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Dietary intake of soy and cruciferous vegetables and treatment-related symptoms in Chinese American and non-Hispanic White breast cancer survivors

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Abstract

PURPOSE—This project examined the association between dietary intake of soy or cruciferous vegetables and breast cancer treatment-related symptoms among Chinese-American (CA) and Non-Hispanic White (NHW) breast cancer survivors.

METHODS—This cross-sectional study included 192 CA and 173 NHW female breast cancer survivors (stages 0–III, diagnosed between 2006–2012) recruited from two California cancer registries, who had completed primary treatment. Patient-reported data on treatment-related symptoms and potential covariates were collected via telephone interviews. Dietary data were ascertained by mailed questionnaires. The outcomes evaluated were menopausal symptoms (hot flashes, night sweats, vaginal dryness, vaginal discharge), joint problems, fatigue, hair thinning/loss and memory problems. Associations between soy and cruciferous vegetables and symptoms were assessed using logistic regression. Analyses were further stratified by race/ethnicity and endocrine therapy usage (non-user, tamoxifen, aromatase inhibitors).

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Conflict of Interest Statement

The authors declare that they have no conflicts of interest.

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RESULTS—Soy food and cruciferous vegetable intake ranged from no intake to 431 and 865 grams/day, respectively, and was higher in CA survivors. Higher soy food intake was associated with lower odds of menopausal symptoms (≥ 24.0 versus 0 grams/day, OR=0.51, 95% CI: 0.25, 1.03), and fatigue (≥ 24.0 versus 0 grams/day, OR=0.43, 95% CI: 0.22, 0.84). However, when stratified by race/ethnicity, associations were statistically significant in NHW survivors only. Compared with low intake, higher cruciferous vegetable intake was associated with lower odds of experiencing menopausal symptoms (≥70.8 versus <33.0 grams/day, OR=0.50, 95% CI: 0.25, 0.97) in the overall population.

CONCLUSIONS—In this population of breast cancer survivors, higher soy and cruciferous vegetable intake was associated with less treatment-related menopausal symptoms and fatigue.

Keywords

Cruciferous Vegetables; Soy Foods; Breast Cancer Survivors; Endocrine Therapy; Late Treatment Effects

Introduction

Breast cancer survivors often experience late effects, defined as cancer or cancer treatment-related health problems occurring months or years after diagnosis or completion of treatment [1,2]. Endocrine therapy (ET) after primary treatment may further contribute to treatment-related symptoms [3,4]. Commonly reported late effects and side effects of ongoing endocrine therapy, include menopausal symptoms (e.g. hot flashes, night sweats), fatigue, cognitive changes (e.g. difficulty concentrating and memory loss), and hair thinning/loss [3–8]. Treatment-related symptoms impact the quality of life in breast cancer survivors [9,10], fostering interest in identifying approaches to ameliorate side/late effects.

Phytochemicals (boactive food components), such as isoflavones in soy and glucosinolates in cruciferous vegetables (e.g. cauliflower, cabbage, bok choy, turnip and mustard greens and broccoli), may be dietary factors with the potential to influence late/side effects. Isoflavones bind to estrogen receptors and exert weak estrogenic effects [11,12], possibly reducing menopausal symptoms and other treatment-related symptoms. Some evidence supports an inverse association between soy isoflavones and menopause-associated vasomotor symptoms (hot flashes, night sweats) in women without cancer [13–15], but in breast cancer survivors, data is limited and inconsistent [16–20]. To our knowledge, no prior studies have investigated the relationship between soy intake and other treatment-related symptoms (e.g. joint pain, fatigue, memory loss). Cruciferous vegetables contain many bioactive components, such as glucosinolates [21], and to our knowledge, no previous studies have investigated the relationship between cruciferous vegetables and breast cancer treatment-related symptoms. However, possible mechanisms exist through which cruciferous vegetable intake may impact treatment-related symptoms, including reducing of inflammation and influencing levels of several phase I (cytochrome P450 1A1) and phase II (glutathione S-transferase) metabolism enzymes, which mediate, among other compounds, levels of estrogen and estrogen-related metabolites [22–27].

Identification of lifestyle factors associated with breast cancer treatment-related effects is essential as they may be used to reduce symptoms. In this study, we examined the association between intakes of soy products, cruciferous vegetables, and major active compounds in these foods, isoflavones and glucosinolates, with common breast cancer treatment-related symptoms (menopausal symptoms, fatigue, joint problems, hair thinning/loss, and memory loss) among Chinese-American (CA) and Non-Hispanic White (NHW) breast cancer survivors.

