Psycho-Oncologie 2025, 19(3), 4157.
https://doi.org/10.18282/po4157

Article

Integrating psychological health management and Fluorine-18 nuclear medicine nursing in cancer treatment: An innovative model for enhanced radiation protection

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CITATION

Zou Y, Bai Y. Integrating psychological health management and Fluorine-18 nuclear medicine nursing in cancer treatment: An innovative model for enhanced radiation protection. Psycho-Oncologie. 2025; 19(3): 4157. https://doi.org/10.18282/po4157

ARTICLE INFO

Received: 25 February 2025
Revised: 24 March 2025
Accepted: 25 March 2025
Available online: 4 July 2025

Abstract: Background: Fluorine-18 (F-18) nuclear medicine procedures often cause cancer patients undergoing the treatment to experience severe psychological distress, while also exposing healthcare workers to occupational radiation exposure. The study aimed to evaluate the integration of psychological health management with the Radiation-Sensitive Nursing Care Model (R-SNCM) to improve patient treatment outcomes, compliance, and healthcare worker safety. **Methods:** A prospective observational study was conducted at a tertiary care cancer center from January 2022 to December 2023. The study involved 236 participants, including 200 cancer patients and 36 healthcare professionals. The R-SNCM framework included patient education, emotion monitoring using the Hospital Anxiety and Depression Scale (HADS), and advanced radiation safety protocols. Outcomes were assessed through psychological scores, radiation exposure indicators, patient satisfaction, and surgical compliance. Statistical analyses were performed through paired *t*-tests, repeated-measures Analysis of Variance (ANOVA), and logistic regression. **Results:** After the intervention, the psychological distress of patients significantly decreased, with anxiety scores reducing from 10.6 ± 3.1 to 7.3 ± 2.6 and depression scores decreasing from 9.4 ± 3.5 to 6.5 ± 2.8 ($p < 0.001$). The monthly radiation exposure of healthcare workers was observably reduced, from 2.6 ± 0.5 mSv to 1.8 ± 0.4 mSv ($p < 0.001$). Patient satisfaction scores increased from 3.8 ± 0.7 to 4.6 ± 0.4 ($p < 0.001$), and surgical compliance improved to 95% in the intervention group compared to 81% in the control group ($p < 0.001$). Logistic regression indicated that attendance at training sessions (Odds Ratio (OR) = 2.85, $p < 0.001$) and baseline anxiety scores ($\beta = 0.42$, $p < 0.001$) were significant predictive factors of compliance and psychological improvement, respectively. **Conclusion:** The integration of psychological health management with the R-SNCM significantly improved psychological outcomes, patient compliance, and satisfaction, while reducing radiation exposure for healthcare workers. These findings support the adoption of this model as a holistic approach to cancer care.

Keywords: nursing; psychological health; cancer; radiation protection; Fluorine-18; nuclear medicine; Radiation-Sensitive Nursing Care Model (R-SNCM)

1. Introduction

Cancer remains one of the leading causes of morbidity and mortality worldwide, with more than 19 million new cases in 2020 alone [1]. Cancer not only brings an enormous psychological burden to patients, but also imposes a heavy economic burden on their families and even society. In the tremendous progress of oncology diagnosis and treatment, as a multidisciplinary field, nuclear medicine can achieve early detection, precise localization of systemic lesions, molecular-level diagnosis, and provide a sufficient basis for clinicians to select appropriate treatment plans [2]. In the treatment of tumors, nuclear medicine can accurately target the delivery of radionuclides to tumor cells, improve the quality of life of patients and prolong survival, so it has irreplaceable value. Among them, nuclear medicine containing Fluorine-18 (F-18) has become the cornerstone of precision imaging and therapy. F-18, widely used in positron emission tomography (PET) imaging, has unparalleled sensitivity and specificity in detecting metabolic abnormalities and can be used for early diagnosis, staging, and monitoring of cancer development [3,4]. As research continues to unleash its full potential, F-18 will undoubtedly play a greater role in shaping the future of medical diagnosis and personalized medicine. However, the application of F-18 in nuclear medicine presents a dual challenge: the mental health of patients and effective radiation protection for medical professionals [5].

