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Co-occurring Gastrointestinal Symptoms Are Associated with Taste Changes in Oncology Patients Receiving Chemotherapy

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Abstract

Background: Over 80% of cancer patients report taste changes. Despite the high prevalence of this symptom and its negative effects on health, few studies have assessed its association with other gastrointestinal (GI) symptoms.

Objectives: Determine the occurrence, frequency, severity and distress of patient-reported "change in the way food tastes" (CFT) and identify phenotypic and GI symptoms characteristics associated with its occurrence.

Methods: Patients receiving chemotherapy for breast, GI, gynecological, or lung cancer completed demographic and symptom questionnaires prior to their 2nd or 3rd cycle of chemotherapy. CFT was assessed using the Memorial Symptom Assessment Scale. Differences in demographic, clinical, and GI symptom characteristics were evaluated using parametric and nonparametric tests.

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Results: Of the 1,329 patients, 49.4% reported experiencing CFT in the week prior to their 2nd or 3rd cycle of chemotherapy. In the univariate analysis, patients who reported CFT had fewer years of education; were more likely to be Black or Hispanic, Mixed race, or other, and had a lower annual household income. A higher percentage of patients with CFT reported the occurrence of thirteen GI symptoms (e.g., constipation, diarrhea, abdominal cramps, feeling bloated). In a multivariable logistic regression analysis, Compared to patients with breast cancer, patients with lung (OR=0.55; p=0.004) had a decrease in the odds of being in the CFT group. Patients who received a neurokinin-1 receptor antagonist and two other antiemetics were at an increased odds of being in the CFT group (OR=2.51; p=0.001). Eight of the thirteen GI symptoms evaluated were associated with an increased odds of being in the CFT group.

Conclusions: This study provides new evidence on the frequency, severity, and distress of CFT in oncology patients undergoing chemotherapy. These findings suggest that CFT is a important problem that warrants ongoing assessments and nutritional interventions.

Keywords

taste changes; chemotherapy; symptoms; nausea; constipation; diarrhea

INTRODUCTION

Taste changes occur in up to 84% of patients undergoing chemotherapy.[1] The sense of taste is vital for nutritional intake and food choices.[2] These changes begin within weeks of starting chemotherapy[3] and recover approximately 8 weeks after the completion of therapy.[4] However, changes can persist for years following treatment.[5] Taste changes may involve a decrease in taste sensitivity (hypogeusia), an absence of taste sensation (ageusia), an alteration in normal taste (dysgeusia), or the occurrence of a taste perception without an external stimulus (phantogeusia).[6] If the sense of taste and perception of food flavors are altered, patients may experience decrements in nutritional status and weight loss.[7] These taste changes and nutritional deficits are associated with poorer responses to treatment as well as increases in adverse effects, morbidity, and mortality.[8,9] Despite the clinical importance of taste changes, they are often overlooked by clinicians and studies of this symptom in patients receiving chemotherapy are limited.

An increased understanding of the phenotypic characteristics associated with changes in the way food tastes may identify modifiable risk factors. Findings from the general population suggest that age, sex, and race influence taste perceptions.[10,11] For example, in two studies that used data from the U.S. National Health and Nutrition Examination Study (NHANES), [12,13] in adults over 40 years of age, the prevalence of taste dysfunction decreased with age in women, but not in men. In addition, taste impairment was greater among non-Hispanic Black Americans compared to other ethnic groups.[12] Other factors associated with self-reported taste alterations included: lower level of education, xerostomia, fair/poor health, and nose/facial injury.[13]

In terms of patients receiving chemotherapy, while several studies reported no relationships, [14–20] in four studies,[21–24] self-reported taste changes were more prevalent among women,

younger patients, and those with higher levels of education. In contrast, patients who smoked or abused alcohol reported fewer taste changes.[22]

With regards to clinical characteristics, several studies reported no associations between taste changes and a variety of clinical characteristics (e.g., cancer diagnosis, time since diagnosis, chemotherapy regimen, prior cancer treatments).[15–18,21,22] However, in one study of patients with lung, pancreatic, and colon cancer, compared to patients with the other two diagnoses, patients with colon cancer reported more severe taste alterations.[22] In another study of patients with heterogeneous cancer diagnoses, prevalence rates for taste changes were highest among patients with colon cancer, followed by breast, lung, and lymphoma cancers.[23] In terms of specific chemotherapy drugs, in one study,[22] the highest rates of taste alterations were reported by patients who received irinotecan, followed by FOLFOX (i.e., 5-fluorouracil, leucovorin, and oxiplatin), and gemcitabine. In another study,[21] the highest percentages of dysgeusia were associated with regimens that contained antimetabolites with platinum derivatives and antimetabolites with cytotoxic antibiotics. These inconsistent findings may be related to a number of factors including sample size, timing of the assessments, and methods used to evaluate taste changes (e.g., objective vs. subjective measures).

