PLOS ONE

RESEARCH ARTICLE

Taste alteration and its relationship with nutritional status among cancer patients receiving chemotherapy, cross-sectional study

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OPEN ACCESS

Citation: Al-Amouri FM, Badrasawi M (2024) Taste alteration and its relationship with nutritional status among cancer patients receiving chemotherapy, cross-sectional study. PLoS ONE 19(5): e0302990. https://doi.org/10.1371/journal.pone.0302990

Editor: Naim Akhtar Khan, Université de Bourgogne: Universite de Bourgogne, FRANCE

Received: October 5, 2023

Accepted: April 16, 2024

Published: May 9, 2024

Peer Review History: PLOS recognizes the benefits of transparency in the peer review process; therefore, we enable the publication of all of the content of peer review and author responses alongside final, published articles. The editorial history of this article is available here: https://doi.org/10.1371/journal.pone.0302990

Data Availability Statement: All relevant data are available on Figshare: Figures data: figshare, DOI: 10.6084/m9.figshare.25037483 Tables raw data: figshare, DOI: 10.6084/m9.figshare.25035959.

Abstract

The aim of this study is to determine the prevalence of taste alterations (TAs) during chemotherapy and their association with nutritional status and malnutrition. In addition to the associated factors with TA, including sociodemographic health-related factors and clinical status, and to investigate coping strategies to manage TA. A multicenter cross-sectional design study was conducted on 120 cancer patients aged at least 18 who had been undergoing at least one round of chemotherapy. TAs were evaluated using the chemotherapy-induced taste alteration scale (CiTAS), the malnutrition universal screening tool (MUST) was used for nutritional screening, the antineoplastic side effects scale (ASES) was used for subjective assessment of chemotherapy side effects, and the Charlson comorbidity index (CCI) was used for comorbidity assessment. SPSS21 software was used to analyze the data, and the independent T-test and one-way ANOVA test were used to determine the association between TAs and a variety of related variables. The prevalence of TAs was 98.3%. Among participants, 48.3% were at low risk of malnutrition, 20% at medium risk, and 31.7% at high risk. Malnutrition risk was associated with taste disorders ($p<0.05$). Patients' age, gender, educational level, and physical status were associated with TAs ($p<0.05$). Type of cancer, chemotherapy regimen, and number of chemotherapy cycles were also associated with TAs ($p<0.05$). A variety of antineoplastic side effects were associated with TAs ($p<0.05$), including nausea, vomiting, dry mouth, sore mouth and throat, excessive thirst, swallowing difficulty, appetite changes, weight loss, dizziness, lack of energy, disturbed sleep, anxiety, and difficulty concentrating. TAs were associated with an increased number of comorbidities, and individuals with diabetes, pulmonary diseases, and hypertension were associated with TAs ($P<0.05$). Patients in this study rarely practice self-management strategies to cope with TAs. A high prevalence (98.3%) of TAs in cancer patients receiving chemotherapy was found, and it was linked to a variety of negative outcomes. Chemotherapy-induced TAs are an underestimated side effect that requires more attention from patients and health care providers.

Funding: The author(s) received no specific funding for this work.

Competing interests: The authors have declared that no competing interests exist.

Introduction

Taste alteration is a negligible side effect in cancer patients. Oncology specialists underestimate it [1], and cancer patients underreport it despite its severity, prevalence, and implications. Patients rarely communicate it to their healthcare providers due to a lack of knowledge and difficulty recognizing and even describing the feelings they experience in the way they perceive tastes [2].

It is estimated that more than 75% of patients receiving chemotherapy reported that their food was too sweet, sour, salty, bitter, or tasteless, or even tasted like cardboard, metal, or sandpaper [2]. Taste disturbances start within 2 to 3 weeks after chemotherapy and can continue throughout treatment [1]. The literature on TA using subjective or objective analysis is limited, but it shows a high prevalence of TAs during chemotherapy ranges between 49.4% [3], and 76.1% [4]. Furthermore, TAs occur in at least one of the five basic tastes, with sweetness being the most affected [5], and patients exhibiting increased sensitivity to sweet taste, accompanied by a significant decrease in sweet thresholds [6]. However, some research found salty tastes to be more affected and difficult to taste than sweet tastes [2].

TA during chemotherapy have been identified as a serious problem [2], and more studies have investigated its effects patients' lifestyles and dietary habits. It has been shown that TA in cancer patients may influence their eating habits and appetite, leading to decreased body weight and possible deficiencies in essential nutrients [7]. In addition, TA may increase the risk of developing malnutrition in cancer patient. However, research on the precise correlation between TAs and malnutrition are limited. While certain studies have suggested that dietary habits may not have a direct relationship with taste alteration during chemotherapy [8], others have emphasized the significance of taste alteration as a side effect in cancer patients [9], which could potentially result in deficiencies of macro- and micronutrients [7].

There are numerous factors associated with TAs during chemotherapy. Smokers and older patients were less affected by chemotherapy-induced taste impairments due to their increased taste thresholds [2, 10]. On the other hand, women were found to be more susceptible to dysgeusia than men [11, 12]. Developing dysgeusia was significantly associated with the type of cancer and the chemotherapy regimen [13]. Lung and breast cancer patients were more likely to have TAs due to chemotherapy regimens employed [2]. Similarly, gynecological cancer patients also showed a greater incidence of TAs [4]. Furthermore, it was observed that the number of chemotherapy cycles were associated with TA [4, 11, 13, 14].

To cope with the TAs, patients applied several behavioral and self-management strategies. Examples included eating highly seasoned foods, experimenting with new recipes, catering to specific food cravings, cutting foods with lemon, eating sweets before meals, drinking sweetened beverages, drinking with a straw, and eating with plastic utensils; brushing teeth and tongue before eating; and using baking soda, salt, or antibacterial mouthwashes [15].

The aim of this study is to investigate the prevalence of taste alterations in cancer patients undergoing chemotherapy and their association with nutritional status, comorbid diseases, and malnutrition. Furthermore, the factors associated with TAs, copings strategies to manage TAs, and the prevalence of malnutrition is investigated.

Methods

Study design and population

The present study used a cross-sectional design. The sample size was estimated using the Coshrans' formula for cross-sectional studies to determine the prevalence of taste changes. The

prevalence of taste alteration was derived from a prior study conducted by Özkan et al. [16]. It was 63%, with an anticipated difference of 10%, an alpha of 0.05, and a power of 80%. The sample size was calculated to be 89 patients, but using the mean difference between two independent groups, an accepted margin of error of 5%, a confidence level of 95%, and a power of 80%. A total of 120 patients were required for the study.

Patients who were included in this study are cancer patients who are at least 18 years old, had chemotherapy at least once, capable of oral intake, and who can sign the consent form, while patients with chronic disease that may affect the taste (i.e., chronic kidney disease), has taste and smell altered prior to starting chemotherapy (i.e., COVID patients), and with cognitive impairment were excluded from the study.

Data collection and research tools

Data was collected from December 1st, 2022, to March 31st, 2023. The study sample was recruited using convenience sampling technique from the oncology departments of three medical centers: An-Najah National University Hospital in Nablus, Al-Hussain Hospital in Beit Jala, and Palestine Medical Complex in Ramallah through face-to-face interviews.

A four-part structured interview was conducted during chemotherapy with subjects who met the inclusion criteria, agreed to participate in the study, and signed the informed consent. Each subject's name was recorded, and a code was assigned to him or her on the data sheet. The interview lasted between 25 and 35 minutes. The first section discusses sociodemographic and lifestyle. The second part focuses on cancer-related information, chemotherapy side effects, changes in taste perception, and the assessment of comorbid diseases. The third section includes nutritional status assessment, and the interview ended with questions about strategies patients might use to cope with TAs.

The study conducted reliability tests for the majority of instruments. Given that the tools were being employed for the first time in research conducted in Palestine, their content validity and dependability were evaluated using reliability testing. Significantly, every tool was either accessible in its Arabic version or had been translated into Arabic before being utilized. Furthermore, as each scale evaluates a distinct variable, reliability tests were performed separately for each scale.

The antineoplastic side effects scale (ASES). The newly designed Arabic scale ASES was used to subjectively measure chemotherapy side effects. It has good validity and reliability with a Cronbach's alpha of 0.91. It evaluates 40 distinctive chemotherapy side effects and consists of three subscales: frequency, severity, and how the side effects affect patients' daily activities [17]. In this study, the reliability test for ASES resulted in Cronbach's alpha of 0.737 for the ASES frequency subscale, 0.876 for the severity subscale, and 0.896 for the daily life effect subscale, whereas the reliability of the total scale was 0.933.

Malnutrition universal screening tool (MUST). Clinical assessment was performed using the Arabic version of the validated and reliable MUST (Cronbach's alpha = 0.79) [18], a validated tool for routine nutrition screening [19]. MUST is a five-step screening tool to identify adults who are malnourished or at risk of malnutrition [20].

