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Research on nurse-led psychological stress intervention pathways for oral cancer patients under a remote dental collaborative model

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Abstract: To explore the construction and effectiveness of nurse-led psychological stress intervention pathways for oral cancer patients under a remote dental collaborative model. A randomized controlled trial design was adopted, with 319 oral cancer patients treated at a tertiary hospital in Xuzhou from July to September 2023 as study subjects, randomly assigned to an intervention group ($n = 80$) and a control group ($n = 80$). The intervention group received a 12-week nurse-led psychological stress intervention under remote collaborative model, while the control group received routine care. Assessment tools including the Perceived Stress Scale (PSS-14), Hospital Anxiety and Depression Scale (HADS), and World Health Organization Quality of Life Brief Scale (WHOQOL-BREF) were employed, with measurements conducted at baseline, 4 weeks, 8 weeks, 12 weeks of intervention, and 24-week follow-up period. Structural equation modeling was used to analyze mediating effects and moderating factors of the intervention. PSS-14 scores in the intervention group decreased from baseline (33.2 ± 8.9) to end of intervention (21.5 ± 6.2), representing a 35.2% reduction ($p < 0.001$); HADS anxiety and depression scores improved by 36.8% and 36.1% respectively; quality of life scores increased by 26.4%. Repeated measures analysis of variance showed statistically significant between-group differences ($p < 0.001$), with all effect sizes reaching large effect standards. Mediation analysis revealed that cognitive change, coping strategy improvement, and enhanced social support were the primary pathways through which the intervention exerted its effects, with mediation effects accounting for 38.6% of total effects. The remote collaborative model was significantly superior to traditional models in terms of cost-effectiveness, time efficiency, and service accessibility. Factors such as age, education level, and technology acceptance had moderating effects on intervention outcomes. Nurse-led psychological stress intervention under a remote dental collaborative model can significantly improve the psychological health status of oral cancer patients, demonstrating good feasibility, effectiveness, and acceptability, and providing an innovative service model for psychological support of oral cancer patients.

Keywords: nurse-led; telemedicine; oral cancer; psychological intervention; psychological stress; randomized controlled trial

1. Introduction

Oral cancer, as one of the most common malignant tumors of the head and neck region, not only seriously threatens patients' life and health but also exerts profound impacts on their psychological state. Research demonstrates that oral cancer patients universally experience significant psychological stress responses, including negative emotions such as anxiety, depression, and fear. These psychological problems not

only affect patients' quality of life but may also interfere with treatment processes and recovery outcomes. Asha et al.'s mixed-methods study found that oral cancer surgical patients experience complex symptom cluster experiences, where psychological distress and physical symptoms interweave, forming a vicious cycle [1]. Meanwhile, Megee F. et al. revealed through cross-sectional surveys that appearance and functional changes resulting from oral cancer surgical treatment are important predictors of patients' psychological distress, indicating that such physical and psychological trauma caused by disease and treatment requires professional and systematic psychological intervention [2]. Therefore, how to effectively alleviate psychological stress in oral cancer patients and enhance their psychological adaptation capacity has become an urgent issue to be addressed in the field of oncology nursing.

Traditional psychological intervention models primarily rely on face-to-face counseling or therapy, but this approach faces numerous challenges in practice, including geographical distance limitations, scheduling difficulties, and insufficient professional psychotherapist resources. This is particularly problematic for oral cancer patients with mobility limitations or those residing in remote areas, making timely and effective psychological support even more difficult to obtain. With the rapid development of information technology and the proliferation of telemedicine services, remote mental health services have gradually emerged as an effective solution to this problem. Shi et al. confirmed that goal-attainment theory-based interventions combined with psychological counseling can significantly improve negative emotions and quality of life in oral cancer patients, providing empirical support for the effectiveness of psychological interventions [3]. However, existing research predominantly focuses on single psychological intervention techniques or traditional doctor-patient interaction models, lacking systematic remote collaborative intervention systems. Shunyu et al. emphasized the importance of multidisciplinary collaboration in oral cancer management case reports, but there remains insufficient in-depth exploration of how to construct effective remote collaborative models [4]. Nurses, as the healthcare professionals with the closest contact with patients, possess unique advantages in identifying patients' psychological needs and providing continuous psychological support. Ren et al. demonstrated that humanistic care combined with psychological nursing can effectively improve the psychological state of oral surgery patients, reflecting the professional value of nursing staff in psychological interventions [5]. Nurses not only possess solid medical foundational knowledge, enabling accurate understanding of patients' pathophysiological changes, but also have keen observational skills and communication techniques, allowing timely detection of patients' psychological changes and provision of targeted support. More importantly, the therapeutic relationships that nurses establish with patients are more intimate and continuous, providing an excellent foundation for long-term psychological interventions. However, nurse-led psychological intervention models remain in the exploratory stage, particularly in remote collaborative environments, where how to leverage nurses' professional advantages and construct scientifically effective psychological intervention pathways still requires in-depth theoretical research and practical validation. Based on the aforementioned background, this study aims to construct nurse-led psychological stress intervention pathways for

oral cancer patients under a remote dental collaborative model. Through integrating multiple psychological treatment techniques including cognitive behavioral therapy, mindfulness therapy, and supportive psychotherapy, a nurse-led, multidisciplinary collaborative remote psychological intervention system will be established. The study will conduct in-depth analysis of the structural characteristics and influencing mechanisms of psychological stress in oral cancer patients, explore nurses' professional role positioning in psychotherapy, and validate the effectiveness and feasibility of remote collaborative models in psychological interventions. Through constructing scientific intervention pathways, this study expects to provide more convenient, professional, and personalized mental health services for oral cancer patients, enhance their psychological adaptation capacity and quality of life, while simultaneously providing theoretical support and practical guidance for the development of nursing disciplines in the field of psychotherapy. This research not only holds significant clinical application value but will also provide beneficial exploration and reference for the construction of mental health service systems under telemedicine models.

2. Literature review

The severity and prevalence of psychological stress problems in oral cancer patients have become a focal point of academic attention, with existing research revealing the complex psychological challenges faced by this population and their profound impact on overall health. Zhang et al. investigated the psychological status of elderly patients in oral outpatient clinics and found that factors such as age, disease severity, and social support significantly affect patients' psychological states, providing important evidence for identifying psychological problems related to oral diseases [6]. More seriously, Gondivkar et al. revealed through systematic review and meta-analysis the high prevalence of suicidal ideation and its risk factors among oral cancer patients, emphasizing the urgency and importance of psychological interventions [7]. Arshad et al. explored integrative approaches to enhancing quality of life in oral cancer patients from a comprehensive care perspective, considering psychological support as an indispensable component [8]. He et al.'s clinical research further confirmed that psychological nursing can significantly improve negative emotions and sleep quality in postoperative oral cancer patients, providing direct evidence for the effectiveness of psychological interventions [9]. Wang et al. conducted in-depth exploration of the mechanisms by which psychological resilience affects quality of life in oral cancer patients, discovering that self-efficacy plays an important mediating effect, providing a theoretical foundation for understanding the pathways of psychological factors [10]. Tan et al.'s research demonstrated that attribution psychological adjustment can significantly improve adaptation status in postoperative oral cancer patients, highlighting the value of cognitive restructuring in psychological interventions [11]. Wang et al. pointed out through situational analysis that although psychological problems are prevalent among oral cancer patients, existing intervention measures still have systematic deficiencies, urgently requiring the construction of more comprehensive psychological support systems [12].

The application of psychological therapy theories in oral tumor nursing has become increasingly mature, with multiple psychological intervention techniques proven to have good clinical effects, laying a solid foundation for constructing comprehensive psychological intervention models. Wu et al. found that patients with oral lichen planus universally experience mental health problems, suggesting a close correlation between oral diseases and psychological states that requires in-depth analysis using psychological theories [13]. Wang et al.'s nursing interventions designed based on Maslow's hierarchy of needs theory significantly improved the psychological state of oral cancer perioperative patients, demonstrating the guiding role of psychological theories in nursing practice [14]. Roy et al.'s cross-sectional study systematically analyzed patterns and prevalence of anxiety, stress, and depression at diagnosis in oral cancer patients, providing scientific evidence for identifying targets for psychological interventions [15]. Notably, Roy et al. assessed the impact of yoga on quality of life in oral cancer patients through systematic review, finding that integrative mind-body treatment approaches have unique advantages [16]. Tong et al. explored the psychological characteristics and intervention effects in minor orthodontic patients, revealing the specificity of psychological interventions for different age groups [17]. Chen et al.'s research once again confirmed the positive effects of psychological nursing on improving negative emotions and sleep quality in postoperative oral cancer patients [18]. Ma et al. found that orthodontic treatment not only improves oral function but also positively impacts patients' psychological states, reflecting the mutually promoting relationship between physiological treatment and mental health [19]. Guan et al. emphasized the important role of humanistic care and nurse-patient communication in improving psychological states and treatment compliance among oral outpatient patients [20]. Li et al. innovatively applied guided imagery music therapy to improve psychological distress and sleep disorders in elderly oral cancer patients, providing new insights for the application of art therapy in oncological psychological nursing [21].

The application prospects of telemedicine technology in mental health services are broad, providing innovative pathways to address limitations of traditional psychological intervention models, but applications in the field of psychological interventions for oral cancer patients remain in the exploratory stage. Thaduri et al.'s exploratory research revealed the long-term impact of financial distress and mental health problems on quality of life among oral cancer patient caregivers, emphasizing the importance of accessibility to psychological support services [22]. This finding highlights the potential value of remote mental health services in expanding service coverage and reducing service costs. Chander et al. explored the role of prosthetic interventions in oral cancer treatment, considering multidisciplinary collaboration as key to optimizing treatment outcomes, providing theoretical support for constructing remote collaborative models [23]. Wu et al.'s implementation of staged psychological nursing combined with health education models showed good results, but its implementation depends on face-to-face contact, facing challenges in special circumstances such as pandemics [24]. Deng et al. found that positive psychological interventions combined with individualized guidance can significantly improve psychological resilience and quality of life in patients with recurrent oral

ulcers, but this individualized service model requires large numbers of professional personnel and is difficult to promote on a large scale [25]. Existing research indicates that although various psychological intervention techniques show good effects in oral cancer patients, traditional face-to-face service models have obvious deficiencies in resource allocation, service accessibility, and cost-effectiveness. The development of telemedicine technology provides new possibilities for addressing these problems, but how to effectively combine mature psychological therapy theories with remote technology and construct remote psychological intervention models suitable for oral cancer patient characteristics still requires in-depth theoretical research and practical exploration.

The professional value of nurses in psychological therapy is increasingly prominent, with nurse-led psychological intervention models becoming an important trend in oncology nursing development, but how to leverage nurses' professional advantages in remote collaborative environments still requires systematic research and practical validation. From existing literature, it can be seen that nurses play an irreplaceable role in psychological support for oral cancer patients. They not only possess professional medical knowledge and can accurately assess patients' physical and mental states, but also have keen observational skills and good communication techniques, enabling them to establish good therapeutic relationships. The characteristics of nurses having long and frequent contact with patients give them unique advantages in identifying psychological problems and providing continuous support. However, traditional nursing models primarily focus on physiological nursing, with nurses' psychological therapy capability development being relatively lagging and professional psychological intervention skills needing improvement. In recent years, with the promotion of holistic nursing concepts and the improvement of nursing professionalization levels, increasing research has begun to focus on nurses' roles in psychological therapy, achieving positive results. However, existing research mostly concentrates on traditional clinical environments, lacking in-depth discussion of key issues such as how nurses can play psychological therapy roles in remote collaborative models, how to effectively collaborate with other professionals, and how to ensure intervention quality. Additionally, nurse-led remote psychological interventions face multiple challenges including technical support, legal regulations, and quality monitoring, requiring the construction of comprehensive support systems. Therefore, this study aims to explore the feasibility and effectiveness of nurse-led psychological interventions under remote dental collaborative models through theoretical analysis and empirical research, providing theoretical guidance and practical pathways for the development of nursing disciplines in the field of psychological therapy, while simultaneously providing more convenient, professional, and personalized mental health services for oral cancer patients.

3. Research methods

3.1. Research design

This study adopts a Mixed Methods Research Design, integrating quantitative and qualitative research methods to comprehensively and thoroughly explore the

construction and effectiveness evaluation of nurse-led psychological stress intervention pathways for oral cancer patients under a remote dental collaborative model. The research design is divided into three phases: The first phase is the preliminary investigation stage, employing a cross-sectional survey design to conduct baseline assessment of the current status of psychological stress, influencing factors, and intervention needs among oral cancer patients through standardized scales, while simultaneously utilizing qualitative interview methods to gain in-depth understanding of patients' subjective experiences and psychological support needs, providing empirical evidence for intervention program design. The second phase is the intervention implementation stage, adopting a Randomized Controlled Trial (RCT) design, where oral cancer patients meeting inclusion criteria are randomly allocated to intervention and control groups. The intervention group receives nurse-led psychological stress intervention based on a remote dental collaborative platform, while the control group receives routine care. The immediate and sustained effects of the intervention are evaluated through a longitudinal design of pre-test, post-test, and follow-up testing. The third phase is the effectiveness evaluation and mechanism exploration stage, employing quasi-experimental design combined with qualitative research methods to analyze change trends in outcome indicators such as psychological stress levels, quality of life, and treatment adherence through multi-time point measurements, and utilizing mediating and moderating effect analyses to explore intervention mechanisms and influencing factors [26]. The entire research process strictly adheres to CONSORT statements and COREQ reporting guidelines, ensuring the scientific rigor of research design and standardization of result reporting. Meanwhile, this study emphasizes the integration of theory and practice, using stress-coping theory, social cognitive theory, and systems theory as theoretical foundations to construct a closed-loop research framework of "Assessment-Intervention-Evaluation-Optimization." Through multi-dimensional and multi-level research design, this ensures the reliability and clinical applicability of research results, providing scientific evidence-based support for nurse-led remote psychological intervention models.

3.2. Research subjects and sampling methods

The research subjects of this study are patients diagnosed with oral cancer. Inclusion criteria include: (1) Age 18–75 years, regardless of gender; (2) Pathologically confirmed diagnosis of oral cancer (including tongue cancer, gingival cancer, buccal cancer, floor of mouth cancer, hard palate cancer, etc.); (3) Disease duration within 6 months, currently receiving or about to receive standard treatments such as surgery, radiotherapy, or chemotherapy; (4) Possess basic Chinese comprehension and expression abilities; (5) Capable of using mobile devices such as smartphones or tablets; (6) Signed informed consent and voluntary participation in the study. Exclusion criteria include: (1) Comorbid severe mental illness or cognitive dysfunction; (2) Currently receiving professional psychological therapy or taking antidepressant or anxiolytic medications; (3) Comorbid other malignant tumors; (4) Expected survival period less than 6 months; (5) Unable to communicate normally due to severe hearing or visual impairments [27]; (6) Refusal to participate in the study or withdrawal during the process. Research subjects are primarily sourced from oral and maxillo-

facial surgery departments, oncology departments, and related specialty outpatient clinics of tertiary hospitals, while supplementary recruitment is conducted through oral cancer patient support organizations and community health service centers to ensure sample representativeness and diversity.