Information on the co-occurrence of other gastrointestinal (GI) symptoms may provide additional insights into the occurrence of taste changes in patients receiving chemotherapy. While the oral cavity gives rise to the perceptions of taste, as well as the flavors of foods and beverages, it is only the beginning of the digestive system that is impacted by chemotherapy. Only two studies were found that evaluated for associations between taste changes and four GI symptoms (i.e., nausea/vomiting, appetite loss, constipation, diarrhea) in patients receiving chemotherapy.[23,25] Greater taste changes were associated with loss of appetite[23,25] and increased severity of nausea and vomiting.[23] A more in-depth analysis of the relationships between taste changes and other GI symptoms in patients receiving chemotherapy will provide increased insights into this clinically important problem. Given the paucity of research on this symptom, the purposes of the study, in a sample of oncology patients (n=1,329) receiving chemotherapy were to: determine the occurrence, frequency, severity, and distress associated with self-reported “change in the way food tastes (CFT) and to identify phenotypic and GI symptom characteristics associated with its occurrence.

METHODS

Patients and settings

This analysis is part of a larger study, funded by the National Cancer Institute, that evaluated the symptom experience of oncology outpatients receiving chemotherapy.[26–28] Eligible patients were ≥18 years of age; had a diagnosis of breast, GI, gynecological, or lung cancer; had received chemotherapy within the preceding four weeks; were scheduled to receive at least two additional cycles of chemotherapy; were able to read, write, and understand English; and gave written informed consent. Patients were recruited from two Comprehensive Cancer Centers, one Veteran’s Affairs hospital, and four community-based oncology programs. Of the 2,234 patients approached, 1,343 consented to participate. For this analysis, 1,329 patients with data of CFT were included.

Instruments

Demographic questionnaire obtained information on age, gender, ethnicity, marital status, living arrangements, education, employment status, and income. Patients completed the Karnofsky Performance Status (KPS) scale[29] and the Self-Administered Comorbidity Questionnaire (SCQ)[30] to evaluate functional status and comorbidity, respectively. Alcohol Use Disorders Identification Test (AUDIT) was used to assess alcohol consumption, alcohol dependence, and the consequences of alcohol abuse in the last 12 months.[31,32]

Memorial Symptom Assessment Scale (MSAS) was used to evaluate the occurrence, severity, frequency, and distress of 38 symptoms commonly associated with cancer and its treatment, including “change in the way food tastes” (CFT). For this analysis, the following GI symptoms were evaluated: CFT, constipation, diarrhea, feeling bloated, abdominal cramps, difficulty swallowing, weight gain, weight loss, increased appetite, lack of appetite, mouth sores, dry mouth, vomiting, and nausea.

Using the MSAS, patients were asked to indicate whether or not they had experienced each symptom in the past week (i.e., symptom occurrence). If they had experienced the symptom, they were asked to rate its frequency of occurrence, severity, and distress. The validity and reliability of the MSAS are well established.[33]

Study procedures

The study was approved by the Committee on Human Research at the University of California, San Francisco and by the Institutional Review Board at each of the study sites. Eligible patients were approached by a research staff member in the infusion unit during their first or second cycle of chemotherapy,to discuss participation in the study. Written informed consent was obtained from all patients. Depending on the length of their chemotherapy cycles, patients completed questionnaires in their homes a total of six times over two cycles of chemotherapy. For this analysis, symptom occurrence data from the enrollment assessment that asked patients to report on their symptom experience for the week prior to the administration of their second or third cycle of chemotherapy were analyzed (i.e., recovery from previous chemotherapy cycle). Medical records were reviewed for disease and treatment information.