Chemotherapy-induced taste alteration scale (CiTAS). The subjective evaluation of taste changes was performed with the instrument CiTAS, which has excellent reliability (Cronbach alpha = 0.9) and good validity [21]. The original version of the CiTAS is an 18-item, self-administered questionnaire using a five-point Likert scale [22]. An increasing score indicates higher TA intensity [23]. The prevalence related to each subscale was determined by counting the number of patients with scores higher than 1 and calculating the sum as a percentage of the study population, and the overall prevalence of TAs was

calculated in the same way, as used by Larsen et al. [24]. In this study, CiTAS was used in the Arabic version after back-to-back translation, and the Cronbach's alpha was determined to be 0.883.

Charlson comorbidities index (CCI). The Charlson comorbidity index is a validated comorbidity assessment tool that can predict mortality in patients with various diseases. The original Charlson index used in this study included 17 comorbidities with dichotomous responses (yes and no). Among these, three comorbid conditions were mutually exclusive: diabetes with chronic complications and diabetes without chronic complications; mild liver disease and moderate or severe liver disease; and any malignancy and metastatic solid tumor [25]. Each comorbid disease is assigned for a weight of 1, 2, 3, or 6, and the CCI total score is determined by summing all weights [26].

Nutritional status assessment. Nutritional status was assessed using anthropometric measurements, biochemical data, and clinical assessment. Weight and height were obtained from patient records. The body mass index was calculated as body weight in kilograms divided by height squared in meters (kg/m^2). Biochemical data for albumin, hemoglobin, total protein, and C-reactive protein were obtained from patient recent records. These measurements were used to assess the patient's overall condition and nutritional status [27]. Clinical assessment was performed using the Arabic version of the mentioned earlier MUST.

Coping-strategies evaluation. A data sheet from a prior study was used to assess how patients tolerate and manage taste alterations throughout treatment [28]. It includes twenty tips for minimizing taste changes that can be adopted. The Cronbach's alpha for coping strategies in this study was 0.877.

Statistical analysis

The data was analyzed using the Statistical Package for the Social Sciences (SPSS) version 21. The normality of the distribution of continuous variables was assessed graphically and using the Shapiro-Wilk Test. Continuous variables were analyzed using descriptive statistics such as means and standard deviation, while categorical variables were described using percentages and frequencies. To investigate the relationship between continuous and categorical variables, the one-way ANOVA or independent sample t-test was used, and the level of significance was set at $p<0.05$.

Ethics

Once a participant is identified to meet the inclusion criteria, they were handled the information sheet which included information about the study and a consent form. Participant were directed to contract the research term if they have any concern or questions before starting the interview. If they agree to participate, they were required to sign the consent form. All data were remained anonymous, and no name was associated with any data resulted from the study. All forms contained only an assigned number used in place of the subject's name in all field notes. All subject information were kept confidential and secure by locking field notes, data sheets, and consent forms in password protected files. The protocol for this study has approved by the institutional review board (IRB) ethical committee at An-Najah National University (Ref: Mas. Oct. 2022/40), while permissions and approval to conduct the study were obtained from the Palestinian Ministry of Health (Ref: 162/2454/2022) and the An-Najah National University Hospital administration.

Results

Patient characteristics

One hundred and twenty cancer patients took part in this study. Participants characteristics are shown in Table 1.

Table 1. Patients' sociodemographic and lifestyle characteristics presented in n (%).

Characteristics (n = 120)		n	%
Gender	Male	29	24.2
	Female	91	75.8
Age	18–35 years	24	20
	36–55 years	54	45
	56–75 years	40	33.3
	Above 75 years	2	1.7
Marital status	Married	99	82.5
	Single	18	15
	Other	3	2.5
Educational level	No formal education	6	5
	Primary school	46	38.3
	Secondary school	39	32.5
	Diploma	11	9.2
	Postgraduate	18	15
Living area	City	52	43.3
	Village	63	52.5
	Camp	5	4.2
Living status	With spouse	93	77.5
	With family	23	19.2
	Alone	2	1.7
	Other	2	1.7
Working status	Full time	20	16.7
	Part time	2	1.7
	Unemployed	95	79.2
	Retired	3	2.5
Monthly income (NIS/month)	< 1500	18	15
	1500–3000	62	51.7
	3000–5000	31	25.8
	> 5000	9	7.5
Smoking status	Smoker	13	10.8
	Former smoker	14	11.7
	Nonsmoker	93	77.5
Sleep duration	< 6 hour/day	21	17.5
	6–8 hour/day	87	72.5
	> 8 hour/day	12	10
Sleeping problem	Yes	82	68.3
	No	38	31.7
Physical activity compared to before CT	More active	4	21.7
	The same	12	10
	Less active	104	86.7

NIS: New Israeli shekel.

https://doi.org/10.1371/journal.pone.0302990.t001

Medical history

Among participants, hypertension (27.5%) and diabetes (20%) were the most common comorbidities. Followed by asthma, mild liver disease, and rheumatic disease (Table 2). The mean score of the CCI was 4.15±2.31. The number of patients with CCI scores 1–2 (mildly ill), 3–4 (moderately ill), and ≥ 5 (severely ill) was 49 (40.8%), 25 (20.9%), and 50 (38.3%), respectively.

Nutritional status assessment

Anthropometric and clinical data. According to BMI, 36.66% were obese, 35% were overweight, 27.5% were normal weight, and 0.83% were underweight. The mean weight before starting chemotherapy was 79.43±17.34 kg, and the mean current weight was 77.41±17.23 kg. The malnutrition universal screening tool revealed that 58 patients (48.3%) were at low risk of malnutrition, 24 (20%) were at medium risk, and 38 (31.7%) were at high risk of malnutrition (Fig 1).

Biochemical data. Biochemical tests revealed that most patients (60.83%) had low hemoglobin (11.46±1.68). Also, 60.83% of the patient's albumin levels were recorded, and most of them (89.04%) had normal levels (3.95±0.52) (Table 3).

Cancer-related data

The most prevalent type of cancer was breast cancer (45.8%), then colon cancer (14.2%), lymphoma (14.2%), and lung cancer (8.3%). Among participants, 64.2% of the patients had no metastasis, and 16.7%, 12.5% were receiving paclitaxel, Adriamycin plus cyclophosphamide chemotherapy drugs, respectively. The mean number of finished chemotherapy sessions

Table 2. Prevalence of comorbid conditions in Charlson comorbidity index presented in n (%).

Comorbid condition	Assigned weighing*	n (%)
Myocardial infraction	1	1 (0.8)
Congestive heart failure		1 (0.8)
Peripheral vascular disease or bypass		0
Cerebrovascular disease or transient ischemic disease		0
Gastric peptic ulcer		0
Pulmonary disease/ asthma		5 (4.2)
Diabetes		24 (20)
Dementia or Alzheimer's		0
Rheumatic or connective tissue disease		3 (2.5)
Hypertension		33 (27.5)
Depression		0
Warfarin		0
Diabetes with end organ damage	2	6 (5)
Cancer (lymphoma, leukemia, solid tumor)		77 (64.2)
Renal disease		1 (0.8)
Skin ulcer/ cellulitis		0
Mild liver disease		3 (2.5)
Severe liver disease	3	0
Metastatic solid tumor	6	43 (35.8)
HIV or AIDS		0

* Weighting of each variable as in the Charlson Comorbidity Index from 1–6, with a weight of six representing the most severe morbidity [29].

