The Impact of Cancer Treatment on the Diets and Food Preferences of Patients Receiving Outpatient Treatment

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Patients undergoing cancer treatment experience a multitude of symptoms that can influence their ability to complete treatment as well as their quality of life during and after treatment. This cross-sectional study sought to describe the dietary changes experienced by cancer patients and to identify associations between these changes and common treatment symptoms. A convenience sample of 1199 cancer patients aged 18 yr and older undergoing active treatment were recruited from 7 cancer centers to complete a self-administered paper-and-pencil survey. Descriptive analyses were conducted to estimate prevalence of dietary changes and chi-squared tests were used to examine associations between dietary changes and health outcomes. Approximately 40% of patients reported a decreased appetite since beginning treatment, and 67.2% of patients reported at least 1 chemosensory alteration. Increased taste sensitivities were more common than decreased taste sensitivities, with increased sensitivity to metallic being the most common taste sensitivity (18.6%). Patients also had increased sensitivities to certain smells including cleaning solutions (23.4%), perfume (22.4%), and food cooking (11.4%). Patients reported a wide range of

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food preferences and aversions. Patients who had less energy or lost weight since beginning treatment were more likely than others to report treatment-related dietary changes.

INTRODUCTION

Approximately 1.66 million people will be diagnosed with cancer in the United States in 2014 (1). Most patients diagnosed with cancer will receive treatment, and patients undergoing treatment experience a multitude of symptoms, including fatigue, pain, difficulty breathing, nausea, appetite loss, and unintentional weight change (2–5). These symptoms can negatively impact one's ability to complete treatment as well as one's quality of life during and after treatment (6–11).

Cancer treatment may affect one's diet, and dietary changes can exacerbate other treatment related symptoms. For example, cancer patients who experience chemosensory alterations, distorted taste, and increased sensitivity to smells due to the cancer itself or as a side effect of treatment (12,13) are more likely to report higher levels of weight loss, lower energy intake, and worse quality of life (12,14–17). A surprisingly high number of patients undergoing cancer treatment report distortions to their sense of taste or smell (17,18). Cancer patients also report early satiety and food aversions as a result of treatment (19). Dietary interventions, such as dietary counseling, flavor enhancement, oral supplementation, or tube feeding, have been found to lessen weight loss and improve health status (9, 20–23).

Most of the research exploring the relationship between diet and health status/quality of life during cancer treatment has focused on specific subgroups, such as patients with advanced cancer (24) or patients with head and neck cancers (18,20), and include smaller sample sizes (19). However, a recent study of 1453 outpatients suggests that a broader range of patients are at nutritional risk during cancer treatment (25). Despite this, nutritional screenings are not routinely conducted with cancer patients.

There is a need to better understand the relationship between treatment and diet among a larger, more diverse group of cancer patients to inform the development of dietary interventions that mitigate symptoms during treatment and improve quality of life. The purpose of this descriptive study is to 1) describe the dietary changes experienced by cancer patients receiving outpatient treatment; 2) to assess associations between dietary changes and selected health outcomes (i.e., changes in energy levels, changes in weight); and 3) to explore the food preferences and aversions of cancer patients undergoing outpatient treatment.

SUBJECTS AND METHODS

Sample

A convenience sample of cancer patients ages 18 years and older undergoing active treatment was recruited from 7 cancer centers: Roswell Park Cancer Institute, New York University Cancer Institute, Dana Farber/Brigham and Women's Cancer Center, Sidney Kimmel Comprehensive Cancer Center at Johns Hopkins, University of Chicago Comprehensive Cancer Center, Mayo Clinic Cancer Center, and Cedars-Sinai/Samuel Oschin Comprehensive Cancer Institute. Between April and December 2012, nurses, therapists, and dietitians at participating centers approached patients in waiting areas and other clinical areas to enroll them in the study. Institutional Review Boards at each center approved the study protocol.

Measures

Participants completed a 15-min self-administered paper-and-pencil survey. Variables included in this analysis follow.

- Demographic variables: age (18-74 years or 75 years and older); gender (male, female); race (Caucasian, African American, Other); and comorbidities (diabetes, heart disease, lung disease, liver disease, kidney disease, HIV/AIDS).
- Cancer-related variables: time since diagnosis (0–6 months, 6–12 months, a year or more); treatment type (chemotherapy, other); and cancer type (breast cancer; lung cancer; gastrointestinal (GI) cancers, including gastrointestinal, pancreatic, liver, or gall bladder; other solid cancers, including brain or spinal, gynecological, head or neck, prostate, kidney or bladder, osteosarcoma, and soft tissue sarcoma; and hematologic cancers, including leukemia, lymphoma, and multiple myeloma).
- Dietary changes: change in appetite; change in frequency of eating; change in thirst; change in frequency of drinking fluids; increased or decreased taste sensitivities—bitter, metallic, salty, sour, and sweet; and increased sensitivity to various aromas.
- Health outcomes: weight change (5 lb or more weight loss since treatment began, within 5 lbs of starting weight, 5 lb or more weight gain); changes in energy level (more energy, about the same amount of energy, less energy).

Statistical Analysis

Descriptive statistics were calculated. Chi-square tests were used to examine associations between dietary changes and demographic characteristics (i.e., cancer type, gender, and age) and dietary changes and health outcomes (i.e., changes in energy level, weight change). When expected cell sizes were small (less than 5), the Fisher's exact test was used. A P value of 0.05 or less was considered to be statistically significant, and all tests were 2-sided. All analyses were conducted using STATA 11 software.

RESULTS

Sample Characteristics

A total of 1199 cancer patients participated in this study (Table 1). A range of different cancer types were

TABLE 1
Sample characteristics by cancer type,[a]%[b] (n)

