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RESEARCH

Correlation between taste and smell alterations and quality of life in patients treated with radiotherapy for nasopharyngeal carcinoma: a cross-sectional study in China

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Abstract

Purpose Taste and smell alterations (TSAs) in nasopharyngeal cancer patients negatively impact their quality of life. This study is aimed at assessing the prevalence of TSAs in patients with nasopharyngeal carcinoma undergoing radiotherapy and at exploring the correlation between TSAs and quality of life.

Methods The research was a cross-sectional survey conducted from June 2023 to March 2024 in which the Taste and Smell Survey (TSS) questionnaires were administered to 135 patients receiving radiotherapy for nasopharyngeal cancer.

Results The mean total score on the TSS scale was 9.37 ± 4.595. A higher TSS score indicates more alterations. We enrolled 135 patients, 91.1% of whom reported alterations in taste and smell. The severity of alterations was classified as mild (6.7%), moderate (33.3%), and severe (51.1%). The occurrence of changes in taste sensitivity to salty, sweet, sour, and bitter flavors were 66.7%, 52.6%, 52.6%, and 53.3%, respectively, while olfactory sensitivity changes were found in 48.9% of the patients. Notably, a statistically significant correlation was found between cumulative dose of radiotherapy and the TSS score ($p < 0.05$). TSAs were significantly correlated with anxiety and overall quality of life ($p < 0.05$).

Conclusion TSAs are prevalent among patients undergoing radiotherapy for nasopharyngeal carcinoma, with the majority experiencing moderate to severe alterations. The findings underscore the importance of implementing targeted interventions to address the sensory alterations and improve the patients' psychological well-being and life quality.

Keywords Nasopharyngeal carcinoma · Dysgeusia · Olfactory · Quality of life

Introduction

According to the Global Cancer Report 2022 (Globocan 2022), there were 120,416 new cases of nasopharyngeal cancer and 73,476 associated deaths worldwide [1]. Cases from China accounted for 42.4% of global nasopharyngeal cancer incidence and 38.7% of the related deaths, highlighting a significant disease burden [2]. With rapid advances in modern imaging techniques and the widespread use of linear accelerators, the clinical outcomes for nasopharyngeal cancer have improved substantially, with the 5-year survival rate having risen from 40% in the 1960 s to 70% nowadays [3].

Owing to the deep anatomical location and complex structure of the nasopharynx, radiotherapy, or radiotherapy-based comprehensive treatment, is widely recognized as the most effective radical treatment for nasopharyngeal cancer [4]. However, radiotherapy inevitably irradiates nearby tissues and organs, leading to varying degrees of damage [5]. Taste receptors, located primarily in the taste buds within the papillae on

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the dorsum and margins of the tongue, and olfactory receptors, situated in the olfactory epithelium within the olfactory fissure at the top of the nasal cavity, are in close proximity to the tissues irradiated during nasopharyngeal cancer treatment. As a result, taste and smell receptors are highly likely to be exposed to radiation damage. Consequently, taste and smell alterations (TSAs) are highly prevalent among nasopharyngeal cancer patients receiving radiotherapy. These alterations diminish the pleasure and satisfaction patients are expected to derive from feeding, thus leading to appetite loss, reduced food intake, malnutrition, and various psychological challenges ranging from discomfort, anxiety, depression, to diminished social functioning [6–9].

In their study on the relationship among psychology, quality of life, and taste changes in 610 patients undergoing outpatient chemotherapy, Ejder and Sanlier [10] concluded that taste alterations in oncology patients can lead to an inability to taste food, which inevitably causes a significant reduction in food intake. This, in turn, causes weakness, fatigue, and an impaired ability to lead a normal life. Over time, these conditions may trigger feelings of isolation and psychological distress, further diminishing appetite and food consumption. Malnutrition, loneliness, psychological resilience, and altered taste perception are identified as key factors impacting the quality of life in cancer patients. Additionally, a literature review revealed that most studies on the relationship between taste or olfactory alterations and quality of life have focused on patients with head and neck tumors [11], oropharyngeal cancers [12], breast cancers [13–15], lung cancers [16], and advanced cancers [17]. Only limited studies have examined the impact of TSAs on patients with nasopharyngeal carcinoma.

Nasopharyngeal cancer has a higher than global average morbidity and mortality rate in China. This study is aimed at investigating TSAs among Chinese patients undergoing radiotherapy for nasopharyngeal cancer. The objectives were to (1) understand the prevalence and characteristics of these sensory alterations specific to nasopharyngeal cancer, (2) further analyze their correlation with patients' quality of life, and (3) offer a reference for symptom evaluation and potential interventions in nasopharyngeal cancer patients in radiotherapy.

Methods

Participants

A convenience sampling method was employed to select nasopharyngeal cancer patients who met the inclusion criteria and were hospitalized at a tertiary specialized oncology hospital in Sichuan Province, China, from June 2023 to March 2024. The sample size was determined using G*Power (Version 3.1) software. A Spearman correlation analysis from a previous study between the TSS score and cumulative radiotherapy dose yielded an *r*-value of 0.338 [18], with $\alpha = 0.05$ and $1\text{-}\beta = 0.95$. Based on this, the minimum required sample size was calculated to be 108, and taking into account a dropout rate of 20%, the required final sample size of this study was 130 cases. Ultimately, a total of 135 patients were enrolled. The questionnaire response rate reached 100%.

Inclusion criteria: (1) age ≥ 18 years, (2) first diagnosis of nasopharyngeal carcinoma confirmed by pathological examination, (3) first radiotherapy treatment initiated, (4) a clear mental state and normal cognitive function, and (5) signed informed consent. Exclusion criteria: (1) insufficient awareness of the disease, (2) preexisting conditions affecting taste or smell prior to treatment, or (3) severe concurrent systemic diseases.

Baseline characteristics

The categories of baseline characteristics were obtained based on a literature review and consultation with clinicians and nurses, including sociodemographic characteristics, treatment-related data, and other relevant characteristics that may affect taste and smell.

Taste and Smell Survey (TSS)

TSS is a widely used scale for the assessment of sensory changes in cancer patients. This scale consists of two sections that address taste changes through nine questions and olfactory changes based on five questions [19]. A patient is considered to experience taste and olfactory changes if they meet any of the following criteria: (1) a response of "yes" to any question regarding taste or olfactory changes; (2) self-reported alterations in the perception of sweet, salty, bitter, or sour flavors, or changes in olfactory sensitivity.