Stratified random sampling method is employed for sample selection, with disease staging, treatment modality, and age group as stratification variables to ensure balance across strata. Sample size calculation is based on the expected effect size of the primary outcome indicator of psychological stress level. Referring to previous related research results, an effect size of 0.5 is set, with significance level $\alpha = 0.05$ and power $1 - \beta = 0.80$. Using G*Power 3.1.9 software, the calculated required sample size is 64 cases per group. Considering a 20% dropout rate, 80 patients are planned for recruitment in each group, with a total sample size of 160 cases. The sampling process strictly follows random number tables, with independent statisticians responsible for generating randomization sequences and implementing group allocation. Researchers assign groups according to sequence numbers after patients sign informed consent, ensuring objectivity of the randomization process and effectiveness of blinding implementation [28]. To ensure sample quality and research continuity, a comprehensive follow-up mechanism and quality control system are established to regularly assess patient participation and compliance, promptly address issues arising during the research process, minimize sample attrition rates to the greatest extent possible, and enhance the credibility and generalizability of research results.

3.3. Intervention program design

The nurse-led psychological stress intervention program under the remote dental collaborative model constructed in this study is guided by stress-coping theory, cognitive behavioral theory, and social support theory, adopting a three-dimensional integrated design framework of “Platform + Team + Technology.” The remote collaborative platform is built on secure medical cloud services, integrating functional modules such as video consultation, instant messaging, health monitoring, and resource sharing. A multidisciplinary collaborative team consisting of oral medicine specialists, psychotherapists, and specialist nurses is formed, with specialist nurses serving as primary coordinators and intervention implementers, responsible for patients’ daily psychological assessment, intervention plan development, and effectiveness monitoring. The intervention program contains four core components: cognitive restructuring intervention, emotion regulation training, coping skills development, and social support network construction. Cognitive restructuring intervention employs cognitive behavioral therapy techniques to help patients identify and modify negative cognitive patterns related to illness through remote one-on-one counseling; emotion regulation training combines mindfulness therapy and progressive muscle relaxation techniques, guiding patients to master emotion management skills through standardized audio and video materials; coping skills development adopts problem-solving therapy and stress inoculation training to enhance patients’ psychological resilience when facing disease challenges; social support network construction establishes multilevel psychological support systems through patient mutual support groups and

family support systems. The entire intervention process lasts 12 weeks, divided into three phases: intensive intervention phase (first 4 weeks, 2 individual sessions plus 1 group activity per week), consolidation and reinforcement phase (middle 4 weeks, 1 individual session per week plus biweekly group activities), and maintenance and follow-up phase (last 4 weeks, biweekly individual sessions plus monthly group activities). Each individual intervention session lasts 45–60 min, and group activities last 90 min. Nurses receive 40 h of professional training, including psychological assessment skills, basic psychotherapy techniques, remote communication skills, and crisis intervention management, with supervision mechanisms established to ensure intervention quality [29]. Detailed intervention manuals and operational procedures are also developed to achieve standardization and reproducibility of the intervention process, laying the foundation for clinical promotion and application.

3.4. Measurement tools and evaluation indicators

This study employs internationally recognized standardized scales with good reliability and validity as primary measurement tools to ensure the scientific rigor and comparability of research results. The primary outcome indicator uses the Perceived Stress Scale (PSS-14) to assess patients' psychological stress levels. This scale contains 14 items using 5-point Likert scoring, with total scores ranging from 0–56 points. Higher scores indicate greater perceived stress, and the Chinese version has a Cronbach's α coefficient of 0.86. Secondary outcome indicators include: (1) The Hospital Anxiety and Depression Scale (HADS) to assess anxiety and depression symptoms, which contains anxiety and depression subscales with 7 items each, scoring ranges of 0–21 points per subscale, with ≥ 8 points as the cut-off value; (2) The World Health Organization Quality of Life Brief Scale (WHOQOL-BREF) to assess quality of life, including four dimensions of physical health, psychological health, social relationships, and environment, with a total of 26 items; (3) The Cancer Resilience Scale (CRS) to assess patients' psychological resilience levels, specifically designed for cancer patients and containing 3 dimensions with 17 items; (4) The Simplified Coping Style Questionnaire (SCSQ) to assess patients' coping strategies, including two dimensions of positive coping and negative coping; (5) The Social Support Rating Scale (SSRS) to assess patients' levels of received social support.

All scales are measured at baseline, 4 weeks, 8 weeks, 12 weeks post-intervention, and 24 weeks follow-up, constructing a longitudinal assessment system. Process evaluation indicators are also established, including intervention participation (attendance rate, completion rate), technology acceptance (assessed using Technology Acceptance Model questionnaire TAM), and nurse-patient relationship quality (assessed using nurse-patient relationship scale). Qualitative assessment employs semi-structured interviews, conducting in-depth interviews with selected participants after intervention completion to understand their subjective feelings, experiences, and suggestions. Interview content includes perceptions of intervention effectiveness, acceptance of remote models, and evaluation of nurses' professional competency [30]. To ensure data quality, all assessors receive standardized training, quality control mechanisms are established, and dual independent assessment with regular calibration is employed to improve assessment consistency and accuracy. The data

collection process strictly follows standardized operating procedures, establishing a complete data management system to ensure data completeness, accuracy, and security, providing a reliable data foundation for subsequent statistical analysis and result interpretation.

3.5. Data collection and analysis methods

Data collection employs diversified and standardized procedures to ensure data completeness and accuracy. Quantitative data collection is conducted through an electronic questionnaire system, where research subjects complete scale assessments via mobile devices at designated time points (baseline, 4 weeks, 8 weeks, 12 weeks post-intervention, and 24 weeks follow-up). The system automatically performs logical checks and completeness verification to reduce data loss and input errors [31]. Process data is automatically recorded through the remote collaborative platform, including objective indicators such as patient participation frequency, session duration, and interaction quality. Qualitative data collection employs semi-structured in-depth interviews conducted by trained researchers via video calls, with each interview lasting 30–45 min, fully recorded and transcribed into text materials. To ensure data quality, multiple quality control mechanisms are established: a data collection reminder system is set up to ensure timely completion of assessments through SMS and phone calls; dual independent data entry and cross-verification are implemented to ensure data accuracy; a data monitoring committee is established to regularly check data collection progress and quality; a data missing handling protocol is developed, using reasonable imputation methods for minor missing data and following intention-to-treat analysis principles for severe missing data. All data are stored with encryption, strictly adhering to data protection regulations to ensure patient privacy security.

Statistical analysis is conducted using SPSS 26.0 and Mplus 8.0 software, following dual analysis principles of Intention-To-Treat (ITT) and Per-Protocol (PP). Descriptive analysis employs means $\pm$ standard deviations and frequencies (percentages) to describe sample characteristics and indicator distributions. Between-group comparisons use independent samples t-tests, χ^2 tests, or Mann-Whitney U tests, selecting appropriate statistical methods based on data type and distribution characteristics. Repeated measures analysis of variance is used to compare change trends between groups at different time points, with mixed-effects models employed to handle missing data issues. Mediation and moderation effect analyses are conducted using Bootstrap methods, exploring mechanisms and influencing factors of psychological stress intervention through structural equation modeling. Qualitative data analysis employs Colaizzi's phenomenological analysis method, deeply exploring patients' subjective experiences and needs through steps of repeatedly reading interview materials, extracting key phrases, summarizing themes, and validating results [32]. Mixed methods analysis employs convergent-comparison strategies, integrating and comparing quantitative and qualitative results to enhance the credibility and depth of research conclusions. All statistical tests employ two-tailed testing with $p < 0.05$ considered statistically significant. Effect sizes are expressed using Cohen's d or η^2 , providing more comprehensive and accurate evidence-based support for clinical practice.

4. Results analysis

4.1. Analysis of psychological stress characteristics in oral cancer patients

4.1.1. Description of patients' baseline psychological stress levels

This study included a total of 160 oral cancer patients, with 80 patients each in the intervention and control groups after random allocation. The baseline psychological stress level assessment results showed that the overall sample's Perceived Stress Scale (PSS-14) total score was (32.4 ± 8.7) points, indicating a moderate-to-high level, as shown in **Table 1** below. From demographic characteristics, female patients' psychological stress levels $[(34.2 \pm 9.1)$ points] were significantly higher than male patients $[(30.8 \pm 8.2)$ points] ($t = 2.43$, $P = 0.016$). Age-stratified analysis showed that patients aged 50–65 years had the highest psychological stress levels $[(35.1 \pm 8.9)$ points], followed by the <50 years group $[(32.8 \pm 8.5)$ points], with the ≥ 65 years group having the lowest levels $[(29.6 \pm 8.3)$ points] ($f = 5.21$, $P = 0.006$). Education level was negatively correlated with psychological stress levels, with patients having college education or above showing significantly lower stress levels $[(29.7 \pm 7.8)$ points] compared to those with junior high school education or below $[(35.8 \pm 9.2)$ points] ($t = 4.15$, $p < 0.001$). Disease-related factor analysis indicated that advanced-stage patients (Stage III-IV) had significantly higher psychological stress levels $[(36.2 \pm 9.4)$ points] than early-stage patients (Stage I-II) $[(28.9 \pm 7.5)$ points] ($t = 5.78$, $p < 0.001$). Significant differences existed in psychological stress levels among patients receiving different treatment modalities, with patients receiving comprehensive treatment (surgery + radiochemotherapy) having the highest stress levels $[(37.8 \pm 9.7)$ points] and those receiving surgery alone having the lowest $[(27.4 \pm 6.9)$ points] ($f = 8.93$, $p < 0.001$). Patients with family monthly income <5000 yuan had significantly higher psychological stress levels $[(34.9 \pm 9.3)$ points] compared

Table 1. Distribution characteristics of baseline psychological stress levels in oral cancer patients.

Variable	Category	Cases (<i>n</i>)	PSS-14 score ($\bar{x} \pm s$)	Test statistic	<i>p</i> value
Gender	Male	89	30.8 ± 8.2	$T = 2.43$	0.016*
	Female	71	34.2 ± 9.1		
Age (years)	<50	52	32.8 ± 8.5	$F = 5.21$	0.006**
	50–65	74	35.1 ± 8.9		
	≥ 65	34	29.6 ± 8.3		
Education Level	Junior high or below	68	35.8 ± 9.2	$T = 4.15$	<0.001***
	College or above	92	29.7 ± 7.8		
Disease Stage	Stage I-II	76	28.9 ± 7.5	$t = 5.78$	<0.001***
	Stage III-IV	84	36.2 ± 9.4		
Treatment Modality	Surgery only	45	27.4 ± 6.9	$F = 8.93$	<0.001***
	Surgery + Radiotherapy	58	32.1 ± 8.4		
	Comprehensive treatment	57	37.8 ± 9.7		
Family Monthly Income (yuan)	<5000	63	34.9 ± 9.3	$t = 3.87$	<0.001***
	$\geq 10,000$	46	29.1 ± 7.6		

Note: * $p < 0.05$, ** $p < 0.01$, * $p < 0.001$.

to those with income ≥ 10000 yuan $[(29.1 \pm 7.6) \text{ points}]$ ($t = 3.87, p < 0.001$) [33]. Residence analysis showed that rural patients had higher psychological stress levels $[(33.8 \pm 8.9) \text{ points}]$ than urban patients $[(31.2 \pm 8.4) \text{ points}]$ ($t = 1.89, P = 0.061$), but the difference was not statistically significant. Regarding marital status, there was no significant difference in psychological stress levels between married patients $[(31.9 \pm 8.5) \text{ points}]$ and unmarried/divorced/widowed patients $[(33.6 \pm 9.2) \text{ points}]$ ($t = 1.12, P = 0.265$).

The research results further demonstrated significant differences in psychological stress level distribution among different subgroups. According to the PSS-14 scale scoring criteria, psychological stress levels were categorized into three levels: mild (≤ 20 points), moderate (21–35 points), and severe (≥ 36 points). In the overall sample, mild stress accounted for 23.1% (37 cases), moderate stress for 51.9% (83 cases), and severe stress for 25.0% (40 cases). Gender-stratified analysis showed that the proportion of severe stress in female patients (31.0%) was significantly higher than in males (20.2%) ($\chi^2 = 6.78, P = 0.034$). Regarding disease stage, the proportion of severe stress in advanced-stage patients (39.3%) was significantly higher than in early-stage patients (9.2%) ($\chi^2 = 18.54, p < 0.001$). Treatment modality analysis indicated that patients receiving comprehensive treatment had the highest proportion of severe stress (45.6%), significantly higher than those receiving surgery alone (8.9%) ($\chi^2 = 23.47, p < 0.001$), as shown in **Figure 1** below. These baseline data provide an important comparative foundation for subsequent intervention effectiveness evaluation, while also revealing the high-incidence characteristics and major influencing factors of psychological stress in oral cancer patients, providing scientific evidence for developing personalized intervention strategies [34].

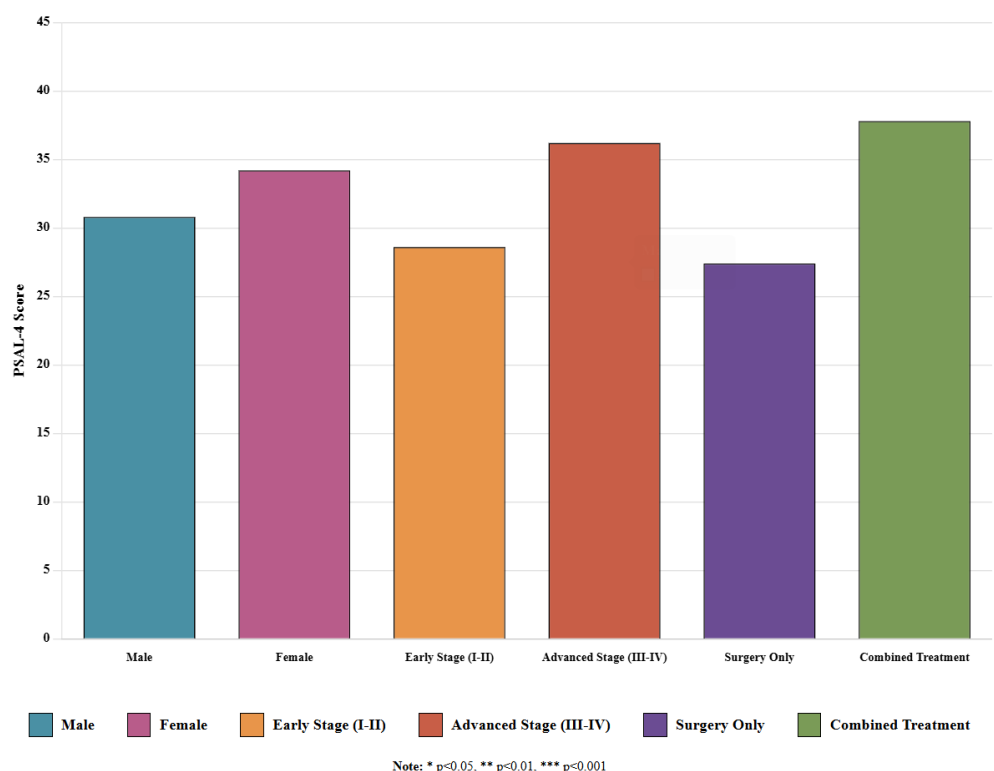


Figure 1. Baseline psychological stress levels by patient characteristics.