	Total (n = 1199)	Breast (n = 207)	GI[c] (n = 155)	Lung (n = 130)	Other solids[d] (n = 290)	Hematologic[e] (n = 238)
Gender						
Male	37.5% (450)	1.5% (3)	54.2% (84)	35.4% (46)	36.9% (107)	53.8% (128)
Female	59.8% (717)	97.6% (202)	43.2% (67)	60.8% (79)	60.0% (174)	43.3% (103)
Age						
18 to 74 yr	87.0% (1,043)	93.2% (193)	85.8% (133)	86.9% (113)	88.5% (257)	85.3% (203)
75 yr or older	12.6% (151)	5.8% (12)	14.2% (22)	13.1% (17)	11.0% (32)	14.7% (35)
Ethnicity						
Caucasian	79.5% (953)	73.9% (153)	82.6% (128)	82.3% (107)	81.0% (235)	79.9% (188)
African American	9.3% (111)	14.0% (29)	5.2% (8)	11.5% (15)	6.2% (18)	10.9% (26)
Other	10.3% (123)	11.6% (24)	11.0% (17)	5.4% (7)	12.8% (37)	8.8% (21)
Time since diagnosis						
Less than 6 mo	39.5% (473)	43.0% (89)	48.4% (75)	42.3% (55)	42.4% (123)	33.6% (80)
6 to 12 mo	13.0% (156)	13.0% (27)	22.6% (35)	15.4% (20)	10.0% (29)	8.8% (21)
More than a year ago	46.3% (555)	43.5% (90)	28.4% (44)	42.3% (55)	46.9% (136)	55.5% (132)
Treatment type						
Chemotherapy	89.2% (1,070)	83.6% (173)	97.4% (151)	96.2% (125)	88.3% (256)	86.5% (206)
Radiation	14.8% (177)	11.6% (24)	11.6% (18)	27.7% (36)	24.1% (70)	4.2% (10)
Surgery	8.2% (98)	9.2% (19)	7.1% (11)	4.6% (6)	12.1% (35)	2.5% (6)
Hormone therapy	4.8% (58)	12.6% (26)	0.7% (1)	None	8.3% (24)	0.4% (1)
Transplant	1.5% (18)	None	0.6% (1)	None	0.3% (1)	5.5% (13)
Comorbidities						
None	58.9% (706)	64.7% (134)	55.5% (86)	54.6% (71)	58.3% (169)	60.5% (144)
Diabetes	12.6% (151)	9.7% (20)	32 (20.7%)	13.1% (17)	11.0% (32)	13.5% (32)
Heart disease	9.2% (110)	1.9% (4)	9.7% (15)	14.6% (19)	9.7% (28)	11.3% (27)
Lung disease	5.2% (62)	2.4% (5)	2.6% (4)	17.7% (23)	2.8% (8)	4.6% (11)
Liver disease	2.3% (28)	2.9% (6)	5.8% (9)	0.8% (1)	1.4% (4)	1.7% (4)
Kidney disease	1.8% (22)	1.0% (2)	None	3.1% (4)	1.4% (4)	3.4% (8)
HIV/AIDS	0.6% (7)	1.0% (2)	1.3% (2)	None	None	0.8% (2)

[a]Participants who did not report cancer type (n = 16), who reported having more than one type of cancer (n = 87), and who reported having "other malignancies" (n = 76) were included in the total, but not in the analyses by cancer type.
[b]Not all percentages add up to 100 because of missing data.
[c]GI = gastrointestinal, pancreatic, liver, or gall bladder.
[d]Other solids = brain or spinal, gynecological, head or neck, prostate, kidney or bladder, osteosarcoma, or soft tissue sarcoma.
[e]Hematologic = leukemia or lymphoma.

represented—17.3% breast cancer, 12.9% GI cancers, 10.8% lung cancer, 24.2% other solid cancers, 19.9% hematologic cancers, and 14.9% had multiple cancers, other malignancies, or unknown malignancies. More than half the sample was female (59.8%), and 87% of patients were under the age of 75 years. The majority of participants were white (79.5%), with the remaining being African American (9.3%) and other (10.3%). Cancer was the only chronic health condition for more than half of the patients; of those who had comorbidities, diabetes (12.6%), and heart disease (9.2%) were the most common. About 40% of participants were diagnosed less than 6 mo ago, 13% were diagnosed 6–12 mo ago, and the remaining 46.3% were diagnosed more than a year ago. Chemotherapy was the most common treatment type (89.2%).

Impact of Cancer Treatment on Diet

Cancer treatment influenced patients' appetites and thirst, and their frequency of eating and drinking. Table 2 summarizes these changes. About 40% of patients had a decreased appetite since starting treatment, and 30% reported eating less, whereas 30.6% of patients reported increased thirst, and 48.9% reported drinking fluids more frequently.

Treatment was also associated with chemosensory alterations, with 67.2% of patients reporting at least 1 taste or smell sensitivity (Table 3). Half the patients (50.2%) reported increased taste sensitivity. Patients were most likely to report an increased sensitivity to metallic taste (18.6%). Decreased taste sensitivities were less common than increased taste sensitivity; 17.8% of patients reported decreased taste sensitivity;

TABLE 2

Impact of treatment on patients' diets by gender, age, and cancer type

	Total	Gender			Age			Cancer type[a]				
		Males (n = 450)	Females (n = 717)	P value	18–74 years (n = 1,043)	75 and older (n = 151)	P value	Breast (n = 207)	GI (n = 155)	Lung (n = 130)	Other solids (n = 290)	Hematologic (n = 238)
Changes in appetite since beginning treatment												
Increased appetite	15.2% (178)	13.5% (60)	16.8% (117)	<0.01	15.2% (158)	12.6% (19)	0.26	18.8% (39)	11.0% (17)	14.6% (19)	14.5% (42)	15.1% (36)
Same	45.4% (531)	51.2% (228)	40.8% (285)		43.5% (454)	50.3% (76)		42.5% (88)	38.7% (60)	36.9% (48)	42.1% (122)	54.5% (130)
Decreased appetite	39.4% (461)	35.3% (157)	42.4% (296)		39.0% (404)	34.4% (52)		36.2% (75)	47.1% (73)	44.6% (58)	41.4% (120)	29.4% (70)
Changes in frequency of eating since beginning treatment												
More often	21.6% (251)	19.8% (88)	22.8% (158)	0.01	21.7% (226)	15.2% (23)	<0.01	21.3% (44)	25.8% (40)	20.8% (27)	19.0% (55)	21.0% (50)
About the same	48.5% (565)	53.8% (239)	44.4% (308)		45.2% (471)	60.9% (92)		45.4% (94)	40.0% (62)	41.5% (54)	43.5% (126)	57.1% (136)
Less often	30.4% (349)	26.4% (117)	32.9% (228)		30.4% (317)	21.2% (32)		30.4% (63)	31.6% (49)	33.1% (43)	34.8% (101)	20.6% (49)
Changes in thirst since beginning treatment												
Increased	30.6% (355)	28.1% (127)	32.3% (224)	0.29	30.9% (322)	21.9% (33)	0.01	37.2% (77)	20.7% (32)	21.5% (28)	27.9% (81)	34.9% (83)
Stayed the same	53.8% (625)	56.0% (247)	51.7% (359)		50.3% (525)	63.6% (96)		48.8% (101)	55.5% (86)	56.9% (74)	49.0% (142)	55.5% (132)
Decreased	15.7% (182)	15.9% (70)	16.0% (111)		15.9% (166)	10.6% (16)		11.6% (24)	20.7% (32)	15.4% (20)	21.0% (61)	7.1% (17)
Changes in frequency of drinking since beginning treatment												
More often	48.9% (570)	47.8% (212)	50.6% (351)	0.65	48.3% (504)	42.4% (64)	0.01	56.0% (116)	38.7% (60)	43.9% (57)	41.7% (121)	57.6% (137)
About the same	40.3% (469)	41.0% (182)	38.6% (268)		37.7% (393)	49.0% (74)		34.3% (71)	43.2% (67)	41.5% (54)	42.1% (122)	35.3% (84)
Less often	10.8% (126)	11.3% (50)	10.8% (75)		11.3% (118)	5.3% (8)		7.3% (15)	15.5% (24)	10.8% (14)	13.5% (39)	5.5% (13)

GI = gastrointestinal.

