

## Original Article

# Effect of trans-theoretical model-based nursing intervention on emotion and fear in post-liver cancer surgery patients

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**Abstract:** Objective: To investigate the efficacy of nursing interventions grounded in the trans-theoretical model on emotion and fear among patients undergoing surgery for hepatocellular carcinoma (HCC). Methods: The study included 188 surgical patients from the Second People's Hospital of Lanzhou City who underwent HCC intervention between March 2020 and May 2022. The control group comprised 81 patients receiving standard postoperative care, while the observation group included 107 patients who received nursing interventions based on the trans-theoretical model. We assessed outcomes using the Fear of Progression Questionnaire-Short Form (FOP-Q-SF), Quality of Life Questionnaire Core 30 (QLQ-C30), Gastrointestinal Comfort Questionnaire (GCQ), Self-Rating Anxiety Scale (SAS), and Self-rating Depression Scale (SDS) before and after the intervention. Logistic regression was used to identify factors influencing post-intervention fear. Results: Both groups showed improvement in FOP-Q-SF, QLQ-C30, GCQ, SAS, and SDS scores after the intervention. However, the observation group demonstrated significantly greater improvements ( $P < 0.05$ ). There was a positive correlation between FOP-Q-SF scores and both SAS and SDS scores (all  $P < 0.05$ ), and a negative correlation with QLQ-C30 and GCQ scores (both  $P < 0.05$ ). Multifactorial logistic regression revealed that age ( $P < 0.001$ , OR: 8.328), gender ( $P < 0.001$ , OR: 0.181), literacy level ( $P < 0.001$ , OR: 0.354), and nursing care regimen ( $P < 0.001$ , OR: 0.078) were significant independent risk factors for persistence of fear post-intervention. Conclusion: The implementation of nursing interventions based on the trans-theoretical model significantly reduces postoperative fear and anxiety, improves pain perception, and enhances overall comfort in patients after liver cancer surgery.

**Keywords:** Trans-theoretical modeling, hepatocellular carcinoma, hepatocellular carcinoma intervention, fearfulness

## Introduction

Hepatocellular carcinoma (HCC) is a malignant gastrointestinal tumor with an exceptionally high mortality, posing a significant threat to human health [1]. According to the Global Cancer Statistics 2022, HCC is the sixth most common cancer globally but ranks third in mortality rate [2]. The specific causes and mechanisms of HCC are not fully understood; however, it arises from a complex interaction between internal physiologic factors and external environmental influences [3]. In China, HCC is predominantly linked to chronic hepatitis B and C

infection, excessive alcohol intake, non-alcoholic cirrhosis, and consumption of aflatoxin-contaminated food [4, 5]. These risk factors can disrupt the balance between the body's internal and external environments, thereby promoting cancer development. Geographically, the incidence of HCC in China is higher in coastal areas, typically affecting individuals between 40 and 50 years of age, with a greater prevalence in men than in women [6].

Transcatheter arterial chemoembolization (TACE) is a preferred treatment modality for liver cancer, especially suitable for managing

intermediate and advanced stages of HCC. TACE involves administering chemotherapeutic agents directly into the liver's arterial supply, followed by embolization to obstruct the tumor's blood supply. This approach is valued for its minimal invasiveness, safety, precision, and ease of use [7-9]. Despite these advantages, managing HCC remains challenging due to its robust blood supply and potential for developing collateral circulation. HCC frequently recurs or metastasizes within five years post-surgery, necessitating repeated treatments to control cancer progression [10-12]. This high recurrence rate often contributes to a prevalent fear of progression (FOP) among patients. Despite its significance, research on interventions to alleviate FOP post-treatment is limited. Therefore, it is crucial for healthcare professionals to develop and implement effective strategies to reduce FOP in clinical settings [13, 14].

The transtheoretical model (TTM) is a psychological framework developed to analyze and facilitate health behavior changes, delineating five stages of change: pre-contemplation, contemplation, preparation, action, and maintenance. It also recognizes relapse as a natural part of the behavior change process [15]. Originally applied to tobacco cessation and weight management programs, the TTM has been extended to various health-related behaviors [16, 17]. For example, Scruggs et al. implemented the TTM in a study with postoperative breast cancer survivors, demonstrating that a TTM-based health education intervention significantly improved patients' self-efficacy, increased their post-surgery exercise duration, and effectively reduced negative perceptions of physical impairment after surgery [18]. Furthermore, Ashing-Giwa utilized the TTM to encourage breast cancer screening among African-American married women, effectively reducing disease incidence and highlighting the model's potential to enhance recovery in postoperative breast cancer patients [19]. Despite these applications, no studies to our knowledge have reported on the use of a TTM-based health education intervention for managing FOP in patients with primary HCC after intervention. This study aimed to evaluate the efficacy of the TTM for managing FOP in these patients and to broaden the spectrum of interventions for clinical and psychological support.

## Materials and methods

### Sample size calculation

Based on statistics from prior studies, the sample size was calculated by assuming a proportion ( $P_1$ ) of 0.3 for the control group and ( $P_2$ ) of 0.5 for the intervention group, with a significance level ( $\alpha$ ) of 0.05 (5% significance level) and a power ( $1-\beta$ ) of 0.80 (80% power). The sample size was calculated using the formula:

$$n = \left( \frac{Z_{\alpha/2} \sqrt{2P(1-P)} + Z_{\beta} \sqrt{P_1(1-P_1) + P_2(1-P_2)}}{P_1 - P_2} \right)^2$$

The calculation indicated that 91 patients were needed in each group. The final sample size was adjusted based on the actual availability of clinical data.