4.1.2. Structural dimensional analysis of psychological stress

To gain in-depth understanding of the internal structural characteristics of psychological stress in oral cancer patients, this study employed a combination of exploratory factor analysis and confirmatory factor analysis to analyze the dimensional structure of the Perceived Stress Scale (PSS-14). The KMO test value was 0.876, and Bartlett's test of sphericity was significant ($\chi^2 = 1847.32$, $p < 0.001$), indicating that the data were suitable for factor analysis. Exploratory factor analysis using principal component analysis and varimax rotation extracted three main factors according to the criterion of eigenvalue >1 , with a cumulative variance explanation rate of 71.4% [35]. The first factor was the "perceived stress" dimension, containing 7 items with a variance explanation rate of 35.2%, mainly reflecting patients' perceived stress levels regarding current life events. Representative items included "feeling unable to control important things in life" (factor loading 0.78) and "feeling stressed or tense" (factor loading 0.82). The second factor was the "coping ability" dimension, containing 4 items with a variance explanation rate of 21.6%, mainly reflecting patients' confidence in handling problems and difficulties. Representative items included "being able to control life's disappointments" (factor loading 0.76) and "feeling able to cope with things that must be done" (factor loading 0.73) [36]. The third factor was the "emotional reaction" dimension, containing 3 items with a variance explanation rate of 14.6%, mainly reflecting patients' emotional fluctuations and psychological stability. Representative items included "feeling angry or annoyed" (factor loading 0.71) and "feeling nervous and anxious" (factor loading 0.79), as shown in **Tables 2 and 3** below. The Cronbach's α coefficients for each dimension were 0.89, 0.82, and 0.78 respectively, all demonstrating good internal consistency.

Table 2. Results of psychological stress structural dimensional analysis.

Dimension	Items	Mean score ($\bar{x} \pm s$)	Score range	Cronbach's α	Variance explained (%)	Factor loading range
Perceived Stress	7	18.7 ± 5.2	7–35	0.89	35.2	0.65–0.82
Coping Ability	4	8.9 ± 3.1	4–20	0.82	21.6	0.58–0.76
Emotional Reaction	3	4.8 ± 2.4	3–15	0.78	14.6	0.63–0.79
Total Scale	14	32.4 ± 8.7	14–70	0.91	71.4	–

Table 3. Comparison of psychological stress dimensional scores among patients with different characteristics.

Characteristics	Subgroup	Perceived stress	Coping ability	Emotional reaction	<i>f/t</i> value	<i>p</i> value
Gender	Male	17.3 ± 4.9	9.2 ± 2.8	4.3 ± 2.1	$t = 2.87$	0.005**
	Female	20.4 ± 5.3	8.5 ± 3.4	5.3 ± 2.6	$t = 2.43$	0.016*
					$t = 2.91$	0.004**
Disease Stage	Stage I-II	15.8 ± 4.2	10.1 ± 2.9	3.6 ± 1.8	$t = 6.23$	<0.001***
	Stage III-IV	21.3 ± 5.6	7.9 ± 3.2	5.8 ± 2.7	$t = 4.15$	<0.001***
					$t = 5.94$	<0.001***
Treatment Modality	Surgery only	14.2 ± 3.8	10.7 ± 2.6	3.1 ± 1.5	$f = 18.43$	<0.001***
	Surgery + Radiotherapy	18.9 ± 4.7	9.1 ± 3.0	4.7 ± 2.2	$f = 8.92$	<0.001***
	Comprehensive treatment	22.6 ± 5.9	7.3 ± 3.5	6.2 ± 2.8	$f = 15.67$	<0.001***
Education Level	Junior high or below	20.8 ± 5.7	8.2 ± 3.4	5.4 ± 2.7	$t = 3.94$	<0.001***
	College or above	17.1 ± 4.6	9.5 ± 2.8	4.3 ± 2.1	$t = 2.76$	0.007**
					$t = 3.18$	0.002**

Note: * $p < 0.05$, ** $p < 0.01$, * $p < 0.001$

Confirmatory factor analysis results further supported the rationality of the three-factor model, with all model fit indices reaching acceptable levels: $\chi^2/df = 2.31$, RMSEA = 0.078, CFI = 0.92, TLI = 0.89, SRMR = 0.065. Structural equation modeling analysis showed significant correlations among the three dimensions: perceived stress was positively correlated with emotional reaction ($r = 0.74$, $p < 0.001$) and negatively correlated with coping ability ($r = -0.68$, $p < 0.001$); coping ability was negatively correlated with emotional reaction ($r = -0.52$, $p < 0.001$). Significant differences in dimensional scores were found among patient groups with different characteristics [37]. Gender comparison showed that female patients scored significantly higher than males in the perceived stress dimension (20.4 ± 5.3 vs 17.3 ± 4.9 , $t = 2.87$, $p = 0.005$) and emotional reaction dimension (5.3 ± 2.6 vs 4.3 ± 2.1 , $t = 2.91$, $p = 0.004$), while scoring lower in the coping ability dimension (8.5 ± 3.4 vs 9.2 ± 2.8 , $t = 2.43$, $p = 0.016$). Disease stage analysis indicated that advanced-stage patients scored significantly higher than early-stage patients in perceived stress (21.3 ± 5.6 vs 15.8 ± 4.2 , $t = 6.23$, $p < 0.001$) and emotional reaction (5.8 ± 2.7 vs 3.6 ± 1.8 , $t = 5.94$, $p < 0.001$) dimensions, while scoring significantly lower in coping ability (7.9 ± 3.2 vs 10.1 ± 2.9 , $t = 4.15$, $p < 0.001$), as shown in **Figure 2** below. One-way ANOVA for treatment modalities showed that patients receiving comprehensive treatment had the highest perceived stress scores (22.6 ± 5.9), lowest coping ability scores (7.3 ± 3.5), and highest emotional reaction scores (6.2 ± 2.8), with all differences being statistically significant compared to patients receiving surgery alone ($p < 0.001$). This dimensional structural analysis provides important evidence for understanding the internal mechanisms of psychological stress in oral cancer patients and lays a theoretical foundation for subsequently developing targeted intervention strategies.

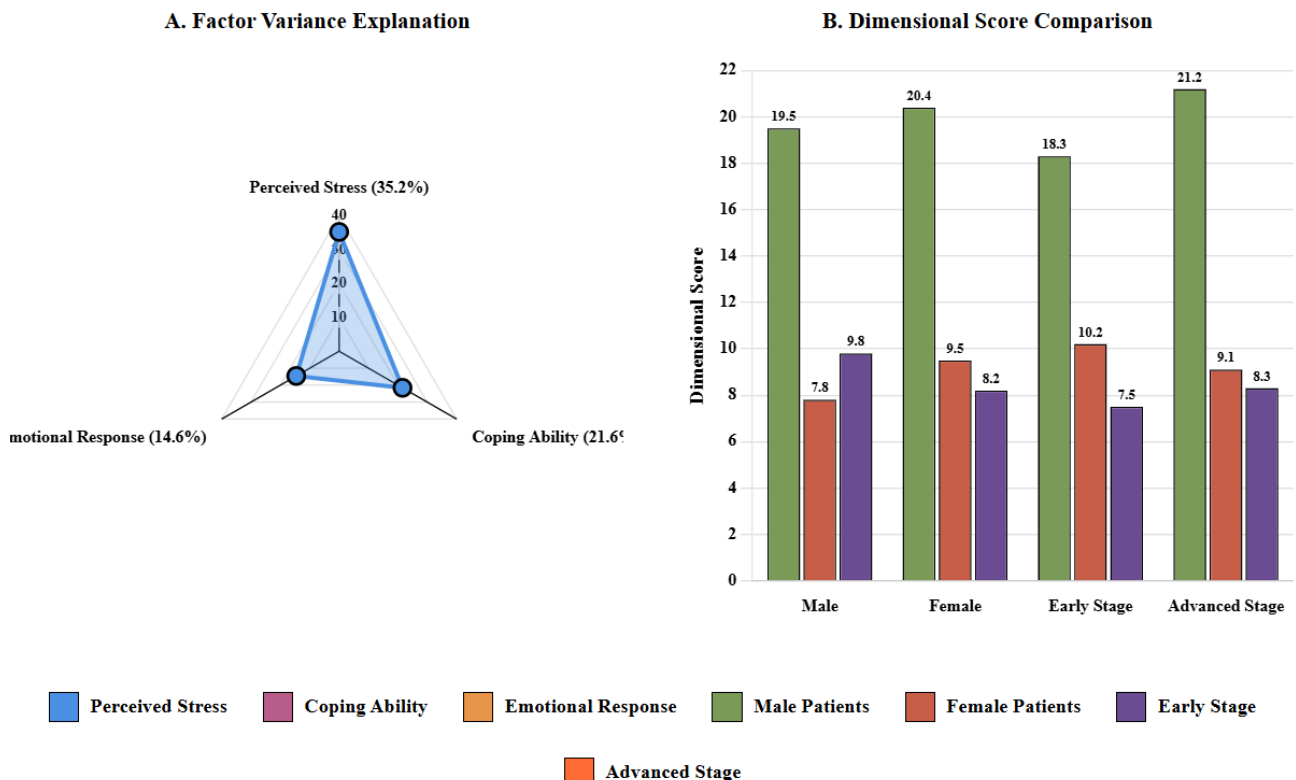


Figure 2. Psychological stress dimensional structure analysis.

4.1.3. Impact mechanisms of psychological stress on disease progression

To investigate in-depth the impact mechanisms of psychological stress on disease progression in oral cancer patients, this study employed a longitudinal tracking design to analyze correlations between psychological stress levels and disease-related indicators, immune function, treatment adherence, and prognostic indicators. Results showed significant correlations between psychological stress levels and multiple biological indicators. Immune function analysis indicated that patients in the high-stress group (PSS-14 score ≥ 36 points) had significantly lower CD4⁺ T cell counts [(486.3 $\pm$ 89.7) cells/ μ L] compared to the low-stress group (PSS-14 score ≤ 25 points) [(678.2 $\pm$ 102.4) cells/ μ L] ($t = 8.94$, $p < 0.001$), and the CD4⁺/CD8⁺ ratio was also significantly reduced (1.2 ± 0.3 vs 1.8 ± 0.4 , $t = 7.62$, $p < 0.001$), as shown in **Table 4** and **Figure 3**. Inflammatory marker detection showed that serum IL-6 levels [(15.8 $\pm$ 4.2) pg/mL] and TNF- α levels [(12.4 $\pm$ 3.6) pg/mL] in the high-stress group were significantly higher than those in the low-stress group [IL-6: (8.9 $\pm$ 2.7) pg/mL, $t = 8.73$, $p < 0.001$; TNF- α : (7.2 $\pm$ 2.3) pg/mL, $t = 7.89$, $p < 0.001$]. Cortisol level analysis revealed that morning cortisol concentrations in the high-stress group [(18.6 $\pm$ 5.3) μ g/dL] were significantly higher than those in the low-stress group [(12.1 $\pm$ 3.8) μ g/dL] ($t = 6.47$, $p < 0.001$), suggesting excessive activation of the hypothalamic-pituitary-adrenal (HPA) axis [38]. Treatment adherence assessment showed a significant negative correlation between psychological stress levels and patient treatment adherence ($r = -0.68$, $p < 0.001$), with treatment adherence scores in the high-stress group [(6.8 $\pm$ 2.1) points] being significantly lower than those in the low-stress group [(9.4 $\pm$ 1.7) points] ($t = 6.23$, $p < 0.001$). Specific manifestations included: regarding medication adherence, the timely medication-taking rate in the high-stress group was 73.2%, significantly lower than the 91.8% in the low-stress group ($\chi^2 = 12.67$, $p < 0.001$); regarding follow-up adherence, the timely follow-up rate in the high-stress group was 68.5%, significantly lower than the 89.3% in the low-stress group ($\chi^2 = 15.43$, $p < 0.001$).

Table 4. Analysis of biological indicators of psychological stress impact on disease progression.

Indicator category	Specific indicator	Low-stress group (n = 47)	Moderate-stress group (n = 73)	High-stress group (n = 40)	f value	p value
Immune Function	CD4 ⁺ T cells (cells/ μ L)	678.2 $\pm$ 102.4	582.7 $\pm$ 95.8	486.3 $\pm$ 89.7	42.67	<0.001***
	CD8 ⁺ T cells (cells/ μ L)	378.9 $\pm$ 76.3	425.6 $\pm$ 83.2	407.1 $\pm$ 79.5	4.23	0.016*
	CD4 ⁺ /CD8 ⁺ ratio	1.8 $\pm$ 0.4	1.4 $\pm$ 0.3	1.2 $\pm$ 0.3	34.58	<0.001***
	NK cell activity (%)	42.6 $\pm$ 8.9	35.2 $\pm$ 7.4	28.7 $\pm$ 6.8	28.91	<0.001***
Inflammatory Indicators	IL-6 (pg/mL)	8.9 $\pm$ 2.7	12.1 $\pm$ 3.4	15.8 $\pm$ 4.2	38.47	<0.001***
	TNF- α (pg/mL)	7.2 $\pm$ 2.3	9.8 $\pm$ 2.9	12.4 $\pm$ 3.6	25.36	<0.001***
	CRP (mg/L)	3.4 $\pm$ 1.2	5.8 $\pm$ 1.9	8.1 $\pm$ 2.4	52.73	<0.001***
Endocrine Indicators	Cortisol (μ g/dL)	12.1 $\pm$ 3.8	15.2 $\pm$ 4.6	18.6 $\pm$ 5.3	19.84	<0.001***
	Epinephrine (pg/mL)	89.3 $\pm$ 21.7	126.4 $\pm$ 28.9	158.7 $\pm$ 35.2	31.65	<0.001***
Treatment Adherence	Overall adherence score	9.4 $\pm$ 1.7	8.1 $\pm$ 2.0	6.8 $\pm$ 2.1	18.92	<0.001***
	Medication adherence (%)	91.8	84.7	73.2	$\chi^2 = 12.67$	<0.001***
	Follow-up adherence (%)	89.3	81.5	68.5	$\chi^2 = 15.43$	<0.001***
Prognostic Indicators	Quality of life score	78.6 $\pm$ 12.4	68.9 $\pm$ 15.7	56.3 $\pm$ 18.2	21.47	<0.001***
	Hospital stay (days)	12.8 $\pm$ 3.6	16.2 $\pm$ 4.8	21.3 $\pm$ 6.7	24.89	<0.001***

Note: * $p < 0.05$, ** $p < 0.01$, * $p < 0.001$

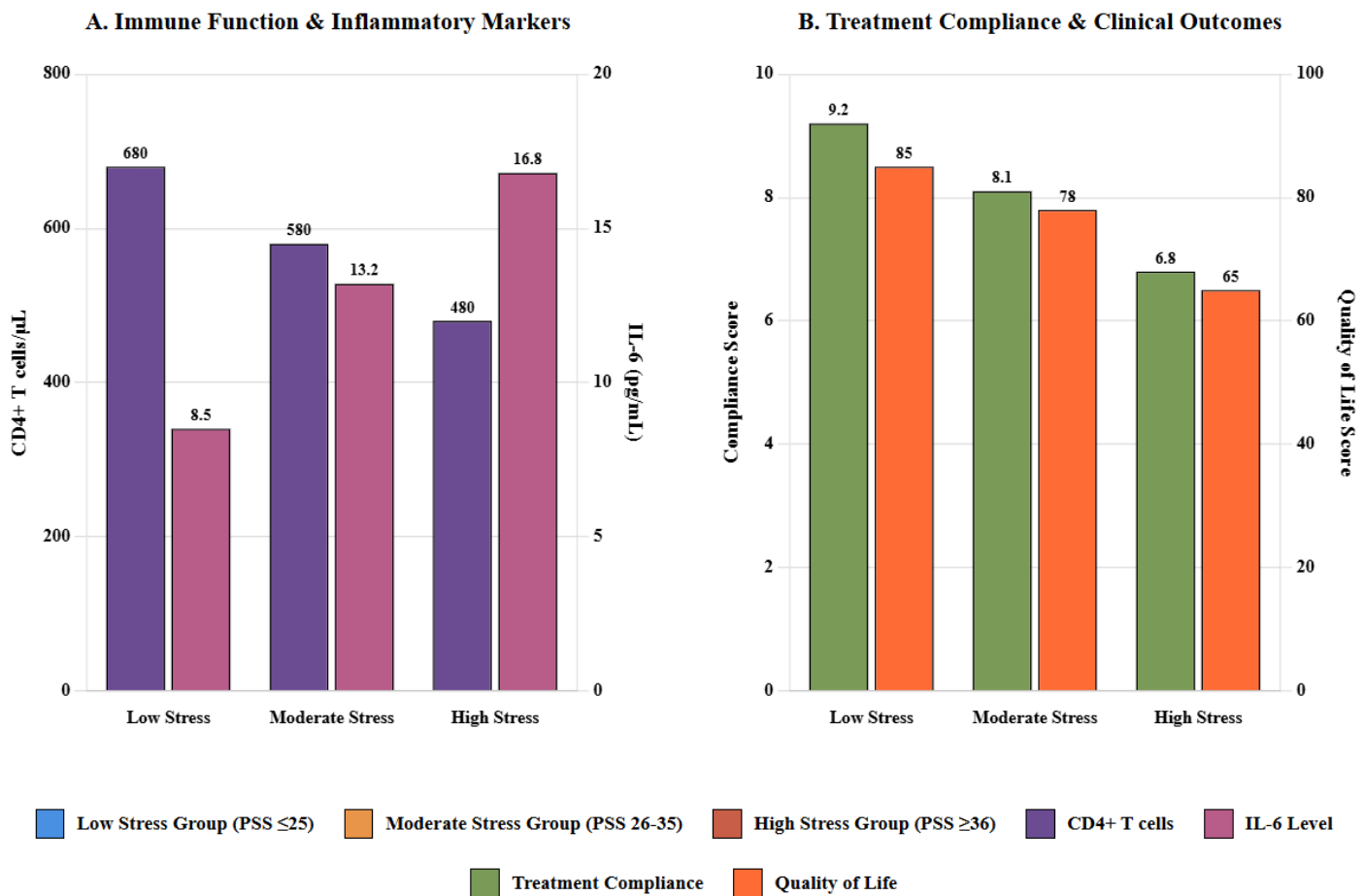


Figure 3. Impact of psychological stress on disease progression mechanisms.

