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Food intake during cancer therapy: a systematic review

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Abstract

Food and beverage intake, as well as weight status, can integrate with cancer treatment to mitigate treatment-related toxicities, support treatment success, and prevent recurrence. Yet, evidence-based recommendations are lacking. This systematic review sought to determine what food or beverages consumed during cancer treatment might prevent recurrence, subsequent malignancies, treatment-related toxicity, or death.

We searched PubMed, Embase, and Cochran for research studies conducted within the last ten years on food and beverage consumption during cancer treatment, with no restrictions on age or cancer type. Two reviewers independently extracted information on intervention type, diet, and outcomes; these data were confirmed by a third reviewer.

Nineteen studies were selected from 1,551 potential studies. Nine were randomized controlled trials, analyzing high protein diets, short-term fasting, low-fat diets, FODMAP diet, or comparing consumption of one specific food or nutrient, including Concord grape juice, onions, and fiber. The remaining ten studies were observational or retrospective and tracked treatment symptoms, general dietary intake, or weight status as well as consumption of specific foods including nuts, coffee, sugar-sweetened beverages, coffee.

Available evidence suggests food can be effective at ameliorating cancer treatment-related toxicities and improving prognosis, but more research is needed.

Keywords

cancer; recurrence or progression; treatment-related toxicities; subsequent malignancies; nausea; diet; nutrition; appetite changes

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INTRODUCTION

Cancer is the second leading cause of death in the United States with over 1.7 million newly diagnosed cases projected for 2018.[1, 2] Within that group, an estimated 40% of annual diagnoses are attributable to patients' overweight and obesity.[3] Weight status before and during treatment can greatly influence clinical outcomes and prognoses.[4] Further, both overweight and underweight patients receiving chemotherapy and other cancer treatments are at greater risk for treatment-related side effects, such as appetite loss, oral mucositis, nausea, vomiting, dysgeusia, xerostomia, and dysphagia, which can in turn modify dietary habits.[5, 6]

Patients can access nutrition guidelines for cancer patients through various organizations, including the American Cancer Society and medical centers such as Memorial Sloan Kettering Cancer Center, which provide a variety of dietary recommendations to ensure patients are adequately nourished during their cancer treatment.[7, 8] Of particular concern is ensuring patients consume sufficient calories and protein, as well as vitamins and other micronutrients.[7, 9] In addition to these general recommendations, specific food and beverage recommendations address common toxicities. For instance, to lessen discomfort from mucositis, pureed foods that are easy to swallow are recommended.[7, 10] As taste preferences change, patients are encouraged to modify the texture, spice content, and preparation of food, as well as maintain proper dental hygiene to ensure unpleasant tastes do not linger.[7, 10, 11]

In spite of these recommendations, little research on the specific interactions between food and beverage intake and cancer treatment effectiveness or treatment-related toxicities is available. Qualitative studies have demonstrated that patients change their dietary habits in response to the symptom burden of cancer treatment, which in turn is associated with lower quality of life and weight loss.[12, 13] Yet, whether certain foods or dietary patterns are associated with better cancer-related outcomes is not known. Therefore, we conducted a systematic review of studies of the impact of food and beverage intake on cancer-related toxicities, treatment success, and recurrence.

METHODS

Data Sources and Searches

This systematic review was conducted in accordance with PRISMA guidelines.[14] The literature search occurred in July 2018. To identify studies for this review, we developed detailed strategies for each database searched with the help of a research informationist (LB). We based these on the search strategy developed for MEDLINE (PubMed), but revised appropriately for each of the following databases: Embase (Elsevier) and Cochrane Central Register of Controlled Trials (Cochrane Library). The search strategy used a combination of controlled vocabulary and free-text terms with truncation published from January 2008 through July 2018. Only studies in English were included. Animal studies were excluded. The following concepts and terms were used: (1) Neoplasms, Patients, Therapeutics; (2) Food, Diet, Diet Therapy; (3) Eating, Consume, Ingest, Intake, Feed; (4) Recurrence, Disease Progression, Second Primary Neoplasms, Mucositis, Nausea, Vomiting. The