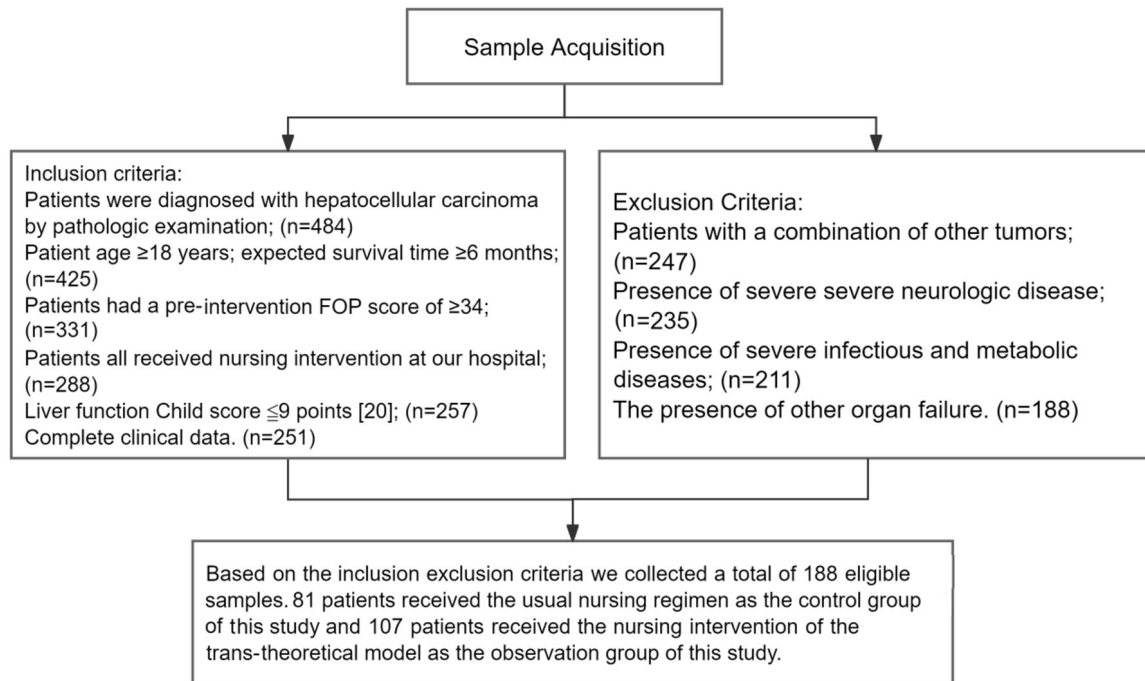
### Clinical data

Data were collected for patients who underwent liver cancer intervention at the Second People's Hospital of Lanzhou City from March 2020 to May 2022. This study was approved by the Medical Ethics Committee of the Second People's Hospital of Lanzhou City. Inclusion criteria were: diagnosis of hepatocellular carcinoma confirmed by pathological examination [20]; age  $\geq 18$  years; expected survival time  $\geq$  six months; FOP score  $\geq 34$  before intervention; participation in nursing intervention at the Second People's Hospital of Lanzhou City; liver function Child-Pugh score  $\leq 9$ ; and complete clinical data. Exclusion criteria included the presence of other malignancies, severe neurological diseases, severe infections, metabolic diseases, and other organ failures. Based on these criteria, 188 patients were enrolled: 81 in the control group receiving standard nursing care, and 107 in the observation group receiving TTM-based nursing interventions (**Figure 1**).

### Intervention programs

The routine nursing program, implemented from March 2020 to March 2021, involved standardized procedures applied uniformly to all patients. The program entailed the following components: Prior to surgery, a comprehensive assessment of the patient's vital signs was conducted alongside psychological preparations, ensuring a minimum fasting period of six

## Trans-theoretical nursing intervention



**Figure 1.** Patient inclusion exclusion and grouping flow chart.

hours. Post-surgery, vigilant monitoring of vital signs was maintained, and dietary adjustments to a high-protein fluid diet were made as needed, with special care provided to the femoral artery puncture site to prevent infection. Effective monitoring and interventions were also in place to address promptly potential fever and complications. These nursing strategies aimed to reduce the incidence of postoperative complications, alleviate patient discomfort, and promote early recovery.

**Trans-Theoretical Model of Care Protocol:** In April 2021, our department enhanced the nursing protocol by introducing a trans-theoretical model of care. This protocol has been employed to manage patient care effectively. It involves a health education intervention based on the TTM, targeting patients post-liver cancer intervention. The intervention spans eight weeks, with sessions conducted twice weekly, lasting 15 to 30 minutes each, and covers both the hospitalization period and post-discharge follow-up.

The intervention was customized according to the patient's stage of behavioral change, incorporating elements such as health education, peer education, and health coaching. Key components included:

**Pre-contemplation Stage:** Conducting one-on-one interviews to bolster patient knowledge about liver cancer and self-care practices.

**Contemplation Stage:** Showcasing successful anti-cancer stories and establishing communication platforms to boost patient confidence.

**Preparation Stage:** Organizing educational lectures for patients and their families to foster a proactive approach to their condition.

**Action Stage:** Facilitating the exchange of information and experiences through social media and group activities.

**Maintenance Stage:** Providing ongoing support via telephone and online follow-ups to reinforce self-management skills.

Additionally, specific interventions such as emotional relief, self-liberation, supportive relationships, counter-conditioning, and regression prevention were implemented at each stage to improve treatment outcome, alleviate fear and anxiety, and enhance the quality of life. All participants underwent a two-month intervention period.