https://doi.org/10.1371/journal.pone.0302990.t002

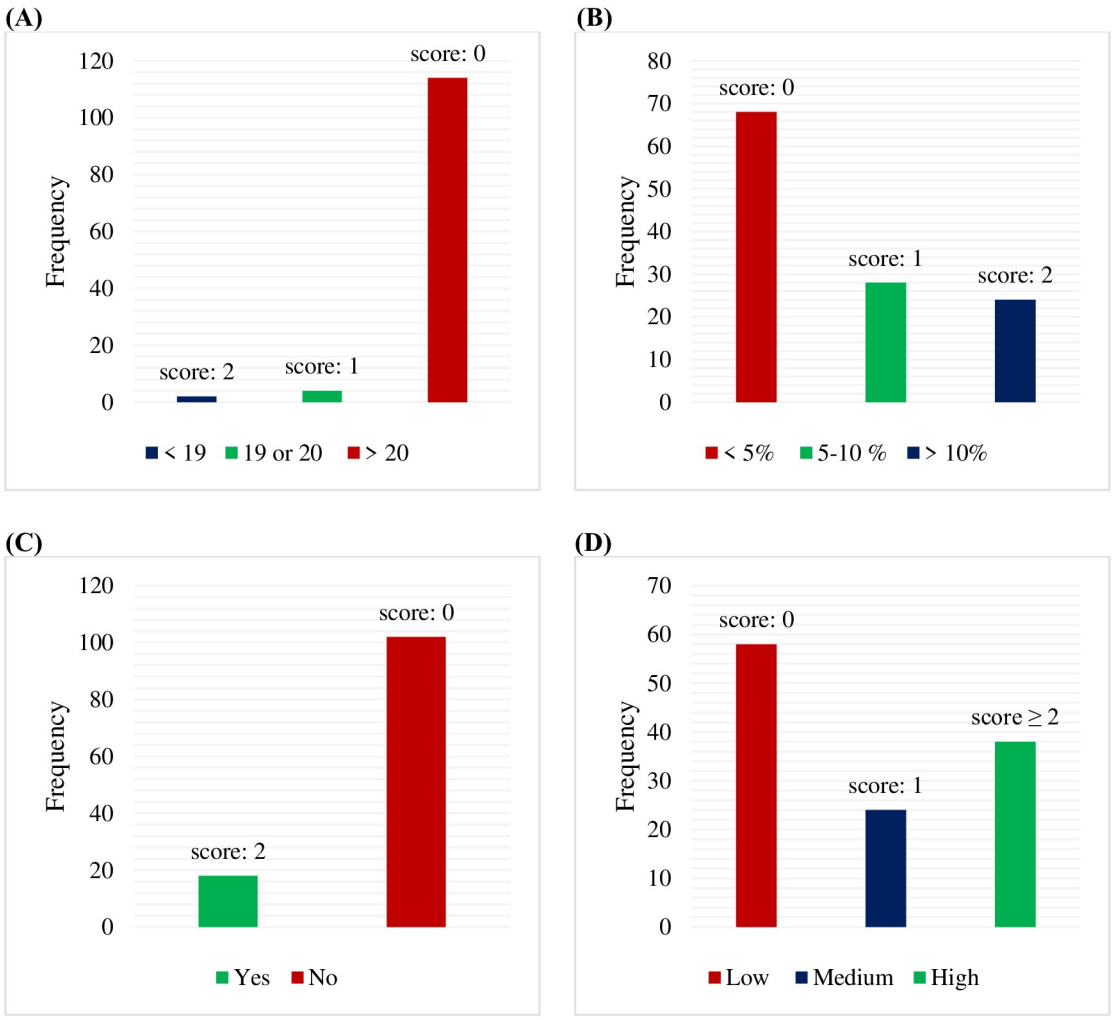

Fig 1. MUST steps for malnutrition screening. (A) BMI. (B) Weight loss percentage. (C) Acute disease effect. (D) Malnutrition risk.

https://doi.org/10.1371/journal.pone.0302990.g001

Table 3. Patient's biochemical levels presented in n (%).

Test (Normal value-lab report)		n	%
Albumin (3.5–5.2 g/dl)	Low	8	10.9
n = 73	Normal	65	89.04
	High	0	0
Hemoglobin (12–16 g/dl)	Low	73	60.83
n = 120	Normal	46	38.33
	High	1	0.8
Total protein (6–8.3 g/dl)	Low	6	14.28
n = 42	Normal	34	80.95
	High	2	4.76
C-reactive protein (0.8–1 mg/dl and lower)	Normal	4	10.25
n = 39	High	35	89.74

https://doi.org/10.1371/journal.pone.0302990.t003

received by the patients was 5.83±7.9, and 20%, 18.3% of the patients received one chemotherapy cycle and three chemotherapy cycles, respectively (Table 4).

Table 5 shows the complete list of the 40 side effects listed in the ASES. Increased or poor appetite (91.6%), lack of energy (89.2%), generalized pain (79.2%), dry mouth (76.6%), hair loss (72.5%), nausea (70.8%), and changes in how things smell, or taste (70.8%) were the most common side effects.

Table 4. Cancer-related characteristics presented in n (%).

Characteristics (n = 120)		**n**	**%**
Cancer diagnosis	Breast	55	45.8
	Colon	17	14.2
	Lymphoma	17	14.2
	Lung	10	8.3
	Other	21	17.4
Metastasis	Yes	43	35.8
	No	77	64.2
Type of therapy	Chemotherapy	120	100
	Radiation	11	9.2
	Biological/hormonal	36	30
	Surgical	32	26.7
Chemotherapy protocol/ drug	Paclitaxel	20	16.7
	AC	15	12.5
	ABVD	8	6.7
	Gemcitabine	8	6.7
	Xelox	8	6.7
	Docetaxel	6	5
	PC	6	5
	Gemcitabine/Cisplatin	4	3.3
	XELIRI	4	3.3
	FOLFOX	3	2.5
	Pemetrexed/Carboplatin	3	2.5
	Arsenic Trioxide/Tretinoin	3	2.5
	Docetaxel/Carboplatin	3	2.5
	Gemcitabine/Carboplatin	2	1.7
	BEACOPP	2	1.7
	EC	2	1.7
	Ifosfamide/Gemcitabine/Vinorelbine	2	1.7
	Capecitabine	2	1.7
	Other	19	15.8
Number of finished chemotherapy cycles	1	24	20
	2	16	13.3
	3	22	18.3
	4	12	10
	5 and over	46	38.3

AC: Adriamycin (doxorubicin hydrochloride), Cyclophosphamide. ABVD: Adriamycin, Bleomycin, Vinblastine, Dacarbazine. BEACOPP: Bleomycin sulfate, Etoposide phosphate, Doxorubicin hydrochloride (Adriamycin), Cyclophosphamide, Vincristine sulfate (Oncovin), Procarbazine hydrochloride, and Prednisone. EC: Epirubicin, Cyclophosphamide. PC: Paclitaxel, Carboplatin. FOLFOX: Oxaliplatin, 5-Fluorouracil, Leucovorin. Xelox: Oxaliplatin, Capecitabine. XELIRI: Irinotecan, Capecitabine.

https://doi.org/10.1371/journal.pone.0302990.t004

Table 5. Chemotherapy side effect frequency, severity, and daily activity effect presented in n (%) and mean (SD).

Side effect	Frequency	Severity	Effect on daily activity (Mean ± SD)
	n (%)	(Mean ± SD)	
Increased or poor appetite	110 (91.6)	6.85 ± 2.43	2.54 ± 1.22
Lack of energy	107 (89.2)	6.74 ± 2.64	2.98 ± 1.41
Generalized pain	95 (79.2)	5.88 ± 3.30	2.61 ± 1.66
Dry mouth	92 (76.6)	5.78 ± 3.53	2.19 ± 1.50
Hair loss	87 (72.5)	6.08 ± 4.15	2.18 ± 1.87
Changes in how things smell or taste	85 (70.8)	5.40 ± 3.86	2.38 ± 1.84
Nausea	85 (70.8)	5.01 ± 3.60	1.85 ± 1.51
Painful/ increased urination	83 (69.2)	4.72 ± 3.54	1.82 ± 1.50
Anxiety	82 (68.3)	4.71 ± 3.48	1.85 ± 1.52
Difficulty remembering things	77 (64.2)	4.42 ± 3.70	1.92 ± 1.72
Disturbed sleep	77 (64.2)	4.92 ± 3.93	2.07 ± 1.81
Dizziness	76 (63.3)	4.36 ± 3.43	1.81 ± 1.54
Feeling angry	74 (61.6)	3.93 ± 3.59	1.70 ± 1.60
Feeling nervous	73 (60.8)	3.86 ± 3.43	1.58 ± 1.53
Feeling bloated	73 (60.8)	4.04 ± 3.52	1.46 ± 1.42
Numbness and tingling sensation in feet or hand	71 (59.2)	3.98 ± 3.55	1.44 ± 1.43
Abdominal pain	70 (58.3)	3.69 ± 3.43	1.37 ± 1.50
Difficulty concentrating	68 (56.6)	3.96 ± 3.68	1.66 ± 1.64
Crying more often	67 (55.8)	3.67 ± 3.65	1.32 ± 1.42
Excessive thirst	66 (55)	4.11 ± 3.94	1.38 ± 1.59
Dry skin	65 (54.2)	3.69 ± 3.57	1.01 ± 1.13
Weight loss	61 (50.8)	3.10 ± 3.30	0.88 ± 1.05
Constipation	60 (50)	3.28 ± 3.52	1.27 ± 1.45
Feeling sad or depressed	58 (48.3)	2.87 ± 3.30	1.23 ± 1.47
Palpitation	58 (48.3)	3.06 ± 3.38	1.21 ± 1.41
Sour mouth or throat	58 (48.3)	3.3 ± 3.62	1.28 ± 1.52
Changes in skin color	58 (48.3)	3.26 ± 3.61	0.97 ± 1.26
Diarrhea	53 (44.2)	2.69 ± 3.30	1.07 ± 1.39
Fear	51 (42.5)	2.58 ± 3.37	0.98 ± 1.33
Weight gain	50 (41.6)	2.29 ± 2.92	0.73 ± 1.07
Easily bruising	47 (39.2)	2.31 ± 3.15	0.62 ± 0.88
Shortness of breath	46 (38.3)	2.45 ± 3.38	0.92 ± 1.33
Itching	46 (38.3)	2.43 ± 3.26	0.79 ± 1.15
Vomiting	43 (35.8)	2.38 ± 3.43	0.88 ±1.38
Confusion	38 (31.6)	2.00 ± 3.12	0.76 ± 1.18
Difficulty swallowing	31 (25.8)	1.69 ± 2.97	0.68 ± 1.27
Problem with sexual interest or activity	22 (18.3)	1.32 ± 2.93	0.32 ± 0.77
Skin rash	19 (15.8)	0.98 ± 2.39	0.33 ± 0.82
Acne	15 (12.5)	0.65 ± 1.89	0.21 ± 0.69
Excessive hair growth	5 (4.2)	0.18 ± 0.96	0.04 ± 0.20

https://doi.org/10.1371/journal.pone.0302990.t005

When the severity subscale of the ASES was considered, increased or poor appetite appeared to be the most acutely perceived side effect with a score of 6.85±2.43 on a scale ranging from 1 to 10, followed by lack of energy, hair loss, generalized pain, dry mouth, changes in how things smell or taste, and nausea with scores of 6.74±2.64, 6.08±4.15, 5.88±3.30, 5.78