Data analysis

Data were analyzed using SPSS version 23[34] and STATA version 14.[35] Descriptive statistics and frequency distributions were calculated for demographic, clinical, and symptom characteristics. MAX 2 scores,[36,37] emetogenicity of the chemotherapy regimen, and anti-emetic regimens were calculated as previously described.[38] Differences in demographics, clinical, and symptom characteristics between patients who did and did not report CFT were evaluated using Independent sample t-tests, Chi Square analyses, and Mann Whitney U tests. In order to evaluate the association between select phenotypic and symptom characteristics and CFT group membership, a backwards, stepwise logistic regression analysis was done. The initial logistic regression model included eleven phenotypic characteristics (i.e., education, ethnicity, KPS score, number of prior cancer treatments, number of metastatic sites, exercise on a regular basis, cancer diagnosis, type of prior cancer treatments, MAX2

score, cycle length, emetogenicity of chemotherapy regimen, antiemetic regimen) that differed between the two groups (Table 1) and the occurrence of the 13 gastrointestinal symptoms on the MSAS. A p-value of <.05 was considered statistically significant.

RESULTS

Sample characteristics

Of the 1,329 patients in this study, 49.4% reported experiencing CFT in the week prior to their second or third cycle of chemotherapy (Figure 1A). Of these 656 patients, 21.7% (n=141) rated the frequency of occurrence of CFT as “almost constantly” and 26.3% (n=171) rated it as “frequently” (Figure 1B). In terms of the severity of CFT, 45.4% (n=292) rated it as “moderate” and 20.4% (n=131) and 8.7% (n=56) rated it as “severe” or “very severe”, respectively (Figure 1C). Over 25% of the patients reported “quite a bit” (13.5%; n=86) or “very much” (12.9%; n=82) distress from CFT (Figure 1D).

Differences in phenotypic and GI symptom characteristics

Patients who reported CFT had fewer years of education, were more likely to be Black or Hispanic, Mixed race, or other, and had a lower annual household income (Table 1). In addition, patients in the CFT group had lower KPS scores, were fewer years from their cancer diagnosis, had received fewer cancer treatments, and had fewer metastatic sites. Furthermore, a higher percentage of patients in the CFT group had breast cancer, had received chemotherapy on a 14-day cycle, had higher MAX2 scores, were receiving highly emetogenic chemotherapy, and were more likely to be receiving an antiemetic regimen that contained a neurokinin-1 (NK-1) receptor antagonist and two other antiemetics (e.g., serotonin (5HT3) receptor antagonist, steroid). Compared to the no CFT group, patients in the CFT group were less likely to exercise on a regular basis; less likely to have gynecological cancer; less likely to have received surgery and chemotherapy, or surgery and radiation therapy, or chemotherapy and radiation; less likely to have received chemotherapy on an 28-day cycle; less likely to have received minimal/low emetogenic chemotherapy, and more likely to have received an antiemetic.

With regard to the GI symptoms, a higher percentage of patients in the CFT group reported constipation, diarrhea, feeling bloated, abdominal cramps, difficulty swallowing, weight gain, weight loss, increased appetite, lack of appetite, mouth sores, dry mouth, vomiting, and nausea (Figure 2).

Phenotypic and GI symptom characteristics associated with CFT

The overall results of the logistic regression analysis were significant (X^2=257.55, p<0.001, Table 2). None of the demographic characteristics were associated with CFT group membership. In terms of clinical characteristics, compared to patients with breast cancer, patients with lung cancer (OR=0.55; p=0.004) had a decrease in the odds of being in the CFT group. In terms of antiemetic regimen, compared to patients who did not receive any antiemetic, patients who received a NK-1 receptor antagonist and two other antiemetics were at an increased odds of being in the CFT group (OR=2.51; p=0.001). Eight of the 11 GI

symptoms evaluated were significantly associated with an increased odds of being in the CFT group.

DISCUSSION

This study is the first and largest to describe phenotypic and GI symptom characteristics associated with CFT in cancer patients following at least one cycle of chemotherapy. Consistent with previously reported prevalence rates that ranged from 25%[39] to 80%,[40] almost 50% of our patients reported experiencing CFT in the week prior to their second or third cycle of chemotherapy. In prior reports that used the MSAS,[41,42] the frequency of occurrence, as well as the severity, and distress related to CFT was highly variable. In terms of frequency, compared to the 21.7% of patients in our study who chose the rating “almost constantly”, in a previous study,[42] only 11.5% of the patients used this rating. In terms of severity, compared to the 8.7% of our patients who rated CFT as severe or very severe, previous reports ranged from 31.9%[41] to 36.8%.[42] Finally, consistent with previous studies that found that between 18%[41] and 35%[43] of patients reported that CFT was “quite a bit or very much distressing”, 26.4% of our patients used these ratings. These wide ranges in occurrence, frequency, severity, and distress ratings may be related to differences in phenotypic characteristics of the samples, heterogeneity in the types of cancer treatments the patients received, and stage of the patients’ disease.