Because of the special nature of cancer, patients often experience a lot of psychological distress, such as anxiety, depression, and a general fear of the future. A cross-sectional study involving 1011 patients showed that the prevalence of depression and anxiety symptoms in all patients was 23.4% and 19.1%–19.9%, respectively. Moreover, depressive symptoms and anxiety symptoms were more common in hospitalized patients than in outpatients ($p < 0.001$) [6]. Diagnostic and therapeutic interventions often exacerbate these feelings, especially in the high-risk setting of nuclear medicine [7]. Research has demonstrated that psychological distress has adverse effects on treatment compliance, decreases the effectiveness of medical intervention, and affects overall quality of life [8]. For example, anxiety about the diagnostic process and outcome can decrease the effectiveness of patient-nurse communication, thereby affecting the provision of optimal care [9]. However, the psychological pressure of patients is not uncontrollable, it can be alleviated by psychological counseling, psychological treatment and other methods. In addition, the lack of understanding of nuclear medicine among patients leads to great fear when undergoing nuclear medicine examinations or treatments. Therefore, integrating mental health management into standard nuclear medicine practice is crucial for managing the overall needs of patients [10].

In addition to the psychological impact on patients, nuclear medicine testing also poses occupational hazards to healthcare workers, especially nurses. A cross-sectional study involving 31 healthcare workers exposed to ionizing radiation showed a significant increase in malondialdehyde (MDA) levels and a significant decrease in superoxide dismutase (SOD) levels, and a significant decrease in red blood cells and hemoglobin levels compared to non-exposed healthcare workers, indicating that ionizing radiation exposure can induce oxidative stress [11]. It has been recognized that prolonged exposure to ionizing radiation, even at low levels, increases the risk of adverse health effects and requires cautious radiation protection measures [12]. In some cases, patients who are undergoing nuclear medicine treatment can easily leave the isolation area due to psychological stress, and nurses are also exposed to additional radiation. The International Commission on Radiological Protection (ICRP) has also stressed that exposure is kept "as low as reasonably achievable" (ALARA) through time management, distance, and shielding techniques [13]. These practices tend to be technology-oriented, with less emphasis on how to modify care procedures to incorporate both patient-centered psychological support and radiation protection.

The role of nurses in F-18 nuclear medicine is critical, encompassing responsibilities ranging from technical preparation and procedural execution to personalized patient care [14]. Although existing nursing frameworks play a critical role at the intersection of clinical expertise and patient interaction, they often prioritize procedural accuracy over mental health, inadvertently leaving a gap in patient-centered comprehensive care. Addressing this gap requires a paradigm shift that combines mental health management with excellent technology in radiation safety.

The newly proposed Radiation-Sensitive Nursing Care Model (R-SNCM) aims to bridge the above gap by providing an innovative dual-perspective cancer care model for the nuclear medicine environment. The R-SNCM combines mental health management with upgraded radiation safety protocols in an effort to provide a safer, more sensitive environment for both patients and healthcare professionals. The important features of the R-SNCM include providing sensitive education to patients based on their unique emotional needs, immediately monitoring psychological reactions, conducting adaptive dose titration for optimal radiation protection, and upgrading shielding practices to protect healthcare professionals [15–18]. This holistic approach aims to improve patient satisfaction, enhance treatment compliance, and establish a new standard for nuclear medicine practice nursing.

This study aims to develop and evaluate the R-SNCM as a new model for incorporating mental health management and radiation protection into cancer care, and to assess the impact of R-SNCM on the mental health of cancer patients undergoing F-18 nuclear medicine treatment.

2. Materials and methods

2.1. Study design

This was a prospective observational study carried out at a tertiary care cancer center from January 2022 to December 2023. The study adopted a mixed methods design, quantitatively measuring psychological outcomes and radiation safety, and qualitatively examining patient and healthcare worker experiences. The R-SNCM was used as the primary framework, with a focus on mental health management, real-time emotional monitoring, and improving radiation safety practices. The study was divided into three phases: baseline assessment, R-SNCM implementation, and follow-up evaluation.

2.2. Participant selection

236 participants were enrolled in the study, including 200 cancer patients who underwent F-18 nuclear medicine procedures and 36 healthcare professionals involved in the administration and management of these procedures. Patients were recruited according to the following inclusion criteria:

1) A proven diagnosis of malignancy necessitating PET scanning or F-18 tracer radiation therapy.
2) Age of 18 to 75 years.
3) The ability to provide informed consent and to communicate in the local language.