For a detailed description of the program, refer to [Supplementary Materials](#).

## Trans-theoretical nursing intervention

### *Data collection*

Data were gathered from the inpatient electronic medical records, outpatient review records, and follow-up visits of patients. Collected data included demographic and socio-economic factors such as age, sex, education, marital status, medical payment status, and monthly household income. To assess the psychological and physical aspects of patients' health, several standardized questionnaires were employed:

**Fear of Progression Questionnaire - Short Form (FOP-Q-SF):** This instrument evaluates fear of disease progression in patients with chronic illnesses, comprising 12 items and yielding scores ranging from 12 to 60, with higher scores indicating greater fear [21].

**Quality of Life Questionnaire Core 30 (QLQ-C30):** This questionnaire measures the quality of life of cancer patients, consisting of 30 questions with scores ranging from 30 to 120, where higher scores denote better quality of life [22].

**Gastrointestinal Comfort Questionnaire (GCQ):** This tool assesses general health and comfort, containing 28 items scored from 1 to 4, with total scores ranging from 28 to 112. Higher scores reflect better health and comfort [23].

**Self-Rating Anxiety Scale (SAS):** This scale quantifies anxiety levels, featuring 20 items scored from 1 to 4. To facilitate clinical interpretation, scores are adjusted (\*1.25), resulting in a range from 25 to 100, where higher values indicate greater anxiety [24].

**Self-rating Depression Scale (SDS):** This scale is designed to assess depressive symptoms, consisting of 20 questions scored from 1 to 4. Similar to the SAS, scores are adjusted (\*1.25) for a total ranging from 25 to 100, with higher scores suggesting more significant depressive symptoms [25].

These instruments were selected for their reliability and validity in assessing the specified psychological and physical health outcome.

### *Outcome measures*

**Primary outcome measures:** The main focus is on the difference in the FOP-Q-SF scores between the control and observation groups,

both pre- and post-intervention [26]. Post-intervention, based on the FOP-Q-SF scores ( $\geq 34$ ), patients were categorized into fearful and non-fearful groups. Logistic regression was employed to identify risk factors influencing patients' fear [27].

**Secondary outcome measures:** Baseline data from the control and observation groups were compared. Changes in the SAS, SDS, QLQ-C30, and GCQ scores were analyzed both before and after the intervention for both groups [28]. Additionally, the correlation between FOP-Q-SF scores and SAS, SDS, QLQ-C30, and GCQ scores post-intervention was examined.

### *Statistical analysis*

SPSS 26.0 was used for data analysis, while Prism 9 was used for data visualization. The Kolmogorov-Smirnov (K-S) test assessed the distribution of the data. The t-test was applied to normally distributed data, with the independent samples t-test for between-group comparisons, and the paired t-test for within-group comparisons. Non-normally distributed data were analyzed using the rank-sum test. Comparisons among multiple groups involved one-way ANOVA with a post hoc LSD-t test. Chi-square tests were used for counted data analysis. Pearson's correlation test examined the relationships between FOP-Q-SF scores and SAS, SDS, QLQ-C30, and GCQ scores, expressed as R. Logistic regression was used to explore risk factors that contribute to ongoing fear post-intervention. Statistical significance was set at  $P < 0.05$ .

## **Results**

### *Comparison of baseline information*

An analysis of baseline data between the two patient groups indicated no significant differences in age, gender, education, marital status, medical payment method, or monthly household income (all  $P > 0.05$ , **Table 1**).

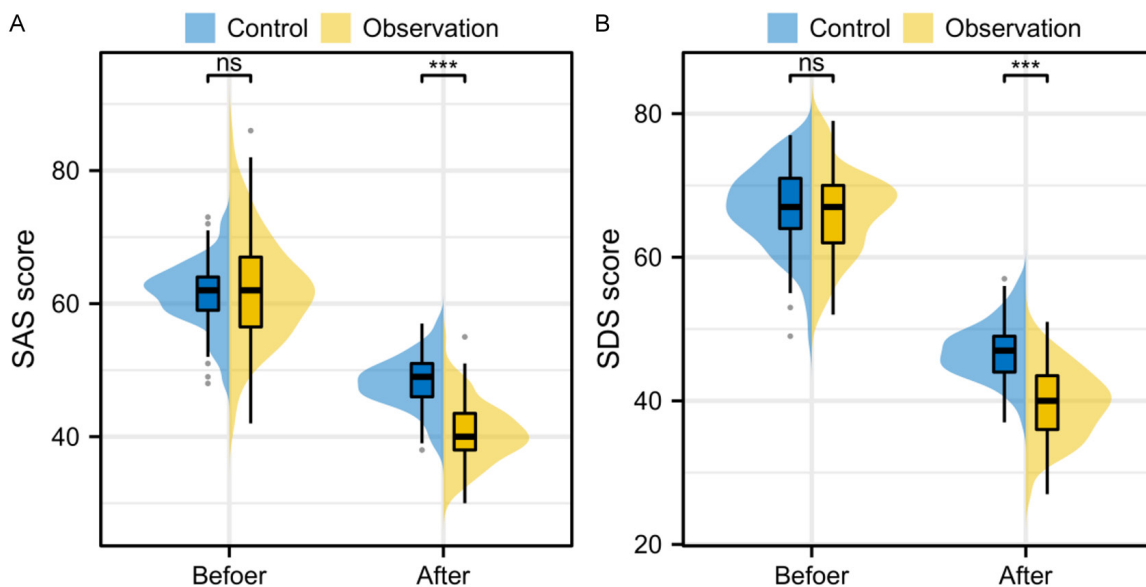
### *Changes in SAS and SDS scores before and after nursing intervention*