While in the univariate analysis, fewer years of education and ethnicity were associated with membership in the CFT group, none of the demographic characteristics remained significant in the multivariable model. While in a population-based study,[12] a higher percentage of African Americans reported taste alterations, no studies were identified that found an association between ethnicity and CFT in oncology patients.

The only two clinical characteristics associated with CFT in the multivariable model were cancer diagnosis and antiemetic regimen. Compared to those with breast cancer, patients with lung cancer had a lower risk of being in the CFT group. While previous studies reported altered taste perceptions in patients with breast[4,20,25,44], lung[45,46], and gynecological[25,47] cancers, no studies were identified that examined relative risk of CFT across cancer diagnoses.

As noted in the Introduction, two studies identified differences in the prevalence of taste changes among various chemotherapy regimens.[21,22] Given the heterogeneity in cancer diagnoses and chemotherapy regimens in our study, we evaluated toxicity of the chemotherapy regimen (i.e., MAX2 score), the relative contribution of the emetogenicity of the chemotherapy regimen, cycle length, and the antiemetic regimen to membership in the CFT group. While all four characteristics were significant in the univariate analysis, only antiemetic regimen remained significant in the multivariable model.

In terms of the antiemetic regimen, being prescribed a NK-1 receptor antagonist with two other antiemetics (i.e., 5-HT-3 receptor antagonist being the most common additional antiemetic followed by a steroid) was associated with a 2.51-fold increased risk of being in the CFT group. Evidence exists to support a role for both of the agonists of the NK-1 (i.e,

Substance P) and 5-HT3 (i.e., serotonin) receptors in taste perception[48–53] and gut motility.[54–56] In terms of taste, NK-1 receptors are present in the gustatory center and taste papillae at substance P-sensitive nerve fibers.[57–59] The administration of an NK-1 receptor antagonist blocked the release of Substance P in a preclinical model.[49] In addition, taste buds release 5-HT directly in response to sour stimuli and indirectly in response to bitter and sweet tasting stimuli. In a preclinical study,[52] the administration of the 5-HT3 receptor antagonist, ondansetron, reduced taste nerve responses to acids and sucrose. Taken together, our findings are the first to suggest that multimodal anti-emetic regimens, which are the standard of care for the treatment of chemotherapy-induced nausea and vomiting,[60,61] may contribute to taste changes in oncology patients undergoing chemotherapy.

In terms of their effects on gut motility, Substance P plays a significant role in GI motility with resultant dysmotility, diarrhea, and edema.[62,63] In terms of 5-HT3, information on its role in gut motility is evolving. While exogenous 5HT-3 may stimulate GI motility, the role of endogenous 5HT-3 in GI motility is under active investigation.[55] However, the administration of NK-1 and 5-HT3 antagonists to patients receiving chemotherapy is associated with increased risk for constipation.[64–66] Finally, both NK-1 and 5HT-3 receptor antagonists act on regions of the brain that are involved in nausea, vomiting, and eating behaviors that overlap with gustatory pathways.[67,68] Therefore, it is possible that direct and indirect effects from both of these antiemetics contribute to CFT during the administration of chemotherapy.

Our study is the first to evaluate the associations among common GI symptoms to CFT in patients undergoing chemotherapy. Consistent with our findings regarding the effects of the antiemetic regimen on taste and GI motility, in a recent review of studies of patients receiving primary or adjuvant chemotherapy,[69] a GI cluster was the most common symptom cluster identified. In studies that used the MSAS to evaluate for symptom clusters,[70–72] the most common symptoms across the various GI clusters identified were: nausea, vomiting, lack of appetite, feeling bloated, and weight loss. In our study, CFT group membership was associated with dry mouth, nausea, feeling bloated, lack of appetite, increased appetite, difficulty swallowing, mouth sores, and constipation. The co-occurrence of these symptoms may be partially related to chemotherapy-induced alterations in the oral and intestinal mucosa.[73,74] For example, chemotherapy-induced alterations in taste are mediated by the sonic hedgehog pathway[75,76] which disrupts taste cell renewal in the oral cavity through the inhibition of progenitor cells.[77,78] Undoubtedly, the mechanisms by which chemotherapy induces taste changes and co-occurring GI symptoms are extremely complex. In addition to the mechanisms cited above, activation of pro- and anti-inflammatory pathways[79], as well as alterations in the gut microbiome[80,81] could alter taste perceptions. Finally, taste alterations could result in dietary changes that contribute to additional GI symptoms. Longitudinal studies are needed to examine the associations between CFT and co-occurring GI symptoms during chemotherapy.