following concepts were excluded from the search strategy: Nutritional Support, Dietary Supplements, and Gastrointestinal Intubation. Concepts were combined using the AND operator. The complete PubMed strategy is available in Appendix 1, Supplemental Digital Content 1, http://links.lww.com/AJCO/A350. All search results were combined in a bibliographic management tool (EndNote) and duplicates were eliminated using the Bramer method for deduplication in Endnote.[15] The final PubMed search strategy can be found in Figure 1 of the Appendix, Supplemental Digital Content 1, http://links.lww.com/AJCO/A350.

Study Selection

Nine studies were included in the final review. Risk of bias for the included studies was assessed independently by two review authors using the Cochran risk of bias tool.[16] Figure 2 in the Appendix, Supplemental Digital Content 1, http://links.lww.com/AJCO/A350 shows the flow chart of the search strategy.

Studies were excluded if they focused solely on nutrient supplementation rather than food consumption. Studies with a focus on foods consumed prior to cancer diagnosis or following the conclusion of treatment were not included. In addition, studies that focused on foods used as topical therapy for mucositis were excluded.

Data Extraction and Quality Assessment

We included interventional and observational studies. All participants were adults. The types of cancers studied in the included papers were colorectal, prostate, esophageal, head and neck, breast, endometrial, ovarian, testicular, pelvic, or unspecified type. The interventions included comparisons between types of diets, consumption of a specific food, amount of food consumed, or energy and protein intakes. A summary of the studies can be found in Table 1 in the Appendix, Supplemental Digital Content 1, http://links.lww.com/AJCO/A350.

Analysis

Details on diet, study type, and outcomes were abstracted and reviewed.

Role of the Funding Source

Funds were provided by the Meg Berté Owen Fund and the NCI (P30CA008748). Funders had no role in the study design, conduct, or reporting.

RESULTS

Data Synthesis and Analysis

The articles included in this review are divided by study type and subdivided by focus on dietary patterns or a single food. Randomized controlled trials are outlined in Table 1, while additional studies are summarized in Supplemental Data.

Randomized Control Trials – Dietary Patterns

Artene et al. followed 165 breast cancer patients for 12 months to determine the effect of a high protein diet and isometric exercises on treatment-related weight loss during

antiestrogenic treatment (Table 1). The patients were divided into either a high protein diet group (which consisted of foods naturally high in protein, omega-3 fatty acids, calcium, and pro- and prebiotics) or a high protein diet group with isometric exercises. Both groups experienced weight loss, while the diet and exercise group also experienced fat loss. Patients who underwent a mastectomy experienced weight and fat loss for both groups, while patients with breast-conserving surgery only reached significant weight and fat loss in the diet and exercise group. Chemotherapy type did not affect the measured outcomes in the diet and exercise group, while the diet only group saw some differences between adjuvant and neoadjuvant, with patients not experiencing fat loss who underwent the additional chemotherapies.[17]

Two studies focused on short-term fasting (STF) diets to determine the impact on treatment side effects. De Groot et al. conducted a randomized controlled trial (RCT) of 13 women with breast cancer receiving neoadjuvant chemotherapy to assess the impact of STF on treatment side effects and hematologic parameters. Patients were randomized to a STF group with a fast lasting 24-hours before and 24-hours after chemotherapy or to a non-STF group instructed to eat a healthy diet during the treatment period. No significant differences were found in self-reported toxicities between the two groups, although the fasting group had higher mean red blood cell and platelet counts, compared to the non-fasting group.[18] A cross-over study by Bauersfeld et al. had a slightly larger sample size, in which 34 breast and ovarian cancer patients were recruited to determine the effect of STF on quality of life (QOL) and fatigue during chemotherapy. The patients were randomized into two groups: 60-hour fasting during the first 3 of 6 chemotherapy cycles (Group A) or 60-hour fasting during the last 3 of 6 chemotherapy cycles (Group B). Short-term fasting in both cohorts was associated with better tolerance to chemotherapy, with less compromised quality-of-life and fatigue. Patients in both studies reported that STF was feasible and well-accepted during treatment.