[a]Participants who reported more than one type of cancer or who reported having an "other malignancy" that did not fall into the five categories were excluded from analyses by cancer type.

TABLE 3
Chemosensory alterations

| | Total | Gender | | | Age | | | Cancer type | | | | |
		Males (n = 450)	Females (n = 717)	P value	18–74 yr (n = 1,043)	75 and older (n = 151)	P value	Breast (n = 207)	GI (n = 155)	Lung (n = 130)	Other solids (n = 290)	Hematologic (n = 238)
				% (n) reporting increased taste sensitivity								
Metallic	18.6% (223)	16.9% (76)	20.1% (144)	0.17	20.2% (211)	8.0% (12)	<0.01	21.7% (45)	23.9% (37)	12.3% (16)	22.4% (65)	12.6% (30)
Salty	14.5% (174)	11.1% (50)	17.0% (122)	0.01	15.2% (159)	9.9% (15)	0.08	14.0% (29)	14.2% (22)	12.3% (16)	17.9% (52)	13.5% (32)
Sweet	13.4% (161)	8.0% (36)	16.9% (121)	<0.01	14.3% (149)	8.0% (12)	0.03	14.5% (30)	14.2% (22)	10.8% (14)	15.2% (44)	14.7% (35)
Bitter	9.3% (111)	6.9% (31)	10.7% (77)	0.03	9.8% (102)	6.0% (9)	0.13	9.7% (20)	10.3% (16)	11.5% (15)	8.3% (24)	8.4% (20)
Sour	7.4% (89)	5.8% (26)	8.4% (60)	0.10	8.0% (83)	3.3% (5)	0.04	8.2% (17)	12.3% (19)	5.4% (7)	8.6% (25)	4.6% (11)
				% (n) reporting decreased taste sensitivity								
Sweet	9.3% (112)	10.4% (47)	9.1% (65)	0.44	10.2% (106)	4.0% (6)	0.02	6.8% (14)	5.8% (9)	6.9% (9)	13.8% (40)	9.7% (23)
Salty	8.6% (103)	9.6% (43)	8.2% (59)	0.44	8.6% (90)	8.0% (12)	0.78	11.1% (23)	7.1% (11)	7.7% (10)	9.7% (28)	8.8% (21)
Sour	4.8% (58)	4.7% (21)	5.2% (37)	0.71	5.0% (52)	4.0% (6)	0.59	6.3% (13)	1.9% (3)	2.3% (3)	7.2% (21)	4.6% (11)
Bitter	4.7% (56)	3.8% (17)	5.3% (38)	0.23	5.0% (52)	2.7% (4)	0.20	6.3% (13)	3.2% (5)	0.8% (1)	6.9% (20)	3.8% (9)
				% (n) reporting sensitivity to aroma								
Cleaning solutions	23.4% (281)	16.4% (74)	28.5% (204)	<0.01	25.0% (261)	12.6% (19)	<0.01	29.5% (61)	20.7% (32)	16.2% (21)	24.5% (71)	22.3% (53)
Perfume	22.4% (268)	13.8% (62)	28.2% (202)	<0.01	24.3% (253)	9.3% (14)	<0.01	35.3% (73)	14.8% (23)	15.4% (20)	21.0% (61)	21.0% (50)
Food cooking	11.4% (137)	8.0% (36)	14.0% (100)	<0.01	12.5% (130)	4.6% (7)	0.01	14.0% (29)	18.1% (28)	10.8% (14)	12.1% (35)	8.0% (19)
Fish	10.8% (130)	6.4% (29)	13.7% (98)	<0.01	11.5% (120)	6.6% (10)	0.07	14.0% (29)	8.4% (13)	4.6% (6)	13.5% (39)	8.8% (21)
Hand sanitizer	8.2% (98)	4.9% (22)	10.5% (75)	<0.01	9.3% (97)	0.7% (1)	<0.01	11.1% (23)	5.8% (9)	6.2% (8)	8.3% (24)	10.9% (26)
Plastic	5.7% (68)	2.2% (10)	8.1% (58)	<0.01	6.0% (63)	2.7% (4)	0.09	9.7% (20)	7.1% (11)	None	5.9% (17)	5.9% (14)

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TABLE 3
Chemosensory alterations (*Continued*)

| | Total | Gender | | | Age | | | Cancer type | | | | |
		Males (n = 450)	Females (n = 717)	P value	18–74 yr (n = 1,043)	75 and older (n = 151)	P value	Breast (n = 207)	GI (n = 155)	Lung (n = 130)	Other solids (n = 290)	Hematologic (n = 238)
Meat	5.3% (63)	4.0% (18)	6.3% (45)	0.09	5.9% (61)	1.3% (2)	0.02	6.8% (14)	9.7% (15)	1.5% (2)	5.2% (15)	3.8% (9)
Poultry	4.2% (50)	2.9% (13)	5.2% (37)	0.06	4.7% (49)	0.7% (1)	0.02	5.3% (11)	8.4% (13)	0.8% (1)	4.1% (12)	3.4% (8)
Dairy	2.3% (27)	1.6% (7)	2.7% (19)	0.22	2.4% (25)	1.3% (2)	0.41	2.4% (5)	3.2% (5)	1.5% (2)	2.1% (6)	2.1% (5)

GI = gastrointestinal.

9.3% of patients reported decreased taste sensitivity to sweet, 8.6% to salty, 4.8% to sour, and 4.7% to bitter; and 43.3% of patients reported being bothered by at least one aroma. The aromas that patients most frequently reported an aversion to were cleaning solutions (23.4%), perfume (22.4%), food cooking (11.4%), fish (10.8%), and hand sanitizer (8.2%) (Table 3).