±3.53, 5.40±3.86, and 5.01±3.60, respectively. Acne (0.65±1.89) and excessive hair growth (0.18±0.96) were the least annoying side effects.

On the ASES subscale describing the impact of side effects on activities of daily living, the highest scores on a scale ranging from 1 to 5 were lack of energy 2.98±1.41, generalized pain 2.61±1.66, increased or poor appetite 2.54±1.22, changes in how things smell or taste 2.38 ±1.84.

Taste alteration-related data

The mean scores of patients from the subscales of the chemotherapy-induced taste alterations scale were as follows: decrease in basic taste 1.81±1.37, discomfort 2.72±0.97, phantogeusia and parageusia 2.4±1.32, and general taste changes 2.66±1.42 (Table 6). With a CiTAS score ranging from 1 to 5, chemotherapy-induced taste changes can be classified as moderate.

Most patients did not try any of the proposed self-management strategies to cope with taste alteration (Table 7). Eating more flavored protein food was the most useful method for 14.2% of the patients to cope with taste alterations, followed by 10.8% for eating more bland food, boiling food to make it blander, and eating cold food. Brushing one's teeth before eating was the least useful advice attempted, while using plastic silverware was the least tried.

Prevalence of taste alteration

The incidence of taste alteration acquired from self-reported taste and smell changes on the antineoplastic side effect scale was 70.8%. The prevalence of overall taste alterations was 98.3%, according to CiTAS. Regarding the CiTAS subscales, 32% of participants reported a reduction

Table 6. Cancer-induced taste alteration scale score presented in n (%) and mean (SD).

		n (%)	Mean ± SD
Taste changes subscales scores	Decline in basic taste	39 (32.5)	1.81±1.37
	Discomfort	115 (95.8)	2.72±0.97
	Parageusia and Phantogeusia	81 (67.5)	2.40±1.32
	General taste alterations	88 (73.3)	2.66±1.42
Characteristic	Have difficulty tasting food	78 (65)	3.07±1.64
	Have difficulty tasting sweetness	33 (27.5)	1.85±1.47
	Have difficulty tasting saltiness	34 (28.3)	1.87±1.46
	Have difficulty tasting sourness	34 (28.3)	1.85±1.44
	Have difficulty tasting bitterness	30 (25)	1.77±1.40
	Have difficulty tasting umami	29 (24.2)	1.74±1.39
	Unable to perceive the smell or flavor of food	52 (43.3)	2.27±1.57
	Everything tastes bad	65 (54.2)	2.61±1.64
	Food doesn't taste as it should	65 (54.2)	2.73±1.72
	Have a bitter taste in the mouth	71 (59.2)	2.75±1.61
	Have a bad taste in the mouth	56 (46.7)	2.47±1.67
	Everything tastes bitter	43 (35.8)	1.98±1.43
	Feel nauseated and queasy	82 (68.3)	3.04±1.55
	Bothered by the smell of food	65 (54.2)	2.59±1.59
	Have difficulty eating hot food	44 (36.7)	2.01±1.45
	Have difficulty eating oily food	60 (50)	2.52±1.69
	Have difficulty eating meat	61 (50.8)	2.56±1.67
	Have a reduced appetite	95 (79.2)	3.64±1.55

https://doi.org/10.1371/journal.pone.0302990.t006

Table 7. Coping and self-management strategies to deal with taste alterations presented in n (%).

Suggestion	n = 120			
	Did not try	Tried but did not help	Helped a little	Helped a lot
Increase seasonings or spices (oregano, basil, cinnamon, ginger)	101 (84.2)	7 (5.8)	7 (5.8)	5 (4.2)
Decrease seasoning or spices	102 (85)	9 (7.5)	2 (1.7)	7 (5.8)
Eat more bland foods	92 (76.7)	8 (6.7)	7 (5.8)	13 (10.8)
Boil food to make them blander	95 (79.2)	4 (3.3)	8 (6.7)	13 (10.8)
Use more salt	102 (85)	7 (5.8)	5 (4.2)	6 (5)
Use less salt	108 (90)	5 (4.2)	4 (3.3)	3 (2.5)
Use more condiments (mustard, ketchup, pickle, relish, hot peppers)	89 (74.2)	5 (4.2)	15 (12.5)	11 (9.2)
Add fats or sauces to food (gravy, butter, sour cream)	113 (94.2)	2 (1.7)	4 (3.3)	1 (0.8)
Eat foods at room temperature	100 (83.3)	5 (4.2)	11 (9.2)	4 (3.3)
Eat cold foods	95 (79.2)	2 (1.7)	10 (8.3)	13 (10.8)
Add something sweet with meats (cranberry, sauce, applesauce)	115 (95.8)	3 (2.5)	2 (1.7)	0
Avoid beef	107 (89.2)	4 (3.3)	5 (4.2)	4 (3.3)
Avoid food with strong smells (fish)	94 (78.3)	7 (5.8)	9 (7.5)	10 (8.3)
Eat more protein food that have been flavored (eggs, beans, chicken)	81 (67.5)	5 (4.2)	17 (14.2)	17 (14.2)
Drink more water with food to help with eating or rinse away bad taste	98 (81.7)	1 (0.8)	11 (9.2)	10 (8.3)
Eat smaller, more frequent meals	99 (82.5)	2 (1.7)	8 (6.7)	11 (9.2)
Brush your teeth before eating	98 (81.7)	10 (8.3)	6 (5)	6 (5)
Suck on hard candy	99 (82.5)	3 (2.5)	7 (5.8)	11 (9.2)
Use plastic silverware	117 (97.5)	1 (0.8)	0	2 (1.7)
Marinate meats to change taste	105 (87.5)	5 (4.2)	7 (5.8)	3 (2.5)

https://doi.org/10.1371/journal.pone.0302990.t007

in basic tastes, 95.8% reported oral discomfort, 67.5% reported phantogeusia and parageusia, and 73.4% reported general taste alterations (Fig 2).

Taste alteration and nutritional status

There was no significant association between the risk of malnutrition and the subscales of basic taste reduction, phantogeusia and parageusia, as well as general taste alterations ($p>0.05$), but the second subscale (discomfort) was significantly associated with the risk of malnutrition ($p<0.05$).

The subscales of MUST: recent weight loss and acute disease effect were significantly associated with the chemotherapy-induced taste changes subscale (discomfort) ($p<0.05$) (Table 8). In addition, there was no statistical significance between the CiTAS subscales and BMI or biochemical data ($p>0.05$).

Taste alteration and sociodemographic characteristic and lifestyle

Age was significantly associated with taste alteration-induced discomfort, phantogeusia and parageusia, as well as general taste alteration subscales ($p<0.05$). According to gender, the phantogeusia and parageusia subscale was significantly associated with gender ($p<0.05$). Educational level was found to be associated with the discomfort subscale ($p<0.05$) (Table 9).

CiTAS scores did not vary according to monthly income and smoking status ($p>0.05$). But sleeping problems were found to be associated with discomfort, phantogeusia and parageusia, as well as the general taste alterations subscale ($p<0.05$). However, patients' physical activity was significantly associated with phantogeusia and parageusia, as well as general taste alterations ($p<0.05$) (Table 9).