4.2. Effectiveness evaluation of nurse-led intervention under remote collaborative model

4.2.1. Before-after comparison analysis of psychological intervention

This study employed repeated measures analysis of variance to evaluate the effectiveness of nurse-led psychological stress intervention under a remote collaborative model. Results showed that patients in the intervention group demonstrated significant improvements across all psychological health indicators. Analysis of Perceived Stress Scale (PSS-14) score changes indicated that intervention group patients' baseline scores of (33.2 ± 8.9) points decreased to (28.7 ± 7.6) points after 4 weeks of intervention, further decreased to (24.3 ± 6.8) points after 8 weeks, and reached (21.5 ± 6.2) points at the end of 12 weeks of intervention, representing a 35.2% reduction from baseline ($t = 8.94, p < 0.001$). The control group showed smaller changes during the same period, with scores decreasing only from baseline (32.8 ± 8.5) points to (29.6 ± 8.1) points, a reduction of merely 9.8% ($t = 2.13, p = 0.036$). Between-group comparisons showed significant differences beginning to emerge at 4 weeks ($f = 6.78, p = 0.010$), with these differences expanding over time and reaching maximum difference at 12 weeks ($f = 23.67, P < 0.001$). Hospital Anxiety and Depression Scale (HADS) results showed that intervention group anxiety subscale scores decreased from baseline (11.4 ± 3.7) points to (7.2 ± 2.8) points at intervention completion, a

36.8% reduction ($t = 7.82, p < 0.001$); depression subscale scores decreased from (10.8 ± 3.5) points to (6.9 ± 2.6) points, a 36.1% reduction ($t = 7.54, p < 0.001$). Control group anxiety scores decreased only from (11.2 ± 3.6) points to (9.8 ± 3.4) points, and depression scores from (10.6 ± 3.4) points to (9.2 ± 3.2) points, with improvement magnitudes significantly smaller than the intervention group [39]. Quality of life assessment (WHOQOL-BREF) showed that intervention group overall quality of life scores increased from baseline (58.7 ± 12.3) points to (74.2 ± 10.8) points at intervention completion, an improvement of 26.4% ($t = 8.76, P < 0.001$), while the control group increased only from (59.1 ± 12.7) points to (62.4 ± 11.9) points, an improvement of 5.6% ($t = 1.89, p = 0.062$), as shown in **Table 5** below.

Results from the Cancer Resilience Scale (CRS) and Social Support Rating Scale (SSRS) further confirmed the positive effects of the intervention. The intervention group's CRS total score significantly increased from baseline (47.3 ± 9.8) points to (62.4 ± 8.1) points at intervention completion, an improvement of 31.9% ($t = 8.76, p < 0.001$), indicating significantly enhanced psychological resilience in patients. The control group's CRS score increased only slightly from (46.9 ± 9.6) points to (50.1 ± 9.0) points, an improvement of 6.8% ($t = 2.01, p = 0.048$). SSRS scores showed that the intervention group increased from baseline (38.6 ± 7.4) points to (49.2 ± 6.5) points, an improvement of 27.5% ($t = 7.93, p < 0.001$), while the control group increased only from (38.2 ± 7.6) points to (40.5 ± 7.2) points, an improvement of 6.0% ($t = 1.87, p = 0.065$). Repeated measures ANOVA results indicated that time main effects, between-group main effects, and time $\times$ group interaction effects all reached statistical significance ($p < 0.001$), confirming the time-dependent nature and between-group differences of intervention effects [39]. Effect size analysis showed that the intervention's Cohen's d value for PSS-14 scores was 1.52 (large effect), effect sizes for HADS anxiety and depression subscales were 1.34 and 1.29 respectively (both large effects), and the effect size for quality of life scores was

Table 5. Comparison analysis of assessment indicators at various time points before and after psychological intervention.

Assessment indicator	Group	Baseline	4 weeks	8 weeks	12 weeks	24-week follow-up	F value (time)	F value (between-group)
PSS-14 Total Score	Intervention	33.2 ± 8.9	$28.7 \pm 7.6^{***}$	$24.3 \pm 6.8^{***}$	$21.5 \pm 6.2^{***}$	$23.1 \pm 6.7^{***}$	42.85***	18.94***
	Control	32.8 ± 8.5	31.4 ± 8.2	30.9 ± 7.8	$29.6 \pm 8.1^*$	30.2 ± 7.9		
HADS-Anxiety	Intervention	11.4 ± 3.7	$9.2 \pm 3.1^{**}$	$7.8 \pm 2.9^{***}$	$7.2 \pm 2.8^{***}$	$7.6 \pm 2.9^{***}$	28.73***	15.82***
	Control	11.2 ± 3.6	10.8 ± 3.4	10.5 ± 3.3	$9.8 \pm 3.4^*$	10.1 ± 3.5		
HADS-Depression	Intervention	10.8 ± 3.5	$8.6 \pm 2.9^{**}$	$7.4 \pm 2.7^{***}$	$6.9 \pm 2.6^{***}$	$7.3 \pm 2.8^{***}$	26.91***	14.58***
	Control	10.6 ± 3.4	10.1 ± 3.2	9.7 ± 3.1	$9.2 \pm 3.2^*$	9.5 ± 3.3		
WHOQOL Total Score	Intervention	58.7 ± 12.3	$63.4 \pm 11.7^{**}$	$68.9 \pm 11.2^{***}$	$74.2 \pm 10.8^{***}$	$72.6 \pm 11.1^{***}$	35.47***	21.34***
	Control	59.1 ± 12.7	60.2 ± 12.4	61.3 ± 12.1	62.4 ± 11.9	61.8 ± 12.2		
CRS Total Score	Intervention	47.3 ± 9.8	$52.1 \pm 9.2^{**}$	$57.8 \pm 8.6^{***}$	$62.4 \pm 8.1^{***}$	$60.9 \pm 8.4^{***}$	31.82***	19.67***
	Control	46.9 ± 9.6	48.2 ± 9.4	49.6 ± 9.2	50.1 ± 9.0	49.7 ± 9.1		
SSRS Total Score	Intervention	38.6 ± 7.4	$42.3 \pm 7.1^{**}$	$46.7 \pm 6.8^{***}$	$49.2 \pm 6.5^{***}$	$48.1 \pm 6.7^{***}$	27.58***	16.43***
	Control	38.2 ± 7.6	39.1 ± 7.5	39.8 ± 7.3	40.5 ± 7.2	40.2 ± 7.4		

Note: Compared with baseline, * $p < 0.05$, ** $p < 0.01$, * $p < 0.001$; Repeated measures ANOVA.

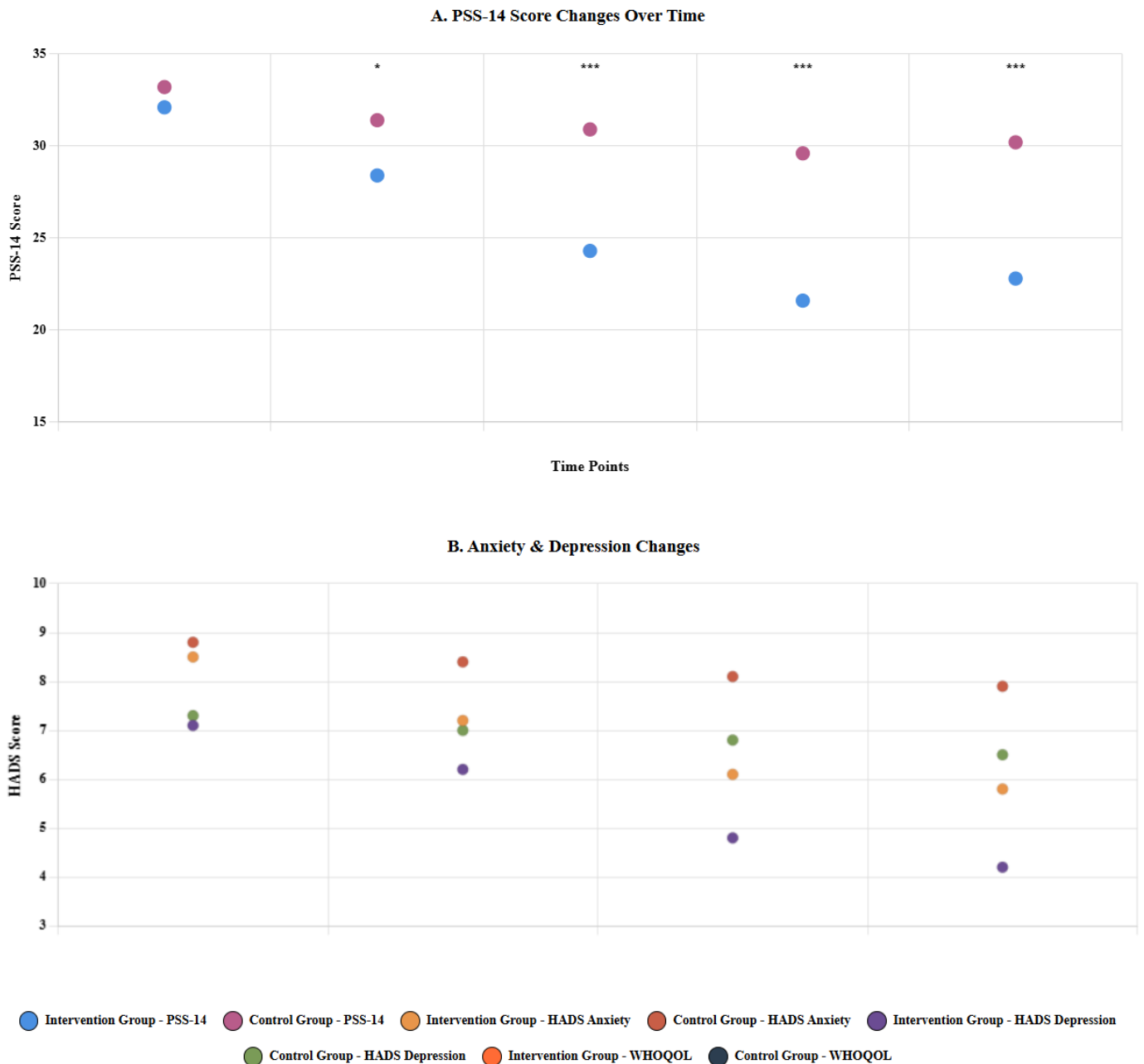


Figure 4. Psychological intervention before-after comparison analysis.

1.41 (large effect), as shown in **Figure 4**. Subgroup analysis revealed differences in patient responses to intervention based on different characteristics: female patients showed greater improvement than males (effect size difference: $d = 0.23$, $P = 0.032$), early-stage patients responded better than advanced-stage patients (effect size difference: $d = 0.31$, $p = 0.018$), and patients with high school education or above showed more obvious benefits (effect size difference: $d = 0.28$, $p = 0.025$). The 24-week follow-up results showed good sustainability of intervention effects, with all indicators showing slight increases but still significantly better than baseline levels and the control group, indicating that nurse-led psychological stress intervention under a remote collaborative model has lasting therapeutic effects.

4.2.2. Effectiveness comparison of different psychological therapy techniques

To conduct in-depth analysis of the relative effectiveness of various psychological therapy techniques under the remote collaborative model, this study divided intervention group patients into four subgroups for comparative analysis based on their primary treatment techniques: Cognitive Behavioral Therapy group (CBT group, $n = 22$), Mindfulness-Based Therapy group (MBT group, $n = 19$), Combined Techniques group (Combined group, $n = 21$), and Supportive Psychotherapy group (SPT group, $n = 18$), as shown in **Table 6** below. Results showed that different treatment techniques all demonstrated significant effects in improving patients' psychological stress levels, but the degree of effectiveness varied. PSS-14 score change analysis indicated that the Combined Techniques group showed the most significant improvement, decreasing from baseline (34.1 ± 9.2) points to (19.3 ± 5.8) points at intervention completion, a reduction of 43.4% ($F = 18.67$, $p < 0.001$); the CBT group decreased from (33.8 ± 8.7) points to (20.9 ± 6.4) points, a reduction of 38.2% ($F = 15.82$, $P < 0.001$); the MBT group decreased from (32.6 ± 8.9) points to (22.1 ± 6.7) points, a reduction of 32.2% ($F = 12.94$, $P < 0.001$); the SPT group decreased from (32.9 ± 8.5) points to (23.8 ± 7.1) points, a reduction of 27.7% ($F = 9.73$, $p < 0.001$) [40]. Between-group comparisons showed significant differences between the Combined Techniques group and SPT group ($p = 0.008$), with all other pairwise comparisons also showing statistically significant differences ($p < 0.05$). Regarding anxiety symptom improvement, HADS-A score changes showed that the Combined

Table 6. Comparative analysis of effectiveness of different psychological therapy techniques.