Patients with prior psychosis, individuals with severe cognitive deficits, and those receiving other concurrent experimental treatments were excluded from the study.

Healthcare workers were included if they had at least six months of experience in nuclear medicine and were directly involved in F-18 procedures. Those who had previous occupational exposure exceeded the above recommended limits or had contraindications to radiation medicine were excluded. Participants were recruited through consecutive sampling, and the final sample size was estimated to account for a 20% attrition rate.

In the study evaluating psychological health management with the R-SNCM, the control group and intervention group were designed to compare the effectiveness of the R-SNCM against standard care. The control group consisted of cancer patients undergoing F-18 nuclear medicine treatment who received standard care without the additional components of the R-SNCM. Standard care typically includes: (1) Providing the patient with basic procedure information; (2) conventional radiation safety measures (such as standard shielding schemes, fixed radiation doses); (3) lack of structured psychological support or emotional monitoring. Standard care represents the current best practice, ensuring that patients in the control group still receive adequate treatment and safety measures.

2.3. Intervention: Radiation-Sensitive Nursing Care Model (R-SNCM)

The R-SNCM model was applied to the intervention group, with an emphasis on the following components:

- Patient education and psychological support: Individualized education sessions were provided to patients based on their emotional needs. Procedural information, safety guidelines, and coping strategies were taught through educational modules to reduce anxiety. The education sessions were conducted by trained nuclear medicine nurses and involved relaxation skills such as guided imagery and breathing.
- Emotional monitoring and response: Real-time monitoring of emotions was performed using a proven assessment tools, the Hospital Anxiety and Depression Scale (HADS), at baseline, after intervention, and on follow-up occasions. An emotional reaction was recorded in order to calibrate the level of psychological care provided.
- Radiation safety procedures:
  (1) Radiation doses are meticulously adjusted based on patient-specific factors to ensure optimal balance between diagnostic/therapeutic efficacy and radiation safety. Key considerations include:

1) Patient size and weight: Smaller patients or pediatric populations may receive reduced doses, as their lower body mass necessitates proportional adjustments to avoid excessive exposure.

2) Organ function: Patients with compromised renal or hepatic function may require dose modifications to minimize metabolic burden and radiation-related risks.

3) Clinical objective: Diagnostic versus therapeutic procedures may influence dose calculations, with therapeutic applications often requiring higher doses to achieve clinical endpoints.

4) ALARA compliance: All dose adjustments adhere to the as low as reasonably achievable ALARA principle, ensuring that radiation exposure is minimized while maintaining procedure effectiveness. This aligns with international guidelines (ICRP 2012) emphasizing radiation protection optimization.

(2) Comprehensive shielding strategies are employed to protect patients and staff:

1) Personal Protective Equipment (PPE): Lead aprons are worn during procedures to shield radiosensitive organs such as the thyroid and gonads, reducing localized exposure.

2) Lead barriers: Fixed or mobile lead shields are positioned to block scattered radiation during imaging or treatment.

3) Distance optimization: Patients are positioned at maximal safe distances from radiation sources, leveraging the inverse-square law to minimize exposure.

4) Streamlined Workflows: Efficient patient positioning and standardized protocols reduce procedural duration, particularly in high-exposure areas.

5) Imaging quality control: Minimizing retakes through real-time image review lowers cumulative radiation exposure.

- Healthcare worker safety: Personal dosimeters were employed to measure the radiation exposure levels of healthcare workers. Time management, distance, and shielding were the radiation protection principles covered in regular training sessions.

2.4. Data collection procedures

Information was collected by integrating structured questionnaires, observation lists, and dosimetric measurement. Demographic and clinical baseline data were retrieved from medical records, psychological patient assessments were conducted using HADS, and occupational exposure of healthcare workers was quantified through the use of thermoluminescent dosimeters (TLDs).