A comparison of SAS and SDS scores before treatment showed no significant differences between the control group and the observation

## Trans-theoretical nursing intervention

**Table 1.** Comparison of baseline data

Item	Control group (n = 81)	Observation group (n = 107)	$\chi^2$ -value	P-value
<b>Age</b>				
18-45 years	12	16	< 0.001	0.999
46-64 years	53	70		
≥ 65 years	16	21		
<b>Gender</b>				
Male	61	77	0.264	0.607
Female	20	30		
<b>Literacy level</b>				
≥ High School	52	59	1.564	0.211
< High School	29	48		
<b>Marital status</b>				
Married	75	93	1.563	0.211
Other	6	14		
<b>Medical payments</b>				
Medical insurance	63	88	0.581	0.446
Self-financed	18	19		
<b>Monthly household income</b>				
< 3,000 yuan	13	20	3.742	0.154
3,000-5,999 yuan	58	82		
≥ 6,000 yuan	10	5		



**Figure 2.** Comparison of SAS and SDS scores before and after patient care intervention. A. Comparison of SAS scores before and after nursing intervention in the two groups of patients. B. Comparison of SDS scores between the two groups of patients before and after care. Note: SAS, Self-Rating Anxiety Scale; SDS, Self-rating depression scale; nsP > 0.05, \*\*\*P < 0.001.

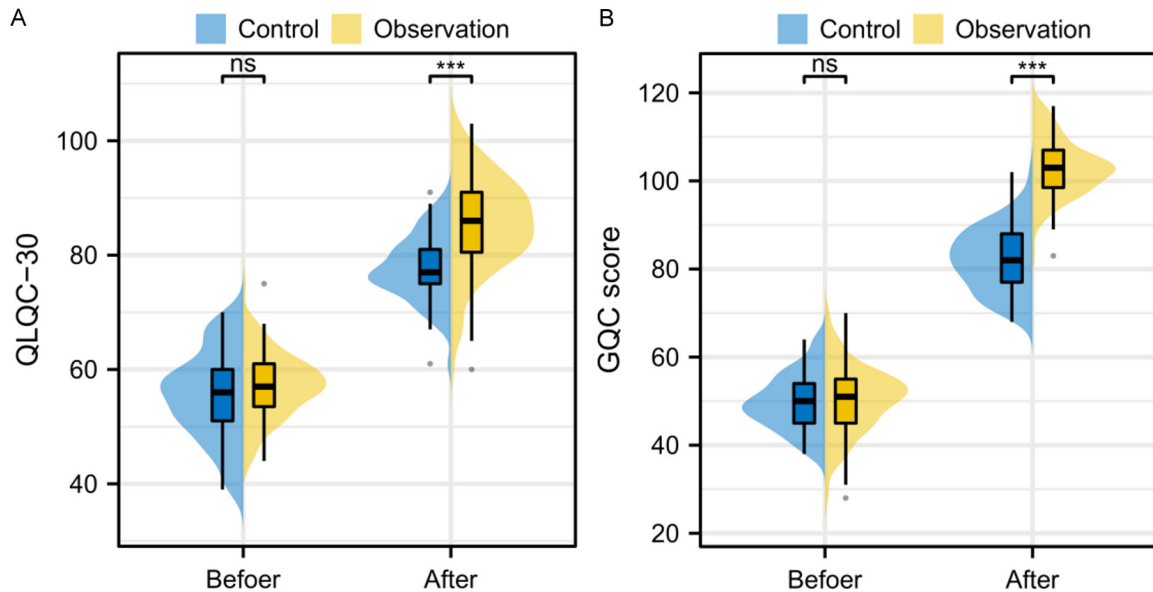
group (both P > 0.05). However, post-intervention, SAS and SDS scores in the observation group were significantly lower than those of the control group, indicating a significant improvement (P < 0.001, **Figure 2**).

### *Changes in QLQC-30 and GCQ scores before and after nursing intervention*

There were no significant differences in the 30 QLQ-C30 and GCQ scores between the control



## Trans-theoretical nursing intervention



**Figure 3.** Comparison of QLQC-30 and GCQ scores before and after patient care intervention. A. Comparison of QLQC-30 scores before and after nursing care in the two groups of patients. B. Comparison of GCQ scores between the two groups of patients before and after nursing care. Note: QLQC-30, Quality of Life Questionnaire Core 30; GCQ, Gastrointestinal Comfort Questionnaire; nsP > 0.05, \*\*\*P < 0.001.

and observation groups before the intervention (both  $P > 0.05$ ). Post-intervention, both QLQC-30 and GCQ scores in the observation group were significantly higher than in the control group, demonstrating a significant improvement (both  $P < 0.001$ , **Figure 3**).

### *Changes in FOP-Q-SF scores before and after nursing intervention*

A comparison of FOP-Q-SF scores between the two groups revealed no significant difference before treatment ( $P > 0.05$ ). However, post-intervention, the FOP-Q-SF scores in the observation group were significantly lower than those of the control group ( $P < 0.001$ , **Figure 4A**). Additionally, when patients were categorized based on a post-intervention FOP-Q-SF score of  $\geq 34$ , the control group contained a higher number of patients who remained fearful compared to the observation group ( $P < 0.001$ , **Figure 4B**).