Because previous studies had shown that many patients undergoing treatment for breast cancer have treatment-related weight gain, Villarini et al. conducted a dietary intervention RCT in 94 breast cancer patients with the aim of preventing weight gain during treatment. The intervention group received dietary recommendations with cooking classes and common meals at least twice per week; the control group received general recommendations based on the Mediterranean diet and macrobiotic recipes. The intervention group had significant reductions in body weight, waist and hip circumferences, and skinfold measurements, compared to the control group.[19] Contrary to the investigators' expectations, however, the control group also lost weight, suggesting that general dietary recommendations may be sufficient to prevent weight gain during breast cancer treatment.

The Women's Intervention Nutrition Study (WINS) was a RCT of 2,437 breast cancer patients undergoing cancer therapy to determine the effect of a low-fat diet during treatment on cancer recurrence. The intervention started with a four-month intensive phase with biweekly in-person counseling sessions followed by a maintenance phase including individual counseling sessions every three months and optional monthly group sessions. Dietary fat intake was significantly reduced in the intervention group, compared to the control, (percent energy from fat at 60 months 23.2%±8.4% vs 31.2%±8.9%, respectively,

P<0.0001) and was associated with a mean 6.1 pound weight difference between the groups (*P*=0.005).[20] In long-term analyses, the low-fat diet had no impact on relapse-free survival, although a post-hoc exploratory analysis suggested that women with estrogen receptor negative tumors may have benefitted.[21, 22]

Soto-Lugo et al. conducted a RCT among 26 cervical or endometrial cancer patients to determine if a diet low in fermentable oligosaccharides, disaccharides, monosaccharides, and polyols (FODMAP) can decrease gastrointestinal toxicity during pelvic external beam radiotherapy. The main symptoms reported were nausea, vomiting, and diarrhea. Patients were assigned to a FODMAP or standard Mexican diet group. The researchers did not find significant differences in toxicities of any grade between the groups and determined that the FODMAP diet did not result in improved outcomes compared to a standard diet.[23]

Wedlake et al. conducted a RCT of 166 pelvic cancer patients receiving radiotherapy to ascertain if fiber intake influences radiation-induced gastrointestinal toxicities; the study was motivated by anecdotal reports of patients being advised to restrict fiber intake prior to pelvic radiation in order to reduce gastrointestinal toxicities. Patients were randomized into a low-fiber group, a habitual fiber group, or a high-fiber group. There was a significant reduction in severity of bowel symptoms experienced in the high fiber group compared to the habitual fiber group, but there was no gradient of effect across the diets.[24] There was a trend towards improvement in the low-fiber group compared to the habitual fiber group, but this was not statistically significant; the authors concluded that the recommendation to restrict fiber intake in this population be should therefore be abandoned.

Randomized Control Trials – Specific Food Consumption

Jafarpour-Sadegh et al. investigated fresh yellow onion consumption in an RCT of 56 breast cancer patients undergoing chemotherapy to assess its effect on treatment efficacy and related toxicities, as determined by serum measurements of carcinoembryonic antigen (CEA), cancer antigen 125 (CA125), AST, ALT, and ALP. Patients were assigned to a high onion intervention group of 100-160g/day or a low onion control group of 30-40g/day. Mean changes in serum AST, ALT, and ALP did not statistically differ between the groups, though there was a trend towards fewer hepatotoxic effects in the high onion group. Both groups had mean decreases in CEA and CA125 serum levels from baseline, though the drop was only statistically significant in the high onion group and clinical significance was not demonstrated.[25]

