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Prevalence of taste and smell dysfunction in mild and asymptomatic COVID-19 patients during Omicron prevalent period in Shanghai, China: a cross-sectional survey study

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ABSTRACT

Objectives COVID-19, which is caused by SARS-CoV-2, is a severe threat to human health and the economy globally. This study aimed to investigate the prevalence of taste and/or smell dysfunction and associated risk factors in mild and asymptomatic patients with Omicron infection in Shanghai, China.

Design This was a questionnaire-based cross-sectional study.

Setting COVID-19 patients at the makeshift hospital in the Shanghai World Expo Exhibition and Convention Centre were recruited from March to April 2022.

Participants In total, 686 COVID-19-infected patients who were defined as mild or asymptomatic cases according to the diagnostic criteria of New Coronavirus Pneumonia Prevention and Control Programme ninth edition (National Health Commission of China, 2022) were enrolled.

Measures Data to investigate taste and smell loss and to characterise other symptoms were collected by the modified Chemotherapy-induced Taste Alteration Scale and Sino-Nasal Outcome Test-22 questionnaires. The risk factors for the severity of taste/smell dysfunction were analysed by binary logistic regression models.

Results 379 males (379/686, 55.2%) and 307 females (307/686, 44.8%) completed the questionnaires to record recent changes in taste and smell ability. A total of 302 patients (44%) had chemosensory dysfunction with Omicron infection, of which 22.7% (156/686) suffered from both taste and smell dysfunction. In addition, cough (60.2%), expectoration (40.5%), fever (33.2%) and sore throat (32.5%) were common symptoms during Omicron infection. The quality-of-life-related indicators were negatively associated with participants' self-reported taste and smell dysfunction.

Conclusions The prevalence of taste or/and smell dysfunction in patients with Omicron infections was 44%. Individuals with chemosensory dysfunction had significantly higher rates of various upper respiratory influenza-like symptoms, xerostomia and bad breath. Moreover, smell dysfunction was a risk factor for the prevalence of taste dysfunction in patients with Omicron infection.

STRENGTHS AND LIMITATIONS OF THIS STUDY

⇒ This study was based on data from the early Omicron wave in Shanghai.
⇒ The prevalence of olfactory and gustatory dysfunction in mild Omicron infections remained above 40%.
⇒ Smell dysfunction was a risk factor for taste dysfunction in mild Omicron-infected patients.
⇒ Age and smoking status had no impact on the prevalence of chemosensory dysfunction in patients with Omicron infection.
⇒ The self-reported data were collected from asymptomatic or mild COVID-19 patients in a makeshift hospital by cross-sectional surveys.

Trial registration number ChiCTR 2200059097.

INTRODUCTION

Since the end of 2019, COVID-19, which is caused by SARS-CoV-2, is a severe threat to human health and the economy globally. WHO has designated five SARS-CoV-2 variants of concern: Alpha (B.1.1.7), Beta (B.1.351), Gamma (P.1), Delta (B.1.617.2) and Omicron (B.1.1.529).[1] The newly recognised variant Omicron was first reported in November 2021 in South Africa.[2] Omicron rapidly swept across the world; more than one million people were infected daily since 24 December 2021.[3] The infectivity of Omicron is nearly 10 times higher than that of the original SARS-CoV-2.[4 5] It has been reported that the average basic reproduction number (R_0) of Omicron is 9.5, ranging from 5.5 to 24, which is 2.5 times higher than that of Delta. The average effective reproduction number (Re) for Omicron is 3.4, which is 3.8 times higher than that of Delta.[6] It is thus clear that

Omicron has higher transmissibility than other variants. By April 2022, Omicron was the predominant variant around the world.

The first Omicron infection case in mainland China was reported on 14 December, 2021 in Tianjin.[7] The Omicron wave swept across the whole country, despite control measures of all detected infections. On 10 April 2022, it was reported that the number of infections in mainland China was 242 291 and continued to increase.[8] The mean viral load measured in nasopharyngeal swabs was significantly higher during the period when Omicron prevailed than during the period when Alpha prevailed, and the rate of subjects with high nasopharyngeal viral load increased more than twofold.[9] Another study showed higher antigen levels in saliva specimens than in mid-turbinate nasal swabs and oropharyngeal swabs.[10] The higher viral load in saliva and the nasopharynx may contribute to the higher transmissibility of Omicron.

The median incubation period of Omicron is about 2–3 days, which is shorter than that of previous variants.[11] Omicron infection is less likely to cause lower respiratory tract symptoms than Delta, and the rate of hospital admission and intensive care was reduced in the UK, France and South Africa.[12–14] Omicron has a much higher rate of asymptomatic carriage than other variants.[15] Meanwhile, Omicron infections resulted in more milder cases (63.2%) than Delta infections (51.8%), and the infection rate of Omicron (68.7%, (66.3%–82.5%)) was higher than that of Delta in vaccinated patients (52.6%, (49.4%–55.7%)).[16] Omicron infection mainly causes mild upper respiratory symptoms, such as cough, fatigue, joint pain, sore throat and congestion or runny nose.[17 18] Smell and taste dysfunction is one of the most common reported symptoms, and its morbidity was about 50%–70% in COVID-19 patients before November 2021.[12 19 20] A recent study investigating Omicron cases in UK showed that the rate of loss of smell was lower (16.7%) during the Omicron wave than during the Delta wave (52.7%).[12] Even though the prevalence of chemosensory dysfunction seems to have decreased, the huge population infected with Omicron leads to high numbers of people suffering from smell or taste alteration. Therefore, more studies are needed to investigate the prevalence and severity of chemosensory dysfunction among Omicron patients.