Taste disturbances and olfactory anomalies are scored on a three-point scale, where zero, one, and two indicate minimal impairment, severe impairment, and a total inability to perceive tastes, respectively. Other related issues are scored on a two-point scale, with zero representing no change and one indicating a positive response. The total score ranges from 0 to 16, which categorizes the changes into four levels, namely, 0 to 1: no change, 2 to 4: mild change, 5 to 9: moderate change, and 10 to 16: severe change.

Previous studies have reported an internal consistency reliability of 0.89 [20]. This study involved translating and refining the TSS using expert consultation, with evaluations conducted in two rounds by several medical oncology and nursing experts. Pre-testing was performed among 15 patients with good reliability (internal consistency test coefficient = 0.832).

Hospital Anxiety and Depression Scale (HAD)

This scale was developed by Zigmond and Snaith [21] in 1983 and has been primarily used to assess anxiety and depression among patients in general hospitals. The HAD is a self-rating scale consisting of 14 items, of which seven items are used to assess depression and the other seven items anxiety. Notably, there are six reverse-scored items (five in the subscale of depression and one in the subscale of anxiety). Each item is scored on a standard scale from zero to three. Annunziata [22] and other researchers have pointed out that, for oncology patients, a score of 9 on the anxiety subscale serves as a cutoff value: scores ≤ 9 indicate no anxiety, while scores > 9 denote the presence of anxiety, with a sensitivity of 83.1% and specificity of 80.5%. Similarly, for the depression subscale, a score of 7 is used as the cutoff value, where scores ≤ 7 are classified as no depression and scores > 7 suggest the presence of depression, yielding a sensitivity of 72.9% and specificity of 79%.

Quality of Life Questionnaire for Head and Neck Cancer (QLQ-H&N35)

The scale was specifically designed by the European Organization for Research and Treatment of Cancer (EORTC) for patients with head and neck malignancies [23]. Researchers applied the Chinese version of this scale to evaluate the quality of life in patients with nasopharyngeal carcinoma, demonstrating good reliability and validity [24]. The scale consists of 35 items divided into seven domains and 11 individual items. The seven domains include pain, swallowing difficulties, sensory problems, speech issues, eating difficulties, social difficulties, and sexual function. The 11 individual items cover dental problems, difficulty in opening the mouth wide, dry mouth, viscous saliva, coughing, feelings of morbidity, use of pain medications, use of nutritional supplements, use of feeding tubes, weight loss, and weight gain.

Except for five items that employ a binary response format (yes/no), the remaining questions are assessed using a four-point Likert scale, categorized as follows: "No = 0", "Somewhat = 1", "Quite a bit = 2", and "Very much = 3". The scores within each domain are summed and divided by the number of items to obtain a raw score for each domain. This raw score is then converted into a standardized score ranging from 0 to 100, calculated using the formula: Standardized Score (S) = [(Raw Score—0)/Score Range] × 100. The same method can be used to calculate an overall standardized score for quality of life. A higher score for each item or domain or quality of life as a whole indicates more severe symptoms or problems and thus reflects a poorer quality of life.

Data analysis

Data were double-checked, and all the analyses were performed using SPSS version 26.0 statistical software. Categorical data were described using frequency and percentage, while continuous data were presented as mean and standard deviation. Spearman's correlation coefficient, *t*-tests, and analysis of variance (ANOVA) were employed to analyze the relationship between various data and the TSS score. Multivariate analysis was performed using multiple linear regression, and a collinearity analysis was conducted prior to the multivariate analysis to test for correlations among the variables. A p-value of less than 0.05 was considered statistically significant.

Results

The influence of baseline characteristics on the TSAs of participants

Results of analyses on basic characteristics of the participants are provided in Table 1, which is split into Table 1(1–1), presenting results of Spearman's correlation analysis of continuous or discrete ordinal data, and Table 1(1–2), presenting results of *t*-test and ANOVA of categorical data.

According to Spearman's correlation analysis, statistically significant correlations were detected between the TSS score and number of radiotherapy treatments (16.03 ± 10.061), cumulative dose of radiotherapy (35.03 ± 22.405 Gy), and number of chemotherapy cycles (3.02 ± 1.385), respectively ($p < 0.05$), whereas age (48 ± 12.071 years), body mass index (BMI), and years of education had no significant influence on TSAs of the patients (Table 1(1–1)). However, significant difference in the TSS score was found among different BMI classifications using ANOVA, as shown in Table 1(1–2) ($p < 0.05$).

Subsequently, a collinearity analysis was conducted among cumulative dose of radiotherapy, number of radiotherapy treatments, number of chemotherapy cycles, and BMI classification. In collinearity analyses, a variance inflation factor (VIF) above ten of a certain variable indicates high multicollinearity with other variables [25]. The results of our analysis revealed strong multicollinearity of cumulative dose of radiotherapy (VIF = 68.292) and number of radiotherapy treatments (VIF = 68.822) with other variables, while BMI classification (VIF = 1.017) and number of chemotherapy cycles (VIF = 1.236) showed no signs of multicollinearity. Since the number of radiotherapy treatments is inevitably highly correlated with cumulative dose of radiotherapy, a multiple linear regression analysis was performed on cumulative dose of radiotherapy, BMI classification, and number of chemotherapy cycles, with the number of radiotherapy treatments