Associations Between Treatment Side Effects and Dietary Changes

Fatigue and weight change are two common treatment side effects reported by cancer patients. Among patients in this study, those with reduced energy levels experienced more diet-related issues than those with normal or increased energy levels (Table 4). Almost seventy-five percent of patients in our sample reported a reduction in energy since beginning treatment, whereas 21.1% reported no change or increased energy levels compared to their pretreatment energy levels. Patients with decreased energy levels were more likely to have a reduced appetite compared to patients with normal/increased energy levels, eat less frequently, be less thirsty, and drink less often. Significantly more patients with reduced energy levels reported either increased taste sensitivities or decreased taste sensitivities. Those with reduced energy levels were also more sensitive to smells, specifically cleaning solutions, food cooking, fish, plastic, and meat.

Similarly, patients who reported weight loss also reported higher levels of dietary issues. A majority of patients experienced a weight change since starting treatment. Only 31.1% of patients stayed within 5 lbs of their normal weight since beginning treatment, and weight lost was more common than weight gain (45.1% vs. 23.8%). Patients who lost weight were more likely to report a decrease in appetite (46.4% vs. 13.0%) and desire for beverages (18.4% vs. 5.9%) and a decreased frequency of eating (35.2% vs. 8.3) and drinking (12.6% vs. 4.4%), than those who stayed within 5lbs or gained weight (Table 5).

Patients who lost weight since treatment began were more likely than patients who stayed the same or gained weight to have an increased sensitivity to metallic and salty tastes and decreased sensitivity to sour and sweet tastes. They also had increased sensitivity to the smells of food cooking and hand sanitizer.

Food Preferences and Aversions

Cancer treatment also influenced the types of foods that patients were consuming. Patients had a wide range of food preferences and aversions (Table 6). The top five preferred foods were fruits and vegetables (62.1%), soup (55.9%), poultry (54.4%), pasta (49.5%), and fish (47.5%). The top five foods patient avoided were greasy/fried foods (45.0%), spicy foods (39.9%), citrus/acid foods (28.1%), Indian food (27.6%), and Mexican food (26.9%).

Patients with lower energy levels were more likely than those whose energy levels remained the same or increased, to avoid most types of foods, including spicy (43.1% vs. 34.0%; $P = 0.01$), Indian (30.9% vs. 20.2%; $P < 0.01$), acidic/citrus foods (30.7% vs. 22.5%; $P = 0.01$), Mexican (30.6% vs. 22.1%; $P < 0.01$), salty (27.2% vs. 20.6%; $P = 0.03$), soy (22.5% vs. 11.9%; $P < 0.01$), Asian (21.3% vs. 12.7%; $P < 0.01$), fruits and vegetables (18.1% vs. 9.9%; $P < 0.01$), crunchy (14.9% vs. 9.1%; $P = 0.02$), chewy (13.5% vs. 6.3%; $P < 0.01$), high fiber foods (12.6% vs. 6.3%, $P = 0.01$), fish (11.7% vs. 7.1%; $P = 0.04$), and vegetarian diet (10.5% vs. 5.1%; $P = 0.01$).

Those who lost at least 5 lbs since starting treatment were more likely to avoid foods than those who stayed within 5 lbs or gained weight. Specifically, they avoided the following foods more frequently: spicy (46.7% vs. 36.5%; $P < 0.01$), Indian (32.1% vs. 25.3%; $P = 0.02$), Mexican (31.9% vs. 24.3%; $P < 0.01$), meat (24.1% vs. 17.3%; $P < 0.01$), Asian (23.4% vs. 16.3%; $P < 0.01$), dairy (21.2% vs. 14.4%; $P < 0.01$), fruits and vegetables (20.8% vs. 12.6%; $P < 0.01$), chewy (14.6% vs. 9.8%; $P = 0.01$), fiber (14.0% vs. 9.0%, $P < 0.01$), fish (13.2% vs. 8.6%; $P = 0.01$, pasta (11.3% vs. 6.6%; $P < 0.01$), vegetarian (11.3% vs. 7.8%; $P = 0.05$), poultry (10.3% vs. 5.0%; $P < 0.01$), and soup (7.8% vs. 3.7%; $P < 0.01$).

Selected Findings by Cancer Type, Gender, and Age

Many of the dietary issues experienced were consistent across all patient types. However, there were some patterns that emerged by cancer type, gender and age.

Breast Cancer

Breast cancer patients were less likely to report losing weight than other types of cancer (30.0% vs. 45.0; $P < 0.01$), and more likely to gain weight, indicating that for some breast cancer patients overnutrition rather than undernutrition may be of concern. Breast cancer patients were more sensitive than other cancer patients to perfume (35.3% vs. 18.9%; $P < 0.01$) and plastic (9.7% vs. 5.2%; $P = 0.02$). In terms of food preferences (Table 7), more breast cancer patients preferred a vegetarian diet than other cancer types (30.4% vs. 19.8%; $P < 0.01$).

GI Cancers

Patients with GI cancers tended to experience a high burden of nutrition-related side effects. Patients with GI cancers were more likely than other cancer patients to report a decreased appetite (48.7% vs. 38.1%; $P = 0.04$). They were more sensitive than other cancer patients to the aromas of food cooking (18.1% vs. 11.2%; $P = 0.02$) and meat (9.7% vs. 4.6%; $P = 0.01$). Patients with GI cancers were more likely than other cancer patients to avoid spicy foods (50.3% vs. 37.3%; $p < 0.01$), Asian

TABLE 4
Association between energy level and patients' diets

Dietary changes	Decreased energy (n = 892) % reporting (n)	Same/more energy (n = 253) % reporting (n)	P value
Changes in appetite since beginning treatment			
Increased appetite	13.0% (116)	22.1% (56)	<0.01
Same	39.8% (355)	64.0% (162)	
Decreased appetite	46.4% (414)	13.0% (33)	
Changes in frequency of eating since beginning treatment			
More often	19.7% (176)	27.3% (69)	<0.01
About the same	44.1% (393)	62.9% (159)	
Less often	35.2% (314)	8.3% (21)	
Changes in thirst since beginning treatment			
Increased	30.6% (273)	28.5% (72)	<0.01
Stayed the same	49.7% (443)	64.8% (164)	
Decreased	18.4% (164)	5.9% (15)	
Changes in frequency of drinking since beginning treatment			
More often	50.0% (443)	45.1% (114)	<0.01
About the same	36.8% (328)	49.8% (126)	
Less often	12.6% (112)	4.4% (11)	
Increased taste sensitivity			
Metallic	21.0% (187)	13.0% (33)	0.01
Salty	16.9% (151)	8.3% (21)	<0.01
Sweet	14.7% (131)	8.7% (22)	0.01
Bitter	10.9% (97)	4.7% (12)	<0.01
Sour	8.4% (75)	4.0% (10)	0.02
Decreased taste sensitivity			
Sweet	10.5% (94)	6.7% (17)	0.07
Salty	10.3% (92)	3.6% (9)	<0.01
Sour	5.6% (50)	2.4% (6)	0.04
Bitter	5.5% (49)	2.0% (5)	0.02
Sensitivity to aroma			
Cleaning solutions	27.0% (241)	15.4% (39)	<0.01
Perfume	24.6% (219)	19.0% (48)	0.06
Food cooking	14.1% (126)	4.0% (10)	<0.01
Fish	13.1% (117)	5.1% (13)	<0.01
Hand sanitizer	9.1% (81)	6.7% (17)	0.24
Plastic	7.2% (64)	1.6% (4)	<0.01
Meat	6.3% (56)	2.8% (7)	0.03
Poultry	4.9% (44)	2.4% (6)	0.08
Dairy	2.4% (21)	2.4% (6)	0.99