Currently, the Omicron pandemic continues in Shanghai, China. Mild or asymptomatic infections based on the diagnostic criteria of New Coronavirus Pneumonia Prevention and Control Programme ninth edition were quarantined at makeshift hospitals and were invited to participate in this study, which aimed to (1) investigate the symptoms of patients with Omicron infection and (2) analyse the prevalence and potential risk factors of smell and taste dysfunction caused by Omicron infection.

Materials and methods

Study population

The cases in the present study were recruited from the makeshift hospital in the Shanghai World Expo Exhibition and Convention Centre from March to April 2022. All cases are mild or asymptomatic COVID-19 infections recruited from multiple districts in Shanghai, whose nasopharyngeal swabs were positive for SARS-CoV-2 based on RT-PCR.

Inclusion criteria were as follows:

Laboratory-confirmed SARS-CoV-2 infection, with or without mild COVID-19 symptoms but with no evidence of pneumonia based on WHO criteria at the time.

Exclusion criteria were as follows

i. Unwilling to participate in the investigation and follow-up.
ii. Neurological or mental disorders.
iii. Patients who had undergone surgery or radiotherapy in the nasopharynx or the oral cavity.
iv. Patients who already had olfactory or taste disorders.
v. Serious head injury.
vi. Patients with allergic rhinitis and chronic sinusitis.
vii. Mucosal diseases in the tongue or other parts of the mouth.

Sample size

The sample size was calculated by the PASS software (V.15.0) based on a prior study[21] using the prevalence of chemosensory dysfunction in SARS-CoV-2 patients (32.5%) with α value of 0.05 and d (error) value of 0.08. The minimum sample size required was 550. Considering the invalid response and drop-out rate, the recruiting period defined the final sample size.

Procedures

On recruitment, a questionnaire was taken by the participants to record recent changes in taste and smell and the occurrence of other COVID-19 symptoms. The general information included (1) demographic characteristics such as age, gender, education, smoking status, etc and (2) medical history. The symptom-related information included health status, recent changes in taste and smell, symptoms in the oral cavity and the occurrence of other COVID-19 symptoms.

The symptom-related questionnaire was developed by the researchers, involving a series of standardised questions of the Chemotherapy-induced Taste Alteration Scale (CiTAS)[22] and the smell alteration questionnaire. Taste dysfunction was evaluated by the CiTAS questions, which included 18 items on a 5-point Likert scale. There were four dimensions of the scale: basic taste; discomfort; phantogeusia and parageusia; and general taste alterations. The scores ranged from 1 to 5 points: 1=no; 2=slightly; 3=somewhat; 4=quite and 5=very. The total score was obtained by summing all scores, so a high score indicates severe taste dysfunction.[22] To evaluate

smell dysfunction, the smell alteration questionnaire was composed of nine items on a 5-point Likert scale. Similarly, scores were summed to determine smell alteration. Referring to the Sino-Nasal Outcome Test-22 (SNOT-22),[23] the questionnaire included questions related to quality of life ('difficulty falling asleep,' 'waking up at night,' 'waking up tired,' 'fatigue,' 'reduced productivity,' 'reduced concentration') and questions related to psychology ('frustrated/restless/irritable,' 'sad' and 'embarrassed').

Statistical analysis

All statistical analyses were performed using SPSS V.23 (IBM SPSS Statistics for Macintosh; IBM), and statistical significance was set at p<0.05. Qualitative variables are presented as frequencies and percentages; normally distributed quantitative variables are presented as mean±SD. Pearson's χ^2 test or one-way analysis of variance was used to analyse associations between variables in patients with taste dysfunction and/or smell dysfunction and patients without taste dysfunction or smell dysfunction. If the assumption for the χ^2 test was violated (the expected value is less than 5), Fisher's exact test was applied. Spearman's correlation analysis was performed to explore the association between the variables and the development of taste dysfunction/smell dysfunction. Binary logistic regression analysis was conducted to explore the association between selected factors and the presence of taste dysfunction/smell dysfunction. The value of predictor variables was calculated individually or in combination. Backward stepwise selection was employed to remove insignificant variables from the model.

The 95% CIs were provided for the reported data where appropriate, and the level of statistical significance was set at two-sided p<0.05.

Patient and public involvement

This study did not involve patients or the public in the design, conduct, reporting or dissemination of our research.

RESULTS

Participant demographics and characteristics

A total of 764 patients were identified as potentially eligible for this study. Following screening of electronic information, 78 questionnaires were excluded because of missing important information or defined as invalid because logical questions were answered with inconsistency. The remaining 686 patients were enrolled.

The baseline characteristics of the subjects are summarised in table 1. In total, 379 males (55.2%) and 307 females (44.8%) were included in the present study. The overall mean age of the patients was 41±4 years old (ranging from 6 to 70 years). Among them, 19 individuals (2.8%) were children/adolescents and 14 individuals (2.0%) were over 60 years old. A majority of the enrolled patients had no habits of tobacco consumption (78.7%) and no pre-existing chronic disease (87.3%). In total, 475 participants (69.2%) had not received college education.