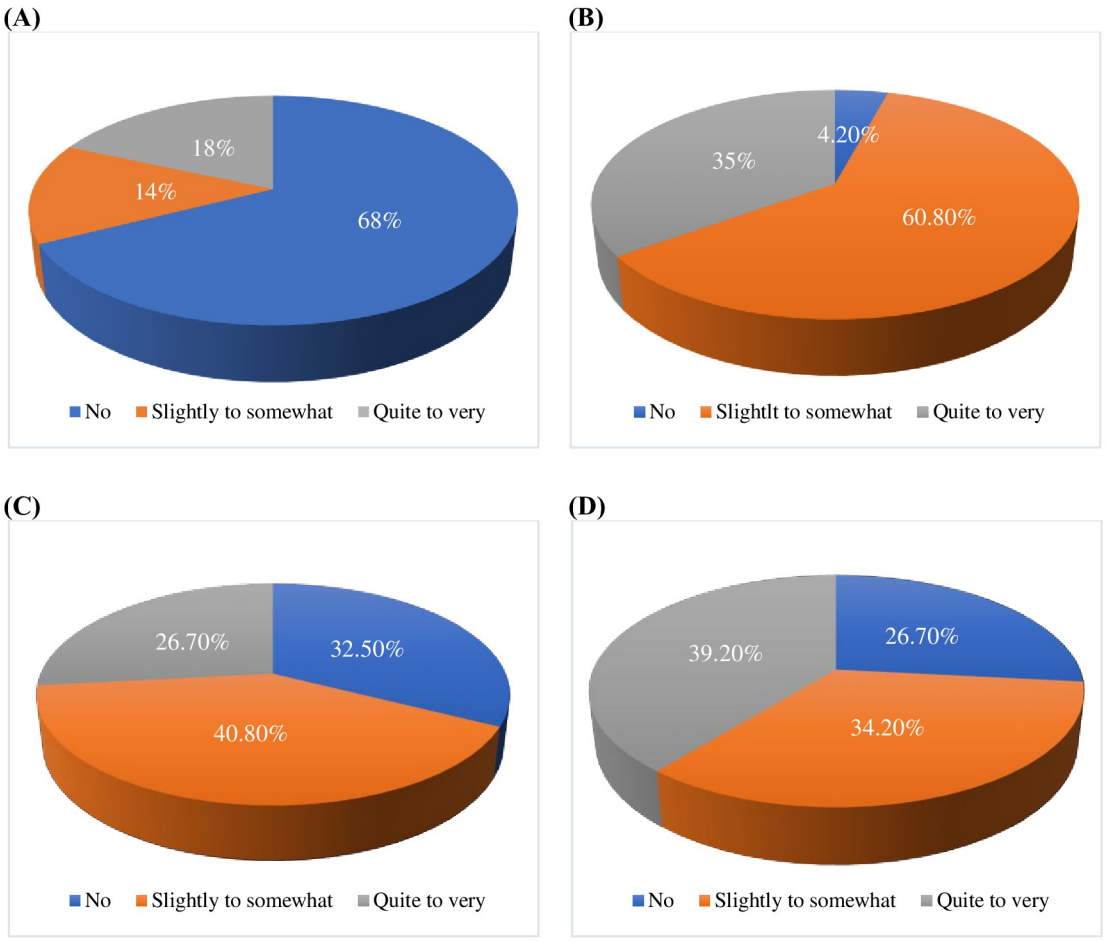

Fig 2. Prevalence of taste alteration according to CiTAS subscale. (A) Basic taste reduction subscale. (B) Taste disorder (discomfort) subscale. (C) Phantogeusia and parageusia subscale. (D) General taste alterations subscale.

https://doi.org/10.1371/journal.pone.0302990.g002

Table 8. Changes in CiTAS according to nutritional status factors measured by malnutrition universal screening tool MUST.

Variables n = 120		Decline in basic taste	Discomfort (Taste disorder)	Phantogeusia and parageusia	General TAs
		Mean ± SD	Mean ± SD	Mean ± SD	Mean ± SD
Malnutrition risk	Low	1.88±1.42	2.42±0.78	2.33±1.28	2.58±1.41
	Medium	1.52±1.17	2.82±1.14	2.09±1.19	2.35±1.40
	High	1.88±1.41	3.12±1.00	2.68±1.43	2.99±1.41
	P-value	0.517	0.002*	0.211	0.187
Recent weight loss %	< 5%	1.87±1.41	2.48±0.82	2.36±1.26	2.61±1.40
	5–10%	1.78±1.42	2.94±1.08	2.27±1.43	2.43±1.51
	> 10%	1.67±1.23	3.15±1.08	2.63±1.38	3.08±1.33
	P-value	0.822	0.005*	0.588	0.239
Acute disease effect	Yes	2.00±1.54	3.33±0.79	2.87±1.41	3.15±1.40
	No	1.78±1.34	2.61±0.97	2.31±1.29	2.58±1.41
	P-value	0.538	0.004*	0.103	0.116

Significant at *: $p<0.05$ according to one-way ANOVA/independent t-test.

https://doi.org/10.1371/journal.pone.0302990.t008

Table 9. Effect of sociodemographic factors and lifestyle on changes in CiTAS.

Variables n = 120		Decline in basic taste	Discomfort (Taste disorder)	Phantogeusia and parageusia	General TAs
		Mean ± SD	Mean ±SD	Mean ± SD	Mean ± SD
Age	18–35 years	1.02±0.12	2.34±0.68	2.01±1.27	1.83±1.18
	36–55 years	2.31±1.59	2.60±1.03	2.64±1.33	3.08±1.42
	56–75 years	1.65±1.23	3.05±0.93	2.35±1.30	2.61±1.37
	> 75 years	1.00±0.00	4.08±0.11	1.33±0.47	2.37±0.17
	P-value	0.001*	0.004*	0.152	0.004*
Gender	Male	1.68±1.28	2.48±0.80	1.94±1.18	2.30±1.47
	Female	1.85±1.40	2.80±1.01	2.54±1.34	2.78±1.39
	P-value	0.575	0.124	0.032*	0.113
Educational level	No school	2.13±1.47	4.19±0.74	3.66±1.05	3.41±0.64
	Primary School	2.02±1.46	2.73±0.90	2.50±1.30	2.84±1.40
	Secondary school	1.87±1.48	2.51±0.99	2.08±1.23	2.51±1.47
	Diploma	1.45±1.19	2.68±0.70	2.60±1.25	2.22±1.33
	Postgrad.	1.27±0.76	2.68±1.02	2.27±1.49	2.54±1.56
	P-value	0.297	0.003*	0.077	0.409
Monthly income	< 1500	1.85±1.34	2.72±1.04	2.35±1.27	2.73±1.62
	1500–5000	1.81±1.37	2.72±0.97	2.40±1.34	2.63±1.37
	> 5000	1.77±1.56	2.77±0.93	2.40±1.39	2.86±1.64
	P-value	0.989	0.987	0.986	0.881
Smoking status	Smoker	2.00±1.63	2.25±0.90	2.25±1.26	2.17±1.40
	Former smoker	1.71±1.13	2.55±0.81	2.14±1.24	2.60±1.38
	Nonsmoker	1.80±1.37	2.81±0.99	2.45±1.35	2.74±1.43
	P-value	0.856	0.122	0.653	0.397
Sleeping issue	Yes	1.94±1.48	2.86±1.02	2.58±1.35	2.95±1.42
	No	1.52±1.07	2.41±0.79	2.00±1.18	2.03±1.22
	P-value	0.118	0.018*	0.024*	0.001*
Physical activity	More active	1.30±0.60	2.33±1.35	2.25±1.89	2.06±1.66
	The same	1.51±1.20	2.36±0.81	1.36±0.65	1.47±0.90
	Less active	1.86±1.41	2.78±0.97	2.52±1.31	2.82±1.40
	P-value	0.529	0.265	0.014*	0.005*

Significant at *: $p<0.05$, **: $p<0.001$ according to one-way ANOVA/independent t-test.

https://doi.org/10.1371/journal.pone.0302990.t009

Taste alteration and cancer-related data, antineoplastic side effects, and comorbidities

The phantogeusia and parageusia CiTAS subscale score was varied based on the type of cancer ($p<0.05$). The CiTAS subscales scores did not vary between patients with and without metastasis ($p>0.05$). According to type of chemotherapy, taxane-based chemotherapy was significantly associated with phantogeusia and parageusia, as well as general taste alteration subscales ($p<0.05$). Adriamycin and cyclophosphamide chemotherapy were also associated with the phantogeusia and parageusia subscale ($p<0.05$). However, CiTAS scores did not vary with platinum-based chemotherapy, gemcitabine, bleomycin, etoposide, or capecitabine chemotherapy regimens ($p>0.05$). Otherwise, basic taste reduction, phantogeusia and parageusia CiTAS subscales were significantly associated with the number of finished chemotherapy cycles ($P<0.05$) (Table 10).

Table 10. Effect of cancer-related data on taste alterations.