Patient adherence to F-18 procedures was measured through the compliance checklist, while patient satisfaction with care was assessed through a five-point Likert scale. The feedback of healthcare workers on the R-SNCM framework was recorded through semi-structured interviews. Interview questions focused on: (1) Describe challenges/facilitators of implementing R-SNCM protocols. (2) How did R-SNCM affect your workflow or patient interactions? (3) What suggestions would you give to improve this framework? Qualitative data were analyzed using NVivo. Employing Braun and Clarke's six-phase thematic analysis framework, our methodology systematically progressed through: (1) Immersive engagement with the dataset to establish contextual understanding; (2) iterative development of provisional coding structures; (3) pattern recognition to surface candidate themes; (4) critical evaluation of theme coherence and relevance; (5) conceptual refinement and semantic anchoring of finalized themes; and (6) synthesis of findings into a comprehensive analytical narrative.

2.5. Evaluation and outcome measures

The research assessed the impact of R-SNCM on the following outcome measures:

- Psychological results in patients: Anxiety and depression ratings were measured at three time points: baseline, post-intervention, and at one month follow-up. The decrease in HADS scores was the main psychological outcome.
- Radiation safety metrics for healthcare professionals: Monthly dosimeter measurements were examined to evaluate occupational radiation exposure prior to and subsequent to the adoption of R-SNCM. The reduction of cumulative radiation doses was considered an improvement.
- Patient satisfaction and compliance: Changes in patient-reported satisfaction scores and adherence to F-18 procedures were analyzed. The enhanced compliance and improved satisfaction scores were indicative of the successful integration of the model.
- Operational efficiency: The average time for procedural preparation and completion was recorded to ascertain the efficiency of the R-SNCM protocols in relation to conventional procedures.

2.6. Statistical analysis

Data were analyzed using Statistical Package for the Social Sciences (SPSS) version 27.0. Continuous variables such as anxiety and radiation exposure levels were expressed as mean ± standard deviation (SD), while categorical variables were represented as frequency and percentage. Paired *t*-tests were used to compare the differences between two measurements for the same group of individuals, such as anxiety and depression scores of patients before and after the intervention, and independent *t*-tests or Mann-Whitney U tests were applied to compare outcomes between two independent samples. Repeated measures Analysis of Variance (ANOVA) evaluated changes in radiation exposure of healthcare workers before and after the implementation of the R-SNCM. Multiple linear regression and logistic regression were applied to identify factors associated with psychological improvement and surgical compliance, respectively. Statistical significance was set at $p < 0.05$, and the results were reported as a 95% confidence interval.

3. Results

3.1. Baseline characteristics of patient and healthcare worker

The baseline characteristics showed significant differences between the patient and healthcare worker groups (**Table 1**). The mean age of patients ($n = 200$) was 52.4 years (SD ± 12.8), with 62% being female and 35% presenting with advanced stage cancer. In contrast, healthcare workers ($n = 36$) were younger, with a mean age of 34.8 years (SD ± 8.5), and 78% were female. The baseline anxiety and depression scores of patients were high, at 10.6 ± 3.1 and 9.4 ± 3.5, respectively, while the average baseline radiation exposure of healthcare workers was 2.6 ± 0.5 mSv per month. Significant differences were observed between the two groups in terms of age and baseline radiation exposure ($p < 0.001$).

Table 1. Baseline characteristics of the assessed sample size.

Characteristic	**Patients (*n* = 200)**	**Healthcare Workers (*n* = 36)**	***p*-value**
Age (years)	52.4 ± 12.8	34.8 ± 8.5	< 0.001
Gender (% Female)	62%	78%	0.04
Cancer Stage (% Advanced)	35%	N/A	-
Baseline Anxiety Score (HADS)	10.6 ± 3.1	N/A	-
Baseline Depression Score (HADS)	9.4 ± 3.5	N/A	-
Baseline Radiation Exposure (mSv)	N/A	2.6 ± 0.5	< 0.001

3.2. Psychological outcomes (HADS scores) in patients and radiation exposure levels in healthcare workers before and after intervention

The implementation of R-SNCM had significantly improved the psychological health of patients (**Figure 1**). After the intervention, anxiety scores decreased from a baseline mean of 10.6 ± 3.1 to 7.3 ± 2.6, while depression scores decreased from 9.4 ± 3.5 to 6.5 ± 2.8. Both of these reductions were statistically significant ($p < 0.001$). These findings highlighted the effectiveness of the model in addressing emotional distress associated with cancer treatment.