Table 1 Baseline characteristics of the patients

1 - 1 The results of Spearman's correlation analysis					
Variable		Mean ± SD	r_S-value	*p*-value	Total ($n = 135$)
Number of radiotherapy treatments		16.03 ± 10.061	0.332	< 0.001	135
Cumulative dose of radiotherapy (Gy)		35.03 ± 22.405	0.349	< 0.001	135
Number of chemotherapy cycles		3.02 ± 1.385	0.172	< 0.05	135
BMI (kg/m.^{2})		23.58 ± 3.119	− 0.125	0.149	135
Years of education		10.29 ± 3.323	0.037	0.673	135
Age (years)		48.70 ± 12.071	0.037	0.670	135
1–2 The results of *t*-test and ANOVA					
Variable	Total ($n = 135$)	Percentage (%)	TSS score (Mean ± SD)	*t*/*F*-value	*p*-value
Sex					
Male	108	80.0	9.31 ± 4.641	− 0.327[a]	0.744
Female	27	20.0	9.63 ± 4.482		
Marital status					
Married	128	94.8	9.43 ± 4.609	1.110[b]	0.354
Unmarried	5	3.7	8.40 ± 5.128		
Widowed	2	1.5	8.00 ± 4.243		
Education level					
Elementary school and below	26	19.3	7.15 ± 5.357	0.736[b]	0.753
Junior high school	61	45.2	10.64 ± 3.873		
Vocational school	12	8.9	10.42 ± 4.621		
College	21	15.6	7.71 ± 4.551		
Bachelor's degree	13	9.6	9.92 ± 3.570		
Graduate degree and above	2	1.5	7.00 ± 9.899		
Occupation					
Employed	49	36.3	8.98 ± 4.679	0.829[b]	0.651
On sick leave	8	5.9	7.25 ± 4.097		
Unemployed	65	48.1	9.57 ± 4.831		
Retired	13	9.6	11.15 ± 2.577		
Tobacco use*					
Smoker	13	9.6	10.15 ± 4.140	0.859[b]	0.617
Former smoker	67	49.6	9.15 ± 4.425		
Non-smoker	55	40.7	9.45 ± 4.943		
Alcohol use*					
Drinker	11	8.1	10.45 ± 4.824	1.645[b]	0.068
Former drinker	69	51.1	9.87 ± 4.155		
Non-drinker	55	40.7	8.53 ± 5.007		
Participation in cooking					
Yes	88	65.2	9.28 ± 4.402	− 1.168[a]	0.303
No	47	34.8	9.53 ± 4.982		
Sufficient economic resources (self-reported)					
Yes	68	50.4	8.84 ± 4.332	− 1.360[a]	0.456
No	67	49.6	8.91 ± 4.820		
Number of chemotherapy cycles					
0	4	3.0	8.75 ± 7.365	1.168[b]	0.303
1	17	12.6	6.29 ± 5.610		
2	24	17.8	10.29 ± 3.884		
3	39	28.9	8.62 ± 4.892		
4	35	25.9	10.46 ± 3.822		
5	10	7.4	11.90 ± 2.514		
6	6	4.4	9.17 ± 2.927		

Table 1 (continued)

Disease stage					
Stage II	7	5.2	8.14 ± 4.880	0.861[b]	0.615
Stage III	48	35.6	9.46 ± 4.789		
Stage IV	80	59.3	9.43 ± 4.497		
BMI classification					
< 18.5 kg/m^2	10	7.4	10.80 ± 3.425	1.738[b]	0.049
18.5 ~ 23.9 kg/m^2	62	45.9	9.69 ± 4.661		
24 ~ 27.9 kg/m^2	53	39.3	9.23 ± 4.453		
≥ 28.0 kg/m^2	10	7.4	6.70 ± 5.458		
Radiation therapy plan					
Image-guided radiation therapy (IGRT)	47	34.8	9.85 ± 4.477	0.760[b]	0.727
Intensity-modulated radiation therapy (IMRT)	83	61.5	9.08 ± 4.641		
Tomotherapy (TOMO)	5	3.7	9.37 ± 4.595		

*Tobacco/alcohol use: patient with any consumption of tobacco/alcohol within the past 12 months of the survey was defined as "smoker/drinker"; any consumption of tobacco/alcohol 12 months before the survey was defined as "former smoker/drinker"; no consumption of tobacco/alcohol so far was defined as "non-smoker/drinker." [a]*t*-value. [b]*F*-value

removed. The results showed that only the cumulative dose of radiotherapy had a significant positive effect on the TSS score ($p < 0.001$), while influence of BMI classification and number of chemotherapy cycles on TSAs was not significant ($p > 0.05$). Detailed results of the multiple linear regression analysis are shown in Table 2.

Status of taste and smell alterations in the patients

Among the 135 participants, 91.1% reported alterations in taste and smell, among whom the severity of alterations was classified as mild in nine cases (6.7%), moderate in 45 cases (33.3%), and severe in 69 cases (51.1%). Only 12 cases (8.9%) claimed no significant changes. The overall TSS score of the participants was 9.37 ± 4.60. More information is specified in Table 3.

The correlation analysis between psychological state and TSAs

The results denoted a correlation between the TSAs and the psychological state of patients. More specifically, in the anxiety dimension of the Hospital Anxiety and Depression Scale (HAD), 81 patients (60.0%) reported no anxiety, with an overall score of 7.96 ± 4.79, while 54 patients (40.0%) claimed to have experienced anxiety, with an overall score of 11.48 ± 3.33. Spearman's correlation analysis of the anxiety score and the TSS score revealed a statistically significant correlation ($r_S = 0.419$, $p < 0.001$). In the depression dimension, 73 patients (54.1%) were classified as non-depressed, with an overall score of 9.07 ± 4.74; 62 patients (45.9%) were classified as depressed, with an overall score of 9.73 ± 4.42. Spearman's correlation analysis of the depression score and the TSS score indicated no statistically significant correlation ($r_S = 0.001$, $p = 0.980$).

The correlation analysis between quality of life and TSAs

Table 4 presents the Spearman's correlation analysis between quality of life and the TSAs of the participants. The results indicated a significant correlation between the TSS score and overall score of quality of life. Besides, the TSAs were also found to be correlated with six domains (sensory domain, eating domain, pain domain, dysphagia domain, speech domain, and social domain) and five individual items (the factors of difficulty in opening the mouth wide, viscous saliva, dry

Table 2 The results of multiple linear regression analysis

Model	Non-standardized coefficients		Standardized coefficients	*t*-value	*p*-value	Collinearity statistics	
	β	Standard error				Tolerance	VIF
(Constant)	8.564	1.581		5.419	< 0.001		
Cumulative radiotherapy dose	0.070	0.018	0.342	3.869	< 0.001	0.819	1.221
BMI classification	− 0.878	0.497	− 0.142	− 1.766	0.080	0.995	1.005
Number of chemotherapy cycles	0.170	0.293	0.051	0.580	0.563	0.819	1.221