Variables n = 120		Decline in basic taste	Discomfort (Taste disorder)	Phantogeusia and parageusia	General TAs
		Mean ± SD	Mean ±SD	Mean ± SD	Mean ± SD
Type of cancer	Breast	2.02±1.52	2.60±1.00	2.81±1.37	2.97±1.41
	Colon	1.82±1.42	2.76±0.93	1.92±1.11	2.58±1.34
	Lymphoma	1.47±1.17	2.39±0.92	2.15±1.31	2.04±1.31
	Lung	1.40±0.84	2.83±0.79	1.83±1.12	2.35±1.07
	Other	1.74±1.25	3.23±0.95	2.15±1.21	2.58±1.62
	P-value	0.518	0.071	0.026*	0.170
Metastasis	Yes	1.83±1.32	2.84±0.88	2.27±1.20	2.69±1.24
	No	1.80±1.41	2.65±1.02	2.46±1.39	2.64±1.52
	P-value	0.895	0.308	0.457	0.859
Taxane CT	Yes	2.07±1.55	2.78±1.07	2.80±1.38	3.16±1.53
	No	1.79±1.27	2.69±0.93	2.21±1.26	2.43±1.31
	P-value	0.162	0.657	0.021*	0.009*
Platinum CT	Yes	2.16±1.44	2.91±0.98	2.41±1.17	2.72±1.30
	No	1.70±1.34	2.66±0.97	2.39±1.37	2.64±1.46
	P-value	0.113	0.220	0.958	0.797
Adriamycin CT	Yes	1.82±1.46	2.58±0.97	2.90±1.37	2.75±1.34
	No	1.81±1.35	2.76±0.97	2.25±1.28	2.63±1.45
	P-value	0.950	0.401	0.025*	0.703
Cyclophosph-amide CT	Yes	2.18±1.61	2.39±1.01	3.15±1.30	3.01±1.39
	No	1.72±1.29	2.80±0.95	2.21±1.26	2.58±1.42
	P-value	0.143	0.0.64	0.002*	0.187
Gemcitabine CT	Yes	1.57±1.22	2.74±0.97	1.88±1.12	2.20±1.29
	No	1.85±1.39	2.72±0.98	2.48±1.34	2.74±1.43
	P-value	0.442	0.933	0.082	0.151
Bleomycin CT	Yes	1.09±0.30	2.51±1.02	2.18±1.09	1.90±1.06
	No	1.88±1.41	2.74±0.97	2.42±1.34	2.74±1.43
	P-value	0.067	0.455	0.569	0.64
Etoposide CT	Yes	2.00±1.26	2.16±0.66	2.22±1.37	2.12±0.84
	No	1.80±1.38	2.75±0.98	2.40±1.32	2.69±1.44
	P-value	0.737	0.151	0.738	0.341
Capecitabine CT	Yes	1.71±1.43	2.71±0.94	1.78±0.99	2.41±1.36
	No	1.83±1.37	2.73±0.98	2.48±1.35	2.71±1.43
	P-value	0.757	0.941	0.66	0.452
Number of finished CT cycle	1 cycle	1.55±1.09	2.66±0.95	2.30±1.17	2.44±1.44
	2 cycles	1.88±1.34	2.96±0.99	2.02±1.15	2.75±1.37
	3 cycles	2.65±1.62	2.83±1.05	2.95±1.29	2.88±1.24
	4 cycles	1.33±1.15	2.84±1.03	1.80±1.25	2.00±1.28
	5 cycles	1.22±0.52	2.75±1.25	3.50±1.44	3.25±1.44
	≥ 6 cycles	1.76±1.45	2.54±0.87	2.18±1.29	2.70±1.54
	P-value	0.025*	0.747	0.006*	0.364

Significant at *: $p<0.05$ according to one-way ANOVA test/independent t-test.

https://doi.org/10.1371/journal.pone.0302990.t010

Taste alteration was associated with some selected side effects and varied significantly concerning the severity of the side effects among the four CiTAS subscales. The decline in basic tastes CiTAS subscale was significantly associated with changes in how things smell or taste ($p<0.05$). The second subscale taste disorder (discomfort) varied significantly with discomfort,

disturbed sleep, dry mouth, sore mouth and throat, nausea, vomiting, appetite changes, difficulty swallowing, anxiety, weight loss, excessive thirst, and lack of energy ($p<0.05$). Also, changes in how things smell or taste, dizziness, disturbed sleep, dry mouth, sore mouth and throat, nausea, weight loss, anxiety, excessive thirst, and difficulty concentrating were significantly associated with phantogeusia and parageusia ($p<0.05$). The general taste alteration subscale was found to be significantly associated with changes in how things smell or taste, dizziness, disturbed sleep, dry mouth, sore mouth or throat, nausea, weight loss, excessive thirst, difficulty concentrating, and lack of energy ($p<0.05$) (Table 11).

The comorbidities score was found to be associated with discomfort on the CiTAS subscale ($p<0.05$). Patients with pulmonary disease were more associated with basic taste reduction ($p<0.05$), as were patients with diabetes mellitus, which was found to be significantly associated with the taste alteration discomfort subscale ($p<0.05$). Unlike diabetes mellitus (DM) with end organs, which has no statistical significance with CiTAS subscales ($p>0.05$). Hypertension, however, was found to be significantly associated with the discomfort subscale ($p<0.05$) (Table 12).

Discussion

Prevalence of taste alterations

Our study showed a high prevalence of self-reported TAs, up to 98.3% which is consistent with previous studies that indicated TAs can occur in up to 49.4% [3], 63.1% [16], 64% [13], 69.9% [10], 76.1% [4], and 93% of cancer patients taking chemotherapy using subjective assessment [24]. According to these findings, the difference in TAs prevalence, including our result, was thought to be due to sample size variation, study methodology, and the type of cancer analyzed in each study. However, several mechanisms have been proposed to clarify the phenomenon of TA regarding chemotherapy. It was hypothesized that TAs induced by chemotherapy were a result of a decrease in the count of receptor cells or impairments in neurotransmission. Taste receptor cells exhibit a brief lifespan and a rapid turnover rate of approximately 10 days, making them susceptible to chemotherapeutic agents that disrupt the metabolic processes of both healthy and malignant cells. Chemotherapy administration leads to the destruction of taste receptor cells, causing TAs that manifest shortly thereafter. However, upon discontinuation of medication, the taste alterations recover. The process of neurotransmission can be impacted in an indirect manner where cranial nerves are destroyed, afferent pathways are modified due to the passage of cytotoxic drugs through the blood-brain barrier, or as a consequence of neuropathy induced by chemotherapy, according to previous research [30]. In an alternative scenario, taste perception may be modified in an indirect manner as a result of chemotherapy-induced impairment of brain regions that regulate taste perception [11].

Taste alterations and nutritional status

In this study, a statistically significant link was found between taste disorders and the risk of malnutrition. According to our results, a higher mean score on the taste disorder subscale suggested a higher risk of malnutrition. The taste disorder or discomfort subscale assesses the link between changes in taste sensation and nausea or vomiting, changes in the sense of smell, difficulty eating hot food, fatty food, meat, and appetite loss [12]. As a result, taste problems were assumed to have a serious effect on eating behavior and food selection, raising the risk of malnutrition, and making taste disorder an important determinant of malnutrition. Our study found no association between malnutrition risk and basic taste reduction, phantogeusia, parageusia, and general taste alteration, which may be attributable to sample size or malnutrition

Table 11. Changes in Ci-TAS according to chemotherapeutic side effects.