Table 1 Detailed characteristics of the population

Total population (n=686)		
Age (Mean±SD)		41±4
Age groups, n (%)	<17 years	19 (2.8)
	18–30 years	233 (34)
	31–40 years	150 (21.9)
	41–50 years	148 (21.6)
	51–60 years	122 (17.8)
	>60 years	14 (2.0)
Gender, n (%)	Male	379 (55.2)
	Female	307 (44.8)
Smoking status, n (%)	Never smoked	540 (78.7)
Nicotine consumption	<10 cpd	68 (9.9)
	11–20 cpd	63 (9.2)
	20–40 cpd	13 (1.9)
	>40 cpd	2 (0.3)
Education background, n (%)	Junior or high school	475 (69.2)
	Associate degree	82 (12)
	Bachelor's degree	106 (15.5)
	Master/doctor's degree	23 (3.4)
Systemic disease, n (%)	None	599 (87.3)
	Hypertension	37 (5.4)
	Diabetes	15 (2.2)
	Heart disease	10 (1.5)
	Kidney disease	3 (0.4)

Percentages may not total 100.0% due to rounding.
cpd, cigarettes per day.

Prevalence and severity of taste and smell dysfunction

Of the 686 participants, 56% (384) reported to have no changes in taste/smell (table 2). Of the remaining participants, 131 (19.1%) had taste dysfunction only, 15 (2.2%) had smell dysfunction only and 156 (22.7%) had both taste and smell dysfunction. Thus, a total of 302 patients with Omicron infection (302/686, 44%) had chemosensory dysfunction (table 3).

As depicted in table 2, there was a significant difference in the distribution of gender. Of all patients without taste dysfunction or smell dysfunction, 60.7% were male. Comparisons of other demographics revealed no significant correlations between these four subgroups in terms of age, smoking status (having smoked vs never smoked) and the development of chemosensory dysfunction (p>0.05). Alteration of taste and/or smell was the most common symptom in this survey, besides cough (60.2%),

Table 2 Prevalence of taste disorders (TD) and smell disorders (SD) and their clinical baseline characteristics

	Patients without SD or TD	Patients with TD only	Patients with SD only	Patients with TD and SD	P value
Total, n (%)	384 (56.0)	131 (19.1)	15 (2.2)	156 (22.7)	
Age, (mean±SD)	39±12	39.47±12.41	43.33±9.82	39.60±10.75	0.597
Age groups, n (%)					0.338
<18 years	12 (3.1)	3 (2.3)	0 (0)	4 (2.6)	
18–30 years	74 (19.3)	33 (25.2)	1 (6.7)	24 (15.4)	
31–40 years	124 (32.3)	38 (29)	6 (40.0)	65 (41.7)	
41–50 years	99 (25.8)	28 (21.4)	5 (33.3)	34 (21.8)	
51–60 years	70 (18.2)	24 (18.3)	2 (13.3)	26 (16.7)	
>60 years	5 (1.3)	5 (3.8)	1 (6.7)	3 (1.9)	
Gender, n (%)					**0.010**
Male	233 (60.7)$_a$	62 (47.3)$_b$	9 (60)$_{a,b}$	75 (48.1)$_b$	
Female	151 (39.3)$_a$	69 (52.7)$_b$	6 (40)$_{a,b}$	81 (51.9)$_b$	
Smoking status, n (%)					0.634
Never smoked	289 (75.3)	111 (84.7)	12 (80)	128 (82.1)	
Smoked	95 (24.7)	20 (15.3)	3 (20)	30 (17.9)	
Systemic disease					
None	343 (70.9)	112 (85.5)	12 (80)	133 (85.3)	0.243
Hypertension	17 (4.4)	10 (7.6)	2 (13.3)	8 (5.1)	0.196
Diabetes	8 (2.1)	4 (3.1)	0 (0)	3 (1.9)	0.817
Heart disease	6 (1.6)	1 (0.8)	0 (0)	3 (1.9)	0.804
Kidney disease	1 (0.3)	1 (0.8)	0 (0)	1 (0.6)	0.431

P value obtained using one-way ANOVA test for quantitative variables and χ^2 test for qualitative variables. The comparison of the distribution of age and systemic disease were tested by Fisher's exact test.
Significant p values in bold.
Subscript letter (a and b) denotes a subset of group categories whose gender proportions do not differ significantly from each other at the 0.05 level.
ANOVA, analysis of variance.

expectoration (40.5%), fever (33.2%) and sore throat (32.5%) (table 3). The duration of fever was 1.8 days (range 1–7 days). In patients with chemosensory dysfunction, the percentage of upper respiratory tract symptoms (URTS) (cough/stuffy nose/runny nose/purulent nasal discharge/sore throat), xerostomia and bad breath was higher than in patients without chemosensory dysfunction (figure 1). Patients with three or more URTS were more likely to suffer taste and/or smell dysfunction.