Table 3 Status of TSAs in the patients

Variable	Total	Percentage (%)
Foods taste different than they used to	118	87.4
I have noticed a change in my sense of taste	114	84.4
I have had a strange taste in my mouth	91	67.4
The treatment has interfered with my sense of taste	116	85.9
I have noticed a change in salt flavor	90	66.7
Stronger	36	40.0
Weaker	54	60.0
I have noticed a change in sweet flavor	71	52.6
Stronger	20	28.2
Weaker	51	71.8
I have noticed a change in sour flavor	71	52.6
Stronger	27	38.0
Weaker	44	62.0
I have noticed a change in bitter flavor	72	53.3
Stronger	27	37.5
Weaker	45	62.5
Rate abnormal sense of taste		
Insignificant	29	21.5
Mild to moderate	78	57.8
Severe to intolerable	28	20.7
I have noticed a change in my sense of smell	73	54.1
Foods smell different than they used to	65	48.1
The treatment has interfered with my sense of smell	71	62.6
I have noticed a change in odors	66	48.9
Stronger	32	48.5
Weaker	34	51.5
Rate abnormal sense of smell		
Insignificant	62	45.9
Mild to moderate	45	33.3
Severe to intolerable	28	20.7

mouth, weight loss, and feeling sick), respectively ($p < 0.05$). However, scores of other domains and items of quality of life including the sexual domain, dental problems, nutrient solution taken, coughing, use of painkillers, nasal feeding tube, and weight gain were not statistically significant with the TSS score ($p > 0.05$). More specific results are shown in Table 4.

Discussion

TSAs among patients with nasopharyngeal carcinoma in radiotherapy

The results of this study showed that most cases were experiencing moderate (33.3%) to severe (51.1%) taste and smell alterations. Deshpande et al. [26], in a systematic review and meta-analysis of head and neck tumors, reported that 70–100% of patients experienced partial or total loss of taste sensation during radiotherapy. Similarly, Li et al. [27] found that 94.2% of patients experienced altered taste sensation. Since TSAs are not life-threatening, healthcare professionals often overlook the assessment and treatment of these symptoms, considering them common post-treatment reactions [28]. Given the high incidence and severity of TSAs in nasopharyngeal cancer patients in radiotherapy, greater attention and intervention from medical personnel are warranted.

As can be seen in Table 3, the taste of salt was the most affected, with a change rate of 66.7%, while the altered taste of sweet, sour, and bitter flavors occurred in approximately half of the participants (52.6%, 52.6%, and 53.3%, respectively). Furthermore, the results demonstrated that reduction was the predominant type of taste alterations. More than half of the participants reported to have experienced a declined ability in the taste of all four flavors, especially in tasting salt.

In contrast, Gunn et al. [29] found that the taste of bitterness was the most significantly affected in patients receiving radiotherapy for head and neck tumors. Asif et al.

Table 4 Correlation analysis of quality of life in different domains/items and TSS score in patients

Domains/items of quality of life	Mean ± SD	r_S-value	p-value
Quality of life	24.01 ± 10.761	0.385	< 0.001
Sensory domain	39.14 ± 19.83	0.463	< 0.001
Eating domain	22.16 ± 16.80	0.352	< 0.001
Pain domain	25.31 ± 19.83	0.309	< 0.001
Dysphagia domain	23.39 ± 20.78	0.237	0.006
Speech domain	12.18 ± 15.76	0.209	< 0.001
Social domain	12.79 ± 15.45	0.214	0.013
Sexual domain	39.26 ± 26.27	0.158	0.067
Difficulty in opening mouth wide	0.39 ± 0.61	0.230	0.007
Viscous saliva	1.57 ± 0.94	0.205	0.017
Dry mouth	1.57 ± 0.83	0.194	0.024
Weight loss	0.47 ± 0.50	− 0.205	0.017
Feeling sick	1.04 ± 0.76	0.203	0.018
Dental problems	0.56 ± 0.71	0.129	0.136
Intake of nutrient solution	0.36 ± 0.48	− 0.146	0.092
Coughing	0.50 ± 0.69	0.092	0.290
Use of painkillers	0.73 ± 0.45	0.007	0.937
Nasal feeding tube	0.89 ± 0.37	− 0.005	0.958
Weight gain	0.90 ± 0.30	0.013	0.885

[30] reported that the taste of sweetness and salt reduced considerably, the bitter taste of bitterness showed a tendency of diminishing, while the taste of sourness remained unchanged. The variability in these results may be attributed to the difference in the cancer type, which lead to varied radiation doses received by the tongue during treatments.

Additionally, 62.6% of nasopharyngeal cancer patients reported that radiotherapy interfered with their sense of smell, a rate similar to the 60% incidence of olfactory changes in head and neck cancer patients reported by a previous study [31]. This rate is higher than the 16–49% incidence of olfactory alterations observed in cancer patients receiving chemotherapy [14]. Olfactory perception plays a critical role in the overall taste experience, but olfactory dysfunction has received less attention than taste alteration and is often misreported as a taste dysfunction. Thus, gradual loss of smell may go unnoticed [32]. The preauricular field is the most commonly targeted area, including the posterior one-third to two-thirds of the nasal cavity, the middle and posterior groups of the ethmoid sinuses, the entire sphenoid sinus, and the preauricular region. This extensive exposure often results in a reduction in olfactory bulb volume and impaired olfactory function [33, 34].

In some cases, olfactory sensitivity either increased (48.5%) or decreased (51.5%) following chemotherapy, and this phenomenon was potentially influenced by sex [20]. Women tend to be more sensitive to taste and smell changes than men. However, nasopharyngeal cancer predominantly affects men, with an incidence rate roughly twice as high as that of women [35]. Given the relatively small sample size of this study, further research with a larger sample size is needed to investigate sex-related differences in TSAs among nasopharyngeal cancer patients.