foods (29.0% vs. 17.9%; $P < 0.01$), fruits and vegetables (22.6% vs. 14.3%; $P = 0.01$), and high fiber foods (19.4% vs. 9.5%; $P < 0.01$) (Table 8).

Lung Cancer

Lung cancer patients experienced a lower burden of nutrition side effects than other cancer types. In fact, patients with lung cancer were less likely than other patients to have an increased sensitivity to metallic taste (12.3% vs. 19.9%; $P = 0.04$), and

less likely than others to avoid meat (13.9% vs. 22.0%; $P = 0.04$) and fruits and vegetables (8.5% vs. 16.6%; $P = 0.02$).

Other Solids

Patients with solid cancers other than breast, GI, and lung were more likely than other cancer patients to report a decreased sensitivity to sweet (13.8% vs. 7.5%; $P < 0.01$), and more likely than others to avoid high fiber foods (14.1% vs. 9.7%; $P = 0.04$).

TABLE 5
Association between weight change and patients' diets

Dietary changes	5 lb or more weight loss (n = 514) % reporting (n)	Stayed within 5 lbs/gained weight (n = 625) % reporting (n)	P value
Changes in appetite since beginning treatment			
Increased appetite	5.5% (28)	22.9% (142)	<0.01
Same	30.5% (156)	57.7% (358)	
Decreased appetite	64.1% (328)	19.4% (120)	
Changes in frequency of eating since beginning treatment			
More often	12.9% (66)	28.4% (175)	<0.01
About the same	36.7% (187)	58.5% (361)	
Less often	50.4% (257)	13.1% (81)	
Changes in thirst since beginning treatment			
Increased	30.6% (155)	30.7% (190)	<0.01
Stayed the same	46.6% (263)	59.1% (365)	
Decreased	22.9% (116)	10.2% (63)	
Changes in frequency of drinking since beginning treatment			
More often	45.6% (232)	52.3% (324)	<0.01
About the same	37.9% (193)	41.5% (257)	
Less often	16.5% (84)	6.3% (39)	
Increased taste sensitivity			
Metallic	21.8% (112)	17.0% (106)	0.04
Salty	18.1% (93)	12.3% (77)	0.01
Sweet	15.2% (78)	12.0% (75)	0.12
Bitter	10.1% (52)	9.1% (57)	0.57
Sour	8.2% (42)	6.9% (43)	0.41
Decreased taste sensitivity			
Sweet	12.1% (62)	8.0% (50)	0.02
Salty	8.8% (45)	9.0% (56)	0.90
Sour	6.6% (34)	3.5% (22)	0.02
Bitter	5.4% (28)	4.2% (26)	0.31
Sensitivity to aroma			
Cleaning solutions	26.1% (134)	22.9% (143)	0.21
Perfume	25.5% (131)	21.4% (134)	0.11
Food cooking	16.9% (87)	7.8% (49)	<0.01
Fish	13.2% (68)	9.9% (62)	0.08
Hand sanitizer	10.7% (55)	6.6% (41)	0.01
Plastic	6.6% (34)	5.4% (34)	0.41
Meat	5.1% (26)	5.9% (37)	0.53
Poultry	5.1% (26)	3.7% (23)	0.25
Dairy	2.7% (14)	1.8% (11)	0.27

Hematologic Cancers

Hematologic cancer patients were also less likely to report several nutrition related issues. They were less likely to report a decreased appetite (29.7% vs. 42.8%; $P < 0.01$), and less likely to report eating less often (20.9% vs. 33.8%; $P < 0.01$). Patients with hematologic cancers (12.6% vs. 20.8%; $P < 0.01$) were less likely than other patients to have an increased sensitivity to metallic taste, and less sensitive to the smell of food cooking than other patients (8.0% vs. 13.6%; $P = 0.02$). Patients with hematologic cancers were less likely than other types of cancer patients to avoid spicy foods (30.3% vs. 42.1%; $P < 0.01$), Indian foods (21.4% vs. 30.6%; $P = 0.01$), meat (15.6% vs. 22.6%; $P = 0.02$), chewy foods (7.1% vs. 13.2%; $P < 0.01$), and high fiber foods (6.7% vs. 12.3%; $P = 0.02$).

TABLE 6
Foods preferences and aversions

	Preferred food	% (n) reporting a food preference		Avoided food	% (n) reporting a food aversion
1	Fruits and vegetables	62.1% (745)	1	Greasy/fried foods	45.0% (563)
2	Soup	55.9% (670)	2	Spicy	39.9% (478)
3	Poultry	54.4% (652)	3	Citrus acidic foods	28.1% (337)
4	Pasta	49.5% (594)	4	Indian	27.6% (331)
5	Fish	47.5% (570)	5	Mexican	26.9% (323)
6	Meat	41.5% (498)	6	Salty foods	24.9% (298)
7	Dairy	39.3% (471)	7	Sweets	22.5% (270)
8	Sweet	37.0% (443)	8	Meat	20.1% (241)
9	High fiber foods	31.0% (372)	9	Soy	19.6% (235)
10	Crunchy foods	25.9% (311)	10	Asian	18.8% (225)
11	Asian	23.1% (277)	11	Dairy	16.9% (203)
12	Salty foods	22.9% (275)	12	Fruits and vegetables	16.3% (195)
13	Vegetarian	21.8% (261)	13	Bland	16.1% (193)
14	Spicy	19.6% (235)	14	Crunchy foods	13.4% (151)
15	Mexican	19.3% (231)	15	Chewy	11.8% (142)
16	Chewy foods	18.9% (227)	16	High fiber	11.1% (133)
17	Citric/acidic foods	17.3% (207)	17	Fish	10.5% (126)
18	Bland foods	12.7% (152)	18	Vegetarian	9.2% (110)
19	Greasy/fried foods	12.0% (144)	19	Pasta	8.5% (102)
20	Indian	8.8% (105)	20	Poultry	7.2% (86)
21	Soy	7.8% (94)	21	Soup	5.5% (66)