Taste/smell manifestations and other symptoms

The distribution of taste alteration in Omicron-infected patients is depicted in figures 2 and 3. There were statistically significant changes in self-ratings of smell and taste between patients with chemosensory dysfunction and patients without chemosensory dysfunction, as determined by the signed-rank test (figure 2 and figure 3). A higher percentage of very mild symptoms was observed. The two most prevalent CiTAS problems were 'having a bitter taste in the mouth' (96/287, 33.4%) and 'having a bad taste in the mouth' (89/287, 31%) (figure 3). These two problems might also be related with the problem 'bad breath', which was most frequently reported to affect COVID-19-infected patients (table 3). Among them, 10 patients (10/287, 3.5%) reported they were unable to perceive the smell or flavour of food.

Nine items were included to evaluate the patients' sense of smell (figure 3). Patients with smell dysfunction declared the most prevalent problem was 'I feel that my sense of smell is diminished,' of which the severity was slight in 50.3% (86/171), mild in 17.54% (30/171), moderate in 5.3% (9/171) and severe in 7.6% (13/171). Other problems were 'I always feel that my sense of smell is different from before' and 'due to the change of smell, eating and drinking are not as pleasant as before.' Loss of smell was mostly very mild, as shown in figure 3.

Quality-of-life-related factors are depicted in figure 4. Patients with chemosensory dysfunction demonstrated a significantly higher score (19.91±9.011, range 11–55) than those without chemosensory dysfunction (12.78±4.064, range 11–19). Fatigue was the most bothering problem, followed by 'lack of a good night's sleep'.

Table 3 Participants' other clinical symptoms besides chemosensory disorder

Features	No of patients (%)						
	Total populatiion (n=686)		Patients without TD or SD (n=384)		Patients with TD and/or SD (n=302)		P value
Fever	228	(33.2)	103	(26.8)	125	(41.4)	**<0.001**
Cough	413	(60.2)	195	(50.8)	218	(72.2)	**0.013**
Expectoration	278	(40.5)	109	(28.4)	169	(56.0)	**<0.001**
Stuffy nose	219	(31.9)	84	(21.9)	135	(44.7)	**<0.001**
Runny nose	129	(18.8)	38	(9.9)	91	(30.1)	**<0.001**
Purulent nasal	42	(6.1)	10	(2.6)	32	(10.6)	**<0.001**
Sore throat	223	(32.5)	84	(21.9)	139	(46.0)	**<0.001**
Xerostomia	213	(31.0)	71	(18.5)	142	(47.0)	**0.002**
Gingivo-paradontal Bleeding	78	(11.4)	31	(8.1)	47	(15.6)	0.361
Ulcers	61	(8.9)	24	(6.3)	37	(12.3)	0.953
Bad breath	103	(15.0)	30	(7.8)	73	(24.2)	**<0.001**

P value obtained using $\chi 2$ test. Significant p values in bold.
SD, smell dysfunction; TD, taste dysfunction.

Risk factors associated with taste and smell dysfunction

The occurrence of taste and/or smell dysfunction in patients is depicted in tables 2 and 3. To further characterise the relationship between these changes and chemosensory modality disorders, Spearman's correlation analysis was conducted to assess predictors in self-rating of taste and smell (online supplemental table S1). The predictor variables that varied significantly between whether patients developed taste dysfunction or not were gender, smoke, fever, xerostomia, bad breath, URTS,