The impact of radiotherapy on TSAs among patients with nasopharyngeal carcinoma

Results of the multivariate analysis indicated that the cumulative dose of radiotherapy is the main influencing factor of TSAs ($p < 0.05$, Table 2). Sapir et al. [36] found that the degree of subjective taste loss was significantly associated with the radiation dose to the oral cavity ($p = 0.005$) and the tongue ($p = 0.019$). Another study also pointed out that the degree of post-radiotherapy taste loss is positively correlated with radiotherapy dose [37]. Radiotherapy for nasopharyngeal cancer typically targets various regions, including the preauricular, prenasal, infraorbital, face, neck, retroauricular, cranial base, cervical tangential, and upper lateral cervical vertical fields. However, normal surrounding tissues, such as the oral cavity, tongue, and olfactory regions, are also exposed to radiation. Consequently, the degree of taste and olfactory alterations in nasopharyngeal carcinoma patients exacerbates with an increasing number of radiotherapy treatments and cumulative radiation dose. Therefore, it is highly suggested that nursing staff should provide early personal assessments, care plans, and guidance based on the patient's stage of disease and radiotherapy dosage, allowing for an early prediction and intervention of TSAs.

Furthermore, the primary cause of TSAs in nasopharyngeal carcinoma patients in radiotherapy is cellular damage. This damage may result from structural changes of cells, modifications on receptor surfaces, disruption of neural coding, or a reduction in the number of healthy cells [38]. Hence, the degree of taste and olfactory sensitivity alterations varies significantly among individuals. Regarding smell dysfunction as well as specific taste changes in salt, sweetness, sourness, and bitterness, different dietary interventions have been suggested. For patients with hyposmia, adding more seasonings (e.g., salt, sugar, spices, and other condiments) or choosing flavorful foods like mushrooms and onions proves to be helpful [39]. For patients with olfactory dysfunction, incorporating ingredients with a spicy smell and taste such as onion, ginger, garlic, star anise, and cinnamon may help [40]. Nevertheless, in the case of severe TSAs, it is highly recommended for the patient to consult a dietitian for further assessment and dietary modifications so as to prevent nutritional deficiencies. It is also worth noting that current dietary interventions are primarily based on

chemotherapy-induced TSAs. Further research is urgently needed to determine whether specific dietary interventions vary for different causes of TSAs and to promote the development of more targeted dietary strategies for patients suffering from radiation-induced TSAs.

The relationship between TSAs and psychological status in nasopharyngeal carcinoma patients in radiotherapy

Previous studies have indicated that nasopharyngeal carcinoma patients are prone to anxiety and depression during radiotherapy, and the incidence and severity of these conditions are closely associated with age, gender, smoking history, education level, treatment-related toxicity, etc. [41]. Among the treatment-related toxicities, altered taste is frequently linked to anxiety and depression. These discomforts may lead to dissatisfaction and anxiety, which may further exacerbate into heightened anxiety and depression, contributing to a decline in patients' physical functioning and quality of life [42].

Our results showed that 40.0% of the patients experienced anxiety, and 45.9% suffered from depression, which is comparable to the results of a study conducted by Wang et al. [43], who reported the incidence of anxiety and depression as 55.1% and 43.9%, respectively, in nasopharyngeal carcinoma patients undergoing radiotherapy. Our results revealed a significant correlation of TSAs with anxiety ($r_S = 0.419$, $p < 0.001$) but no correlation with depression. This contrasts with previous findings that both anxiety and depression were associated with acute radiotoxicity in nasopharyngeal carcinoma patients in radiotherapy, with depression being a predictor of taste disturbances and anxiety of vomiting and dysphagia [44]. This discrepancy of the results may be explained by the fact that the focus of our study was on the combined impact of TSAs on psychological status, whereas most existing research has concentrated on the psychological effects of taste alterations alone. Additionally, researchers have also found that more severe taste abnormalities, particularly those associated with oral mucosal clusters, are correlated with lower levels of psychological and environmental comfort [45]. Therefore, healthcare providers should guide patients in adopting effective emotion regulation strategies to mitigate treatment side effects, in order to improve patients' psychological state and, more importantly, their quality of life [46].

The relationship between TSAs and quality of life in nasopharyngeal carcinoma patients in radiotherapy

A significant positive correlation was found between TSAs and quality of life, a finding consistent with the studies by Ying et al. [46] and Wu et al. [47]. More specifically, our results demonstrated that TSAs significantly affected quality of life in various domains, including the sensory domain, eating domain, pain domain, dysphagia domain, and language domain, as well as in the forms of symptoms including difficulty in opening the mouth wide, viscous saliva, dry mouth, weight loss, and feeling sick. This manifested that the negative effects caused by TSAs can be reflected in multiple aspects of a patient's quality of life.

Symptoms such as dry mouth, viscous saliva, difficulty in opening the mouth wide, oral pain, and dysphagia are common among nasopharyngeal cancer patients and are known to affect nutritional status [48]. The results of our study demonstrated that these nutrition-impacting symptoms are correlated with TSAs. Similar conclusions were drawn by Crowder et al. [48] who highlighted the importance of addressing taste disorders to ensure adequate protein and calorie intake, which plays a crucial role in improving the quality of life for head and neck cancer patients. Besides, Thorne et al. [49] emphasized that the assessment of TSAs is essential, as these changes can be associated with other common issues such as weight loss. TSAs are not only significant symptoms but also independent predictors of quality of life, necessitating targeted management by healthcare professionals [11]. Hence, it is critical not only to assess the psychological impact of radiotherapy-induced TSAs but also to evaluate how these changes affect items of quality of life such as pain, and issues concerning feeding, saliva, and mouth, and provide patients with targeted advice. A holistic assessment can to a great extent enhance the care, support, and empathy provided by healthcare staff for the patients. For instance, patients with dry mouth should be advised to drink 2000–3000 ml of fluids per day (light fruit juice and tea included) and to carry beverages at all times to reduce oral dryness, which can effectively mitigate the impact of TSAs on their quality of life [39].

When severe TSAs occur, referral to a dietitian for further assessment and potential dietary adjustments is highly recommended. Additionally, multidisciplinary professionals should proactively inform patients of the possibility of TSAs to alleviate anxiety and depression. Furthermore, providing patients with educational materials on taste change management, dietary counseling, and strategies to enhance food flavor can also help improve eating behaviors and prevent weight loss, ultimately preventing a reduction in their quality of life [49].

Limitations

This is a cross-sectional study with a relatively small sample size, and longitudinal changes in TSAs were not explored. Larger-scale and longitudinal studies in the future will help to further investigate the influence of TSAs on cancer patients specific to tumor type.