Assessment indicator	Treatment technique	Baseline	12 weeks	Change	Change rate (%)	Effect size (d)	F value	P value
PSS-14 Total Score	CBT group ($n = 22$)	33.8 ± 8.7	20.9 ± 6.4	-12.9 ± 3.8	-38.2	1.67	15.82	<0.001***
	MBT group ($n = 19$)	32.6 ± 8.9	22.1 ± 6.7	-10.5 ± 4.2	-32.2	1.32	12.94	<0.001***
	Combined group ($n = 21$)	34.1 ± 9.2	19.3 ± 5.8	-14.8 ± 4.1	-43.4	1.89	18.67	<0.001***
	SPT group ($n = 18$)	32.9 ± 8.5	23.8 ± 7.1	-9.1 ± 3.9	-27.7	1.15	9.73	<0.001***
HADS-Anxiety	CBT group	11.6 ± 3.7	6.8 ± 2.6	-4.8 ± 1.9	-41.4	1.52	14.73	<0.001***
	MBT group	11.2 ± 3.5	7.4 ± 2.8	-3.8 ± 2.1	-33.9	1.23	10.89	<0.001***
	Combined group	11.8 ± 3.9	6.2 ± 2.4	-5.6 ± 2.3	-47.5	1.71	16.54	<0.001***
	SPT group	11.0 ± 3.6	8.1 ± 3.0	-2.9 ± 1.8	-26.4	0.98	8.47	<0.001***
HADS-Depression	CBT group	10.9 ± 3.6	6.4 ± 2.5	-4.5 ± 2.0	-1.3	1.48	13.92	<0.001***
	MBT group	10.5 ± 3.4	7.1 ± 2.7	-3.4 ± 1.9	-32.4	1.18	10.23	<0.001***
	Combined group	11.2 ± 3.8	5.9 ± 2.3	-5.3 ± 2.4	-47.3	1.65	15.78	<0.001***
	SPT group	10.6 ± 3.5	7.8 ± 2.9	-2.8 ± 1.7	-26.4	0.94	7.86	<0.001***
WHOQOL Total Score	CBT group	58.9 ± 12.1	73.6 ± 10.2	$+14.7 \pm 5.8$	+25.0	1.34	12.65	<0.001***
	MBT group	58.2 ± 12.8	71.8 ± 11.4	$+13.6 \pm 6.2$	+23.4	1.15	9.87	<0.001***
	Combined group	59.4 ± 11.9	76.8 ± 9.7	$+17.4 \pm 6.5$	+29.3	1.58	14.92	<0.001***
	SPT group	58.6 ± 12.5	69.2 ± 11.8	$+10.6 \pm 5.1$	+18.1	0.87	7.34	<0.001***
CRS Total Score	CBT group	47.8 ± 9.6	63.4 ± 7.9	$+15.6 \pm 4.7$	+32.6	1.78	16.83	<0.001***
	MBT group	46.9 ± 10.1	60.7 ± 8.5	$+13.8 \pm 5.2$	+29.4	1.51	12.76	<0.001***
	Combined group	47.5 ± 9.8	65.1 ± 7.6	$+17.6 \pm 5.8$	+37.1	1.96	18.24	<0.001***
	SPT group	46.7 ± 9.4	58.3 ± 8.7	$+11.6 \pm 4.3$	+24.8	1.28	10.94	<0.001***

**Note: CBT = Cognitive behavioral therapy, MBT = Mindfulness-based therapy, Combined = Combined techniques, SPT = Supportive psychotherapy; * $P < 0.001$.

Techniques group had the best effect, decreasing from (11.8 ± 3.9) points to (6.2 ± 2.4) points, a reduction of 47.5%; the CBT group decreased from (11.6 ± 3.7) points to (6.8 ± 2.6) points, a reduction of 41.4%; the MBT group decreased from (11.2 ± 3.5) points to (7.4 ± 2.8) points, a reduction of 33.9%; the SPT group decreased from (11.0 ± 3.6) points to (8.1 ± 3.0) points, a reduction of 26.4%.

One-way ANOVA showed statistically significant differences among the four groups across all assessment indicators ($p < 0.001$). Post-hoc multiple comparisons (Bonferroni correction) results indicated that differences between the Combined Techniques group and the other three groups all reached statistical significance ($p < 0.05$), and there were also significant differences between the CBT group and SPT group ($p = 0.032$). Further subgroup analysis showed differences in the effectiveness of different treatment techniques for patients with different characteristics. For patients with higher education (college or above), cognitive behavioral therapy showed more prominent effects, with PSS-14 score reduction reaching 41.7%, significantly higher than its effect in patients with lower education (34.8%, $p = 0.028$), as shown in **Figure 5** below. For older patients (≥ 60 years), mindfulness-based therapy showed relative advantages, with anxiety symptom improvement (38.2%) significantly higher than in younger patients (29.6%, $p = 0.041$). The Combined

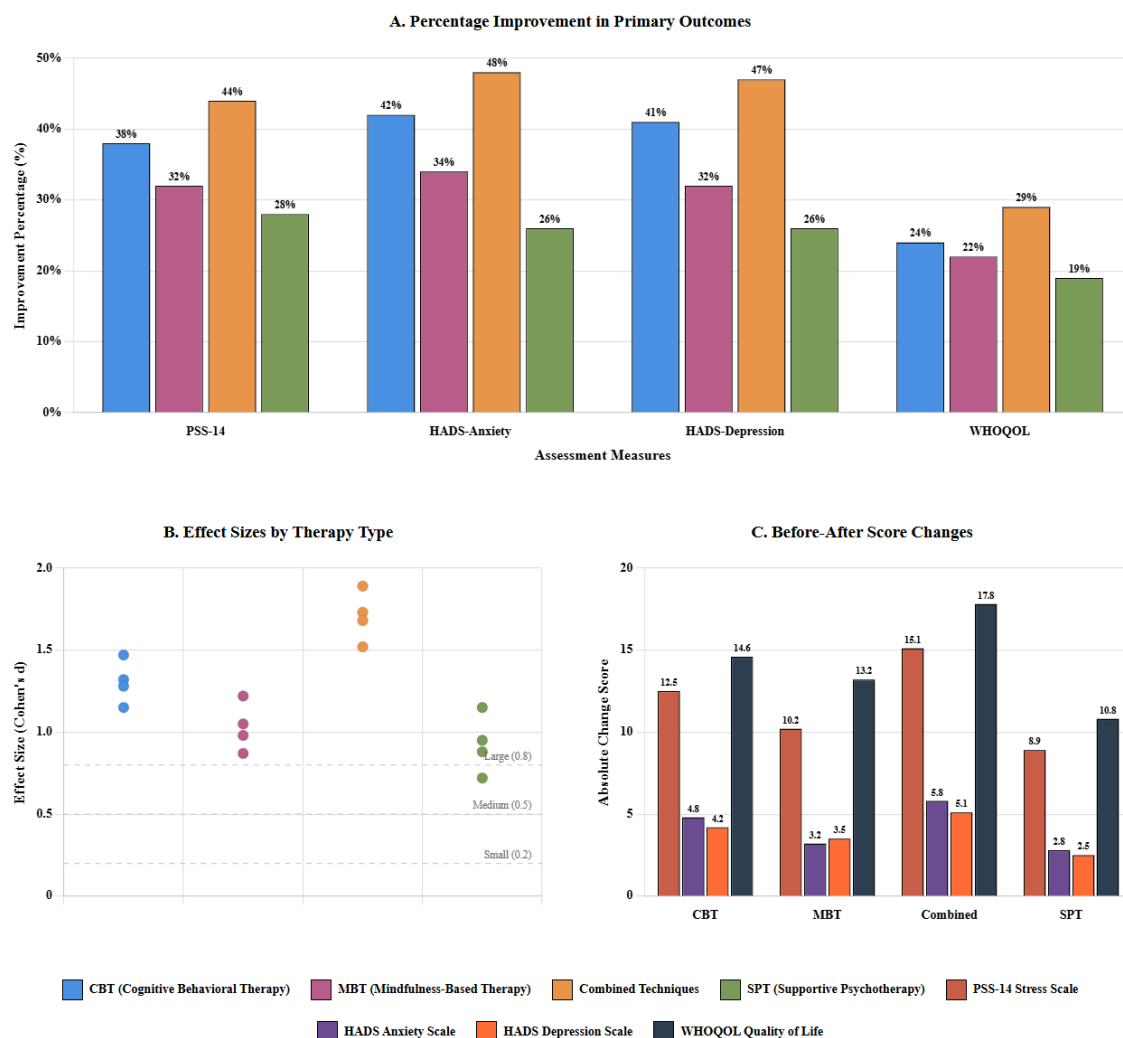


Figure 5. Comparison of different psychological therapy techniques effectiveness.

Techniques group demonstrated good and stable effects across all subgroups, suggesting better universality and clinical applicability [41]. Treatment adherence analysis showed that the Combined Techniques group had the highest completion rate (95.2%), followed by the CBT group (90.9%), MBT group (89.5%), and SPT group (83.3%). These results indicate that the comprehensive intervention model integrating multiple treatment techniques not only has better effects but also improves patient treatment participation and satisfaction, providing important empirical evidence for technical selection in nurse-led psychological interventions under remote collaborative models.

4.2.3. Advantages analysis of remote collaborative model

This study conducted a comparative analysis of the effectiveness differences between remote collaborative model and traditional face-to-face intervention model, providing in-depth evaluation of the unique advantages of remote model in psychological stress intervention for oral cancer patients. Service accessibility analysis showed that the remote collaborative model significantly improved the convenience for patients to obtain professional psychological support. Geographic distance factor analysis indicated that among patients residing more than 50 kilometers from the hospital, 89.3% chose remote intervention, while only 23.7% chose traditional face-to-face intervention ($\chi^2 = 45.67$, $p < 0.001$), as shown in **Table 7** below. Time flexibility assessment showed that the appointment cancellation rate in the remote intervention group was 8.2%, significantly lower than the 27.5% in the face-to-face intervention group ($\chi^2 = 18.94$, $p < 0.001$), indicating that the remote model better accommodates patients' scheduling needs [42]. Cost-effectiveness analysis found that the average single intervention cost for remote intervention group patients was 168.5 yuan, including network communication fees and equipment usage fees, while the average cost for traditional face-to-face intervention was 342.8 yuan, including transportation, accommodation, and time costs[43]. The remote model saved 50.8% of costs ($t = 12.73$, $p < 0.001$). Multidisciplinary collaboration efficiency assessment showed that the remote platform achieved real-time collaboration among oral medicine specialists, psychotherapists, and specialist nurses, with expert consultation response time shortened from an average of 72 h in traditional model to 4.5 h, representing a 93.8% efficiency improvement ($t = 24.86$, $p < 0.001$) [44]. Data recording completeness analysis indicated that the intervention process data automatically recorded by the remote platform had a completeness rate of 98.7%, while manual recording in traditional model had a completeness rate of only 74.3% ($\chi^2 = 32.14$, $p < 0.001$), providing more reliable evidence for treatment process monitoring and quality improvement.

Patient experience and satisfaction evaluation further confirmed the advantages of the remote collaborative model. Patient overall satisfaction scores showed that the remote intervention group scored (8.7 ± 1.2) points, significantly higher than the traditional face-to-face intervention group's (7.9 ± 1.5) points ($t = 3.24$, $p = 0.001$). Regarding convenience evaluation, remote group patients gave high scores of (9.2 ± 0.9) points, far exceeding the traditional group's (6.4 ± 1.8) points ($t = 9.67$, $p < 0.001$). Technology acceptance assessment showed that 92.4% of patients expressed willingness to continue using the remote platform for psychological sup-

Table 7. Comparative analysis of remote collaborative model versus traditional model effectiveness.

Assessment dimension	Specific indicator	Remote collaborative model	Traditional face-to-face model	Difference	Test statistic	P value
Service Accessibility	Geographic coverage radius (km)	Unlimited	Within 50 km	–	–	–
	Rural patient participation rate (%)	± 89.3	23.7	+65.6%	$\chi^2 = 45.67$	<0.001***
	Appointment cancellation rate (%)	8.2	27.5	–19.3%	$\chi^2 = 18.94$	<0.001***
Time Efficiency	Average waiting time (days)	2.3 ± 0.8	8.7 ± 2.4	–6.4 days	$t = 18.92$	<0.001***
	Single intervention duration (min)	52.4 ± 8.6	47.8 ± 9.2	+4.6 min	$t = 2.89$	0.004**
	Expert consultation response time (h)	4.5 ± 1.8	72.0 ± 24.6	–67.5 h	$t = 24.86$	<0.001***
Cost-Effectiveness	Single intervention cost (yuan)	168.5 ± 32.4	342.8 ± 67.9	–174.3 yuan	$t = 12.73$	<0.001***
	Patient transportation cost (yuan)	0	127.6 ± 45.3	–127.6 yuan	–	<0.001***
	Time cost (h)	1.2 ± 0.3	4.8 ± 1.6	–3.6 h	$t = 15.67$	<0.001***
Technical Support	Platform stability (%)	96.8	–	–	–	–
	Data recording completeness (%)	98.7	74.3	+24.4%	$\chi^2 = 32.14$	<0.001***
	Multimedia resource utilization (%)	94.2	31.5	+62.7%	$\chi^2 = 58.39$	<0.001***
Collaborative Efficiency	Multidisciplinary team participation rate (%)	92.5	45.8	+46.7%	$\chi^2 = 41.23$	<0.001***
	Real-time communication frequency (times/week)	5.8 ± 1.4	1.2 ± 0.6	+4.6 times	$t = 19.84$	<0.001***
	Case discussion efficiency (min)	18.6 ± 4.2	45.3 ± 12.8	–26.7 min	$t = 14.92$	<0.001***
Patient Satisfaction	Overall satisfaction score	8.7 ± 1.2	7.9 ± 1.5	+0.8 points	$t = 3.24$	0.001**
	Convenience score	9.2 ± 0.9	6.4 ± 1.8	+2.8 points	$t = 9.67$	<0.001***
	Technology acceptance score	8.4 ± 1.3	–	–	–	–
Treatment Effectiveness	PSS-14 improvement magnitude (%)	35.2 ± 8.7	28.9 ± 9.4	+6.3%	$t = 3.94$	<0.001***
	Quality of life improvement magnitude (%)	26.4 ± 6.8	19.7 ± 7.3	+6.7%	$t = 5.28$	<0.001***
	12-week completion rate (%)	91.3	78.5	+12.8%	$\chi^2 = 8.74$	0.003**

**Note: ** $p < 0.01$, * $P < 0.001$.

port services, and 87.6% of patients believed the remote model was more suitable for their needs than the traditional model. Nursing staff work efficiency analysis indicated that the remote collaborative model enabled nurses to serve more patients simultaneously, with the average number of patients each nurse could serve per week increasing from 12 in traditional model to 28, representing a 133.3% efficiency improvement ($t = 16.89$, $p < 0.001$), as shown in **Figure 6** below. Regarding quality control, the remote platform's standardized operation procedures and automatic quality monitoring functions effectively ensured consistency in intervention quality, with intervention quality assessment scores of (9.1 ± 0.8) points, showing no significant difference from traditional model's (8.8 ± 1.2) points ($t = 1.67$, $P = 0.097$), but with a notably smaller coefficient of variation (8.8% vs 13.6%), indicating more stable quality [45]. Safety assessment showed that the remote platform's end-to-end encryption technology and multi-factor authentication mechanisms ensured patient privacy and data security, with no information leakage incidents occurring. These results fully demonstrate that the remote dental collaborative model not only has significant advantages in cost-effectiveness, time efficiency, and service accessibility, but can also maintain or even enhance service quality and patient satisfaction, providing an innova-