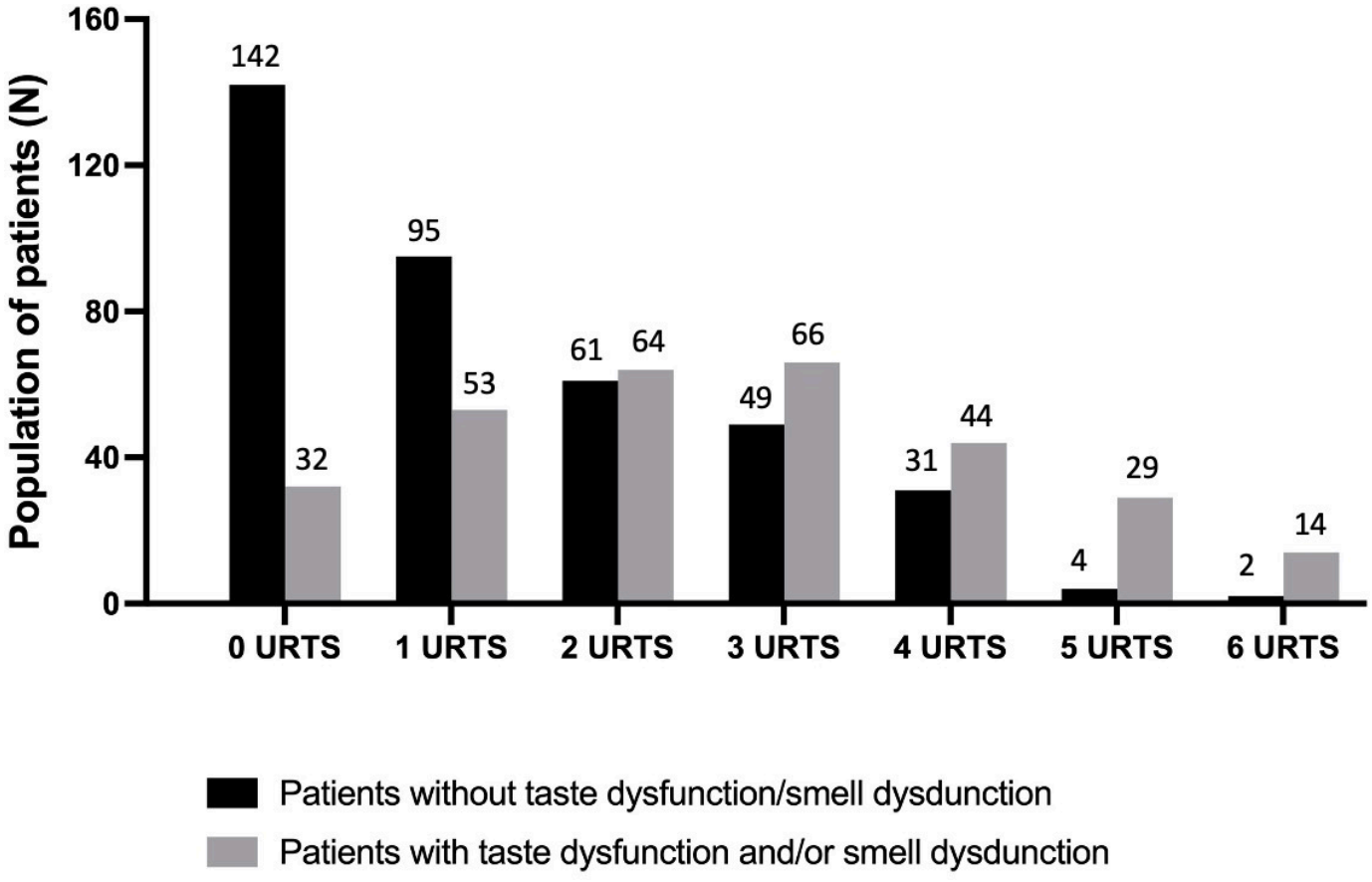

Figure 1 Presenting upper respiratory tract infection symptoms (URTS) with 0–6 factors among patients without taste dysfunction/smell dysfunction and patients with taste dysfunction and/or smell dysfunction.

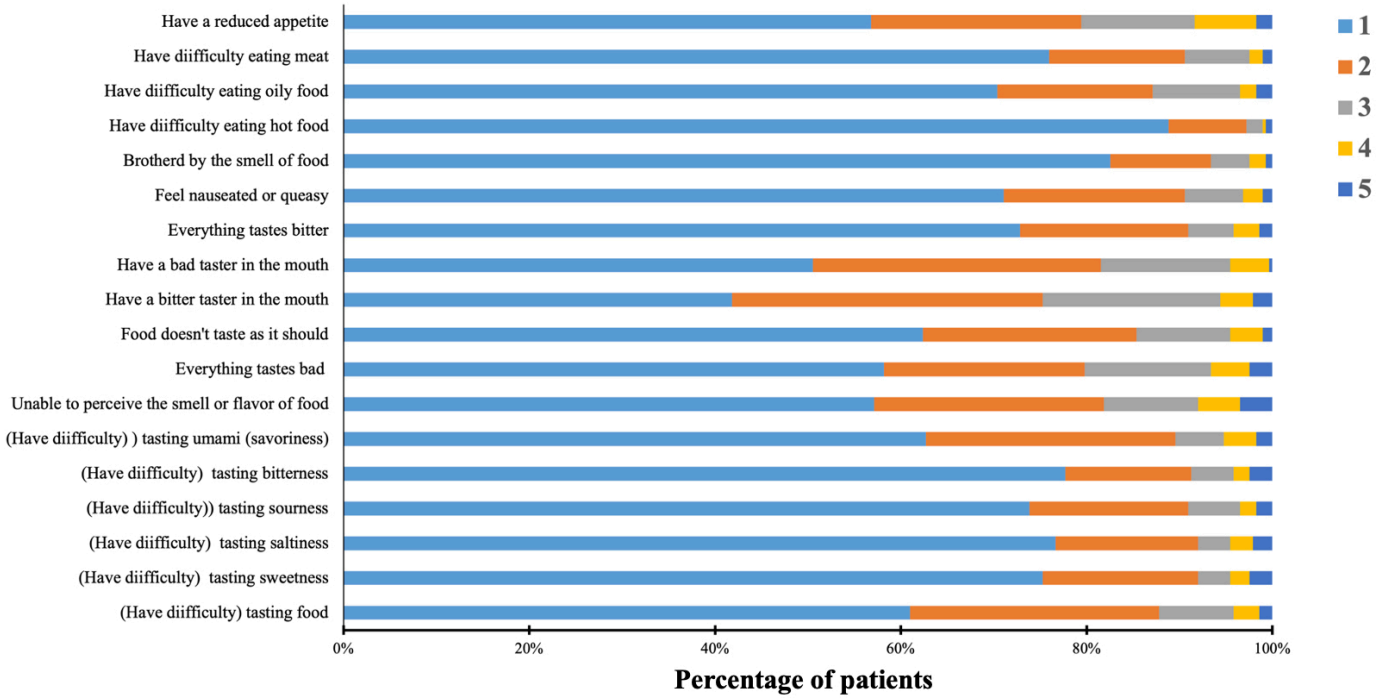

Figure 2 Distribution of taste alteration problems in the CiTAS scale reported in the patients with taste dysfunction group. CiTAS score=27.18±10.455 (mean±SD). CiTAS, Chemotherapy-induced Taste Alteration Scale.

smell dysfunction and purulent nasal discharge. When all eight predictor variables were considered together, binary logistic regression analysis after adjustment showed a statistically significant association between four variables and the development of taste dysfunction (table 4): URTS (OR 1.417; 95% CI 1.242 to 1.615), smell dysfunction (OR 0.068; 95% CI 0.016 to 0.293), xerostomia (OR 0.360; 95% CI 0.238 to 0.545) and bad breath (OR 0.470; 95% CI 0.280 to 0.789).