### *Correlation analysis of patients' post-intervention fear scores with other scores*

Post-intervention FOP-Q-SF scores were positively correlated with SAS scores ( $R = -0.219$ ,  $P = 0.003$ ) and SDS scores ( $R = 0.215$ ,  $P = 0.003$ ), and negatively correlated with QLQC-30 scores ( $R = 0.201$ ,  $P = 0.006$ ) and GCQ

scores ( $R = 0.398$ ,  $P < 0.001$ ) ( $P < 0.05$ , **Figure 5**).

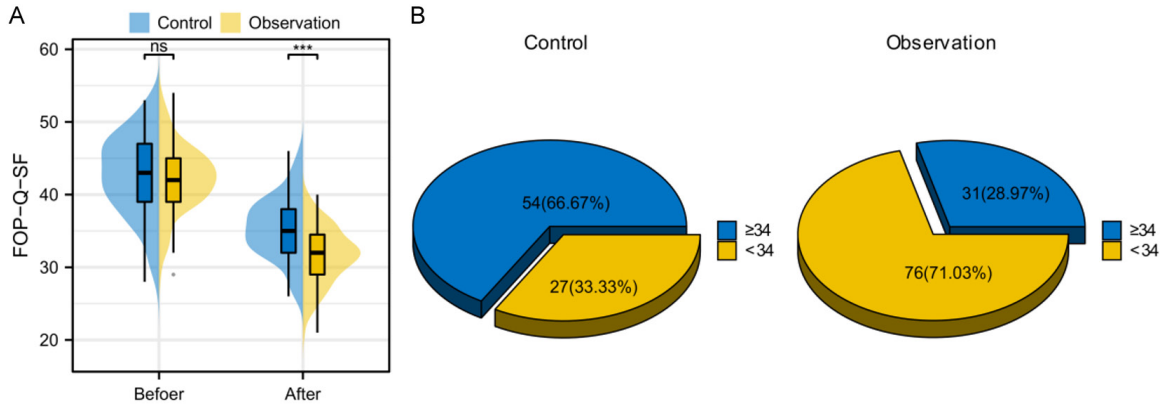
### *Risk factors contributing to patient fear post-intervention*

We analyzed baseline and post-intervention data to identify factors associated with sustained fear. Significant differences were observed in age ( $P < 0.001$ ), gender ( $P < 0.001$ ), literacy level ( $P = 0.006$ ), monthly household income ( $P = 0.009$ ), post-intervention SAS score after the nursing program ( $P = 0.008$ ), post-intervention SDS scores ( $P < 0.001$ ), post-intervention QLQC-30 scores ( $P = 0.011$ ), and post-intervention GCQ scores ( $P < 0.001$ ) (**Table 2**). Subsequently, we assigned numerical values to the indicators that showed variations in baseline information (**Table 3**). Multifactorial logistic regression analysis identified that age ( $P < 0.001$ , OR: 8.328), gender ( $P < 0.001$ , OR: 0.181), literacy level ( $P < 0.001$ , OR: 0.354), and care regimen ( $P < 0.001$ , OR: 0.078) were independent risk factors for post-intervention fear (**Table 4**).