Observational Studies – Dietary Patterns

De Vries et al. conducted an observational study of chemotherapy-related symptoms and diet characteristics (Supplemental Table 1). Their study included 117 breast cancer patients receiving chemotherapy and 88 women without cancer. Food frequency questionnaires (FFQ) and 24-hour recalls were used; the baseline diet was similar for both groups. During treatment, breast cancer patients had less energy, protein, fat, and alcohol intake than the comparison group. Patients undergoing chemotherapy reported more side effects than the comparison group, including dry mouth, lack of energy, nausea, and difficulty chewing, all of which were associated with lower energy intake.[26]

Di Fiore et al. collected nutrition parameters on 101 patients with esophageal cancer to study whether nutritional status during treatment was associated with greater treatment-related toxicity, recurrence, or mortality. Nutrition parameters were retrospectively collected at baseline, at 5-8 weeks follow up, and at 11 weeks follow up. Median overall survival among participants that were undernourished during treatment was 25 months, compared to 42 months among well-nourished participants. Undernourished participants showed a significantly lower treatment response rate than their well-nourished counterparts. Among participants who responded to chemotherapy, underweight or undernourished participants had worse median survival than well-nourished participants (33 vs 59 months, $p<0.001$ and 29 vs 61 months, $p=0.001$, respectively).[27]

Zahn et al. conducted a prospective, single-arm, observational study of 40 head and neck cancer patients receiving radiation therapy to assess the impact of nutrition on oral mucositis. A registered dietician established nutrition goals for patients and oral mucositis symptom severity was measured weekly. Meeting the protein goal of 1.5g/kg/day in the same or previous week was associated with lower oral mucositis severity; no significant associations with other measured nutrition parameters were identified.[28]

IJpma et al. analyzed side effects of changes in taste and smell, food preferences, dietary intake, and body composition among 21 testicular cancer patients undergoing cisplatin-based chemotherapy compared to 48 healthy controls with similar demographics. Testicular cancer patients reported lower taste function, appetite, and hunger, than controls. Food preference varied over the study duration, but cancer patients described a drop in preference for high protein savory foods and an increase in preference for high protein sweet foods. Among controls, no changes were found in dietary intake or food preference.[29]

Ganzer et al. conducted a cross-sectional study on the relationship between oral symptom burden (xerostomia, thick secretions, and mucosal sensitivity), energy and protein intake, and weight change in 43 participants with head and neck cancer. Energy and protein intake were collected using 24-hour dietary recalls excluding ten participants using feeding tubes, whose intake was determined by formula type and volume. Xerostomia and mucosal sensitivity were associated with decreased energy and protein intake at the mid-recovery stage (4.0-9.9 months post-completed chemoradiation), whereas thick phlegm was not. Overall, the authors found that the symptom burden was high at the beginning of the recovery process and lessened over time, but was never completely gone among any of the participants, regardless of dietary intake or weight change.[30]

The impact of energy and protein intake on fatigue and 6-month mortality was in investigated in a 285-patient prospective observational study by Stobaus et al.[37] Mortality was significantly higher among advanced cancer patients undergoing chemotherapy who were found to have a low protein intake compared to high protein intake. Protein intake of less than one gram per kilogram body weight was the factor most strongly associated with fatigue and mortality, even after adjustment for treatment-related weight loss.

Ingersoll et al. investigated whether Concord grape juice would decrease the severity and incidence of chemotherapy-induced nausea and vomiting among 76 participants with cancer

by lessening the severity of chemotherapy-induced cellular damage. The authors measured all participant food intake to account for flavonoid-enhancing or -depleting foods. Participants consumed grape juice or a grape-flavored placebo for each week following four chemotherapy treatments, in addition to the standard supportive care. While the study suffered from a high attrition rate of 50%, which prevented any statistically significant results, the intervention group had a trend towards reduction in nausea frequency, nausea distress, and vomiting distress compared to the placebo group.[31]