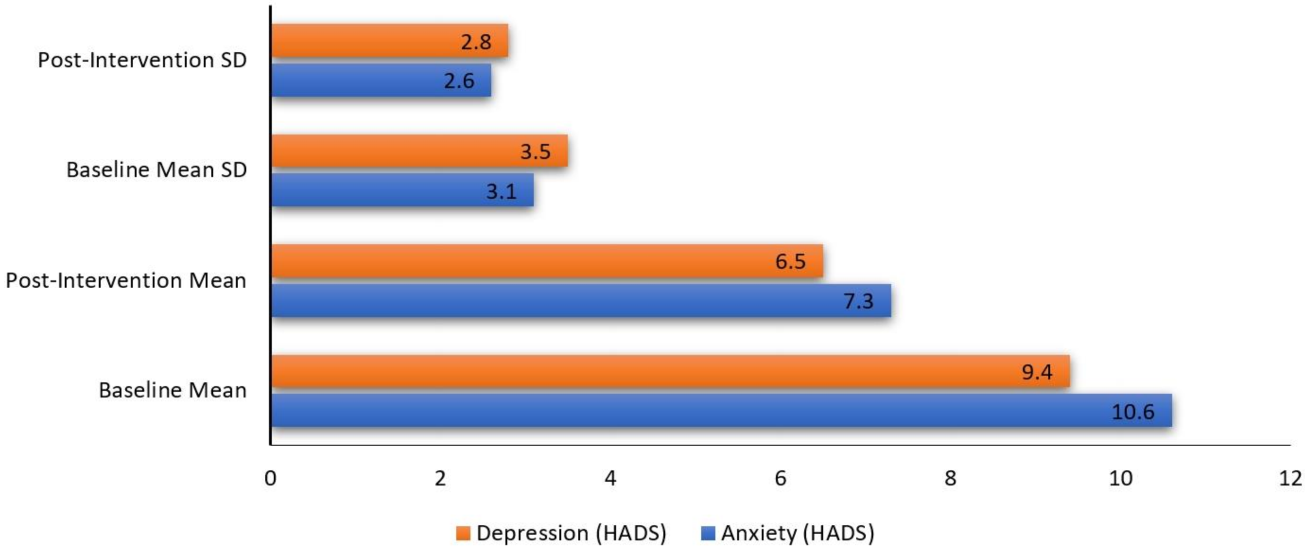

Figure 1. Psychological outcomes (HADS scores) in patients before and after intervention.

After the intervention, the radiation exposure of healthcare workers had a significant reduction (**Figure 2**). Monthly exposure levels decreased from an average of 2.6 ± 0.5 mSv to 1.8 ± 0.4 mSv, while cumulative annual exposure levels decreased from 31.2 ± 6.0 mSv to 21.6 ± 4.8 mSv. These reductions were both substantial and statistically significant ($p < 0.001$), reflecting the success of the enhanced radiation safety protocols within the R-SNCM.