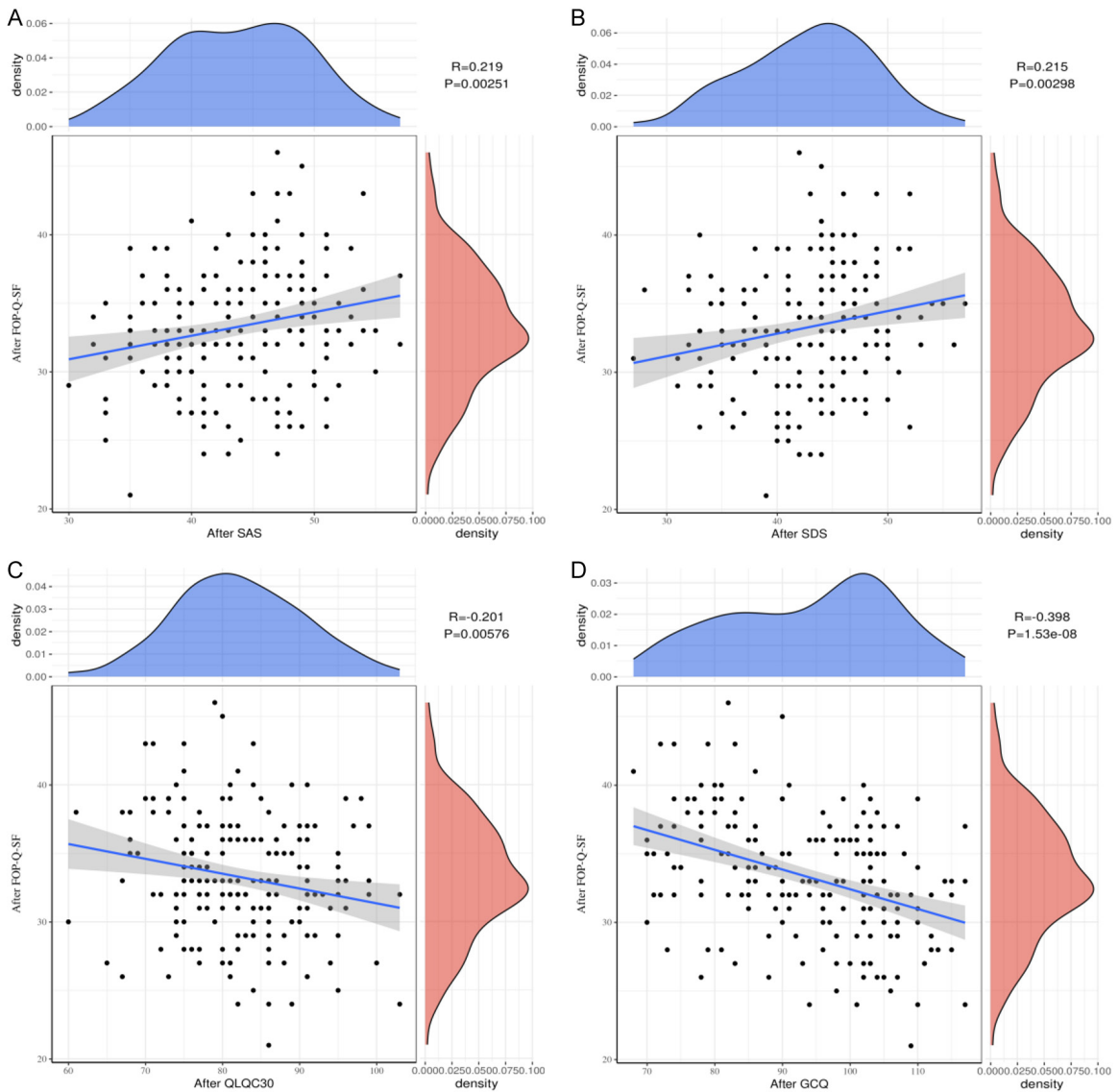
## Discussion

After surgery for hepatocellular carcinoma (HCC), patients face a continuous risk of recurrence [29]. This risk is more pronounced in

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**Figure 4.** Comparison of FOP-Q-SF scores before and after patient care intervention. A. Comparison of FOP-Q-SF scores before and after nursing interventions in two groups of patients. B. Comparison of the number of patients with FOP-Q-SF  $\geq 34$  points after care in both groups. Note: FOP-Q-SF, Fear of Progression Questionnaire - Short Form; nsP > 0.05, \*\*\*P < 0.001.



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**Figure 5.** Correlation analysis between patients' post-intervention FOP-Q-SF scores and post-intervention SAS, SDS, QLQC-30, and GCQ scores. A. Correlation between patients' post-intervention FOP-Q-SF scores and post-intervention SAS scores. B. Correlation analysis between patients' post-intervention FOP-Q-SF scores and post-intervention SDS. C. Correlation analysis between patients' post-intervention FOP-Q-SF score and post-intervention QLQC-30. D. Correlation analysis between patients' post-intervention FOP-Q-SF scores and post-intervention GCQs. Note: FOP-Q-SF, Fear of Progression Questionnaire - Short Form; QLQC-30, Quality of Life Questionnaire Core 30; GCQ, Gastrointestinal Comfort Questionnaire; SAS, Self-Rating Anxiety Scale; SDS, Self-rating depression scale.

**Table 2.** Comparison of baseline data

Item	Non-fear group (n = 103)	Fear group (n = 85)	$\chi^2/t/Z$ value	P-value
Age				
18-45 years	26	2	31.911	< 0.001
46-64 years	69	54		
≥ 65 years	8	28		
Gender				
Male	87	51	14.279	< 0.001
Female	16	34		
Literacy level				
≥ High School	70	41	7.493	0.006
< High School	33	44		
Marital status				
Married	92	76	0.000	0.984
Other	11	9		
Medical payments				
Medical insurance	86	65	1.454	0.228
Self-financed	17	20		
Monthly household income				
< 3,000 yuan	19	14	9.475	0.009
3,000-5,999 yuan	82	58		
≥ 6,000 yuan	6	18		
Nursing regimen				
Control group	27	54	26.444	< 0.001
Observation group	76	31		
Post-intervention SAS scores	42.82±5.85	44.98±5.27	2.662	0.008
Post-intervention SDS scores	41.00 [37.00, 45.00]	45.00 [42.00, 48.00]	3.969	< 0.001
Post-intervention QLQC-30 scores	83.60±8.09	80.53±8.20	-2.572	0.011
Post-intervention GCQ scores	99.00 [91.50, 105.50]	86.00 [80.00, 101.00]	-4.919	< 0.001

Note: QLQC-30, Quality of Life Questionnaire Core 30; GCQ, Gastrointestinal Comfort Questionnaire; SAS, Self-Rating Anxiety Scale; SDS, Self-rating depression scale.

elderly patients, who may also experience heightened fear of disease progression due to comparatively lower psychological resilience [30]. Such persistent negative emotions can adversely affect their postoperative recovery. Thus, well-designed nursing interventions are crucial to enhance both the physical and mental well-being of patients, which in turn improves treatment compliance and efficacy.

In this study, we observed that patients in the observation group, who participated in the TTM

nursing program, demonstrated significant improvements across several measurements - including FOP, anxiety, depression, quality of life, and overall health and comfort - compared to the control group, which received conventional care. The effectiveness of the TTM care regimen in reducing disease-related fear, anxiety, and depression, and in enhancing quality of life, is primarily attributed to its comprehensive approach. This approach not only addresses the physical aspects of care but also intensively manages psychological states and supports



## Trans-theoretical nursing intervention

**Table 3.** Assignment table

Item	The content of the assignment
Age	18-45 years = 0, 46-64 years = 1, ≥ 65 years = 2
Gender	Male = 1, Female = 0
Literacy level	≥ High school = 1, < High school = 0
Monthly household income	< 3,000 yuan = 0, 3,000-5,999 yuan = 1, ≥ 6,000 yuan = 2
Nursing program	Control group = 1, Observation group = 0
Post-intervention SAS scores	≥ 44.5 = 1, < 44.5 = 0
Post-intervention SDS scores	≥ 43.5 = 1, < 43.5 = 0
Post-intervention QLQC-30 scores	≥ 91.5 = 1, < 91.5 = 0
Post-intervention GCQ scores	≥ 78.5 = 1, < 78.5 = 0

Note: QLQC-30, Quality of Life Questionnaire Core 30; GCQ, Gastrointestinal Comfort Questionnaire; SAS, Self-Rating Anxiety Scale; SDS, Self-rating depression scale.