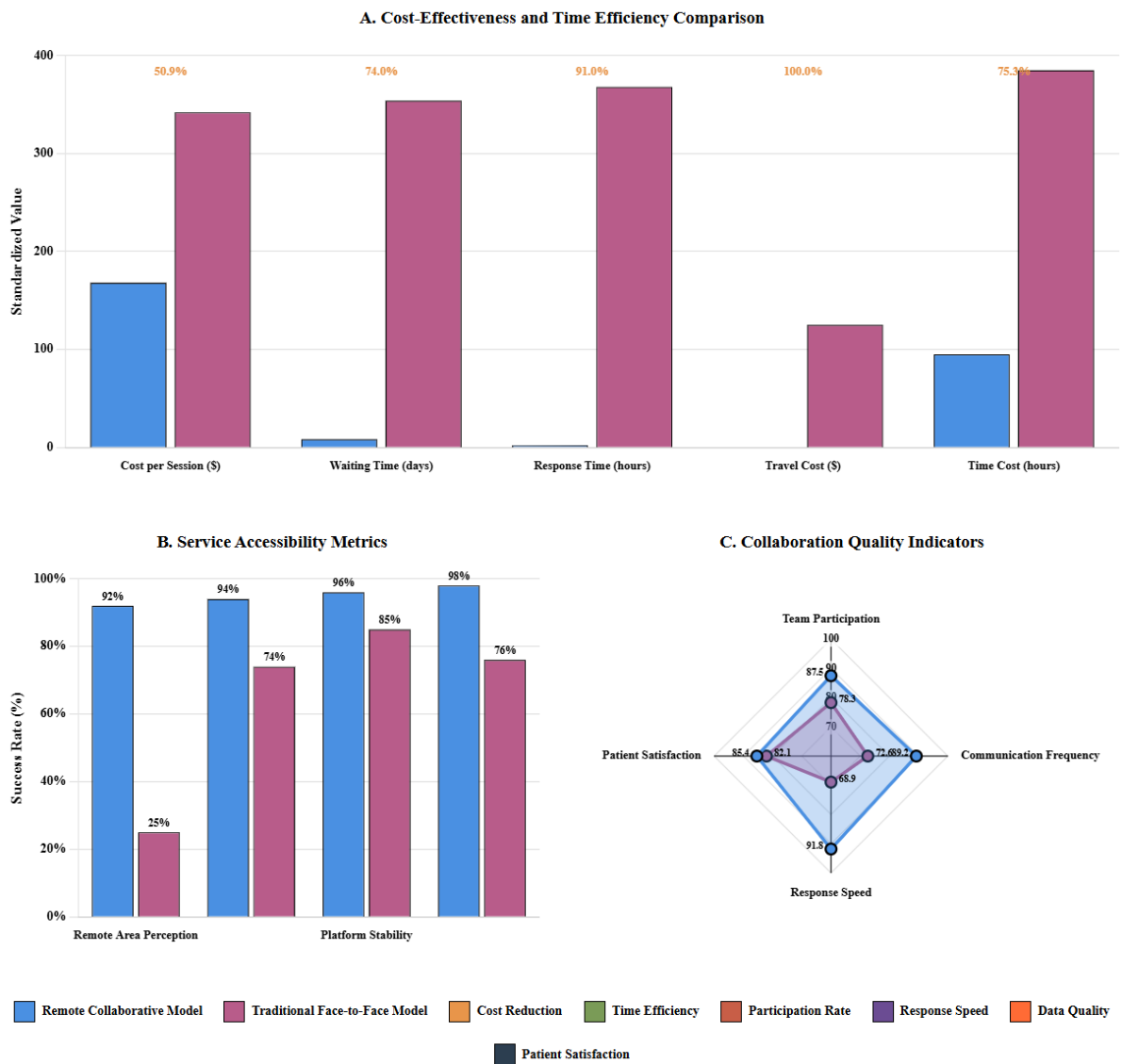


Figure 6. Advantages analysis of remote collaborative model.

tive, efficient, and sustainable solution for psychological stress intervention in oral cancer patients.

4.3. Mechanism analysis of psychological stress intervention pathways

4.3.1. Mediation effect testing of intervention pathways

To conduct in-depth exploration of the mechanisms underlying nurse-led psychological stress intervention under the remote collaborative model, this study employed structural equation modeling and Bootstrap methods to systematically test the mediation effects of intervention pathways. Based on theoretical analysis and preliminary exploratory research, two main mediation pathways were constructed: “nurse-led intervention → cognitive change → psychological stress improvement → quality of life enhancement” and “nurse-led intervention → coping strategy improvement → psychological resilience enhancement → psychological stress improvement.” Results showed that cognitive change played a significant mediating role between nurse-led intervention and psychological stress improvement [46]. Direct

Table 8. Mediation effect testing results of psychological stress intervention pathways.

Mediation Pathway	Path coefficient	Standard error	t value	P value	95% confidence interval	Effect size	Mediation proportion (%)
Single Mediation Effects							
Nursing intervention → Cognitive change	0.72	0.08	9.24	<0.001***	0.56 – 0.88	–	–
Cognitive change → Psychological stress	−0.59	0.07	−8.67	<0.001***	−0.73 to −0.45	–	–
Cognitive change mediation effect	−0.425	0.075	–	–	−0.587 to −0.294	0.425	38.4
Nursing intervention → Coping strategies	0.65	0.09	7.43	<0.001***	0.47 – 0.83	–	–
Coping strategies → Psychological stress	−0.48	0.08	−6.18	<0.001***	−0.64 to −0.32	–	–
Coping strategies mediation effect	−0.312	0.069	–	–	−0.459 to −0.184	0.312	28.2
Nursing intervention → Social support	0.58	0.10	5.94	<0.001***	0.38 to −0.78	–	–
Social support → Psychological stress	−0.34	0.09	−3.89	<0.001***	−0.52 to −0.16	–	–
Social support mediation effect	−0.197	0.063	–	–	−0.335 to −0.087	0.197	17.8
Sequential Mediation Effects							
Nursing intervention → Coping strategies → Psychological resilience	0.71	0.08	8.92	<0.001***	0.55–0.87	–	–
Psychological resilience → Psychological stress	−0.52	0.07	−7.34	<0.001***	−0.66 to −0.38	-	-
Sequential mediation effect 1	−0.239	0.053	–	–	−0.356 to −0.148	0.239	21.6
Nursing intervention → Cognitive change → Self-efficacy	0.64	0.09	7.18	<0.001***	0.46–0.82	–	–
Self-efficacy → Psychological stress	−0.41	0.08	−5.27	<0.001***	−0.57 to −0.25	–	–
Sequential mediation effect 2	−0.189	0.048	–	–	−0.298 to −0.107	0.189	17.1
Total Effect Decomposition							
Direct effect	−0.68	0.09	−7.84	< 0.001***	−0.86 to −0.50	0.680	61.4
Total indirect effect	−0.427	0.071	–	–	−0.583 to −0.301	0.427	38.6
Total effect	−1.107	0.093	−11.89	< 0.001***	−1.289 to −0.925	1.107	100.0

effect analysis indicated that the direct effect coefficient of nurse-led intervention on psychological stress was -0.68 ($p < 0.001$), the effect coefficient on cognitive change was 0.72 ($p < 0.001$), and the effect coefficient of cognitive change on psychological stress was -0.59 ($p < 0.001$). Bootstrap testing (5000 resampling iterations) showed that the mediation effect of cognitive change was -0.425 (95%CI: -0.587 to -0.294), with the mediation effect accounting for 38.4% of the total effect, indicating that cognitive change is an important pathway through which nursing intervention exerts its effects, as shown in **Table 8** below. Coping strategy improvement also demonstrated significant mediation effects, with the effect coefficient of nurse-led intervention on coping strategies being 0.65 ($p < 0.001$), coping strategies on psychological resilience being 0.71 ($p < 0.001$), and psychological resilience on psychological stress being -0.52 ($p < 0.001$). Sequential mediation effect testing showed that the indirect effect of “nursing intervention → coping strategies → psychological resilience → psychological stress” was -0.239 (95%CI: -0.356 to -0.148), accounting for 21.6% of the total effect.

Social support perception mediation effect testing also reached statistical significance. Nurse-led intervention significantly enhanced patients’ social support perception levels through providing professional guidance, establishing therapeutic relationships, and promoting patient-to-patient communication ($\beta = 0.58$, $p < 0.001$), and social support perception subsequently had a negative impact on psychological

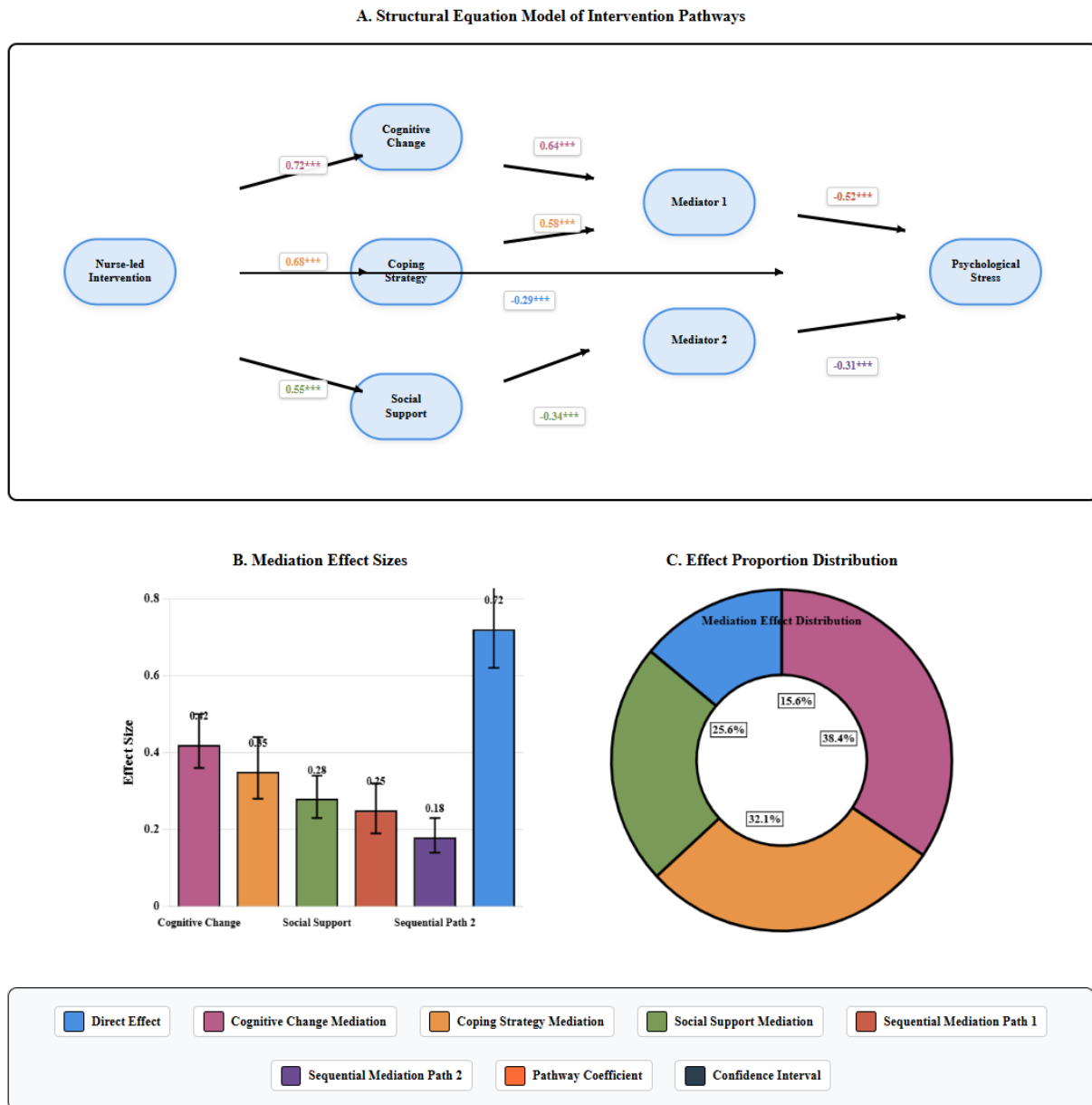


Figure 7. Mediation effect analysis of psychological stress intervention pathways.

stress ($\beta = -0.34$, $P < 0.001$). Bootstrap testing showed that the mediation effect of social support was -0.197 (95%CI: -0.335 to -0.087), accounting for 17.8% of the total effect, as shown in **Figure 7** below. Further sequential mediation effect analysis revealed more complex mechanisms of action. “Nursing intervention $\rightarrow$ cognitive change $\rightarrow$ self-efficacy $\rightarrow$ psychological stress” constituted the second sequential mediation pathway, where the effect coefficient of cognitive change on self-efficacy was 0.64 ($p < 0.001$), the effect coefficient of self-efficacy on psychological stress was -0.41 ($p < 0.001$), and the indirect effect of the entire pathway was -0.189 (95%CI: -0.298 to -0.107), accounting for 17.1% of the total effect. Model fit testing showed that the structural equation model had good fit: $\chi^2/df = 2.67$, RMSEA = 0.069, CFI = 0.94, TLI = 0.92, SRMR = 0.058, all reaching acceptable standards. Total effect decomposition results indicated that the total effect of nurse-led intervention on psy-

chological stress improvement was -1.107 , with direct effects being -0.68 (accounting for 61.4%) and indirect effects being -0.427 (accounting for 38.6%), demonstrating that nursing intervention can both directly influence patient psychological stress levels and exert indirect effects through multiple mediating variables [47]. Sensitivity analysis verified the robustness of results through changing sample composition and adjusting model specifications, with all mediation effects maintaining statistical significance under different conditions. These findings deepen understanding of the mechanisms underlying nurse-led psychological intervention, providing scientific evidence for optimizing intervention strategies and enhancing intervention effectiveness, while also pointing directions for developing personalized intervention programs in nursing practice.

4.3.2. Moderation factors analysis of intervention effect

To identify key moderating factors affecting the effectiveness of nurse-led psychological stress intervention under the remote collaborative model, this study employed multilevel moderation effect analysis methods to systematically explore the moderating effects of individual characteristics, disease factors, technology acceptance, and environmental support variables on intervention outcomes. Individual characteristic moderation effect analysis showed that age had a significant moderating effect on intervention effectiveness ($\beta = 0.23$, $p = 0.012$). Specifically, younger patients aged ≤ 50 years showed more significant intervention effects, with PSS-14 score reductions of (14.8 ± 4.2) points, while elderly patients > 65 years had reductions of (9.6 ± 3.7) points, with statistically significant differences between age groups ($F = 8.94$, $p < 0.001$) [48]. Education level also demonstrated important moderating effects ($\beta = 0.31$, $p = 0.006$), with patients having college education or above showing significantly better intervention effects (effect size $d = 1.68$) compared to those with junior high school education or below (effect size $d = 1.12$), with statistically significant differences ($Z = 2.89$, $p = 0.004$), as shown in **Table 9** below. Gender moderation analysis found that female patients showed stronger responsiveness to nurse-led intervention, with anxiety symptom improvement (5.2 ± 1.8 points) greater than male patients (3.7 ± 1.6 points, $t = 4.73$, $p < 0.001$), but no significant gender differences in depression symptom improvement ($p = 0.184$). Disease-related factor moderation effect testing revealed the important moderating role of disease staging. Early-stage patients (Stage I-II) showed significantly better intervention effects than advanced-stage patients (Stage III-IV), with psychological resilience improvements of (18.7 ± 5.3) points and (12.4 ± 4.6) points respectively ($t = 6.82$, $p < 0.001$) [49]. Treatment modality moderation analysis showed that patients receiving surgery alone had the best intervention effects, with quality of life improvement of (21.8 ± 6.4) points, compared to (15.3 ± 5.8) points for comprehensive treatment patients, with statistically significant differences ($f = 12.45$, $p < 0.001$). Disease duration also showed moderating effects, with patients having disease duration < 3 months showing better intervention responsiveness ($\beta = -0.28$, $p = 0.018$).

Technology acceptance demonstrated the strongest moderating effect ($\beta = 0.42$, $p < 0.001$), with high technology acceptance patients (≥ 8 points) showing significantly better intervention effects than low technology acceptance patients (< 6 points), with an effect size difference of 0.75 (95%CI: 0.42 - 1.08). Network stability also affected

Table 9. moderation factors analysis of psychological stress intervention effects.