Conclusions

The incidence of taste and smell alterations (TSAs) among patients undergoing radiotherapy for nasopharyngeal cancer is both high and severe, with notable individual variability. Patients frequently experience diminished perceptions of salty, sweet, sour, and bitter tastes and olfactory dysfunction. Additionally, these alterations are associated with heightened anxiety, leading to reduced psychological comfort. Furthermore, TSAs are closely linked to the quality of life in various domains, including pain, dysphagia, and issues concerning speech, sensation, and feeding. Specific symptoms such as difficulty in opening the mouth wide, viscous saliva, dry mouth, weight loss, and feeling sick are also significantly correlated with TSAs.

It is essential for clinical practitioners to assess these alterations comprehensively, not only focusing on the TSAs but also evaluating the broader effects of the alterations on the patient's quality of life in various aspects. Through this, healthcare providers are able to deliver more personalized nursing care, offer more targeted nursing interventions, counseling, and health education aimed at mitigating the adverse effects of TSAs, and ultimately improve the patient's overall quality of life.

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Data availability No datasets were generated or analysed during the current study.

Declarations

Ethical approval All procedures performed in the study involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki Declaration and its later amendments or comparable ethical standards. This research has been reviewed and approved by the Ethics Committee of the institution, with the ethical approval number SCCHEC- 02–2022 - 078.

Informed consent Informed consent was obtained from the patients.

Competing interest The authors declare no competing interests.

References

1. Bray F, Laversanne M, Sung H, Ferlay J, Siegel RL, Soerjomataram I, Jemal A (2024) Global cancer statistics 2022: GLOBOCAN estimates of incidence and mortality worldwide for 36 cancers in 185 countries. CA: A Cancer J Clin 74(3):229–263. https://doi.org/10.3322/caac.21834
2. Yao YF, Sun KX, Zheng RS (2024) Interpretation and analysis of the global cancer statistics report 2022: a comparison between China and the world. Chin J Bases Clin Gen Surg 31(07):769–780. https://doi.org/10.7507/1007-9424.202406046
3. Zhao JF, Xu M, Chen WH, Zhao FZ, Wang YM, Zhuang CH (2016) Expressions of cyclooxygenase-2 and basic fibroblast growth factor in nasopharyngeal carcinoma and their association with radiotherapy sensitivity. Nan fang yi ke da xue xue bao = J South Med Univ 36(12):1718–1722. https://doi.org/10.3969/j.issn.1673-4254.2016.12.22
4. Lang J, Hu C, Lu T, Pan J, Lin T (2019) Chinese expert consensus on diagnosis and treatment of nasopharyngeal carcinoma: evidence from current practice and future perspectives. Cancer Manag Res 11:6365–6376. https://doi.org/10.2147/CMAR.S197544
5. Cheng YK, Liu LZ, Jiang N, Yue D, Tang LL, Zhang F, Lin L, Liu X, Chen L, Ma J (2014) MRI-detected skull-base invasion: prognostic value and therapeutic implication in intensity-modulated radiotherapy treatment for nasopharyngeal carcinoma. Strahlenther Und Onkol 190(10):905–911. https://doi.org/10.1007/s00066-014-0656-7
6. Drareni K, Bensafi M, Giboreau A, Dougkas A (2021) Chemotherapy-induced taste and smell changes influence food perception in cancer patients. Support Care Cancer: Off J Multinatl Assoc Support Care Cancer 29(4):2125–2132. https://doi.org/10.1007/s00520-020-05717-1
7. O'Donoghue A, Barrett M, Dhuibhir PU, Kennedy A, O'Leary N, Walsh D (2023) Taste and smell abnormalities in advanced cancer: negative impact on subjective food intake. Nutr Clin Pract: Off Publ Am Soc Parenter Enter Nutr 38(4):807–816. https://doi.org/10.1002/ncp.10943
8. Ni YD, Chen YH, Xu L, Liang W (2021) Study on chemotherapy-induced taste changes in elderly patients with gastrointestinal cancer and the effects on nutrition, psychological status and quality of life. Pract Geriatr 05:451–454. https://doi.org/10.3969/j.issn.1003-9198.2021.05.005
9. Dai L (2014) Influence and regulation of taste on emotion (Master's thesis, Yunnan Normal University). Master's Degree. http://kns--cnki--net--https.cnki.scrm.scsycy.vip:2222/kcms2/article/abstract?v=0-LBHIej7Qkpcu43mTw4JE9_ZwIwe7lDvNCcTEs1NFtJawbtiXfc0K_MvW-q9xYWERQuX9LvjSBcQCXvVTFDu6vSOMaq_g1ak5sn6Hsk0SnPGMccRQyUKe9JHgHHvdgz