Variables n = 120		Decline in basic taste	Discomfort (Taste disorder)	Phantogeusia and parageusia	General TAs
		Mean ± SD	Mean ± SD	Mean ± SD	Mean ± SD
Changes in how things smell or taste	Not exist	1.00±0.00	2.53±1.00	1.54±0.81	1.32±0.67
	Moderate	1.40±0.76	3.09±0.91	2.14±1.28	1.92±1.16
	Severe	2.23±1.55	2.78±0.96	2.82±1.33	3.36±1.21
	P-value	0.000**	0.265	0.000**	0.000**
Dizziness	Not exist	1.78±1.44	2.44±0.95	1.81±1.20	2.17±1.44
	Moderate	1.47±0.88	2.72±0.90	2.56±1.03	2.46±1.32
	Severe	1.92±1.42	2.91±0.98	2.75±1.34	3.05±1.33
	P-value	0.506	0.049*	0.001*	0.006*
Disturbed sleep	Not exist	1.63±1.26	2.38±0.77	1.89±1.20	1.97±1.28
	Moderate	1.83±1.17	2.88±0.47	2.38±1.49	2.66±1.20
	Severe	1.92±1.45	2.92±1.06	2.70±1.30	3.08±1.37
	P-value	0.552	0.015*	0.005*	0.000**
Dry mouth	Not exist	1.72±1.36	2.31±0.87	1.69±0.92	2.13±1.33
	Moderate	2.27±1.50	2.58±1.00	2.12±1.35	2.46±1.52
	Severe	1.77±1.35	2.89±0.97	2.69±1.35	2.88±1.39
	P-value	0.437	0.022*	0.002*	0.046*
Sore mouth or throat	Not exist	1.62±1.21	2.42±0.82	1.97±1.01	2.34±1.38
	Moderate	1.74±1.47	2.45±1.04	2.23±1.69	2.25±1.51
	Severe	2.08±1.52	3.18±0.99	3.00±1.40	3.18±1.32
	P-value	0.209	0.000**	0.000**	0.005*
Nausea	Not exist	1.77±1.47	2.31±0.87	1.77±1.09	2.17±1.47
	Moderate	1.71±1.30	2.55±0.87	2.52±1.53	2.36±1.57
	Severe	1.86±1.35	2.97±0.98	2.69±1.28	2.99±1.27
	P-value	0.907	0.003*	0.003*	0.012*
Vomiting	Not exist	1.89±1.46	2.56±0.93	2.34±1.30	2.58±1.45
	Moderate	1.21±0.60	2.46±0.72	2.60±1.43	2.34±1.49
	Severe	1.83±1.32	3.19±1.02	2.46±1.37	2.98±1.30
	P-value	0.317	0.006*	0.782	0.296
Increased or poor appetite	Not exist	1.87±1.64	1.77±0.58	1.54±1.09	1.68±1.43
	Moderate	1.08±0.19	2.88±0.99	2.11±1.14	2.56±1.36
	Severe	1.89±1.41	2.78±0.96	2.50±1.34	2.75±1.41
	P-value	0.151	0.015*	0.103	0.119
Difficulty swallowing	Not exist	1.88±1.49	2.51±0.83	2.29±1.32	2.63±1.49
	Moderate	1.28±0.50	2.96±1.29	2.70±1.21	2.58±1.29
	Severe	1.73±1.04	3.46±1.03	2.71±1.33	2.82±1.20
	P-value	0.444	0.000**	0.322	0.836
Weight loss	Not exist	1.79±1.42	2.37±0.82	2.08±1.25	2.33±1.36
	Moderate	1.95±1.49	2.54±0.96	2.60±1.38	2.61±1.53
	Severe	1.77±1.26	3.29±0.93	2.73±1.31	3.13±1.34
	P-value	0.881	0.000**	0.040*	0.021*
Anxiety	Not exist	1.52±1.16	2.35±0.82	1.95±1.19	2.25±1.38
	Moderate	1.47±0.98	2.71±1.01	2.51±1.46	2.54±1.37
	Severe	2.07±1.53	2.94±0.99	2.62±1.31	2.93±1.41
	P-value	0.084	0.012*	0.046*	0.062

(*Continued*)

Table 11. (Continued)

Variables n = 120		Decline in basic taste	Discomfort (Taste disorder)	Phantogeusia and parageusia	General TAs
		Mean ± SD	Mean ± SD	Mean ± SD	Mean ± SD
Excessive thirst	Not exist	1.77±1.33	2.36±0.82	1.98±1.08	2.32±1.32
	Moderate	1.45±1.05	2.62±1.19	2.20±1.14	2.31±1.12
	Severe	1.90±1.45	3.07±0.97	2.81±1.43	3.03±1.47
	P-value	0.657	0.000**	0.004*	0.024*
Difficulty concentrating	Not exist	1.65±1.28	2.55±0.96	2.01±1.15	2.26±1.33
	Moderate	1.75±1.42	2.72±0.82	2.66±1.54	2.69±1.47
	Severe	1.97±1.45	2.88±1.01	2.68±1.34	3.03±1.41
	P-value	0.478	0.238	0.025*	0.020*
Lack of energy	Not exist	1.38±0.96	2.21±1.04	1.74±1.01	1.65±0.96
	Moderate	1.74±1.46	2.04±0.55	2.38±1.56	2.46±1.73
	Severe	1.87±1.41	2.84±0.95	2.48±1.33	2.81±1.40
	P-value	0.479	0.015*	0.164	0.019*
Confusion	Not exist	1.84±1.45	2.60±0.96	2.23±1.35	2.53±1.46
	Moderate	1.53±0.97	2.81±0.73	2.37±0.84	2.63±0.96
	Severe	1.81±1.25	3.03±1.03	2.87±1.28	3.05±1.38
	P-value	0.813	0.125	0.083	0.243

Significant at *: $p<0.05$, **: $p<0.001$ according to one-way ANOVA test.

https://doi.org/10.1371/journal.pone.0302990.t011

assessment method. Otherwise, our findings indicated a significant association between TAs and weight loss, as it is observed to be increased among individuals with TA.

Previous findings on the association between TA and malnutrition are limited and controversial. One study found that half of patients with TAs were malnourished or at risk of

Table 12. Effect of comorbidities on taste alterations.

Variables n = 120		Decline in basic taste	Discomfort (Taste disorder)	Phantogeusia and parageusia	General TAs
		Mean ± SD	Mean ±SD	Mean ± SD	Mean ± SD
CCI score	Mild (1,2)	1.80±1.45	2.33±0.80	2.41±1.37	2.55±1.56
	Moderate (3,4)	1.90±1.40	3.24±1.13	2.66±1.45	2.95±1.43
	Severe (≥5)	1.78±1.29	2.85±0.90	2.23±1.19	2.63±1.25
	P-value	0.935	0.000**	0.432	0.517
Pulmonary disease	Yes	3.00±1.87	2.46±0.96	2.40±1.94	2.70±1.78
	No	1.76±1.33	2.73±0.98	2.40±1.30	2.66±1.41
	P-value	0.049*	0.547	1.000	0.958
Diabetes mellitus	Yes	1.52±0.97	3.18±1.05	2.31±1.27	2.75±1.10
	No	1.88±1.45	2.61±0.92	2.42±1.34	2.64±1.49
	P-value	0.250	0.009*	0.741	0.750
DM end organ	Yes	2.33±1.78	2.52±1.11	2.00±1.17	3.08±1.27
	No	1.78±1.38	2.73±0.97	2.42±1.33	2.64±1.43
	P-value	0.346	0.612	0.612	0.464
Hypertension	Yes	2.09±1.52	3.22±1.14	2.64±1.43	3.03±1.41
	No	1.71±1.30	2.53±0.83	2.30±1.27	2.52±1.40
	P-value	0.177	0.000**	0.221	0.78

Significant at *: $p<0.05$, **: $p<0.001$ according to one-way ANOVA/independent t-test.

https://doi.org/10.1371/journal.pone.0302990.t012

malnutrition, and malnourished patients had more severe taste changes [16], and TAs have a serious effect on eating behaviors among cancer patients which might lead to nutritional deficiencies [7, 10]. In contrast, a recent study found no statistically significant link between malnutrition and weight loss and taste and smell alterations [8], and dietary habits were not directly related to taste changes during chemotherapy [31]. Malnutrition during chemotherapy is attributed to metabolic changes such as inflammation, increased catabolism, anabolic resistance, and antineoplastic side effects like anorexia, nausea, and vomiting [32]. However, according to our findings, taste alteration is a contributing factor in developing malnutrition, though not the only one. Nevertheless, further studies are necessary to obtain more comprehensive results. Weight loss and TAs showed contradictory findings as well. While some studies found that weight loss occurred among patients who experienced impaired taste [33, 34], others found no link between TAs and weight changes [35].

Findings from our study did not find any association between TAs and biochemical measurements (hemoglobin, albumin, total protein, and C-reactive protein). However, in our findings, elevated levels of C-reactive protein were attributed to a systematic inflammatory state associated with poor nutritional status in cancer patients [36]. In addition, a low level of hemoglobin is a manifestation of anemia, where its incidence increases during chemotherapy [37].

Regarding BMI, our findings are in line with those of earlier research [12, 13, 35, 38] which found no appreciable differences in outcomes between patients with and without dysgeusia in terms of BMI. However, evidence confirms that the relationship between BMI and taste perception is complex, and the ability to recognize taste decreased as BMI increased [39, 40]. It is worth noting that the majority of our study participants showed a high percentage of being overweight or obese. This could be related to several factors other than nutritional status, including changes in body composition related to increased fluid retention, which is a common side effect of chemotherapy [41]. In addition, it is possible that patients had pre-existing obesity or were overweight, as indicated by the non-significant difference between their body weight before and after CT in our study. Moreover, approximately fifty percent of the study participants are breast cancer patients, who usually tend to gain weight after breast cancer diagnosis due to decreased energy expenditure, hormonal imbalance, and depression, according to previous findings [42].

Taste alteration risk factors

Sociodemographic and lifestyle. Chemotherapy-induced TA was affected by patients' sociodemographic characteristics. In this study, age was found to be associated with basic taste reduction, taste disorder, and general taste alteration. Basic taste reduction and general taste alteration mean scores were higher in patients aged between 36 and 55 years, while taste disorder score increased as age increased. Similar studies using CiTAS for self-reported taste impairment found that age did not affect TAs [12], while others found that age is associated with the basic taste reduction subscale [24], and TAs onset was associated with younger age [43]. Evidences revealed that older adults reported fewer TAs and late taste perception due to increased taste thresholds [2, 44]. Aging also reduces taste acuity, which diminishes after 60 due to aging-related physiology, reduced taste receptors, and some elderly medications [44].