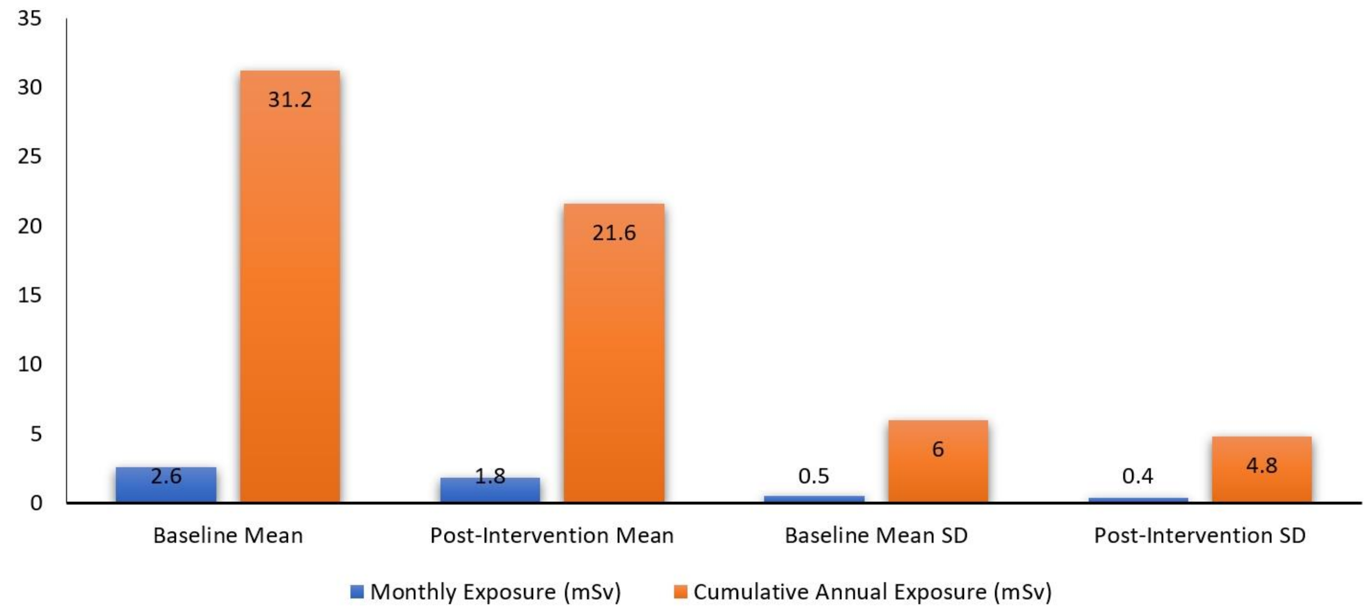

Figure 2. Radiation exposure levels in healthcare workers before and after intervention.

3.3. Patient satisfaction and adherence to F-18 procedures

The satisfaction scores reported by patients in the intervention group (4.6 ± 0.4) were significantly higher than those in the control group (3.8 ± 0.7, $p < 0.001$, **Table 2**). In addition, adherence to F-18 procedures was markedly improved, with 95% of patients in intervention group completing all recommended procedures, compared to 81% in the control group ($p < 0.001$). These results highlighted the positive impact of the R-SNCM on patient compliance and satisfaction.

Table 2. Patient satisfaction and adherence to F-18 procedures.

Outcome Measure	Intervention Group Mean ± SD	Control Group Mean ± SD	*p*-value
Patient Satisfaction (1–5 scale)	4.6 ± 0.4	3.8 ± 0.7	< 0.001
Adherence to Procedures (%)	95%	81%	< 0.001

3.4. Predictors of psychological improvement and radiation safety adherence

Multiple regression analysis identified baseline anxiety scores ($\beta = 0.42$, 95% Confidence Interval (CI) = 0.31 to 0.53, $p < 0.001$) and cancer stage ($\beta = -0.31$, 95% CI = −0.45 to −0.17, $p < 0.001$) as significant predictors of psychological improvement (**Table 3**). Higher educational levels were associated with greater improvements ($\beta = -0.28$, 95% CI = −0.39 to −0.17, $p < 0.001$), while female gender had a weaker but significant association ($\beta = 0.15$, 95% CI = 0.02 to 0.28, $p = 0.03$). These findings emphasized the multifactorial nature of psychological responses in cancer patients.

Table 3. Predictors of psychological improvement (multiple regression analysis).

Predictor Variable	Beta Coefficient	95% Confidence Interval	*p*-value
Baseline Anxiety Score	0.42	0.31 to 0.53	< 0.001
Educational Level	−0.28	−0.39 to −0.17	< 0.001
Gender (Female)	0.15	0.02 to 0.28	0.03
Cancer Stage (Advanced)	−0.31	−0.45 to −0.17	< 0.001

Logistic regression analysis showed that participating in more training sessions (Odds Ratio (OR) = 2.85, 95% CI = 1.90 to 4.28, $p < 0.001$) and gaining more nuclear medicine experience (OR = 1.12, 95% CI = 1.04 to 1.20, $p = 0.02$) significantly improved radiation safety compliance (**Table 4**). Lower baseline radiation exposure (OR = 0.72, 95% CI = 0.63 to 0.82, $p < 0.001$) was also a strong predictor, indicating the importance of initial safety measures. Gender had no significant impact on adherence (OR = 1.25, 95% CI = 0.98 to 1.58, $p = 0.08$), suggesting limited influence in this context.