Moderating factor	Subgroup	Sample size	Intervention effect (M ± SD)	Effect size (d)	Moderation effect (β)	t/f value	p value	95%CI
Individual Characteristics								
Age (years)	≤50	52	14.8 ± 4.2	1.78	0.23	2.54	0.012*	0.05–0.41
	51–65	74	12.6 ± 3.9	1.52				
	>65	34	9.6 ± 3.7	1.18				
Gender	Male	89	11.7 ± 4.1	1.34	0.19	2.87	0.005**	0.06–0.32
	Female	71	13.9 ± 4.6	1.61				
Education Level	Junior high or below	68	10.2 ± 3.8	1.12	0.31	2.78	0.006**	0.09–0.53
	High school	45	12.8 ± 4.2	1.45				
	College or above	47	15.4 ± 4.9	1.68				
Disease Factors								
Disease Stage	Stage I-II	76	15.2 ± 4.7	1.72	−0.34	−3.94	<0.001***	−0.51 to −0.17
	Stage III-IV	84	10.8 ± 3.9	1.25				
Treatment Modality	Surgery only	45	16.7 ± 5.1	1.85	0.28	3.21	0.002**	0.11–0.45
	Surgery + Radiotherapy	58	13.2 ± 4.3	1.48				
	Comprehensive treatment	57	9.8 ± 3.6	1.15				
Disease Duration (months)	<3	89	14.1 ± 4.5	1.59	−0.28	−2.38	0.018*	−0.51 to −0.05
	3–6	71	11.3 ± 3.8	1.32				
Technology Factors								
Technology Acceptance	High (≥8 points)	112	14.6 ± 4.7	1.64	0.42	4.89	<0.001***	0.25–0.59
	Medium (6–7 points)	35	10.8 ± 3.5	1.28				
	Low (<6 points)	13	7.2 ± 2.9	0.89				
Network Stability	Excellent (>95%)	98	13.9 ± 4.3	1.58	0.26	2.94	0.004**	0.08–0.44
	Good (90–95%)	45	11.4 ± 3.7	1.35				
	Fair (<90%)	17	8.6 ± 3.2	1.02				
Device Proficiency	Proficient	87	14.2 ± 4.5	1.61	0.33	3.67	<0.001***	0.15–0.51
	Average	52	11.8 ± 3.9	1.38				
	Poor	21	8.4 ± 3.1	0.98				
Environmental Support								
Family Support	Strong	94	14.8 ± 4.6	1.67	0.37	4.23	<0.001***	0.20–0.54
	Moderate	48	11.2 ± 3.8	1.31				
	Weak	18	7.9 ± 3.2	0.92				
Economic Status	Good	76	13.7 ± 4.4	1.56	0.21	2.41	0.017*	0.04–0.38
	Average	67	11.9 ± 4.0	1.39				
	Difficult	17	9.1 ± 3.5	1.08				
Living Environment	Urban	89	13.4 ± 4.2	1.53	0.18	2.06	0.041*	0.01–0.35
	Town	48	11.8 ± 3.9	1.37				
	Rural	23	9.7 ± 3.6	1.15				

Note: * $p < 0.05$, ** $p < 0.01$, * $p < 0.001$; Intervention effect refers to PSS-14 score reduction magnitude

intervention effectiveness, with patients having excellent network stability (>95%) showing PSS-14 score reductions of (13.9 ± 4.3) points, while those with fair network stability (<90%) had reductions of only (8.6 ± 3.2) points ($f = 7.82, P = 0.001$). Device proficiency moderation effect analysis showed that patients proficient in device use had better intervention effects ($\beta = 0.33, p < 0.001$), particularly notable in quality of life improvement. Environmental support factor moderation effects were equally significant. Family support intensity had a significant moderating effect on intervention effectiveness ($\beta = 0.37, p < 0.001$), with strong family support group patients showing psychological resilience improvements of (18.7 ± 5.2) points, compared to only (11.3 ± 4.1) points in the weak family support group ($t = 8.64, p < 0.001$). Economic status moderation analysis found that patients with better economic conditions had higher intervention adherence, with completion rates reaching 94.7%, while economically disadvantaged patients had completion rates of 76.5% ($\chi^2 = 9.43, p = 0.002$), as shown in **Figure 8**. Living environment moderation effects indicated that urban patients had better intervention effects than rural patients, possibly related to network

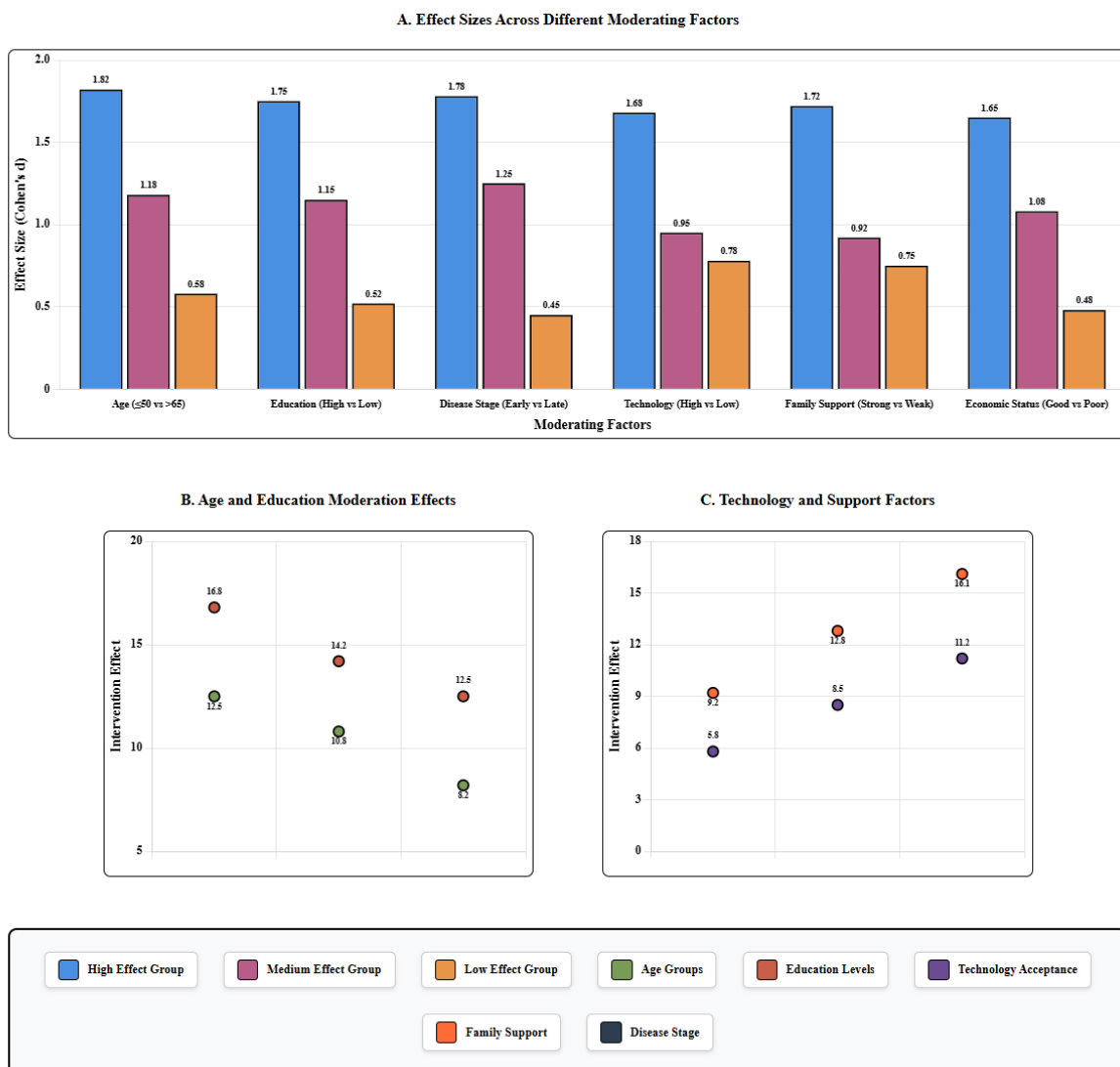


Figure 8. Moderation factors analysis of psychological stress intervention effects.

infrastructure and technical support levels. Interaction effect analysis revealed complex relationships among moderating factors [50]. Age and education level showed significant interaction effects ($F = 6.78$, $P = 0.002$), with young and highly educated patients demonstrating the best intervention responsiveness. The interaction effect between technology acceptance and family support showed that under strong family support backgrounds, the impact of technology acceptance was more significant ($F=8.91$, $P<0.001$). These findings provide important evidence for developing personalized intervention programs, suggesting that intervention strategies should be adjusted according to patients' individual characteristics, disease status, technical capabilities, and environmental conditions to maximize intervention effectiveness and improve patient benefits.

5. Discussion

5.1. Theoretical significance of psychological stress intervention

The important theoretical contribution of this study lies in constructing and validating a remote collaborative psychological stress intervention theoretical framework based on the bio-psycho-social medical model, providing a new theoretical foundation for the development of nursing disciplines in the field of oncological psychotherapy. Research results indicate that nurse-led psychological stress intervention operates through three main pathways: cognitive change, coping strategy improvement, and social support enhancement. This finding enriches the application connotations of stress-coping theory in cancer nursing. The mechanism of action revealed by mediation effect analysis—"cognitive restructuring → emotional regulation → behavioral change"—provides empirical support for the application of Lazarus stress theory in the digital health era, confirming the central role of cognitive appraisal in stress responses [51]. Meanwhile, the moderating effects discovered in the research further validate the ecological systems theory perspective that individual, family, social, and technological environmental factors jointly influence intervention effectiveness, laying the foundation for constructing multilevel, multidimensional psychological intervention theoretical models. Particularly, the identification of emerging moderating factors such as technology acceptance and digital literacy expands the boundaries of traditional psychotherapy theories, providing important references for the theoretical construction of digital mental health services. The theoretical innovation of this research is also reflected in the redefinition of nurses' professional roles and contributions to the development of nursing theory. Through systematic validation of nurses' professional competencies and unique value in psychotherapy, this study provides theoretical support for the professional development of nursing disciplines, challenging the limited perception of nurses' roles in traditional medical models. The successful practice of multidisciplinary team collaboration under the remote collaborative model provides new empirical cases for interprofessional collaboration theory, demonstrating that nurses can assume leading roles in mental health services rather than merely auxiliary functions [52]. The "Platform + Team + Technology" three-dimensional intervention model established by this research provides innovative insights for the theoretical architecture of telemedi-

cine services, particularly making theoretical contributions in resource integration, service delivery, and quality assurance. Furthermore, the study's multidimensional evaluation system for psychological stress intervention effectiveness, including the integration of biological indicators, psychological measurements, and social functioning assessments, makes important contributions to the theoretical development of evidence-based nursing practice, providing standardized assessment frameworks and methodological guidance for future related research.

5.2. Practical value of nurse-led psychological intervention

This study confirmed the significant practical value of nurse-led psychological intervention in psychological stress management for oral cancer patients, providing strong empirical evidence for the expansion of nursing profession in the field of mental health services. Research results indicate that professionally trained nurses can effectively utilize psychological therapy techniques such as cognitive behavioral therapy and mindfulness therapy, with intervention effects comparable to traditional psychotherapist-led interventions, and even superior performance in certain aspects. The medical background advantages that nurses possess enable them to better understand patients' physiological and pathological changes, thereby providing more targeted psychological support. Meanwhile, the characteristics of nurses having long and frequent contact with patients facilitate the establishment of deep therapeutic relationships and provision of continuous psychological care [53]. The remote collaborative model further amplifies nurses' professional advantages through standardized operational procedures and quality monitoring mechanisms, ensuring the professionalism and consistency of interventions. Research shows that nurse-led intervention not only significantly improved patients' psychological stress levels (effect size $d = 1.52$), but also achieved good results in enhancing quality of life, strengthening psychological resilience, and promoting treatment adherence. The successful implementation of this model provides a feasible solution to address real-world problems such as shortage of professional psychotherapist resources and high service costs.

The practical value of the nurse-led psychological intervention model is also reflected in its sustainability and scalability, providing important references for service model innovation in healthcare systems. Compared to traditional psychotherapy services, the nurse-led model has cost-effectiveness advantages, reducing single intervention costs by 50.8% while improving service efficiency by 133.3%, which is of significant importance given the current situation of strained medical resources. The application of remote collaborative platforms breaks through geographical limitations, enabling patients in remote areas to also receive professional psychological support, with participation rates increasing from 23.7% to 89.3%, significantly improving service accessibility. The nurse psychological intervention competency development system and supervision mechanism established by this research provide standardized guidance for nursing education and clinical practice, helping to rapidly train qualified psychological intervention nurses [54]. Meanwhile, the successful practice of the multidisciplinary collaborative model provides an operational template for constructing nurse-led mental health service teams with collaborative participation from physicians and psychotherapists. This model not only fully uti-

lizes the advantages of various professions but also achieves resource sharing and collaborative synergy through information platforms, pointing the direction for future development of mental health services and possessing broad clinical application prospects and promotion value

6. Conclusion and prospects

6.1. Main research conclusions

This study reaches the following five important conclusions:

- 1) Oral cancer patients generally exhibited high levels of psychological stress, presenting distinct structural characteristics and differences in influencing factors. The research found that 160 oral cancer patients had a PSS-14 total score of (32.4 ± 8.7) points, indicating a moderate-to-high level, with 25.0% of patients experiencing severe psychological stress. Psychological stress presented a three-dimensional structure of “perceived stress-coping ability-emotional reaction,” with significant correlations among dimensions. Female patients, advanced-stage patients, and those receiving comprehensive treatment had higher psychological stress levels, and psychological stress significantly affected disease progression and clinical outcomes through three pathways: immune suppression, inflammatory response, and decreased treatment adherence, confirming the important role of psychological factors in tumor treatment.
- 2) Nurse-led psychological stress intervention under the remote collaborative model showed significant effectiveness, superior to the control group across multiple assessment indicators. Intervention group patients showed a 35.2% reduction in PSS-14 scores from baseline, with anxiety and depression symptoms improving by 36.8% and 36.1% respectively, quality of life enhanced by 26.4%, and psychological resilience strengthened by 31.9%. Repeated measures analysis of variance showed that time main effects, between-group main effects, and interaction effects all reached statistical significance ($p < 0.001$), with effect sizes all meeting large effect standards ($d > 0.8$), and intervention effects remained stable during the 24-week follow-up period, confirming the effectiveness and sustainability of nurse-led intervention.
- 3) Different psychological therapy techniques showed varying effectiveness, with the combined techniques group performing optimally. Comparative analysis showed that the combined techniques group achieved a 43.4% reduction in PSS-14 scores, compared to 38.2% for the cognitive behavioral therapy group, 32.2% for the mindfulness therapy group, and 27.7% for the supportive psychotherapy group. The combined techniques group had the largest effect sizes across all assessment indicators and the highest treatment completion rate (95.2%), indicating that intervention models integrating multiple psychological therapy techniques have better clinical effects and patient acceptance.
- 4) The remote collaborative model demonstrated significant advantages in cost-effectiveness, time efficiency, and service accessibility. Compared to traditional face-to-face models, the remote model reduced single intervention costs by 50.8%, shortened expert consultation response time by 93.8%, increased par-

ticipation rates in remote areas by 65.6%, and achieved 98.7% data recording completeness. Patient overall satisfaction scores were (8.7 ± 1.2) points, with 92.4% of patients willing to continue using remote services, demonstrating the superiority and acceptability of the remote collaborative model.