Our study found that female participants had higher mean scores in phantogeusia and parageusia subscales exclusively, although a previous study found that taste disorder subscale mean was greater in women [24]. Arikan et al. find no link between gender and TAs subscales. However, female patients are more sensitive to TAs than male, although the reasons are not clearly known [12]. In addition, educational level was found to be associated with the taste discomfort

subscale, and patients with no school level presented the highest mean score. Our result was found to be contrary to recent studies findings [13, 16], which suggests that taste changes have been found to be more common in younger patients with higher education levels. Individuals with a high level of education are likely to be more sensitive to taste changes and to recognize them more rapidly [16]. Variations between our results and prior findings were assumed to be related to sample size, as more than 70% of participants are at school level, making them more susceptible to TAs.

Regarding lifestyle factors, TAs were significantly associated with sleeping problems for taste disorders, phantogeusia and parageusia, and general TAs subscales. Taste changes can have a psychological impact on a patient's lifestyle due to the loss of enjoyment during food intake and the pleasure of eating, as well as other CT side effects that cause anxiety and insomnia that disrupt their sleeping pattern. In a recent study on taste changes and functional status, patients with taste changes had more sleeping problems [3]. Physical activity, on the other hand was associated with phantogeusia, parageusia, and general TAs. Patients who had the least physical activity had higher mean scores. In line with our findings, previous studies found an association between TAs and being tired or fatigued [4, 10]. In addition, our findings revealed no association between smoking status and TAs. However, smoking has a negative impact on taste functions [24, 43], which is assumed to be due to having a higher threshold than nonsmokers and reduced taste sensitivity [45]. Therefore, smokers were shown to be less affected by chemotherapy-induced taste changes [2, 10].

Clinical features (cancer-related data). In our study, type of cancer was associated with phantogeusia and parageusia, whereas breast cancer patients had the highest mean score, followed by lymphoma, colorectal cancer, and lung cancer. Similar studies that used CiTAS found no link between type of cancer and TAs [12, 24]. In contrast, Ponticelli et al. discovered that TA is associated with cancer type [13].

In addition, our results showed that chemotherapy regimens did cause significant variations in phantogeusia and parageusia in patients receiving taxane-based chemotherapy as well as adriamycin and cyclophosphamide chemotherapy. In addition, taxane-based chemotherapy showed significant variations in the general taste alteration subscale. Taxane derivatives (paclitaxel and docetaxel) are mostly used for breast cancer treatment, which might explain the high prevalence of phantogeusia and parageusia among breast cancer patients. In previous studies [2, 13, 46, 47], taxane-based chemotherapy was associated with a higher rate of TAs. Still, no mechanism is documented to explain how taxane induces taste alterations [30]. Otherwise, cyclophosphamide has two mechanisms for taste disturbance: direct and indirect. It was shown that cyclophosphamide directly induces the destruction of the lingual epithelial cells, resulting in the death of sensory cells in taste buds, increasing the taste threshold and decreasing the ability of taste discrimination. Furthermore, when aged gustative cells die, cyclophosphamide indirectly prevents their replacement by suppressing the normal taste cell replacement process [30, 48].

The number of completed chemotherapy cycles results in significant variation in basic taste reduction as well as phantogeusia and parageusia. However, the mean score pattern is quite fluctuating. A previous study showed that TAs were associated with the number of cycles of chemotherapy in an increasing manner [11]. Another study reported that patients' ability to taste decreased directly after the first round of chemotherapy [14], and patients were found to have more severe taste impairments at the beginning of the treatment compared to the subsequent rounds [49].

Comorbidities. In the present study, we found that the number of comorbidities may increase the risk of TA, and patients with pulmonary disease, diabetes, and hypertension represent higher levels of TAs.

Chronic diseases are one of many factors that influence chemotherapy-induced TAs among patients who have moderate taste alterations [49]. A new study found that chronic obstructive pulmonary disease (COPD) and asthma patients are more susceptible to develop oral disorders, including TAs during inhalation therapy [50], which may explain our findings. On the other hand, through decades, patients with diabetes showed a high prevalence of TAs [51–53]. To the best of our knowledge, no previous studies have investigated the relationship between TAs and hypertension, but one study discovered that a high prevalence of hypertension was associated with impaired salt taste perception [54].

Antineoplastic side effects and taste alteration relationship

In the present study, patients with nausea and vomiting showed higher levels of TAs than patients without nausea and vomiting, which is consistent with earlier findings [12, 55]. Furthermore, patients with dry mouth, sore mouth and throat, excessive thirst, and swallowing difficulties showed higher levels of TAs. Dry mouth, or xerostomia, was found to be strongly associated with TAs in previous studies, and the presence of taste impairments was found to be significantly high in patients who reported xerostomia [14, 56], sore mouth and throat [46], and swallowing difficulties [24, 56]. In our findings, excessive thirst is thought to be related to xerostomia, and more investigation is required.

Consistent with previous findings [13, 24, 33], our results revealed that participants who had increased or poor appetite, weight loss, dizziness, lack of energy showed a higher levels of TA. In addition, patients with disturbed sleep, anxiety, and difficulty concentrating showed higher levels of TAs. However, recent evidence suggests that taste changes are associated with neurophysiological adverse effects, including anxiety, sleep disturbances, and impairment in cognitive function [3].

Coping strategies

This study examined coping mechanisms for chemotherapy-treated cancer patients who were suffering TAs. Our data showed that patients were infrequently given any kind of self-care or management instruction for taste impairment symptoms. Furthermore, most patients were surprised to learn that TAs are a chemotherapy-induced side effect. The most common and effective technique among the suggested strategies was to consume flavorful protein foods such as poultry, white beans, and eggs. Eating bland food was another technique encountered by a few individuals to manage with TA, who discovered that food with fewer spices and low fiber content was more suitable for them. Another group of participants prefers to boil their food since it is more acceptable to them than consuming oil-based or spicy-rich foods. Cold food was also thought to offer them a better feeling in the mouth than hot food, and it was assumed to reduce the queasy feeling caused by taste impairments. Brushing one's teeth before eating, on the other hand, was observed to be ineffective by those who tried it. While half of the patients who tried to suck on hard candies and gum found it to be a beneficial strategy, otherwise, they indicated that as soon as they stopped doing so, their uncomfortable mouth sensation returned. It was also noted that patients rarely tended to have more frequent and smaller meals and often stuck to traditional cooking methods rather than trying out new ones. As an additional suggestion, patients stated that they prefer sour flavors over other flavors and consume lemon more frequently. Previous studies evaluating self-management strategies are limited. In a study that used the same data sheet we used in our study, it was discovered that coping strategies varied depending on the type of taste impairments patients complained of, and the most common coping strategies were eating blander food, eating frequent and smaller meals, oral care before eating, and avoiding foods with a strong smell and taste. Patients

recommend trying new flavors and avoiding certain foods, particularly hot and oily foods and those with tomato sauces [57]. In addition, patients avoided certain foods, rinsed their mouths frequently, ate cold foods, and avoided the sight and smell of some foods [58]. Furthermore, adding lemon, orange, or mint to drinking water, exploring new flavors, and practicing good oral hygiene were excellent self-care behaviors for individuals with TAs [59].

Limitations

This study has some limitation like being subjective and self-reported study that relies on the patient's own statements which make them more susceptible to recall and selection bias due to the nature of cross-sectional studies. Another limitation is the small sample size and the lack of information regarding dietary habits obtained by diet recall, which was challenging for patients to get, as well as body circumferences due to the patients' physical status. Furthermore, participants in this experiment were given different chemotherapy regimens, with some receiving monotherapy and others receiving combination chemotherapy, making it difficult to distinguish the precise effect of individual chemotherapy on taste while ignoring the effect of combination chemotherapy.

Conclusions

In this study, it was found that a significant proportion (98.3%) of cancer patients experienced taste changes during chemotherapy. Discomfort was an important determinant of the risk of malnutrition, and it showed the highest prevalence among participants, followed by general TA, phantogeusia and parageusia, and basic taste reduction. TAs are associated with the severity of a variety of antineoplastic side effects (nausea, vomiting, dry mouth, sour mouth, and throat; difficulty swallowing; excessive thirst; lack of energy; increased and poor appetite; weight loss; dizziness; distrusted sleep; anxiety; difficulty concentrating). Patients with pulmonary disease, diabetes, and hypertension were at greater risk of developing taste alterations. In light of these results, more attention is recommended at the educational, clinical, and research levels to present a better quality of life for cancer patients during their course of treatment and minimize the intensity of the chemotherapy-induced taste alterations. Furthermore, it could be beneficial for patients to actively engage in self-care by attentively monitoring their dietary habits and exploring new recipes. This proactive approach will allow them to identify food preferences that they are more likely to eat after chemotherapy, thereby mitigating the adverse effects of weight loss, decreased appetite, and risk of malnutrition.

Acknowledgments

We would like to thank each patient who participates in this work.

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