Gender

Females were more likely than males to have a decreased appetite and to report eating less frequently. Although the rankings were the same for both males and females, females were more likely than males to have increased sensitivity to salty, sweet, and bitter tastes. Females were more sensitive to several smells than males, including an increased sensitivity to the smell of cleaning solution, perfume, food cooking, fish, hand sanitizer, and plastic. Males were more likely than females to prefer meat (49.3% vs. 36.8%; $P < 0.01$) and spicy foods (23.1% vs. 17.2%; $P = 0.01$), whereas females were more likely than males to prefer a vegetarian diet (26.1% vs. 14.9; $P < 0.01$). Females had more food aversions and were more likely than males avoid spicy foods (43.7% vs. 34.9%; $P < 0.01$), Indian foods (30.4% vs. 23.6%; $P = 0.01$), Mexican foods (29.2% vs. 23.6; $P = 0.04$), sweets (24.8% vs. 18.9%, $P = 0.02$), meat (22.7% vs. 16.4%; $P = 0.01$), Asian foods (21.3% vs. 15.3%; $P = 0.01$), and dairy (19.8 vs. 12.9; $P < 0.01$).

Age

Younger patients were more likely to experience nutritional issues than older patients, including eating less frequently (30.4% vs. 21.2%), being more thirsty (30.9% vs. 21.9%) and drinking fluids more often (48.3% vs. 42.4%). Younger patients were also more likely than older patients to report increased sensitivity to metallic, sweet, and sour, and a decreased sensitivity to sweet (10.2% vs. 4.0%; $P = 0.02$). Younger patients were more likely than older patients to report sensitivities to smells; specifically they were more likely to report sensitivity to the smells of fish, meat, poultry, cleaning solution, hand sanitizer, perfume, plastics, and food cooking. Older patients were more likely to report a preference for meat (50.3% vs. 40.3%; $P = 0.02$), whereas younger patients were more likely to prefer Asian (24.2% vs. 15.2%; $P = 0.02$), Mexican (21.3% vs. 5.3%; $P < 0.01$), spicy (20.6% vs. 11.9%; $P = 0.01$), and Indian (9.6% vs. 2.7%; $P = 0.01$). In terms of food aversions, younger patients were more likely to avoid meat (21.2% vs. 13.3%; $P = 0.02$) and poultry (9.8% vs. 3.3%; $P = 0.05$).

DISCUSSION

This study provides detailed data on the ways in which treatment alters the diets of a diverse group of cancer patients. In exploring dietary changes among cancer patients currently undergoing outpatient treatment, we found that decreased appetite was more common than increased appetite. Sixty-seven percent of patients reported at least 1

Food preferences by gender, age, and cancer type

	Gender			Age			Cancer type[a]				
	Males (n = 450)	Females (n = 717)	P value	18–74 years (n = 1043)	75 and older (n = 151)	P value	Breast (n = 207)	GI (n = 155)	Lung (n = 130)	Other solids (n = 290)	Hematologic (n = 238)
Fruits and vegetables	62.4% (281)	62.3% (447)	0.97	62.1% (648)	62.3% (94)	0.98	62.3% (129)	67.1% (104)	53.9% (70)	61.0% (177)	65.6% (156)
Soup	55.6% (250)	56.2% (403)	0.82	54.9% (573)	62.9% (95)	0.07	53.6% (111)	58.1% (90)	55.4% (72)	55.5% (161)	55.5% (132)
Poultry	56.0% (252)	53.7% (385)	0.44	53.4% (557)	60.3% (91)	0.11	54.1% (112)	58.1% (90)	54.6% (71)	51.4% (149)	55.9% (133)
Pasta	48.7% (219)	50.1% (359)	0.64	48.6% (507)	56.3% (85)	0.08	47.3% (98)	56.8% (88)	47.7% (62)	46.2% (134)	51.3% (122)
Fish	50.7% (228)	46.3% (332)	0.15	47.5% (495)	47.0% (71)	0.92	47.8% (99)	50.3% (78)	50.0% (65)	45.9% (133)	50.0% (119)
Meat	49.3% (222)	36.8% (264)	<0.01	40.3% (420)	50.3% (76)	0.02	35.8% (74)	43.9% (68)	40.8% (53)	39.0% (113)	46.2% (110)
Dairy	41.6% (187)	37.7% (270)	0.18	39.0% (407)	42.4% (64)	0.43	38.2% (79)	41.9% (65)	37.7% (49)	39.0% (113)	42.0% (100)
Sweet	35.3% (159)	38.2% (274)	0.32	36.3% (379)	41.1% (62)	0.26	35.3% (73)	42.6% (66)	35.4% (46)	36.9% (107)	35.7%(85)
High fiber foods	30.7% (138)	31.2% (224)	0.84	31.1% (324)	31.8% (48)	0.85	31.9% (66)	36.1% (56)	27.7% (36)	27.9% (81)	32.8% (78)
Crunchy foods	22.9% (103)	28.0% (201)	0.05	25.6% (267)	27.8% (42)	0.56	28.5% (59)	29.7% (46)	17.7% (23)	25.2% (73)	26.5% (63)
Asian	25.8% (116)	21.2% (152)	0.07	24.2% (252)	15.2% (23)	0.02	20.3% (42)	23.9% (37)	21.5% (28)	26.6% (77)	21.4% (51)
Salty foods	20.9% (94)	24.6% (176)	0.15	23.7% (247)	16.6% (25)	0.05	29.5% (61)	25.2% (39)	20.8% (27)	21.0% (61)	23.5% (56)
Vegetarian	14.9% (67)	26.1% (187)	<0.01	22.2% (232)	17.9% (27)	0.22	30.4% (63)	21.9% (34)	16.2% (21)	21.7% (63)	17.7% (42)
Spicy	23.1% (104)	17.2% (123)	0.01	20.6% (215)	11.9% (18)	0.01	19.8% (41)	17.4% (27)	20.0% (26)	20.7% (60)	20.2% (48)
Mexican	19.3% (87)	19.3% (138)	0.97	21.3% (222)	5.3% (8)	<0.01	20.8% (43)	23.9% (37)	16.9% (22)	20.7% (60)	18.5% (44)
Chewy foods	18.2% (82)	19.8% (142)	0.50	19.1% (199)	17.2% (26)	0.59	21.7% (45)	20.0% (31)	12.3% (16)	16.2% (47)	20.6% (49)
Citric/acidic foods	18.4% (83)	16.2% (116)	0.32	16.7% (174)	21.2% (32)	0.17	17.4% (36)	16.1% (25)	16.2% (21)	19.0% (55)	17.7% (42)
Bland foods	10.4% (47)	14.2% (102)	0.06	12.9% (135)	11.3% (17)	0.56	15.0% (31)	12.9% (20)	10.0% (13)	13.8% (40)	10.1% (24)
Greasy/fried foods	16.4% (74)	9.1% (65)	<0.01	12.5% (130)	9.3% (14)	0.26	8.2% (17)	11.6% (18)	20.8% (27)	12.1% (35)	10.5% (25)
Indian	8.0% (36)	9.3% (67)	0.43	9.6% (100)	2.7% (4)	<0.01	8.7% (18)	10.3% (16)	7.7% (10)	11.7% (34)	6.3% (15)
Soy	7.8% (35)	8.2% (59)	0.78	8.2% (85)	6.0% (9)	0.35	10.1% (21)	10.3% (16)	7.7% (10)	8.3% (24)	4.6% (11)