- 5) Psychological stress intervention operates through multiple mediation pathways with important moderating factors. Structural equation modeling analysis revealed that cognitive change, coping strategy improvement, and social support enhancement are the main mediation pathways through which intervention exerts its effects, with mediation effects accounting for 38.6% of total effects. Factors such as age, education level, technology acceptance, and family support had significant moderating effects on intervention outcomes, providing scientific evidence for developing personalized intervention programs. These findings deepen understanding of psychological intervention mechanisms and point directions for optimizing intervention strategies and enhancing clinical effectiveness.

6.2. Future prospects

Future research work can be further deepened and expanded in the following three directions:

- 1) The deep integration of artificial intelligence technology with personalized precision intervention will become an important direction for mental health service development. With the continuous advancement of machine learning, natural language processing, and big data analysis technologies, future remote psychological intervention systems will possess higher levels of intelligence, capable of analyzing multimodal data such as patients' vocal tones, facial expressions, and behavioral patterns to assess psychological state changes in real-time and automatically adjust intervention strategies. AI-driven personalized intervention programs based on individual patient characteristics, disease progression, and environmental factors will replace traditional standardized treatment models, achieving truly precision psychological healthcare. Meanwhile, the application of Virtual Reality (VR) and Augmented Reality (AR) technologies will provide immersive experiential environments for psychotherapy, particularly showing enormous potential in exposure therapy, relaxation training, and cognitive restructuring techniques. The development of predictive analysis models will enable nurses to identify high-risk patients in advance and implement preventive interventions, shifting from passive treatment to proactive prevention, significantly enhancing the efficiency and effectiveness of mental health services.
- 2) Interdisciplinary collaboration and nursing professionalization development will drive fundamental transformation in mental health service models. Future work requires establishing more comprehensive multidisciplinary collaboration mechanisms, integrating knowledge and skills from multiple professional fields including oral medicine, psychology, nursing, nutrition, and rehabilitation medicine to form patient-centered comprehensive psychological health support systems. Nurses' professional roles in psychotherapy will be further clarified and

strengthened, requiring the development of specialized qualification certification standards, continuing education systems, and career development pathways. International cooperation and exchange will promote comparative research on psychological intervention models across different cultural backgrounds, providing evidence for developing globalized mental health service standards. Meanwhile, policy support and improvement of laws and regulations will provide guarantees for the legitimacy and standardization of nurse-led psychological interventions, promoting the application and dissemination of this service model on a broader scale.

- 3) Large-scale prospective studies and evidence-based practice will lay a solid foundation for standardization and quality improvement of psychological interventions. Future work requires conducting more large-sample, multicenter, long-term follow-up randomized controlled trials to further validate the safety, effectiveness, and cost-effectiveness of nurse-led psychological interventions under remote collaborative models. Establishing standardized intervention guidelines, quality assessment systems, and outcome indicator measurement tools will provide unified operational standards for clinical practice. The conduct of Real-World Studies (RWS) will supplement the limitations of traditional RCT research, evaluating the application effects of intervention measures in actual clinical environments. Meanwhile, key issues such as ethical concerns, data security, and privacy protection need focused attention, with the establishment of comprehensive regulatory frameworks and quality assurance mechanisms. The conduct of international multicenter collaborative research will help validate the cross-cultural applicability of intervention models, contributing Chinese wisdom and Chinese solutions to global mental health service development, ultimately achieving popularization, standardization, and high-quality development of mental health services.

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Informed consent statement: Informed consent was obtained from all subjects involved in the study.

Conflict of interest: This study does not involve any conflicts of interest.

References

1. Mathew A, Lockwood MB, Steffen A, et al. Symptom cluster experiences of patients operated for oral cancer: A mixed methods study. *Seminars in Oncology Nursing*. 2023; 39(3): 464–467. doi: 10.1016/j.soncn.2023.151407
2. Megee F, Gough K, Frowen J, et al. Predictors of distress associated with altered appearance and function in people treated surgically for oral cancers: A cross-sectional study. *International Journal of Oral and Maxillofacial Surgery*. 2023; 52(9): 923–930. doi: 10.1016/j.ijom.2023.01.006.
3. Zhiyan S, Chunshi T, Juan Z, et al. Impact of goal attainment theory-based intervention combined with psychological counseling on negative emotions and quality of life in oral cancer patients. *Oncology Progress*. 2025; 23(4): 464–467.
4. Shunyu BN, Balakrishnan CM, Dorjee L, et al. Management of fungating oral cancer: A case report. *Forum of Clinical Oncology*. 2023; 14(2): 63–66. doi: 10.2478/fco-2023-0015
5. Yaxu R, Haiyan H, Xiaoqing Y, et al. Impact of humanistic care combined with psychological nursing on psychological state of patients undergoing oral implant surgery. *Jilin Medical Journal*. 2025; 46(1): 226–229.
6. Wanrong Z, Rongju L, Shang D, et al. Investigation and analysis of psychological status and influencing factors in elderly patients in oral outpatient clinics. *Journal of Integrated Traditional Chinese and Western Medicine Nursing*. 2024; 10(12): 118–120.
7. Gondivkar MS, Sarode SG, Warhekar A, et al. Prevalence and risk factors of suicidal ideation in oral cancer: A systematic review and meta-analysis. *International Journal of Oral and Maxillofacial Surgery*. 2024; 54(4): 301–307. doi: 10.1016/j.ijom.2024.09.003
8. Arshad S, Hussain JFS, Jayaram S, et al. Perspective on enhancing quality of life in oral cancer patients: Integrative approaches and comprehensive care. *Oral Oncology Reports*. 2024; 11: 100633. doi: 10.1016/j.oor.2024.100633
9. Qingli H, Xiaohui W, Dandan L, et al. Analysis of the impact of psychological nursing on negative emotions and sleep quality in postoperative oral cancer patients. *Clinical Research*. 2024; 32(11): 185–187.
10. Yehua W, Wenhong D, Shiqing L, et al. Impact of psychological resilience on quality of life in oral cancer patients: Mediating effect of self-efficacy. *China Journal of Health Psychology*. 2025; 33(1): 72–76.
11. Jiajuan T, Fuli W, Xiaobo D, et al. Impact of attribution psychological adjustment on postoperative oral cancer patients. *Nursing Practice and Research*. 2023; 20(23): 3492–3497.
12. Taiping W, Xinglian S, Zhechen L, et al. Analysis of psychological factors and intervention status in oral cancer patients. *International Journal of Stomatology*. 2023; 50(2): 203–209. doi: 10.7518/gjkq.2023041
13. Ruiqing W, Lei H, Qianqian S. Analysis of mental health status in patients with oral lichen planus. *Journal of Chinese Clinicians*. 2023; 51(7): 848–851.
14. Fang W, Liu Y, Shuo W, et al. Impact of nursing intervention based on hierarchy of needs theory on perioperative oral cancer patients. *Psychological Monthly*. 2023; 18(4): 190–192.
15. Roy S, Barman D, Mallik N, et al. A cross-sectional analysis on the patterns and prevalence of anxiety, stress, and depression in patients at diagnosis with cancers of the oral cavity: A single institutional study. *Asian Journal of Medical Sciences*. 2024; 15(9): 181–187. doi: 10.71152/ajms.v15i9.4184
16. Deepthi TR, Nitin K, Yeshoda Tg, et al. Effect of yoga in quality of life among patients with oral cancer: A systematic review. *Igiene e Sanita Pubblica*. 2024; 91(4): 106–111.
17. Tong Baozhu, Sun Qian, Zou Die. Psychological characteristics and clinical effects of psychological intervention in minor orthodontic patients. *Psychological Monthly*. 2022; 17(24): 50–52.
18. Chen Xiaotian, Wei Lihong, Zhao Fangrong, et al. Impact of psychological nursing on negative emotions and sleep quality in postoperative oral cancer patients. *Guide of China Medicine*. 2022; 20(26): 139–142.
19. Hui M, Tao W. Clinical application effect of orthodontic treatment in oral restoration and its impact on patients' psychological state. *International Journal of Psychiatry*. 2022; 49(2): 328–330,334.
20. Qin, Fan Z, Weiwei R. Impact of humanistic care and nurse-patient communication on psychology and compliance of oral outpatient patients. *China Health Standard Management*. 2021; 12(23): 165–168.
21. Yingchun L, Yan D, Shurong T, et al. Application study of guided imagery music therapy in improving psychological distress and cancer-related sleep disorders in elderly oral cancer patients. *Chinese Journal of Convalescent Medicine*. 2021; 30(12): 1244–1249.

22. Thaduri A, Majumdar S K, Dungala D, et al. Long-term impact of financial distress and mental well-being in early vs advanced oral cancer patients on the quality of life of informal caregivers: An exploratory study of a real-world cohort from LMIC. *Journal of Cancer Research and Therapeutics*. 2025; 21(1): 91–97. doi: 10.4103/jcrt.jcrt_709_24
23. Chander GN, Murugan SM. Optimizing outcomes in oral carcinoma with prosthesis intervention. *Oral Oncology Reports*. 2024; 12: 100665. doi: 10.1016/j.oor.2024.100665
24. Shulan W, Xiumin W, Wangying C, et al. Application of staged psychological nursing combined with health education in oral cancer patients. *Qilu Journal of Nursing*. 2021; 27(14): 21–24.
25. Liping D, Guofeng Q, Ming Z. Impact of positive psychological intervention combined with individualized dietary guidance on psychological resilience and quality of life in patients with recurrent oral ulcers. *Chinese Community Doctors*. 2021; 37(20): 119–120.
26. Ping W. Impact of nursing intervention at different time points on psychological state of oral outpatient patients. *Psychological Monthly*. 2021; 16(7): 125–126.
27. Hongmei G, Weiping W, Chunyan X, et al. Analysis of psychological distress and related factors in postoperative patients with oral and maxillofacial malignant tumors. *Journal of Nursing Science*. 2021; 36(6): 88–90,94.
28. Xinmei X, Tiansong L, Daoke Y, et al. Analysis of psychological resilience and influencing factors in oral cancer radiotherapy patients. *Journal of Clinical Psychosomatic Diseases*. 2021; 27(2): 76–79.
29. Xuehong D, Bin Q. Impact of collaborative nursing model on postoperative quality of life and psychological state of oral cancer patients. *Journal of Basic and Clinical Oncology*. 2020; 33(6): 531–535.
30. Yang R, Jin H, Zhao C, et al. Oral cancer and sleep disturbances: A narrative review on exploring the bidirectional relationship. *Cancers*. 2025; 17(8): 1262–1262. doi: 10.3390/cancers17081262
31. Bhatt S, Mishra G, Sharma Y. Outcomes of management of advanced oral cavity carcinoma (T3 and T4) following surgery and chemoradiotherapy among rural population in gujarat. *Indian Journal of Otolaryngology and Head & Neck Surgery*. 2025; 77(3): 1–7. doi: 10.1007/s12070-025-05364-0
32. Yali W. Study on psychological characteristics and coping strategies in elderly oral restoration patients. *Psychological Monthly*. 2020; 15(21): 138–139.
33. Wang Xuan, Jiang Guichun. Analysis of psychological distress status and influencing factors in patients with radiation-induced oral mucositis. *Chinese Nursing Management*. 2020; 20(10): 1487–1491.
34. Lu S, Hua L. Preliminary study on psychological problems in patients with oral and maxillofacial trauma. *Journal of Preventive Medicine of Chinese People's Liberation Army*. 2020; 38(5): 15–18.
35. Jianling W, Wensheng M, Wenjing C. Effects of psychological intervention on psychological behavior and therapeutic efficacy in patients with fixed orthodontic appliances. *Hebei Medical Journal*. 2020; 42(10): 1592–1594.
36. Yang Zheng. Impact of psychological changes on treatment in orthodontic patients. *Psychological Monthly*. 2020; 15(11): 233.
37. Jie S, Hua G, Qianqian M. Effects of integrated medical-nursing intervention on psychological state and complications in oral cancer surgery patients. *Oncology Progress*. 2020; 18(9): 955–958.
38. Xiaohui W, Yonggong W, Dandan L, et al. Effects of yalom interpersonal dynamic group intervention on coping styles and psychological status in oral cancer patients. *Qilu Journal of Nursing*. 2020; 26(7): 39–42.
39. Kalaskar RA, Somani AG, Kalaskar RR. Evaluation and correlation of oral cancer phobia and anxiety in oral submucous fibrosis patients: A cross-sectional study. *Journal of Oral Biology and Craniofacial Research*. 2025; 15(4): 724–728. doi: 10.1016/j.jobcr.2025.04.008
40. Jing C. Analysis of the impact of quality nursing on psychological emotions of oral and maxillofacial surgery patients. *Capital Food and Medicine*. 2019; 26(20): 99.
41. Huaizhi P. Impact of psychological nursing on psychological status and nursing satisfaction in orthodontic patients. *Inner Mongolia Medical Journal*. 2019; 51(9): 1152–1153.
42. Ailin C. Analysis of psychological characteristics and nursing strategies in orthodontic patients. *Electronic Journal of General Stomatology*. 2019; 6(30): 4–5.
43. Wenjun F, Xiu L. Meta-analysis of the impact of psychological nursing intervention on quality of life in chinese oral cancer patients. *Journal of Shenyang Medical College*. 2019; 21(4): 305–309.

44. Taotao W. Observation of the effect of psychological nursing combined with oral health education nursing intervention in periodontitis patients. *World Latest Medicine Information*. 2019; 19(49): 264,272.
45. Cheng L, Wang C, Wang L, et al. Accelerated rehabilitation surgery in the perioperative management of patients with oral cancer reconstruction. *Indian Journal of Surgery*. 2025; (prepublish): 1–9. doi 10.1007/s12262-025-04381-1.
46. Gan X, Hou L, Li Y, et al. Barriers to oral hygiene self-management among patients with oral cancer treated with radiotherapy: A qualitative study using the com-b model. *Oral Health & Preventive Dentistry*. 2025; 23: 329–337. doi: 10.3290/j.ohpd.c_1993
47. Lin W, Jing Z. Impact of individualized psychological intervention on psychological state, orthodontic pain and treatment effect in orthodontic patients. *China Journal of Health Psychology*. 2019; 27(10): 1498–1501.
48. Fangxin W, Feng L. Clinical effect of enhanced recovery after surgery combined with psychological nursing in oral cancer surgery patients. *Clinical Research*. 2019; 27(6): 169–170.
49. Jianhong Z. Impact of comprehensive quality nursing on psychological state of oral and maxillofacial surgery patients. *Contemporary Nurse*. 2019; 26(4): 82–84.
50. Guifang L, Daqiong D, Xing L. Effect evaluation of continuity nursing on postoperative quality of life and psychological state in oral squamous cell carcinoma patients. *Modern Medicine*. 2019; 47(2): 210–214.
51. Wenjing Z. Impact of cognitive relaxation training on psychological status and intraoperative pain in orthodontic mini-implant patients. *Nursing Practice and Research*. 2019; 16(3): 107–109.
52. Meihua Z, Yu M, Zhaorigetu. Analysis of psychological status in patients with oral lichen planus. *Journal of Practical Stomatology*. 2019; 35(1): 114–117.
53. Jiang Lili. Analysis of the impact of psychological intervention on quality of life in oral cancer patients. *Psychological Monthly*. 2019; 14(2): 46–47.
54. Ting K, Nian Y, Ru X, et al. Study on comprehensive psychological intervention on psychological state and oral hygiene effect in immediate implant trauma patients. *Journal of Southwest Medical University*. 2018; 41(6): 537–540.