avLow0o4KNG5O5mvuQkx4iBrphSwXjI38UjSVqwFi44nRoUlGqfmHGwLzGIE3cNt01hdfrg_Cn8=&uniplatform=NZKPT&language=CHS
10. Ejder ZB, Sanlier N (2023) The relationship between loneliness, psychological resilience, quality of life and taste change in cancer patients receiving chemotherapy. Support Care Cancer: Off J Multinatl Assoc Support Care Cancer 31(12):683. https://doi.org/10.1007/s00520-023-08156-w
11. Alvarez-Camacho M, Gonella S, Ghosh S, Kubrak C, Scrimger RA, Chu KP, Wismer WV (2016) The impact of taste and smell alterations on quality of life in head and neck cancer patients. Qual Life Res: An Int J Qual Life Asp Treat Care Rehabil 25(6):1495–1504. https://doi.org/10.1007/s11136-015-1185-2
12. Lilja M, Markkanen-Leppänen M, Viitasalo S, Saarilahti K, Lindford A, Lassus P, Mäkitie A (2018) Olfactory and gustatory functions after free flap reconstruction and radiotherapy for oral and pharyngeal cancer: a prospective follow-up study. Eur Arch Oto-Rhino-Laryngol: Off J Eur Fed Oto-Rhino-Laryngol Soc (EUFOS): Affiliated Ger Soc Oto-Rhino-Laryngol - Head Neck Surg 275(4):959–966. https://doi.org/10.1007/s00405-018-4883-x
13. de Vries YC, Boesveldt S, Kelfkens CS, Posthuma EE, van den Berg MMGA, de Kruif JTCM, Haringhuizen A, Sommeijer DW, Buist N, Grosfeld S, de Graaf C, van Laarhoven HWM, Kampman E, Winkels RM (2018) Taste and smell perception and quality of life during and after systemic therapy for breast cancer. Breast Cancer Res Treat 170(1):27–34. https://doi.org/10.1007/s10549-018-4720-3
14. Jeong An H, Kang SJ (2023) The relationship between taste and smell alterations and quality of life among women with breast cancer receiving chemotherapy. Oncol Nurs Forum 50(4):499–508. https://doi.org/10.1188/23.ONF.499-508
15. Denda Y, Niikura N, Satoh-Kuriwada S, Yokoyama K, Terao M, Morioka T, Tsuda B, Okamura T, Ota Y, Tokuda Y, Sasano T, Shoji N (2020) Taste alterations in patients with breast cancer following chemotherapy: a cohort study. Breast Cancer (Tokyo, Japan) 27(5):954–962. https://doi.org/10.1007/s12282-020-01089-w
16. Drareni K, Dougkas A, Giboreau A, Laville M, Souquet PJ, Nazare JA, Fournel P, Bensafi M (2023) Loss of smell in lung cancer patients undergoing chemotherapy: prevalence and relationship with food habit changes. Lung Cancer (Amsterdam, Netherlands) 177:29–36. https://doi.org/10.1016/j.lungcan.2023.01.007
17. Otani H, Amano K, Morita T, Miura T, Mori N, Tatara R, Kessoku T, Matsuda Y, Tagami K, Mori M, Taniyama T, Nakajima N, Nakanishi E, Kako J, Shirado AN, Yokomichi N, Miyashita M (2023) Impact of taste/smell disturbances on dietary intakes and cachexia-related quality of life in patients with advanced cancer. Support Care Cancer Off J Multinatl Assoc Support Care Cancer 31(2):141. https://doi.org/10.1007/s00520-023-07598-6
18. Liang H, Yin L, Yang Q (2023) Correlation between changes of taste or smell and self-reported symptoms in patients with nasopharyngeal carcinoma received radiotherapy and chemotherapy. Guangdong Med J 44(3):330–335. https://doi.org/10.13820/j.cnki.gdyx.20224418
19. Heald AE, Pieper CF, Schiffman SS (1998) Taste and smell complaints in HIV-infected patients. AIDS (London, England) 12(13):1667–1674. https://doi.org/10.1097/00002030-199813000-00015
20. McGreevy J, Orrevall Y, Belqaid K, Wismer W, Tishelman C, Bernhardson BM (2014) Characteristics of taste and smell alterations reported by patients after starting treatment for lung cancer. Support Care Cancer: Off J Multinatl Assoc Support Care Cancer 22(10):2635–2644. https://doi.org/10.1007/s00520-014-2215-2
21. Zigmond AS, Snaith RP (1983) The hospital anxiety and depression scale. Acta Psychiatr Scand 67(6):361–370. https://doi.org/10.1111/j.1600-04471983.tb09716.x
22. Annunziata MA, Muzzatti B, Bidoli E, Flaiban C, Bomben F, Piccinin M, Gipponi KM, Mariutti G, Busato S, Mella S (2020) Hospital Anxiety and Depression Scale (HADS) accuracy in cancer patients. Support Care Cancer: Off J Multinatl Assoc Support Care Cancer 28(8):3921–3926. https://doi.org/10.1007/s00520-019-05244-8
23. Bjordal K, Hammerlid E, Ahlner-Elmqvist M, de Graeff A, Boysen M, Evensen JF, Biörklund A, de Leeuw JR, Fayers PM, Jannert M, Westin T, Kaasa S (1999) Quality of life in head and neck cancer patients: validation of the European organization for research and treatment of cancer quality of life questionnaire-H&N35. J Clin Oncol: Off J Am Soc Clin Oncol 17(3):1008–1019. https://doi.org/10.1200/JCO.1999.17.3.1008
24. Zhang XF, Zheng XF, Hao YT, Zhang C (2013) Assessment of EORTC QLQ C30 /H&N35 in nasopharyngeal carcinoma patients quality of life. New Med 07:467–471. https://doi.org/10.3969/g.issn.0253-9802.2013.07.008
25. O'brien RM (2007) A caution regarding rules of thumb for variance inflation factors. Qual Quant 41:673–690. https://doi.org/10.1007/s11135-006-9018-6
26. Deshpande TS, Blanchard P, Wang L, Foote RL, Zhang X, Frank SJ (2018) Radiation-related alterations of taste function in patients with head and neck cancer: a systematic review. Curr Treat Options Oncol 19(12):72. https://doi.org/10.1007/s11864-018-0580-7
27. Li HM, Jin S, Zhang LC, Jin SL, Cui HJ, Lu Q (2018) A longitudinal study of taste changes in patients with head and neck malignant tumors undergoing radiotherapy. Chin J Clin Nutr 26(4):207–213. https://doi.org/10.3760/cma.j.issn.1674-635X.2018.04.003
28. Yang ZR, Zhang T, Tian CY, Yang M, Chen HL, Li R, Li L (2019) Correlation between taste and smell alterations and self-reported symptoms in patients with cervical cancer chemotherapy. Nurs Res 33(11):1918–1921. https://doi.org/10.12102/ji.ssn.1009-6493.2019.11.022
29. Gunn L, Gilbert J, Nenclares P, Soliman H, Newbold K, Bhide S, Wong KH, Harrington K, Nutting C (2021) Taste dysfunction following radiotherapy to the head and neck: a systematic review. Radiother Oncol: J Eur Soc Ther Radiol Oncol 157:130–140. https://doi.org/10.1016/j.radonc.2021.01.021
30. Asif M, Moore A, Yarom N, Popovtzer A (2020) The effect of radiotherapy on taste sensation in head and neck cancer patients - a prospective study. Radiat Oncol (London, England) 15(1):144. https://doi.org/10.1186/s13014-020-01578-4
31 Álvarez-Camacho M, Gonella S, Campbell S, Scrimger RA, Wismer WV (2017) A systematic review of smell alterations after radiotherapy for head and neck cancer. Cancer Treat Rev 54:110–121. https://doi.org/10.1016/j.ctrv.2017.02.003
32. Enriquez K, Lehrer E, Mullol J (2014) The optimal evaluation and management of patients with a gradual onset of olfactory loss. Curr Opin Otolaryngol Head Neck Surg 22(1):34–41. https://doi.org/10.1097/MOO.0000000000000013
33. Qiu Q, Chen S, Meng C, Liao F, Li T (2001) Observation on the changes in nasopharyngeal carcinoma patients' olfactory before and after radiotherapy. J Clin Otorhinolaryngol 15(2):57 (**Europe PMC Article 12541862**)
34. Veyseller B, Ozucer B, Degirmenci N, Gurbuz D, Tambas M, Altun M, Aksoy F, Ozturan O (2014) Olfactory bulb volume and olfactory function after radiotherapy in patients with nasopharyngeal cancer. Auris Nasus Larynx 41(5):436–440. https://doi.org/10.1016/j.anl.2014.02.004
35. Wang L (2019) Analysis of the epidemiological trends and effects of radiotherapy in nasopharyngeal carcinoma and influencing factors (Master's thesis, Nanhua University). http://link--cnki--net--https.cnki.scrm.scsycy.vip:2222/doi/10.27234/d.cnki.gnhuu.2019.00020310.27234/d.cnki.gnhuu.2019.000203