TABLE 7

[a]Participants who reported more than one type of cancer or who reported having an "other malignancy" that did not fall into the five categories were excluded from analyses by cancer type.

TABLE 8
Food aversions by gender, age, and cancer type

| | Gender | | | Age | | | Cancer type[a] | | | | |
	Males (n = 450)	Females (n = 717)	P value	18–74 years (n = 1,043)	75 and older (n = 151)	P value	Breast (n = 207)	GI (n = 155)	Lung (n = 130)	Other solids (n = 290)	Hematologic (n = 238)
Greasy/fried foods	40.2% (181)	51.7% (371)	<0.01	48.1% (502)	39.1% (59)	0.04	54.5% (113)	56.1% (87)	38.5% (50)	45.5% (132)	42.9% (102)
Spicy	34.9% (157)	43.7% (313)	<0.01	40.1% (418)	39.1% (59)	0.81	41.1% (85)	50.3% (78)	33.1% (43)	42.4% (123)	30.3% (72)
Citric/acidic foods	25.1% (113)	30.7% (220)	0.04	29.1% (303)	21.9% (33)	0.07	31.9% (66)	32.9% (51)	24.6% (32)	27.6% (80)	22.7% (54)
Indian	23.6% (106)	30.4% (218)	0.01	27.5% (287)	29.1% (44)	0.68	32.9% (68)	34.8% (54)	23.1% (30)	30.0% (87)	21.4% (51)
Mexican	23.6% (106)	29.2% (209)	0.04	26.2% (273)	33.1% (50)	0.07	30.9% (64)	33.6% (52)	23.9% (31)	26.6% (77)	22.7% (54)
Salty foods	21.8% (98)	26.6% (191)	0.06	24.5% (255)	28.5% (43)	0.29	19.8% (49)	14.1% (35)	11.3% (28)	26.9% (78)	24.4% (58)
Sweets	18.9% (85)	24.8% (178)	0.02	23.3% (243)	17.9% (27)	0.14	23.7% (49)	25.2% (39)	18.5% (24)	21.7% (63)	24.0% (57)
Meat	16.4% (74)	22.7% (163)	<0.01	21.2% (221)	13.3% (20)	0.02	25.1% (52)	24.5% (38)	13.9% (18)	23.8% (69)	15.6% (37)
Soy	14.2% (64)	23.0% (165)	<0.01	19.3% (201)	22.5% (34)	0.35	22.2% (46)	26.5% (41)	17.7% (23)	19.7% (57)	18.1% (43)
Asian	15.3% (69)	21.3% (153)	0.01	18.3% (191)	22.5% (34)	0.22	21.7% (45)	29.0% (45)	15.4% (20)	18.3% (53)	15.6% (37)
Dairy	12.9% (58)	19.8% (142)	<0.01	17.4% (181)	13.3% (20)	0.21	21.7% (45)	16.8% (26)	16.2% (21)	16.9% (49)	14.7% (35)
Fruits and vegetables	14.2% (64)	17.7% (127)	0.12	16.7% (174)	13.9% (21)	0.39	14.5% (30)	22.6% (35)	8.5% (11)	14.1% (41)	17.7% (42)
Bland	15.6% (70)	16.5% (118)	0.68	16.6% (173)	11.9% (18)	0.14	15.9% (33)	18.1% (28)	17.7% (23)	15.2% (44)	18.9% (45)
Crunchy foods	12.4% (56)	13.8% (99)	0.50	13.7% (143)	11.9% (18)	0.55	13.0% (27)	14.8% (23)	13.9% (18)	16.6% (48)	9.2% (22)
Chewy foods	12.2% (55)	11.4% (82)	0.69	11.3% (118)	15.9% (24)	0.10	9.2% (19)	14.8% (23)	13.9% (18)	14.8% (43)	7.1% (17)
High fiber foods	8.0% (36)	13.1% (94)	<0.01	11.1% (116)	11.3% (17)	0.96	7.3% (15)	19.4% (30)	7.7% (10)	14.1% (41)	6.7% (16)
Fish	9.3% (42)	11.0% (79)	0.36	10.6% (111)	9.9% (15)	0.79	13.5% (28)	12.9% (20)	6.9% (9)	9.7% (28)	10.9% (26)
Vegetarian	9.8% (44)	8.9% (64)	0.63	9.3% (97)	8.6% (13)	0.78	7.7% (16)	12.9% (20)	10.0% (13)	11.0% (32)	7.6% (18)
Pasta	8.2% (37)	9.1% (65)	0.62	8.8% (92)	6.6% (10)	0.37	8.2% (17)	8.4% (13)	4.6% (6)	10.3% (30)	8.0% (19)
Poultry	6.2% (28)	8.1% (58)	0.24	7.8% (81)	3.3% (5)	0.05	7.3% (15)	10.3% (16)	5.4% (7)	6.9% (20)	8.0% (19)
Soup	4.7% (21)	6.0% (43)	0.33	5.5% (57)	5.3% (8)	0.93	3.4% (7)	7.1% (11)	3.9% (5)	4.8% (14)	8.8% (21)

GI = gastrointestinal.
[a]Participants who reported more than one type of cancer or who reported having an "other malignancy" that did not fall into the five categories were excluded from analyses by cancer type.

chemosensory alteration. Increased taste sensitivities were more prevalent than decreased taste sensitivity, and increased sensitivity to metallic taste was the most common taste sensitivity across patients (18.6%). More than 20% of patients were bothered by the smells of cleaning solutions or perfumes.