Some limitations warrant consideration. While the sample size was large, only a single item was used to evaluate “change in the way food tastes”. We acknowledge that “a change in the way food tastes”, goes beyond the traditional definition of taste (i.e., sweet, sour, bitter, salty, and umami) and likely incorporates changes in flavor perception.[82,83] Therefore, studies that

incorporate additional self-report measures, as well as quantitative psychophysical measures of taste are needed to identify which taste qualities are affected and to confirm our findings on the associations between CFT and GI symptoms and antiemetic regimens. The combination of both subjective and objective measures of taste and smell function would provide increased insights into patients' experiences and draw connections with food behaviors and nutritional status. Moreover, the present study focuses on a single time point during chemotherapy treatment. A prospective longitudinal study would allow for the exploration of the effects that chemotherapy and antiemetic regimens have on CFT and GI symptoms throughout treatment and during recovery. In addition, studies that explore the molecular mechanisms that underlie CFT would provide information on inter-individual differences in this symptom in oncology patients. More information is needed to understand how CFT and GI symptoms influence changes in patients' food behaviors, dietary intake, and nutritional status.

In summary, while CFT is a severe and distressing symptom, clinicians fail to assess it and its associated impact on patients' nutritional status. Considering the high prevalence of CFT, ongoing assessment of this symptom is warranted. In addition, patients taking an NK-1 receptor antagonist as part of their antiemetic regimen may require additional symptom management interventions because their CFT and GI related symptoms may be more severe.

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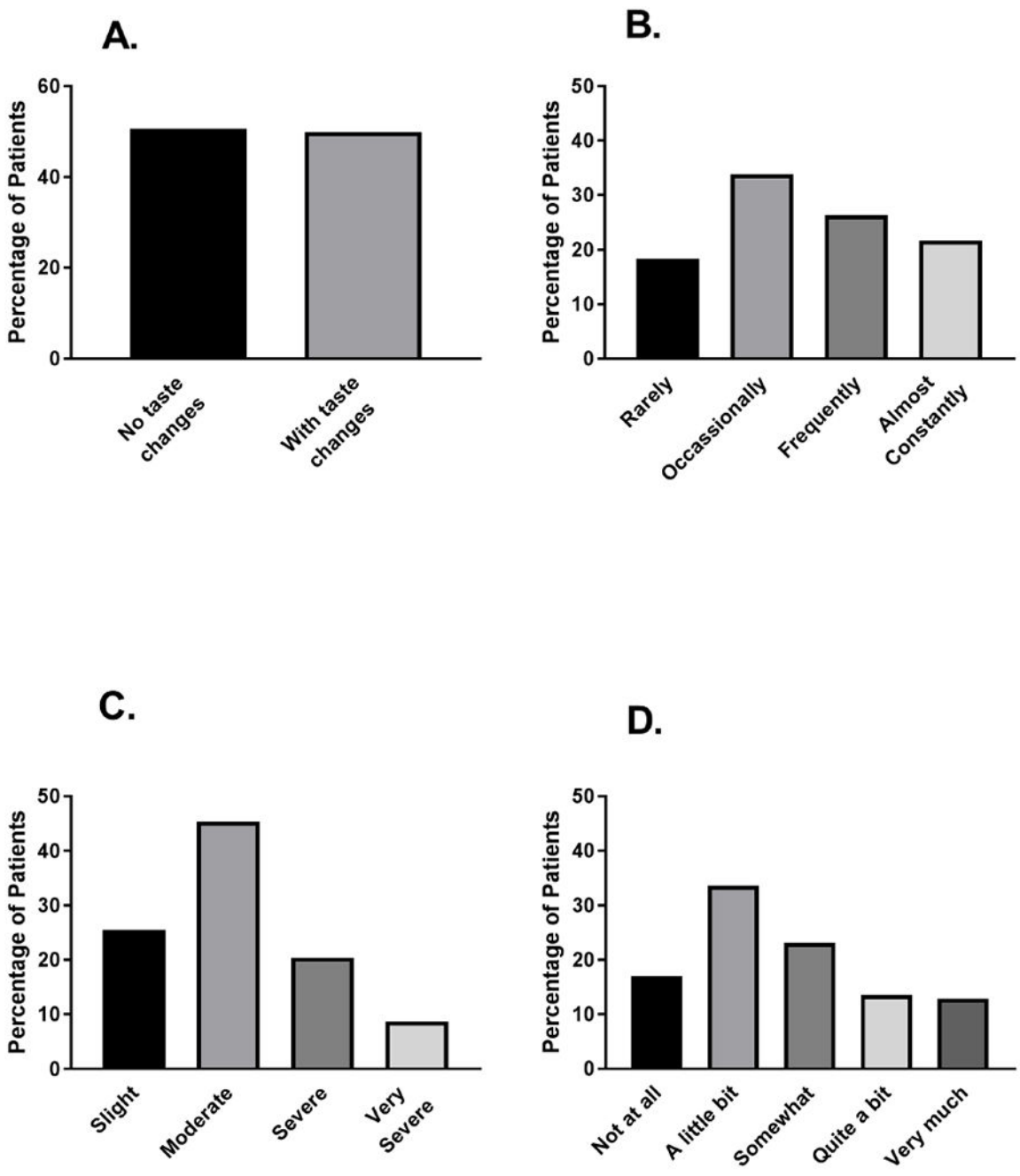