**Table 4.** Independent risk factors for fear remaining after patient care

Item	β	SE	χ <sup>2</sup>	P value	OR	95% CI	
						Lower Limit	Upper Limit
Age	2.120	0.415	26.103	< 0.001	8.328	3.693	18.781
Gender	-1.710	0.467	13.405	< 0.001	0.181	0.072	0.452
Literacy level	-1.039	0.412	6.364	0.012	0.354	0.158	0.793
Monthly household income	-0.238	0.417	0.326	0.568	0.788	0.348	1.786
Nursing regimen	-2.548	0.453	31.703	< 0.001	0.078	0.032	0.190
After SAS	0.320	0.501	0.409	0.522	1.378	0.516	3.676
After SDS	0.337	0.466	0.522	0.470	1.400	0.562	3.492
After GCQ	-0.556	0.925	0.361	0.548	0.574	0.094	3.515
After QLQC-30	-0.267	0.444	0.362	0.548	0.766	0.321	1.827

Note: SAS, Self-Rating Anxiety Scale; SDS, Self-rating depression scale; QLQC-30, Quality of Life Questionnaire Core 30; GCQ, Gastrointestinal Comfort Questionnaire.

behavioral changes - components often neglected in conventional care [31]. The TTM program employs staged, systematic psychological and behavioral interventions to effectively mitigate patients' fear of disease progression, anxiety, and depressive symptoms, thereby enhancing their quality of life [32]. It tailors interventions to the stages of patients' behavioral changes and integrates health education and peer support, thus fostering a supportive community environment and strengthening social support networks and self-efficacy.

Furthermore, ongoing support after discharge, including continuous monitoring of the patient's status through telephone and internet, offers long-term psychological and behavioral management guidance. This integrated, personalized care model has proven more effective in supporting patients' comprehensive recovery and long-term health management than conventional care. For instance, Tung et al. demon-

strated that a one-time sexual health education session based on the TTM model significantly improved sexual knowledge, attitudes, and self-efficacy among cervical cancer patients, thereby enhancing their sexual health and confidence [33]. Likewise, Liu et al. showed that a dietary care intervention based on the TTM improved dietary management behaviors, which helped prevent malnutrition, reduce the incidence of sarcopenia, and enhance the quality of life and survival rates among maintenance hemodialysis patients [34]. Additionally, Lipschitz et al. emphasized the significance of the TTM model in assessing and addressing the readiness of anxious patients to confront avoidance behaviors, tailoring intervention strategies to improve treatment engagement and effectiveness, especially in patients with low readiness [35].

FOP adversely affects disease treatment in multiple ways. It not only reduces patients'

adherence to treatment but also worsens mental health, diminishes social interactions, disrupts treatment decision-making, and directly impacts treatment outcome and recovery speed [36]. This persistent fear can lead patients to skip necessary medical tests and delay medication adherence, thereby increasing the risk of anxiety and depression, decreasing social interactions, and complicating decision-making processes regarding treatment options [37]. Our correlation analysis revealed a significant association between FOP and increased levels of anxiety and depression, as well as decreased quality of life and overall health and comfort. These findings underscore the critical need for intervention of FOP throughout the treatment process.

Even after nursing interventions, high FOP levels can severely impact a patient's adherence to treatment. This may lead to the avoidance of necessary medical tests and treatments, thus negatively affecting treatment outcome and recovery [38]. Persistent fear can also exacerbate psychological burdens, such as increased anxiety and depression, which may further impair physical health. Therefore, identifying and screening for these risk factors is crucial to allow physicians to effectively target and address them during diagnosis and intervention, thereby promoting overall patient recovery.

At the conclusion of the study, multifactorial logistic regression analysis based on patients with a post-intervention FOP-Q-SF score  $\geq 34$  identified age, gender, literacy, and care regimen as independent risk factors influencing persistent fear after care. The analysis indicated that older patients often become increasingly concerned about their health status and life fragility as they age [39]. Elderly patients may feel more helpless and anxious due to physical and psychological declines, especially when facing treatment and recovery from chronic or severe illnesses [40]. Studies have shown that women tend to exhibit higher emotional sensitivity and fear in the face of illness, reflecting gender differences in emotional processing and psychological coping mechanisms [41]. Additionally, low literacy levels can hinder understanding of medical information, reducing effective engagement with treatment processes and increasing fear of the unknown.

Moreover, limited household income can restrict access to medical resources and support systems, heightening fears of future health deterioration. Financial stress can further exacerbate the psychological burden, complicating the process of coping with both the material challenges of the disease [42].

The use of conventional care protocols may not adequately address the psychological and emotional needs of patients, especially in managing fear and anxiety, compared to more personalized and comprehensive care protocols like the care. The TTM care, with its focus on assessing and intervening in the patient's psychological state, can effectively reduce fear. These findings highlight the importance of considering factors such as patients' age, gender, and economic status in individualizing care plans to provide comprehensive support for their mental health and overall well-being, thereby enhancing fear reduction and improving treatment outcomes.