Consistent with previous research dietary changes were associated with other treatment-related side effects (12, 14–17). Specifically, patients who reported decreased energy levels since beginning treatment were also more likely to report dietary changes, including decreased appetite (46.4% vs. 13.0%), increased sensitivity to certain tastes and smells (e.g., metallic taste: 21.0% vs. 13.0%), and avoidance of particular foods than those reporting equivalent or greater energy levels. Similar trends were seen for patients who lost weight compared to those who stayed the same or gained weight. Therefore, it is possible that addressing nutrition issues can also help manage other common treatment-related side effects and improve overall quality of life (13).

This study also provides insight into subgroups of patients who may be more prone to experiencing dietary changes during treatment. Previous studies have had mixed findings regarding the association between gender and chemosensory alterations, with some studies finding no gender differences (14) and others finding females more likely than males to experience sensitivities (26). In this study, females were more likely than males to report some chemosensory alterations. In general, there is evidence that females are more sensitive to odors and smells than males (27, 28), and it is possible that cancer treatment heightens these sensitivities. Younger patients were more likely than older patients to report chemosensory alterations, which may be attributable to olfactory and gustatory functions diminishing with age (29).

There were also noteworthy patterns that emerged by cancer type. GI cancer patients, who experienced a high burden of dietary changes, most clearly depicted the relationship between diet and other treatment side effects. Study participants were asked about their treatment symptoms and GI cancer patients were more likely than other cancer types to report experiencing diarrhea (33.6% vs. 17.6%) and nausea (32.9% vs. 25.3%). Their dietary changes corresponded to these side effects. For example, GI cancer patients were more likely than other patients to avoid spicy foods, fruits and vegetables and high fiber food, all foods that can exacerbate diarrhea. Although it is possible that these are learned aversions, information on foods that can either lessen or exacerbate treatment side effects would be useful for all patients.

Breast cancer patients were unique in that they were more likely to gain weight following treatment than lose weight. There is an adverse relationship between weight change and prognosis for breast cancer patients (10,11), and consequently patients likely to gain weight need nutritional advice on how to avoid gaining weight. This highlights a shift in the relationship between cancer and weight. Historically, weight

loss in cancer patients has been the concern because of the association with poor prognosis (30). Though weight loss continues to be a concern for some cancer patients, for others weight gain is now more of a concern (31). Therefore, certain patients need to be reeducated on expectation in terms of weight change, and appropriate diet during treatment. For example, many patients expressed a preference for pasta. Whereas pasta is a recommended food for those who are struggling with adequate energy intake because it is a high calorie food, overconsumption can be problematic for those more likely to gain weight.

This study has both strengths and limitations. A primary strength is the large, diverse sample of 1199 cancer patients undergoing treatment at 7 different cancer centers throughout the United States. It captured detailed data on the dietary changes and food preferences of cancer patients receiving outpatient treatment, primarily chemotherapy. Unfortunately, we did not collect more detailed information on therapeutic agents; therefore, we were unable to assess differences by the specific therapeutic agent used.

The study used a convenience sample so we do not know how participants may have differed from those who declined to participate, which limits generalizability of findings. In addition, this was a cross-sectional study so only associations (and not causality) could be examined. We attempted to address temporality by asking about changes since beginning treatment. Furthermore, the health outcome measures (e.g., fatigue, weight loss) were based on nonvalidated questions. We did not collect patient's starting weight, so we do not know the percent weight loss that 5 lbs or more represents for each patient; nor did we collect cancer stage, which is a predictor of nutrition risk. Lastly, it is possible that when patients identified foods that they preferred and avoided that they selected foods that they "should" or "shouldn't" eat given their desire to eat healthier after being diagnosed with cancer.

Despite these limitations, it is evident that for many patients, cancer treatment makes it difficult to obtain adequate nutrition. The findings from this study shed light onto common nutritional concerns in general and by cancer type, gender, and age. Treatment often alters one's sense of smell and taste decreasing both the desire to eat and the enjoyment of eating, which can lead to weight loss and nutritional deficiencies (12). Nevertheless, many cancer patients are not routinely receiving nutritional guidance. The large number of patients reporting nutritional concerns supports the need for nutrition counseling as a standard part of care (22). Clinicians can use the findings from this study to inform patients of possible nutritional issues given their profile and refer them to resources to proactively address these issues.

These data can also inform the development of nutritional resources for cancer patients. Our findings suggest that prevalent concerns that could be targets for nutritional interventions include 1) mitigating increased sensitivity to metallic taste and other chemosensory alterations, 2) maintaining or increasing

energy levels (e.g., energy dense, high protein foods), and 3) addressing other common side effects (e.g., dry mouth, constipation, diarrhea, nausea, fatigue) that could inhibit adequate energy intake.

Although there have been some efforts to address nutrition issues during treatment, there continues to be a need for solutions (17, 18, 32). Nutrition strategies that have been recommended include dietary counseling, oral nutritional supplementation, and/or flavor enhancers (12, 15, 21–23). It is important to acknowledge that the association between cancer treatment and nutrition is complex and differs for each patient, supporting the need for tailored interventions rather than a one-size-fits-all approach. Patients in this study had a multitude of food preferences and aversions in terms of cuisines, textures, and flavors. The specific preferences and aversions of individual patients have also been found to change over the course of treatment, with foods and tastes that are well tolerated at one point, no longer being tolerable at another (33). Intervention strategies need to be able to accommodate varying preferences and changing preferences.

There is a need for partnerships between physicians, nutrition researchers, registered dietitians, food scientists, chefs, and patients/survivors to develop strategies that both address prevailing patient concerns and are appealing to patients and this study provides preliminary data to guide such efforts. Nutrition resources that could be widely disseminated to cancer patients include websites or mobile apps that include recipes and other evidence-based nutrition information (e.g., general information about nutrition during treatment, the latest cancer nutrition research and implications for patient care). These formats would enable tailoring of information based on the specific needs/desires of patients. For example, recipes can be indexed by side effects, ingredients, and other relevant designations (e.g., quick to prepare). Patients could then select recipes based on their specific concerns and food preferences (e.g., "I am nauseous and want comfort food" or "foods that help with fatigue"). There is also a continued need for innovative solutions for addressing decreased appetite and chemosensory alterations that integrate knowledge of sensory science.

The data from this study provide clinicians and care providers a foundation to understand the sensory changes cancer patients experience that affect dietary intake. Future research will be needed to test 1) the effectiveness of novel nutrition-based interventions for cancer patients, and 2) the extent to which addressing nutritional concerns translates into improvements in health and quality of life outcomes.

FUNDING

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