Figure 1 –.

Percentages of patients with and without self-reported change in the way food tastes (CFT, A) and distribution of patients' ratings of frequency (B), severity (C), and distress associated with CFT.

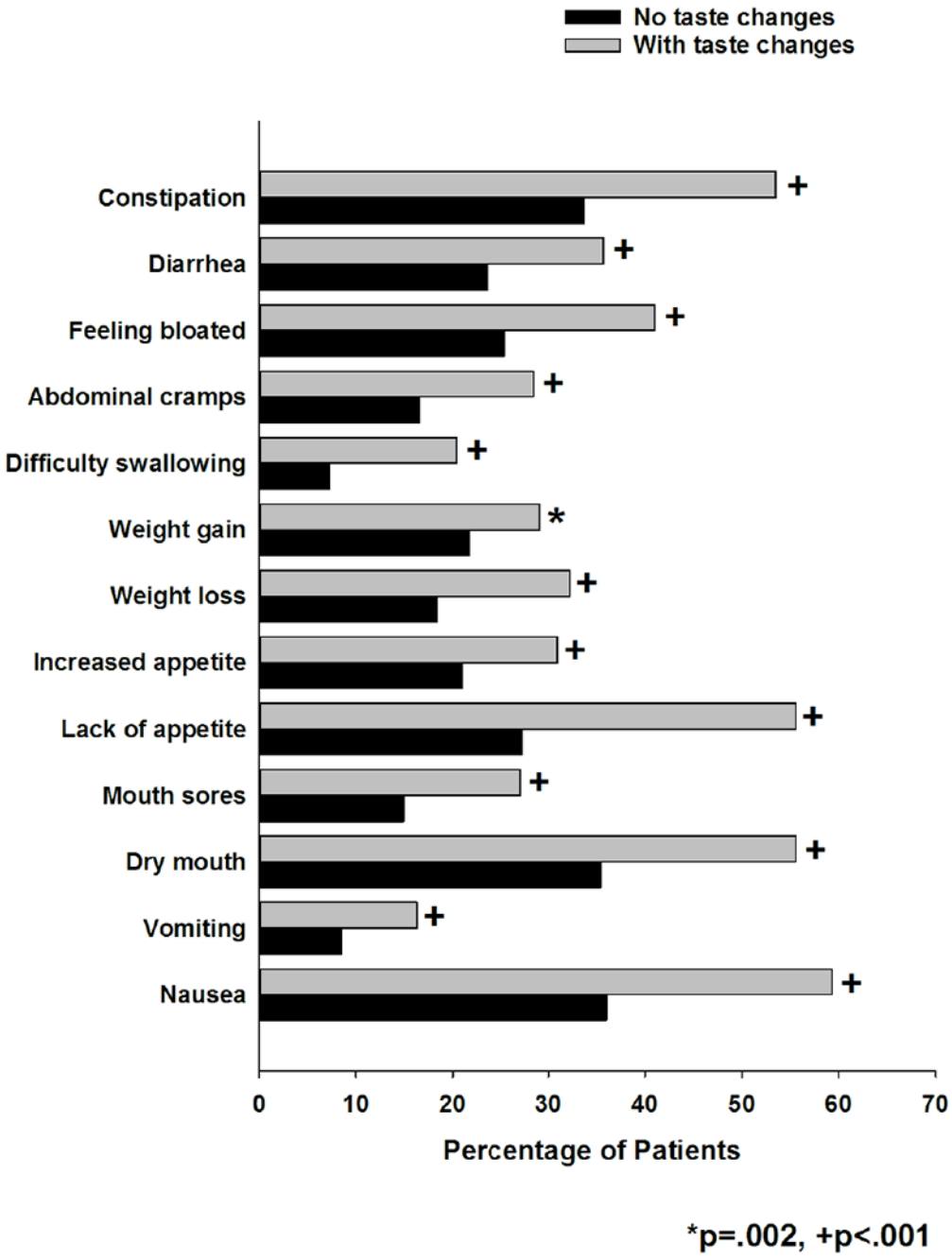

Figure 2 –.

