (1) Targeted design: The items closely align with the clinical characteristics of patients who are critically ill following liver transplantation (eg, line management, postoperative complication risks, and multidisciplinary collaboration), integrating core recommendations from the 'Expert Consensus on Enhanced Recovery Management during the Perioperative Period for Liver Transplantation in China', ensuring the tool's high relevance to clinical practice. (2) Multidimensional coverage: Existing tools mostly focus on a single dimension of knowledge or practice [27], whereas our questionnaire comprehensively reflects the knowledge, attitude, and practice of ICU nurses through a collaborative assessment across 3 dimensions: knowledge (17 items), attitude (10 items), and practice (13 items), which aligns more closely with the interpretation of KAP theory regarding the continuity of behavioral changes [14,22]. (3) Advantages in reliability and validity: The Cronbach's α coefficient, CVI, and cumulative variance contribution rate of this questionnaire are higher than those of similar tools [16], indicating good measurement precision and structural stability of the scale in the preliminary validation stage.

Clinical Significance and Application Prospects of the Research Findings

The formulation of this questionnaire provides scientific references for improving the quality of ICU nursing for patients undergoing liver transplantation. In addition to its rigorous psychometric properties, this questionnaire provides an important reference for clinical practice and healthcare policy in the preliminary application stage. Clinically, it can serve as a targeted assessment tool to accurately identify nurses' knowledge gaps (eg, unclear understanding of mobilization timing following liver transplantation) and attitude barriers (eg, excessive concern about the risk of graft injury), providing a basis for developing personalized educational intervention programs and standardizing early mobilization practices. By addressing these deficiencies, the approach can indirectly improve patient outcomes, such as reducing the incidence of postoperative complications (eg, deep vein thrombosis, pulmonary infection) and shortening hospital stays, aligning closely with the goals of the Enhanced Recovery After Surgery protocol for liver transplant recipients. At the institutional and policy levels, the questionnaire can be integrated into nursing quality control systems to monitor and enhance the specialized rehabilitation nursing competence of ICU teams, offering empirical data for optimizing post-liver transplant nursing training programs and improving clinical practice guidelines. This practical relevance enhances the study's academic value and provides robust support for advancing evidence-based improvements in specialized nursing care.

Study Limitations

This study has some limitations. First, although the sample size met the statistical requirements for EFA, the surveyed population was only from tertiary hospitals performing liver transplantation in several regions of China. Moreover, the sample selection was based on convenience sampling, which led to certain regional limitations in sample representativeness and in the coverage of ICU nursing staff across different levels of medical institutions in China. Second, as this was a preliminary validation study, we conducted EFA to explore the factor structure. The absence of CFA in an independent sample means the three-factor structure requires further verification. Future research should recruit a separate, larger sample to perform CFA and cross-validate the model. Third, this study did not perform cross-cultural validation of the questionnaire, and the scale was developed based on the clinical guidelines and expert consensus of Chinese liver transplantation perioperative management; therefore, its applicability in other countries and regions with different medical systems, clinical practice norms, and nursing education backgrounds is unknown, and cross-cultural adaptation and validation are needed in the follow-up. Finally, this study only relied on the KAP model to construct the questionnaire framework, which only focuses on the continuous relationship between knowledge, attitude, and practice, and may not fully cover all the factors affecting nurses' early mobilization practice, such as organizational management factors, resource support factors, and inter-professional collaboration factors. Future research should incorporate other theoretical models such as the TPB to complement and verify the research results.

Conclusions

This study successfully completed the preliminary development and validation of a specialized KAP assessment tool for ICU nurses regarding the early mobilization of critically ill

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patients after liver transplantation. The scale covers 3 dimensions – knowledge, attitude, and practice – and demonstrates satisfactory reliability and validity in the current research sample. It fills the gap in specialized assessment tools in China, addresses the limitations of traditional general tools and provides a standardized basis for accurately identifying nurses' competency gaps, formulating targeted training programmes and optimizing the perioperative rehabilitation nursing process for liver transplantation. The tool also facilitates implementation of the patient-centred enhanced recovery concept in critical care, enriches the array of liver transplantation nursing assessment tools, and offers a reusable measurement instrument for subsequent research. Future research could expand the sample coverage to verify the tool's cross-scenario applicability, adopt mixed research methods to analyze underlying influencing factors, develop systematic training and intervention programs based on this tool and validate their effectiveness, explore its integration with electronic nursing quality management systems, and construct a dynamic system for continuous improvement of nursing quality.

Declaration of Figures' Authenticity

All figures submitted have been created by the authors who confirm that the images are original with no duplication and have not been previously published in whole or in part.