This study, however, presents some limitations. First, the potential underrepresentation of the sample might limit the broad applicability of the findings, as the results may not be generalizable to a wider population if the sample is predominantly from a specific region or healthcare organization. Second, the use of a cross-sectional study design, while providing valuable data, does not allow for the determination of causality or the tracking of intervention effects over time. Furthermore, the study did not assess the long-term effects of the intervention, which limits our understanding of the enduring impact of TTM interventions. To address these limitations, future research should broaden the scope and diversity of the sample, employ a longitudinal design to assess the effects of interventions, and conduct long-term follow-up to ensure the reliability and generalizability of the findings.

In summary, nursing interventions based on the TTM can effectively improve patients' postoperative fear and mood, reduce postoperative pain, and enhance overall comfort.

### **Disclosure of conflict of interest**

None.

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## Supplementary Materials

### **Routine care program**

#### *Preoperative preparation*

Conduct a comprehensive physical examination of the patient, including liver and kidney function, blood pressure, blood routine, coagulation function test and electrocardiogram, etc., to ensure that all the test results are within the normal range before scheduling surgery.

Patients are required to abstain from food and drink for 4 to 6 hours. At the same time, psychological care is carried out to ensure that the patient understands the specific requirements of intraoperative cooperation.

#### *Postoperative vital signs monitoring*

Monitor the patient's vital signs such as heart rate, respiration, blood pressure, oxygen saturation, etc. every 30 minutes and record them in time. If there is any abnormality, the doctor should be notified immediately.

#### *Dietary care*

In the early postoperative period, if the patient's gastrointestinal symptoms are mild, high-protein fluid food can be provided after 6 hours.

If the patient's gastrointestinal symptoms are more severe, fluid food should be given after 1 day of fasting. The diet should be light, ensure that the daily water intake is between 2,000 and 3,000 milliliters, and adjust the food type and portion size according to the patient's constitution.

#### *Nursing care at the puncture site*

After the end of treatment, the femoral artery puncture site is bandaged with pressure, and the patient is required to rest in bed for 24 hours, restrict the activity of the punctured limb for 12 hours, and use sandbags to compress it for 6 hours. Check the dressing at the puncture every hour to ensure that it is dry and clean.

#### *Fever care*

Fever that may occur after the procedure is usually caused by the intervention itself or by infection. If the temperature does not exceed 38.5°C, patients are advised to drink plenty of water and may take physical cooling measures. If the temperature exceeds 38.5°C, notify the doctor immediately and follow the medical advice.

#### *Complications care*

Postoperative patients may experience complications such as nausea, vomiting and pain. Therefore, it is necessary to explain the possible complications to the patients in detail before the operation, and closely observe the patients' condition after the operation, and notify the doctor immediately to deal with the complications as soon as they occur.

### **Nursing program across theoretical models**

In this study, the intervention group implemented a trans-theoretical modeling (TTM)-based health education intervention based on routine care in the control group for patients after liver cancer intervention. This intervention program lasted for 8 weeks, was conducted twice a week for 15 to 30 minutes per intervention, and covered the hospitalization period and the post-discharge follow-up phase.



## Trans-theoretical nursing intervention

The intervention during hospitalization included health education, peer education, and health coaching. Specific interventions were adapted to the patient's behavioral stage, which was assessed using the Behavioral Stage Scale. The following are the interventions for each stage:

1. Pre-intention stage: one-on-one interviews to understand patients' knowledge of liver cancer, introduction of liver cancer-related knowledge, reinforcement of self-care behaviors, popularization of knowledge of other diseases, and promotion of smoking and alcohol cessation.
2. Intention stage: share successful cases of fighting cancer, improve patients' confidence in fighting the disease, conduct self re-evaluation and environmental re-evaluation, solve the difficulties of life after the disease together, and create a platform for communication between doctors and patients.
3. Preparation stage: organizing patients and their families to attend lectures, encouraging them to face up to their illnesses, drawing up plans, and attending lectures and exchanges on a regular basis.
4. Action stage: create a WeChat group to encourage patients to share their recovery experiences, push out knowledge about liver cancer, answer patients' questions and correct their misconceptions.
5. Maintenance stage: Instruct patients to strengthen self-coping with their condition, consolidate self-fear coping, enhance communication and give positive support.

Post-discharge interventions were mainly carried out through telephone follow-up and online communication, including:

Nurses make plans according to the patient's psychological status and remind the patient through WeChat or telephone.

Regular follow-up visits to understand the patient's psychological status, and a systematic monitoring system that incorporates family members, relatives, and friends to jointly promote positive change in the patient.

In addition, there are specific interventions for different stages:

1. Vivid liberation: sharing anti-cancer success stories with patients to improve confidence.
2. Self-liberation: Organize lectures for patients and their families to enhance their sense of efficacy and self-confidence.
3. Helpful relationship: create WeChat groups to encourage patients to share their experiences and push related knowledge.
4. Anti-conditioning: require patients to develop the habit of keeping a diary and set specific goals and reward and punishment mechanisms.
5. Avoiding regression to the previous stage: strengthening patients' active participation, organizing regular symposiums and exchanges, and strengthening monitoring of patients by healthcare and family members.

The whole intervention process aims to help post-interventional hepatocellular carcinoma patients better manage their disease, reduce fear and anxiety, and improve their quality of life through personalized health education and support.