Table 4. Predictors of radiation safety adherence (logistic regression analysis).

Predictor Variable	Odds Ratio	95% Confidence Interval	*p*-value
Training Sessions Attended	2.85	1.90 to 4.28	< 0.001
Experience in Nuclear Medicine (Years)	1.12	1.04 to 1.20	0.02
Gender (Female)	1.25	0.98 to 1.58	0.08
Baseline Radiation Exposure (mSv)	0.72	0.63 to 0.82	< 0.001

4. Discussion

Cancer, as one of the most harmful diseases to human health in the current society, not only brings a physical burden to patients, but also brings huge psychological pressure to them and their families [19]. Early diagnosis and treatment are crucial for improving the survival rate of cancer patients. Nuclear medicine, due to its uniqueness, holds significant importance in the diagnosis and treatment of numerous diseases, particularly tumors [20]. The application of nuclear medicine in the precise diagnosis, staging, efficacy evaluation, and recurrence monitoring of malignant tumors is very extensive [21]. However, nuclear medicine treatment not only brings a heavy psychological burden to patients, but also may bring occupational exposure to healthcare workers. Therefore, it is of great significance for nuclear medicine to explore an effective care model in the diagnosis and treatment of cancer. This study evaluated the implementation of the Radiation-Sensitive Nursing Care Model (R-SNCM), an innovative approach designed to integrate mental health management with enhanced radiation safety protocols in cancer patients undergoing Fluorine-18 (F-18) nuclear medicine treatment. The research results indicated that the implementation of this model had significantly improved the mental health of patients, healthcare worker safety, procedural adherence, and patient satisfaction, highlighting the practicality and broad applicability of it in clinical practice.

Due to concerns about diagnosis and possible changes in treatment strategies, patients often experience emotional problems such as anxiety and depression when undergoing nuclear medicine examination or treatment. These emotions will bring certain challenges to the clinical diagnosis and treatment of cancer. For example, anxiety can cause patients to have a negative experience with PET/CT tests and increase the likelihood of false positives, which can affect image quality [22]. Moreover, depression may also have a negative impact on the prognosis of patients and reduce their survival period [23]. Therefore, it is also very important to alleviate emotional issues such as anxiety and depression in patients in nuclear medicine. One of the most striking results of this study was the remarkable reduction in anxiety and depression of patient following the intervention. Baseline scores on the Hospital Anxiety and Depression Scale (HADS) indicated that patients had high levels of psychological distress, which was consistent with previous studies emphasizing the emotional burden of cancer diagnosis and treatment [24,25]. The reductions in anxiety (mean decrease of 3.3 points) and depression (mean decrease of 2.9 points) after intervention highlighted the effectiveness of psychological health management strategies incorporated into the R-SNCM. Personalized patient education, emotional monitoring, and support techniques such as guided imagery and breathing exercises might contribute to these improvements. These findings were consistent with previous research, indicating that targeted interventions for psychological distress can enhance patient compliance and overall treatment outcomes [4,5,26].

Radiation exposure of healthcare workers, another critical focus of this study, was also significantly decreased after implementing the R-SNCM. The monthly exposure level decreased by 30.8%, while the cumulative annual exposure decreased by 30.8%, demonstrating the effectiveness of the enhanced radiation protection measures of the model. Improved shielding techniques, time management strategies, and adaptive dose adjustments were instrumental in achieving these outcomes. The substantial reduction in exposure levels is in line with international radiation safety guidelines, such as those recommended by the International Commission on Radiological Protection (ICRP), which emphasize minimizing occupational risks through practical evidence-based interventions [27,28]. This highlights the importance of incorporating security protocols into daily clinical practice to protect healthcare workers.

Patient satisfaction can alleviate their anxiety and depression to a certain extent, and enhance their compliance. Patient compliance can ensure that they remain still and immobile during nuclear medicine examinations or treatments, thereby improving safety and accuracy [29]. Improving patient satisfaction and compliance also plays a very important role in nuclear medicine. In this study, we indicated that patient satisfaction and adherence to F-18 procedures were significantly higher in the intervention group compared to the control group. The satisfaction score of the five-point Likert scale was 4.6, reflecting the level of importance that patients placed on the comprehensive care provided by the R-SNCM. 95% of patients in the intervention group showed improvement in surgical compliance, indicating that addressing psychological barriers and providing individualized support can overcome common challenges associated with complex medical procedures. These findings are consistent with existing literature that links patient-centered care with improved treatment compliance and outcomes [30–33].