References:

1. Carrion AF, Martin P. Keeping patients with end-stage liver disease alive while awaiting transplant: Management of complications of portal hypertension. Clin Liver Dis. 2021;25(1):103-20
2. Yu H, Wang XM, Wang R, et al. Interpretation of the key points of the consensus recommendations of enhanced recovery for liver transplantation issued by the International Liver Transplantation Society. Medical Journal of Peking Union Medical College Hospital. 2024;15(1):68-76
3. Shen Y, Chen L, Fei KH, et al. Construction and application of early ICU mobilization programs in patients after liver transplantation. Journal of Nursing Science. 2021;36(11):33-36
4. Expert Committee of Enhanced Recovery after Surgery, National Health and Family Planning Commission Medical Management Center. Expert consensus on enhanced recovery during perioperative period of liver transplantation in China (2018 Edition). Chinese Journal of General Surgery. 2018;33(3):268-72
5. Yi XP, Guo H, Shen YL, et al. Investigation of the status quo of obstructed perception of early mobilization among ICU nurses and the analysis of influencing factors. Chongqing Medicine. 2024;53(10):1589-93, 1600
6. Lee J, Kim Y, Lee HJ. Nurse-involved early mobilization in the intensive care unit: A systematic review and meta-analysis. Nursing in Critical Care. 2025;30(2):e13278
7. Neilson AJ, Keogh S, Ingleman J. Mobilisation OverViEw in a Quaternary intensive care unit: A cross-sectional descriptive survey. Australian Critical Care. 2026; 39(1):101499
8. du Plessis I, Francis S, Morrow B. Early mobilization in Windhoek intensive care units: Practices, attitudes and barriers. South African Journal of Physiotherapy. 2025;81(1):a1612
9. Ali ZA, Ajani K, Sohaib M, et al. Promoting a multidisciplinary team for early mobilisation in mechanically ventilated patients: An innovation in health professional education-a quasi-experimental pre-post study. Nurs Crit Care. 2025;30(5):e70132
10. Knutsen K, Solbakken R, Gallagher S, et al. Patients' experiences with early rehabilitation in intensive care units: A qualitative study about aspects that influence their participation. J Adv Nurs. 2024;80(5):1984-96
11. Kapıkıran Gürkan, Yılmaz D, Kaya A, et al. The effect of nurses' attitudes towards evidence-based nursing on the level of compliance with isolation measures in nurses caring for liver transplant patients. J Eval Clin Pract. 2025;31(2):14113
12. Hu Z L, Liu J, Wang Y, et al. The effect of enhanced recovery after surgery nursing on the recovery in patients after liver transplantation. Transplant Proc. 2024;56(9):2890-96
13. Larson EM, Goss JA, Rosenthal P, et al. Critical care and mechanical ventilation practices surrounding liver transplantation in children: A multicenter collaborative. Pediatric Critical Care Medicine. 2022;23(11):e974-e81
14. Zeng CT, Hua RY, Liang GM. Application of feedback method combined with the knowledge, attitude, and practice theory-based model in improving the perception of medical viscous skin injury among nurses working for head and neck surgery. Chongqing Medicine. 2021;50(5):883-86
15. Boulkedid R, Abdoul H, Loustau M, et al. Using and reporting the Delphi method for selecting healthcare quality indicators: A systematic review. PLoS One. 2011;6(6):e20476
16. Wu TQ, Gan XN, Gao Y, et al. Development and reliability test of a questionnaire on the nursing knowledge, attitude, and practice for enteral nutrition refeeding syndrome. Chinese Journal of Nursing. 2024;59(7):835-41
17. Luo C. Formulation and investigation of status quo of knowledge, attitude, and practice questionnaire for PICU nurses regarding early mobilization in critically ill children. Hunan University of Chinese Medicine. 2023
18. Hodgson CL, Bailey M, Bellomo R, et al. A binational multicenter pilot feasibility randomized controlled trial of early goal-directed mobilization in the ICU. Crit Care Med. 2015;43(6):1147-56
19. Tipping CJ, Harrold M, Holland A, et al. The effects of active mobilization and rehabilitation in ICU on mortality and function: A systematic review. Intensive Care Med. 2017;43(2):171-83
20. Connolly B, O'Neill B, Salisbury L, et al. Physical rehabilitation interventions for adult patients during critical illness: An overview of systematic reviews. Thorax. 2016;71(10):881-90
21. Mahaptra HS, Muthukumar B, Pursnani L, et al. Development and validation of a knowledge, attitude, and practice (KAP) questionnaire and its utility study towards nutritional habits among non-dialytic CKD patients: A prospective study. Journal of Renal Nutrition. 2025
22. Hu Y, Hu XY, Xiao J, et al. Meta-analysis of effects of early mobilization on physical function status of ICU patients. Chinese Critical Care Medicine. 2019;31(4):458-63
23. Wang L, Zhang JH, Wu LP, et al. Meta-analysis of effects of early systemic rehabilitation activities on muscle strength and prognosis of mechanically ventilated patients in ICU. Chinese Critical Care Medicine. 2023;35(11):1212-17
24. Sobeck J, Smith-Darden J, Gartner D, et al. Antibiotic knowledge, beliefs, and behaviors: Testing competing hypotheses using an urban community sample. Health Commun. 2022;37(7):862-71
25, Lim BC, Kueh YC, Arifin WN, et al. Modelling knowledge, health beliefs, and health-promoting behaviours related to cardiovascular disease prevention among Malaysian university students. PLoS One. 2021;16(4):e0250627
26. Wang JX, Wang WX. Formulation and reliability and validity test of knowledge, attitude, and practice scale for prevention of deep venous thrombosis in patients treated with artificial liver support system. Journal of Nursing Science. 2023;38(17):44-47
27. Shi JZ, Mo XK, Sun ZQ. Application of content validity index in scale formulation. Journal of Central South University(Medical Science). 2012;37(2):152-55

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