36. Sapir E, Tao Y, Feng F, Samuels S, El Naqa I, Murdoch-Kinch CA, Feng M, Schipper M, Eisbruch A (2016) Predictors of dysgeusia in patients with oropharyngeal cancer treated with chemotherapy and intensity modulated radiation therapy. Int J Radiat Oncol Biol Phys 96(2):354–361. https://doi.org/10.1016/j.ijrobp.2016.05.011
37. Qian LJ, Lu Q, Yang P, Jin SL, Pang D, Liu F, Cui HJ, Si LM (2017) Chemotherapy-induced taste alterations among cancer patients. JournalofNursingScience 32(03):27–31. https://doi.org/10.3870/j.issn.1001-4152.2017.03.027
38. Hovan AJ, Williams PM, Stevenson-Moore P, Wahlin YB, Ohrn KE, Elting LS, Spijkervet FK, Brennan MT, Dysgeusia Section, Oral Care Study Group, Multinational Association of Supportive Care in Cancer (MASCC)/International Society of Oral Oncology (ISOO) (2010) A systematic review of dysgeusia induced by cancer therapies. Support Care Cancer: Off J Multinatl Assoc Support Care Cancer 18(8):1081–1087. https://doi.org/10.1007/s00520-010-0902-1
39. Zhang TT, Zhang LY (2020) Advance in intervention of chemotherapy-induced taste changes [J]. J Nurs Sci 35(12):99–102. https://doi.org/10.3870/j.issn.1001-4152.2020.12.099
40. Dong YG, Zhang XJ, Lu ZQ, Yang Z, Wang Y, Chen F (2020) Summary of best evidence on assessment of and nursing measures for chemotherapy-induced taste alteration. J Nurs Sci 35(12):33–37. https://doi.org/10.3870/j.issn.1001-4152.2020.12.033
41. Chen YJ, Chen SC, Wang CP, Fang YY, Lee YH, Lou PJ, Ko JY, Chiang CC, Lai YH (2016) Trismus, xerostomia and nutrition status in nasopharyngeal carcinoma survivors treated with radiation. Eur J Cancer Care 25(3):440–448. https://doi.org/10.1111/ecc.12270
42. Zhang N (2020) Symptom clusters and comfort status among nasopharyngeal carcinoma during radiotherapy: a longitudinal study (Master's thesis, Qingdao University). http://link--cnki--net--https.cnki.scrm.scsycy.vip:2222/doi/10.27262/d.cnki.gqdau.2020.00007410.27262/d.cnki.gqdau.2020.000074
43. Wang C, Chen J, Su L, Hua Y, Ye J, Song X, Lv W, Zhang M, Huang F, Tian J, Hong J (2022) The psychological status in patients with nasopharyngeal carcinoma during radiotherapy. Eur Arch Oto-Rhino-Laryngol Off J Eur Fed Oto-Rhino-Laryngol Soc (EUFOS) Affiliated German Soc Oto-Rhino-Laryngol - Head Neck Surg 279(2):1035–1042. https://doi.org/10.1007/s00405-021-06892-5
44. Li R, Su L, Hua Y, Ye JR, Song XR, Tian J, Song JH, Hong JS (2021) Anxiety and depression status prior to radiotherapy in patients with nasopharyngeal carcinoma and its effect on acute radiation toxicities. Eur J Cancer Care 30(6):e13487. https://doi.org/10.1111/ecc.13487
45. Sloan E, Hall K, Moulding R, Bryce S, Mildred H, Staiger PK (2017) Emotion regulation as a transdiagnostic treatment construct across anxiety, depression, substance, eating and borderline personality disorders: a systematic review. Clin Psychol Rev 57:141–163. https://doi.org/10.1016/j.cpr.2017.09.002
46. Ying L, Zhu Y, Wang W (2019) Longitudinal study on the correlation between taste alteration and quality of life among nasopharyngeal carcinoma patients undergoing radiotherapy. Chin J Pract Nurs 35(34):2682–2687. https://doi.org/10.3760/cma.j.issn.1672-7088.2019.34.009
47. Wu WY, Yang FY, Yang SY, Ye CX, Li WY, Li X, Dai Q (2017) Longitudinal study on the correlation between symptoms and quality of life among nasopharyngeal carcinoma patients undergoing radiotherapy. Chin Mod Nurs 23(16):2100–2104. https://doi.org/10.3760/cma.j.issn.1674-2907.2017.16.006
48. Crowder SL, Douglas KG, YaninaPepino M, Sarma KP, Arthur AE (2018) Nutrition impact symptoms and associated outcomes in post-chemoradiotherapy head and neck cancer survivors: a systematic review. J Cancer Survivorship Res Pract 12(4):479–494. https://doi.org/10.1007/s11764-018-0687-7
49. Thorne T, Olson K, Wismer W (2015) A state-of-the-art review of the management and treatment of taste and smell alterations in adult oncology patients. Support Care Cancer Off J Multinatl Assoc Support Care Cancer 23(9):2843–2851. https://doi.org/10.1007/s00520-015-2827-1