The same methods were used for smell dysfunction. Explanatory variables on the development of smell dysfunction were fever, xerostomia, bad breath and URTS. Results from the regression models showed that fever (OR 0.386; 95% CI 0.198 to 0.752), URTS (OR 1.593; 95% CI 1.298 to 1.969), xerostomia (OR 0.225; 95% CI 0.081 to 0.627) and bad breath (OR 0.365; 95% CI 0.184 to 0.724) showed significant associations.

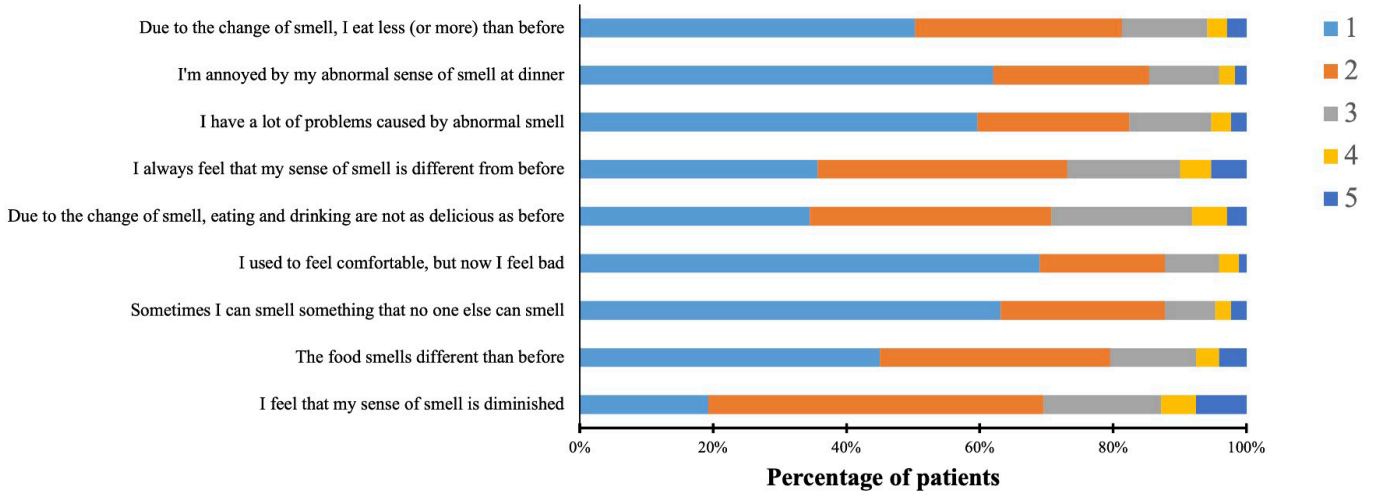

Figure 3 Distribution of smell alteration problem reported in the patients with smell dysfunction group. Smell dysfunction score=16.37±6.943 (mean±SD).