Observational Studies - Specific Food Consumption

Richman et al. conducted a large-scale prospective study on the intake of fruits and vegetables following a diagnosis of non-metastatic prostate cancer among 1,560 men to ascertain if specific food groups have varying effects on cancer prognosis. The authors used FFQs to determine dietary intake, and prostate progression was defined as recurrence, secondary treatment, metastasis, or prostate cancer-related death. Cruciferous vegetable intake was found to have an inverse relationship with prostate cancer progression: HR 0.41 (95% CI 0.22, 0.76) when comparing the highest quartile of cruciferous vegetable intake to the lowest quartile.[32]

Three separate prospective studies investigated specific food intake among patients with stage III colon cancer undergoing treatment through a National Cancer Institute clinical trial. All three studies used FFQs to determine dietary intake, and the outcomes measured were disease-free survival (DFS), recurrence-free survival (RFS), and overall survival (OS). In a prospective observational study of 826 patients with stage III colon cancer, Fadelu et al determined that increased consumption of tree nuts was associated with both improved disease-free and overall survival after a median follow up 6.5 years.[33] Fuchs et al. conducted a prospective observational study of sugar-sweetened beverages and recurrence or mortality among 1,011 patients with stage III colon cancer. After a median follow-up of 7.3 years, consuming 2 or more servings of sugar sweetened beverages per day was associated with a greater risk of cancer recurrence and mortality (HR 1.67, CI 1.04-2.68), with the strongest association among patients who were both overweight and sedentary.[34] In a study with 953 participating colon cancer patients, Guercio et al. found that increased total coffee intake was associated with a reduction in cancer recurrence and mortality and improvement in OS. These results did not hold for decaffeinated coffee or herbal tea.[35]

DISCUSSION

Evidence that some foods or dietary patterns during cancer treatment result in reduced cancer recurrence, subsequent malignancies, or treatment-related toxicity is slim (Table 2). In this systematic review, we found nineteen papers that investigated this issue. Some acute toxicities, including nausea, xerostomia, mucosal sensitivity, and weight gain were relieved with changesd in dietary habits and patterns.[17-19, 23, 24, 26, 28-30, 36] Changes in consumption of specific foods were associated with a lower risk of cancer progression or cancer cell proliferation.[25, 31, 33-35] Furthermore, specific nutritional patterns and habits were associated with lower risk of recurrence, better response to treatment, and less cancer cell proliferation.[20, 27, 37]

The scope of this review was intentionally narrow: foods consumed *during* cancer treatment and treatment-related toxicities, or cancer-related endpoints. Studies that used supplements were excluded to permit a focus on the consumption of whole foods. While supplements have utility in treating nutritional deficiencies, eating whole foods for nutritional support is preferrable.[38-42]

Several important themes emerged from the included studies, including the importance of weight status. Treatment can induce weight loss, while patients who are underweight tend to have worse prognoses following treatment.[43] Weight gain during treatment is an common long-term side effect of some cancer therapies and can impact treatment effectiveness.[4, 44] In this review, a small number of studies suggested that higher caloric consumption was associated with better prognosis.[17, 26-28, 30] Consumption of fat, protein, or fiber, as well as short-term fasting, had the suggestion of benefit, although outcomes were heterogeneous.[17, 18, 20, 24, 36]

Feasibility of dietary changes was explored in a few studies. Notably, patients short-term fasting feasible to implement and maintain.[17, 18] After a cancer diagnosis and during treatment, patients often have a greater readiness to change, with increased motivation for improving overall health as patients work towards the best possible treatment outcomes.[45, 46] In their study, Hoy et al. specifically focused on the social cognitive theory of behavioral change to ensure greater uptake of the intervention.[20] While this component is promising when determining general dietary recommendations for cancer treatment patients, small sample size limits conclusions about generalizability. Nonetheless, based on the available evidence, dietary interventions during cancer treatment appear to be feasible.