The multivariate analyses further elucidated the factors influencing the success of the R-SNCM. Baseline anxiety levels ($\beta = 0.42$), educational attainment ($\beta = -0.28$), and cancer stage ($\beta = -0.31$) were significant predictors of psychological improvement, highlighting the role of patient-specific characteristics in shaping responses to interventions. These results suggest that tailoring psychological support based on individual needs can enhance the effectiveness of such models. Logistic regression analysis revealed the predictors of radiation safety adherence during the R-SNCM. Training sessions attended (OR = 2.85) and experience in nuclear medicine (OR = 1.12) had a significantly positive correlation with the improvement of radiation safety adherence. In other words, the more training courses attended by healthcare workers and the more experience in nuclear medicine, the higher the radiation safety compliance. Previous studies have shown that radiation protection education and training methods will help to improve the qualifications and capacity of health professionals to ensure the application of high standards of quality and safety in medical uses of ionizing radiation [34,35]. At the same time, due to the continuous development of the field of nuclear medicine, there are often new developments and advances, so regular training courses are essential. The more nuclear medicine experience the healthcare workers have, the more skilled the operation process, the more experience in soothing the patient's emotions and dealing with emergencies, and therefore the higher the safety [36]. Understandably, the baseline radiation exposure (OR = 0.72) had a significantly negative correlation with the improvement of radiation safety adherence. In conclusion, this study pointed out that training sessions and previous experience were key predictors of radiation safety adherence among healthcare workers, emphasizing the necessity of continuing education and professional development in nuclear medicine [10,31–33]. It is also necessary to strictly follow the guidelines for radiation protection and safe use in medical procedures published by ICRP, and set a safe baseline radiation exposure.

Although this study has achieved promising results, there are still some limitations worth discussing. Firstly, the single-center design may limit the generalizability of the findings. Expanding this model to multi-center studies with diverse patient populations in future research would provide a broader perspective on its applicability. Secondly, the follow-up period, while sufficient to assess immediate outcomes, may not yield long-term psychological and safety-related benefits. Future research should consider longitudinal designs to evaluate the sustained impact of the R-SNCM on patients and healthcare workers. Thirdly, while this current study considered several confounding variables, psychological outcomes may be affected by unmeasured factors such as cultural differences or external stressors. In addition, due to the special nature of the profession, the number of healthcare professionals involved in the management of F-18 nuclear medicine procedures in this tertiary care cancer center is small, so we will consider recruiting healthcare workers from other care centers in the follow-up statistics to strengthen the statistical power of the study. Moreover, some results lack a control group. In subsequent studies, attention will be paid to the setting of the control group in order to clarify the effectiveness of the intervention.

5. Conclusion

The R-SNCM had shown great potential to enhance mental health, optimize radiation safety, and improve patient satisfaction and compliance with F-18 nuclear medicine treatments. The integration of personalized psychological support with advanced radiation safety measures provides a transformative approach for nuclear medicine nursing. By addressing both patient-centered and occupational needs, the R-SNCM has established a framework that is not only clinically effective but also in line with global best practices in cancer care. In future research, we will conduct multi-center settings and extend follow-up time to explore the scalability and adaptability of this model in different healthcare settings to maximize its impact on patient and provider outcomes.

Author contributions: Conceptualization, YZ; methodology, YZ; software, YZ and YB; validation, YZ and YB; formal analysis, YZ and YB; investigation, YZ and YB; resources, YZ and YB; data curation, YZ and YB; writing—original draft preparation, YZ; writing—review and editing, YZ; visualization, YZ and YB; supervision, YZ and YB; project administration, YZ and YB. All authors have read and agreed to the published version of the manuscript.

Institutional review board statement: The ethical review of the study was approved by the institutional review board (IRB approval number: XYZ/2021/IRB/035).

Informed consent statement: Written informed consent was obtained from all participants prior to enrollment. Patient and healthcare worker information was kept confidential during the study.

Conflict of interest: The authors declare no conflict of interest.

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