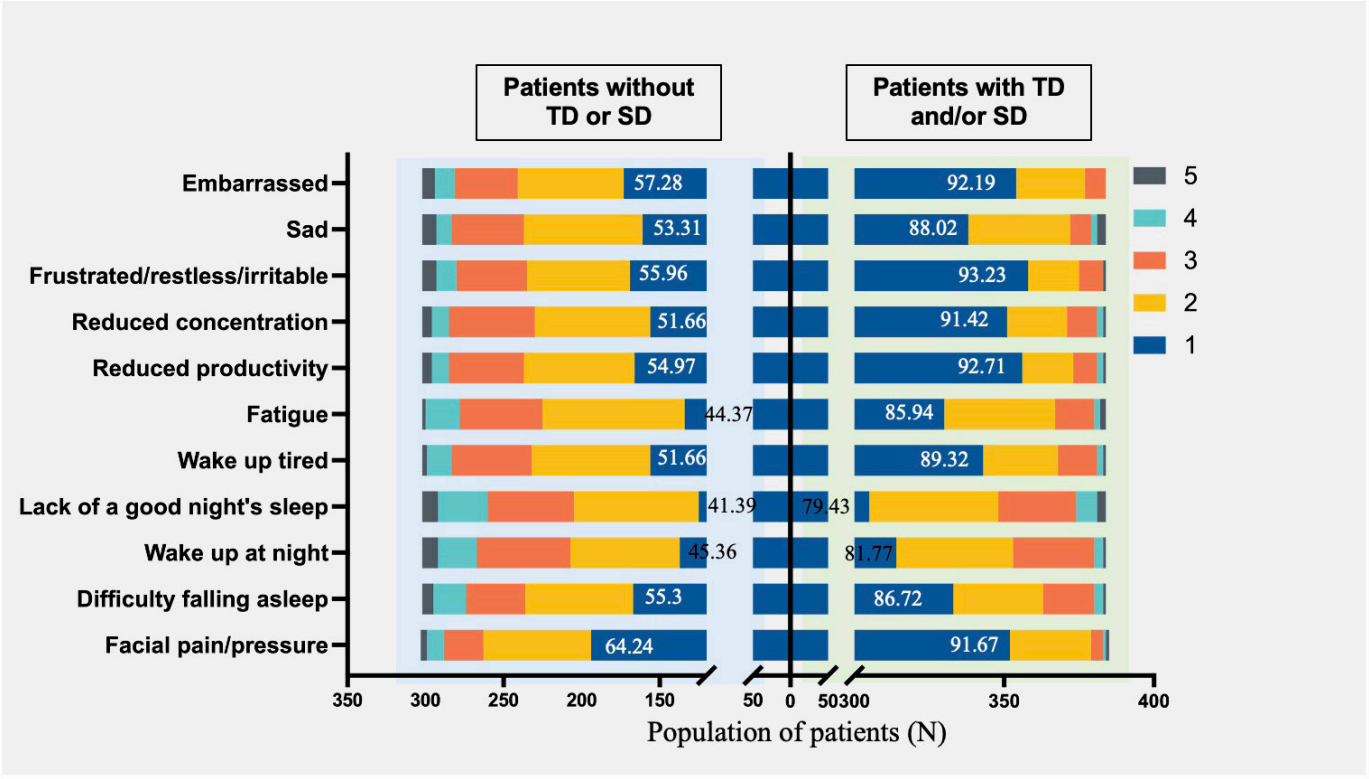

Figure 4 Quality-of-life-related problems reported to most greatly affect patient health. The number on the purple bar represents the ratio. SD, smell dysfunction; TD, taste dysfunction.

DISCUSSION

In total, 686 Omicron patients were enrolled in this study. Of these, 302 (44%) participants suffered from chemosensory dysfunction; 15 patients (2.2%) reported only smell dysfunction, 131 patients (19.1%) reported only taste dysfunction and 156 subjects (22.7%) reported both taste and smell dysfunction. These results are consistent with previous studies which showed that the prevalence and severity of self-reported chemosensory dysfunction during the proxy Omicron period was significantly lower (32.5%) than that during the comparator period (66.9%).[21]

SARS-CoV-2 binds to host cells via the cell surface receptor ACE2; thus, ACE2 mediates viral entry into cells and affects the infectivity, transmissibility and antibody resistance of the virus.[24] ACE2 is highly expressed on the epithelial cells of respiratory epithelium and oral mucosa, especially on the tongue and in the salivary glands.[25 26] But ACE2 expression in olfactory receptor neurons is absent or minimal; thus, the virus rarely directly infects the neurons.[27] Sustentacular support cells in Bowman glands express ACE2 and transmembrane serine protease 2.[28] SAR-CoV-2 enters the olfactory epithelium via damaging the sustentacular support cells and secretory

Table 4 Logistic regression analysis of factors associated with taste and/or smell dysfunctions disturbances among COVID-19 patients

	Variables	Regression coefficients (β)	OR (95% CI)	P value
Taste dysfunction	URTS	0.348	1.417 (1.243 to 1.615)	**<0.001**
	Smell dysfunction	−2.687	0.068 (0.016 to 0.293)	**<0.001**
	Xerostomia	−1.021	0.360 (0.238 to 0.545)	**<0.001**
	Bad breath	−0.756	0.470 (0.280 to 0.789)	**0.004**
Smell dysfunction	Fever	−0.952	0.386 (0.198 to 0.752)	**0.005**
	URTS	0.466	1.593 (1.289 to 1.969)	**<0.001**
	Xerostomia	−1.490	0.225 (0.081 to 0.627)	**0.004**
	Bad breath	−1.007	0.365 (0.184 to 0.724)	**0.004**

P-value obtained using binary logistic regression. Significant *P* values in bold.
URTS, upper respiratory tract symptom.

cells, indirectly leading to injury to the olfactory sensory neurons.[29 30] Similarly, ACE2 is not expressed in taste buds or taste papillae but is highly expressed in epithelial cells of the basal region of filiform papillae, so taste impairment in COVID-19 is likely caused by indirect damage to taste receptors through infection of epithelial cells and a local inflammatory response.[31] Omicron has a high mutation rate; the virus' spike protein has 26–35 amino acid substitutions compared with the original SARS-CoV-2 virus or the Delta variant.[18] These mutations may change the interaction between the virus and host cells, causing chemosensory dysfunction.