The results of this review have implications for specific foods in the diets of patients undergoing cancer treatment. An increase in consumption of vegetables, especially cruciferous vegetables, is a reasonable recommendation, based on the available evidence.[32, 47] Nuts, Concord grape, and onion consumption were shown to be modestly beneficial in lessening side effects and improving prognosis during treatment and could be considered.[31, 33, 48] At a minimum, the available evidence suggests that adequate fruit and vegetable should continue to be recommended.[7, 8]

It is difficult to quantify the effects of specific foods with regards to an impact on treatment-related toxicities or cancer endpoints, primarily due to confounding factors, but some mechanisms can be postulated based on nutritional composition. Nutrients in nuts like unsaturated fatty acids, protein, fiber, vitamins, minerals, and phytochemicals could be anticarcinogenic, anti-inflammatory, and antioxidant, all of which can be significant during cancer treatment.[33] Research on yellow onions points to their immunomodulatory, antiproliferative, antioxidant, and anti-hormonal effects.[25] As noted, the available studies underscore the need for further research into these questions. Furthermore, consideration of the overall dietary pattern or nutrient interactions when examining specific foods in real-word settings will be critical.

This systematic review had several limitations. Few studies were available, and sample sizes are small, limiting summary statistics. These limits in the data may be explained, in part, by

the challenges of study recruitment during cancer treatment. Patients may not want to take part in a study that requires additional obligations when they already have the burden of cancer diagnosis and treatment. This barrier may account for the low sample size and high attrition rates of some studies. In addition, clinicians may not want to encourage patients to consume foods whose interactions with prescribed treatments are not well-known.

While the efficacy of dietary interventions need to be determined by quantitative research, other considerations such as health disparities should be incorporated into food-related practices and recommendations. Studies have found that fruit and vegetable consumption is disproportionally lower in low-income areas.[49] Richman et al. found that the men with prostate cancer who consumed the most vegetables were more educated and had higher annual household incomes.[32] As connections between dietary factors and cancer treatment are found, it is worth noting that socioeconomic and geographical constraints exist that prevent all people from heeding dietary advice.

Overall, this review found limited evidence that the consumption of nutritious foods may mitigate side effects and benefit quality of life in patients undergoing cancer treatment. Emerging evidence suggests the possibility that foods may support treatment effectiveness. Investigators should have confidence that patients are willing to enroll in diet studies at the time of cancer diagnosis, and recruitment for patients receiving cancer therapy is feasible. Future studies should focus on whole foods, rather that nutrient consumption or inadequacies, so that findings are generalizable and dietary recommendations for cancer patients can be clear. In addition, the use of patient-reported outcomes as well as hard endpoints (such as recurrence) should be emphasized. Recently, the National Institutes of Health (NIH) released the 2020 Strategic Plan for NIH Nutritional Research (https://www.niddk.nih.gov/about-niddk/strategic-plans-reports/strategic-plan-nih-nutrition-research), which highlighted the importance of using diet to reduce the burden of disease in clinical settings; investigators should look to the NIH for research resources, such as the recently updated Diet History Questionnaire III, and funding of this work.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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Data Availability Statement:

The data that support the findings of this study are available in public library databases as cited below including Medline (PubMed), EMBASE, and Cochran Library. The search criteria used are fully detailed in the appendix to this manuscript.

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Novelty & Impact: While cancer risk attributable to food intake has been well-described, the impact of food intake during treatment is not well-understood. In this systematic review, studies of foods eaten during cancer treatment were sought; these results are extremely relevant for patients and providers seeking evidence-based guidelines for what to eat while undergoing treatment for cancer.

Table 1:

Studies of the impact of food intake during cancer treatment on toxicities and cancer-related endpoints; randomized controlled and crossover trials.