Differences in the occurrence rates for thirteen gastrointestinal symptoms between patients who did and did not report change in the way food tastes.

Table 1.

Differences in Demographic and Clinical Characteristics Between Patients With and Without Self-Reported Change in the Way Food Tastes (n=1329)

Characteristic	No Taste Changes (0) 50.6% (n = 673)	With Taste Changes (1) 49.4% (n = 656)	Statistics
	Mean (SD)	Mean (SD)	
Age (years)	57.50 (12.50)	57.02 (12.15)	t = 0.72; p = 0.474
Education (years)	16.41 (3.09)	15.97 (2.94)	t = 2.66; p = 0.008
Body mass index (kg/m^2)	25.91 (5.31)	26.52 (6.02)	t = −1.94; p = 0.052
Karnofsky Performance Status score	81.97 (12.20)	78.10 (12.38)	t = 5.63; p < 0.001
Number of comorbidities	2.37 (1.41)	2.46 (1.46)	t = −1.19; p = 0.236
SCQ score	5.33 (3.03)	5.66 (3.36)	t = −1.85; p = 0.064
AUDIT score	3.12 (2.51)	2.82 (2.43)	t = 1.73; p = 0.084
Time since cancer diagnosis (years)	2.26 (4.23)	1.71 (3.50)	U; p = 0.037
Time since cancer diagnosis (median, years)	0.45	0.42	
Number of prior cancer treatments	1.70 (1.52)	1.48 (1.48)	t = 2.66; p = 0.008
Number of metastatic sites including lymph node involvement	1.32 (1.22)	1.16 (1.24)	t = 2.44; p = 0.015
Number of metastatic sites excluding lymph node involvement	0.86 (1.05)	0.71 (1.04)	t = 2.56; p = 0.011
MAX2 score	0.16 (0.08)	0.18 (0.08)	t = −4.01, p <.001
	% (n)	% (n)	
Gender			
Female	75.8 (510)	79.73 (523)	χ^2 = 4.20; p = 0.122
Male	24.2 (163)	20.1 (132)	
Transgender	0.0 (0)	0.2 (1)	
Ethnicity			χ^2 =19.14; p < 0.001
White	75.3 (499)	64.4 (418)	0 > 1
Black	5.6 (37)	8.9 (58)	0 < 1
Asian or Pacific Islander	10.7 (71)	13.9 (90)	NS
Hispanic, Mixed, or Other	8.4 (56)	12.8 (83)	0 < 1
Married or partnered (% yes)	66.2 (440)	62.5 (403)	FE, p = 0.167
Lives alone (% yes)	20.0 (133)	23.2 (150)	FE, p = 0.179