This study showed a higher rate of chemosensory dysfunction than a previous study which showed the prevalence of self-reported chemosensory dysfunction was 32.5%, and the prevalence of alteration of only smell and taste sense was 24.6% and 26.9%, respectively.[21] In the previous study, symptoms were self-reported, while in our study the modified CiTAS and SNOT-22 scales were used, which provide sensitive recognition of symptoms.[32] The difference is also attributed to the fact that most of the participants (98%) are aged less than 60 years old, with a mean age of 41±4 years. Some other studies reported that alteration of smell and taste was significantly more common among younger individuals.[20 33 34] No statistically significant association between taste or smell dysfunction and age was found in our study because the population above 60 was too small. As people get older, gustatory dysfunctions are more frequent because of degradation of gustatory peripheral tissues and different neural signatures in the central nervous system.[35] Therefore, gustatory degeneration in ageing people make them less sensitive to recognise changes due to Omicron infection. In the present study, 51.7% of the individuals with chemosensory dysfunction were females and only 39.3% of patients without chemosensory dysfunction were females ($p<0.05$). While some other studies also reported that alteration of smell and taste was significantly more common among female individuals, it may be attributed to the fact that women are more sensitive than men on chemosensory assessment.[20 33]

Additionally, Omicron variant infection mainly causes mild upper respiratory symptoms such as cough, sore throat, congestion or a runny nose.[17 18] This study revealed that the population with chemosensory dysfunction has significantly higher rates of reported various upper respiratory influenza-like symptoms, especially cough (72.2%) and expectoration (56%). Logistic regression analysis proved that chemosensory dysfunction was strongly associated with URTS after Omicron infection. This supports a previous study, which showed that chemosensory dysfunction is associated with broader symptoms of COVID-19.[36] COVID-19-positive patients have a much higher rate of chemosensory dysfunction than those with influenza-like symptoms but a negative COVID-19 test.[37] Interestingly, 47% of patients with smell and taste dysfunction complained dry mouth simultaneously, while this percentage was only 18.5% in patients without chemosensory dysfunction. A similar study showed that the rate of dry mouth is 45.9% in COVID-19 patients, and among them 76.5% suffer from xerostomia for the first time.[38] Furthermore, logistic regression analysis showed that chemosensory dysfunction was related to xerostomia and bad breath. A cross-sectional study also showed that the xerostomia and dysgeusia rates were significantly higher in the SARS-CoV-2 RNA-positive group, while other oral manifestations were insignificant.[39] Therefore, chemosensory dysfunction and xerostomia should be considered as screening symptoms due to their high specificity.

Quality-of-life-related questions from SNOT-22 showed that scores in patients with chemosensory dysfunction were significantly higher (19.91±9.011, range 11–55) than in those without chemosensory dysfunction (12.78±4.064, range 11–19). This is consistent with a previous study[40] and indicates that chemosensory dysfunction reduces the quality of life of Omicron patients. It has been reported that the median duration is about 10 days in subjects with mild COVID-19 and 5 days for Omicron patients.[12] Moreover, 89% of patients with mild COVID-19 completely recover within 4 weeks after diagnosis.[41] But 12.8%–48% of SARS-CoV-2 patients reported persistent chemosensory dysfunction.[19 40 42] Further assessments are necessary to investigate the recovery rate of Omicron-related chemosensory disorders and its persistent impact on patients' quality of life.

According to other studies, type II diabetes mellitus (T2DM) is associated with olfactory and gustatory dysfunction.[43] T2DM with hyperglycaemia can elevate the expression of ACE2 in lungs and other tissues[44]; therefore, it may be a risk factor for increased severity of COVID-19 and lead to higher rates of chemosensory dysfunction. As subjects infected with Omicron SARS-CoV-2 were significantly younger (median age, 42 years) than patients infected with previous variants (median age, 63 and patients with systemic disease tend to develop severe COVID-19,[45] the participants with mild Omicron infection had a lower prevalence of these comorbidities in the present study. Given the small number of participants reported having diabetes or other chronic systemic diseases in this study, this effect did not reach statistical significance in the groups with/without chemosensory dysfunction .

This study had some limitations. First, the symptoms of hospitalised patients with moderate or severe COVID-19 were not recorded, so the results are not representative of the general population. Investigations on moderate to severe Omicron infections are needed to determine the prevalence of chemosensory dysfunction in all infected patients. Second, symptoms were self-reported and based on cross-sectional surveys, and therefore, may contain suboptimal sensitivity. A previous report has shown that subjectivity of self-reporting may lead to underestimation of the prevalence of olfactory dysfunction,[19] and some smell and taste tests seem to measure changes in smell and taste more objectively.[46] Ultimately, the viral load was

significantly higher in symptomatic than in asymptomatic subjects.[47] In this study, SARS-CoV-2 RNA tests did not provide the test results as cycle threshold values, which may be strongly associated with symptoms of Omicron infections.

CONCLUSION

Although the prevalence of taste and smell dysfunction in mild COVID-19 patients during Omicron waves was much lower than that during Delta waves, more than 40% of patients suffered from it. Individuals with chemosensory dysfunction had significantly higher rates of various upper respiratory influenza-like symptoms, xerostomia and bad breath. Among the analysed risk factors, age (under 60 years) and smoking status had no impact on the prevalence of chemosensory dysfunction in patients with Omicron infection. The impact of systemic diseases needs further clarification.

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Contributors All authors have read and approved the manuscript. JW had full access to all data in the study and takes responsibility for the integrity of the data and the accuracy of the data analysis.Study concept and design: JW, YC, SR and ZH. Acquisition of data: JW, YC, JH, CN, PZ, KY, XZ, QJ, SR and ZH. Drafting of the manuscript: JW and SR. Critical revision of the manuscript for important intellectual content: SR and ZH. Statistical analysis: JW, YC, JH, CN and PZ. Administrative, technical or material support: YC. Study supervision: ZH and SR. JW, SR and ZH are the guarantors. All methods were carried out in accordance with relevant guidelines and regulations.

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