Reference	Sample	Study Design	Outcome measures
Artene et al.	165 breast cancer patients on anti-estrogenic medication	Randomized controlled trial • High protein diet • High protein diet combined with 4 minutes of isometric exercises per day	Weight loss Fat loss
Bauersfield et al.	34 breast or ovarian cancer patients undergoing chemotherapy	Cross-over study • Short-term fasting (STF) during either the first three of six chemotherapy treatments or during the last three of six chemotherapy treatments	Quality of life using the functional assessment of chronic illness therapy measure, general well-being and fatigue
de Groot et al.	13 women with diagnosis of HER2-negative stage II and III breast cancer and receiving neo adjuvant TAC-chemotherapy	Randomized controlled trial • Short-Term Fasting (STF) group fasted starting 24hr before and continuing 24hr after the start of chemotherapy • Non-STF group ate in accordance with guidelines for healthy nutrition with minimum of two pieces of fruit per day during chemotherapy	Severity of chemotherapy-induced side effects and hematologic parameters
Fadelu et al.	826 stage III colon cancer patients enrolled in a National Cancer Institute chemotherapy clinical trial	Prospective cohort study • Association between nut intake and cancer recurrence and mortality	Disease-free survival and recurrence-free survival
Fuchs et al.	1,011 stage III colon cancer patients enrolled in a National Cancer Institute adjuvant chemotherapy clinical trial	Prospective cohort study • Sugar-sweetened beverage intake and cancer recurrence • Patients completed semi-quantitative food frequency questionnaires	Disease-free survival and recurrence-free survival
Guercio et al.	953 stage III colon cancer patients participating in a National Cancer Institute adjuvant chemotherapy clinical trial	Prospective cohort study • Coffee intake assessed via semi-quantitative food frequency questionnaire	Disease-free survival and recurrence-free survival
Hoy et al.	2,437 women with breast cancer between 48 and 79 years of age undergoing cancer therapy from the Women's Intervention Nutrition Study	Randomized controlled trial • Low fat intervention group received a low-fat eating plan and unannounced 24hr dietary recalls to reduce percentage of total energy intake from fat down to 15% while maintaining nutritional adequacy (n=975) • Control group whose diet was not restricted (n=1,462)	Breast cancer recurrence
Jafarpour-Sadegh et al.	56 breast cancer patients undergoing doxorubicin-based chemotherapy at Tabriz University of Medical Sciences in Iran	Randomized controlled trial • High onion group consumed BMI-dependent raw onion amount (100-120g/day for BMI<24.9, 140-160g/day for BMI>25) besides main meals	Serum carcinoembryonic antigen, cancer antigen-125 and hepatic enzymes

Reference	Sample	Study Design	Outcome measures
		• Low onion group consumed 30-40g/day raw onion in addition to meals	
Soto-Lugo et al.	26 patients with cervical or endometrial cancer at the Mexican National Medical Center	Randomized controlled trial • FODMAP diet (n=13) • Standard Mexican Official Standard diet (n=13)	Pelvic external beam radiation therapy-induced gastrointestinal toxicity
Villarini et al.	96 breast cancer patients undergoing chemotherapy at the National Cancer Center of Milan	Randomized controlled trial • Intervention group received cooking classes and meals for a diet based on Mediterranean and macrobiotic recipes designed to lower insulin levels (n=47) • Control group received baseline dietary recommendations (n=47)	Weight gain; feasibility of recruiting women early in breast cancer treatment and compliance with a weight control program during chemotherapy
Wedlake et al.	166 pelvic cancer patients receiving radiotherapy	Randomized controlled trial • Low fiber (n=55) • Habitual fiber (n=55) • High fiber (n=56) Each group had daily target fiber goals	Chronic radiation-induced gastrointestinal toxicity, patient quality of life, stool frequency and form and nutritional intake

Table 2:

Main findings: Studies of food intake and cancer-related outcomes.

• Cancer patients are willing to participate in diet studies and recruiting at the time of diagnosis or during treatment is feasible.
• Evidence for or against specific foods or dietary patterns during cancer treatment is slim.
• Limited evidence suggests that dietary interventions during treatment may prevent weight gain for those at risk.
• Adequate nutritional status during treatment is associated with overall survival, although causation has not been demonstrated.