Characteristic	No Taste Changes (0) 50.6% (n = 673)	With Taste Changes (1) 49.4% (n = 656)	Statistics
	Mean (SD)	Mean (SD)	
Child care responsibilities (% yes)	20.1 (133)	23.9 (153)	FE, p = 0.108
Care of adult responsibilities (% yes)	6.7 (41)	9.1 (54)	FE, p = 0.164
Currently employed (% yes)	35.7 (238)	34.6 (224)	FE, p = 0.686
Income			
< $30,000	17.0 (102)	19.9 (117)	
$30,000 to < $70,000	20.1 (121)	22.2 (131)	U, p = 0.020
$70,000 to < $100,000	15.6 (94)	17.8 (105)	
≥ $100,000	47.3 (284)	40.1 (236)	
Specific comorbidities (% yes)			
Heart disease	5.5 (37)	6.1 (40)	FE, p = 0.725
High blood pressure	29.6 (199)	31.4 (206)	FE, p = 0.475
Lung disease	12.8 (86)	9.8 (64)	FE, p = 0.084
Diabetes	9.2 (62)	9.0 (59)	FE, p = 0.924
Ulcer or stomach disease	4.0 (27)	5.6 (37)	FE, p = 0.200
Kidney disease	1.5 (10)	1.4 (9)	FE, p = 1.000
Liver disease	6.2 (42)	6.7 (44)	FE, p = 0.739
Anemia or blood disease	11.1 (75)	13.6 (89)	FE, p = 0.183
Depression	19.5 (131)	18.9 (124)	FE, p = 0.835
Osteoarthritis	11.3 (76)	13.3 (87)	FE, p = 0.278
Back pain	23.9 (161)	27.7 (182)	FE, p = 0.117
Rheumatoid arthritis	2.8 (19)	3.7 (24)	FE, p = 0.440
Exercise on a regular basis (% yes)	74.1 (492)	67.6 (430)	FE, p = 0.010
Smoking current or history of (% yes)	36.8 (245)	33.8 (217)	FE, p = 0.272
Cancer diagnosis			$\chi^2 = 16.57$; p = 0.001
Breast	36.0 (242)	44.5 (292)	0 < 1
Gastrointestinal	30.2 (203)	20.7 (204)	NS
Gynecological	20.7 (139)	14.3 (94)	0 > 1
Lung	13.2 (89)	10.1 (66)	NS
Type of prior cancer treatment			$\chi^2 = 13.27$; p = 0.004
No prior treatment	23.1 (151)	26.9 (172)	NS
Only surgery, CTX, or RT	39.8 (260)	44.3 (283)	NS
Surgery & CTX, or Surgery & RT, or CTX & RT	23.7 (155)	16.0 (102)	0 > 1
Surgery & CTX & RT	13.3 (87)	12.8 (82)	NS
CTX cycle length			$\chi^2 = 11.71$; p = 0.003
14-day cycle	38.2 (257)	46.0 (301)	0 < 1

Characteristic	No Taste Changes (0) 50.6% (n = 673)	With Taste Changes (1) 49.4% (n = 656)	Statistics
	Mean (SD)	Mean (SD)	
21-day cycle	52.7 (354)	48.5 (317)	NS
28-day cycle	9.1 (61)	5.5 (36)	0 > 1
Emetogenicity of CTX			$\chi^2 = 16.41$; $p < 0.001$
Minimal/Low	22.1 (149)	16.8 (110)	0 > 1
Moderate	62.4 (420)	59.6 (390)	NS
High	15.5 (104)	23.5 (154)	0 < 1
Antiemetic regimens			$\chi^2 = 37.27$; $p < 0.001$
None	9.1 (60)	5.0 (32)	0 > 1
Steroid alone or serotonin receptor antagonist alone	22.2 (146)	18.6 (119)	NS
Serotonin receptor antagonist and steroid	50.7 (333)	44.6 (285)	NS
NK-1 receptor antagonist and two other antiemetics	18.0 (118)	31.8 (203)	0 < 1

Abbreviations: AUDIT = Alcohol Use Disorders Identification Test, CTX = chemotherapy, FE = Fisher's Exact test, kg = kilograms, m^2 = meter squared, NK-1 = Neurokinin-1, NS = not significant, RT = radiation therapy, SCQ = Self-administered Comorbidity Questionnaire, SD = standard deviation, X^2 = Chi square test, U = Mann Whitney U test

* Chi Square test done without the transgender participant

Table 2 –

Multiple Logistic Regression Analysis Predicting Change in the Way Food Tastes Group Membership (n = 1280)

Predictor	Odds Ratio (95% CI)	p-value
Cancer diagnosis		0.019
Gastrointestinal vs. breast	0.86 (0.63, 1.16)	0.313
Gynecological vs. breast	0.70 (0.49, 0.99)	0.046
Lung vs. breast	0.55 (0.36, 0.83)	0.004
Antiemetic regimen		0.001
Steroid alone or serotonin receptor antagonist alone vs. none	1.48 (0.86, 2.54)	0.160
Serotonin receptor antagonist and steroid vs. none	1.45 (0.87, 2.41)	0.149
NK-1 receptor antagonist and two other antiemetics vs. none	2.51 (1.47, 4.29)	0.001
Dry mouth	1.44 (1.11, 1.86)	0.006
Nausea	1.39 (1.07, 1.81)	0.014
Feeling bloated	1.34 (1.02, 1.77)	0.037
Lack of appetite	2.31 (1.76, 3.02)	<0.001
Increased appetite	1.56 (1.17, 2.08)	0.003
Difficult swallowing	1.87 (1.26, 2.78)	0.002
Mouth sores	1.57 (1.15, 2.16)	0.005
Constipation	1.50 (1.16, 1.94)	0.002
Overall model fit: degrees of freedom = 17; $X^2 = 257.55$, $p < .001$		

Abbreviations: NK-1 = neurokinin 1, vs = versus