Methods

Study Population

This study utilized cross-sectional survey data collected as part of a cross-cultural research project on breast cancer survivorship among Chinese-American (CA) and Non-Hispanic White (NHW) living in California, USA. Women diagnosed with breast cancer between May 2006 and January 2012 were recruited from the U.S. National Cancer Institute's Surveillance, Epidemiology and End Results Program (SEER) cancer registries in the Greater Bay and Los Angeles areas. Potential participants were randomly selected and sent an invitation letter, a brochure summarizing study objectives and procedures, and an opt-out form with a pre-stamped envelope. Those who did not mail back the opt-out form two weeks after our mailing were contacted by phone. Among 1,910 mailed letters, 61.3% (N=1,171) of patients either returned the opt-out form (N=89 CA, 92 NHW) or were reached by telephone (N=633 CA, 357 NHW). A total of 220 CA and 216 NHW women were eligible and consented to participate. Breast cancer patients were eligible for the study if they met the follow criteria: (1) Chinese or NHW ethnicity, (2) ≥21 years-old at the time of enrollment, (3) stage 0–III primary breast cancer diagnosis, (4) completed primary cancer treatment (surgery, radiation, chemotherapy) 1–5 years prior to recruitment, and (5) no breast cancer recurrence or other cancers. NHW cases were age matched to CA cases (± 5 years). For the present project, women were additionally excluded if they did not complete the food frequency questionnaire (FFQ) (16.3% of participants). The final sample size included 365 breast cancer survivors (N=192 CA, 173 NHW). This study was approved by the Institutional Review Boards at Georgetown University Medical Center, the California Health and Human Services Agency, and the Cancer Prevention Institution of California. Written informed consent were obtained from all study participants.

Data collection

Data were obtained through a one-hour long survey administered via telephone. An optional FFQ and photographs of food serving sizes were mailed to participants to fill at home or report via telephone. Trained, bilingual interviewers interviewed participants in their preferred language. All NHW cases were interviewed in English and about 70% of CA were interviewed in Mandarin or Cantonese.

Treatment-related symptoms—The primary study outcome, treatment-related symptoms, were ascertained by a questionnaire adapted from two existing instruments, the Memorial Symptom Assessment Scale (MSAS) [28] and the Breast Cancer Prevention Trial Symptom Checklist [29]. The MSAS has previously been used in Chinese survivors [30].

Women were asked if they experienced any of 34 possible treatment-related symptoms and its severity within the past 12 months from the interview date. Symptoms were assessed using a 5-level scale, from “not at all” to “very much”. Participants who responded “not at all” to a symptom were categorized as not having the symptom and all other responses were categorized as experiencing the symptom.

The primary outcomes in the present analysis were menopausal symptoms, joint problems, fatigue, hair thinning/loss and memory problems. Menopausal symptoms and joint problems variables were derived by combining several questions. Presence of menopausal symptoms was defined as having any of the following three symptoms: hot flashes or night/cold sweats, vaginal dryness or pain with intercourse, and vaginal discharge. Joint problems encompassed four symptoms: muscle pain, joint stiffness, joint pain, and bone thinning. Individual items of each particular symptom category were summed (ranged from 0–3 for menopausal symptoms and 0–4 for joint problems) and categorized as binary presence/absence of symptoms. Additionally, fatigue, hair thinning/loss, and memory loss were evaluated because they were commonly mentioned symptoms and were previously reported to be influenced by diet (40, 41).

Dietary assessment—A 28-item FFQ, adapted from existing and validated FFQs to ascertain specific food groups of interest among CA and NHW breast cancer survivors, was administered [31–36]. The FFQ ascertained typical intake of cruciferous vegetables (12 questions), allium vegetables (5 questions), soy foods (4 questions), meat/fish (3 questions), green tea (1 question), and alcoholic beverages (2 questions). Participants were asked to indicate how often, on average, they ate each food item over the past three months. For each item there were nine frequency options (never/less than one time a month - 2 or more times a day) and three serving size choices (small, medium, and large). Photographs and descriptions were provided to assist serving size estimation. Isoflavone and glucosinolate intakes were estimated using typical amounts of the bioactive food components reported for each food item. Isoflavone intake was estimated using nutrient databases published by the U.S. Department of Agriculture [37]. Glucosinolate intake was derived from estimates of glucosinolates content in common food sources [38].

Covariates—Patient-reported demographic information included age, race, birthplace, education, health insurance coverage, marital and employment status, and annual household income. Survivors were asked whether they had received any ET, including tamoxifen or aromatase inhibitors (AIs) to prevent breast cancer recurrence. Clinical variables were provided by the cancer registries and included: cancer stage, diagnosis date, age at diagnosis, status of hormonal receptors, and type of primary treatment. Time since diagnosis was estimated using a survivor’s interview date subtracted from the date of diagnosis.

Patient-reported menopausal status at the time of interview and cause (e.g. natural, surgical), height and current weight were also assessed. Menopausal status classification was based on the presence/absence of menstrual cycles, age and whether menopause was related to cancer treatment. Patient-reported menopausal status was classified into 4 groups: postmenopausal, peri-menopausal, treatment-induced menopause and premenopausal. Survivors were classified as postmenopausal if they reported no menstrual cycle for 12 consecutive months

or had menopause and were ≥58 years of age. Women who reported lack of regular menstruation, but not for 12 consecutive months, and were <58 years of age were classified as peri-menopausal. Survivors whose menopause was induced by breast cancer treatment or who just completed the treatment and were not sure if periods would return, were classified as treatment-induced menopause. The remaining women were classified as premenopausal.

Physical activity was assessed using the International Physical Activity Assessment Questionnaire (IPAQ) [39,40]. Participants self-reported number of days per week and duration of moderate and vigorous physical activity, and walking. Physical activity was classified into 3 levels: inactive, minimally active, and health enhancing physical activity (HEPA). Metabolic equivalent of task (MET)-minutes per week were calculated following the IPAQ scoring method [41]. HEPA was defined as vigorous activities at least 3 days/week, accumulating at least 1500 MET-minutes/week or any intensity level of activity every day of the week achieving a minimum of 3000 MET-minutes/week. Survivors reporting different intensity activity of at least 600 MET-minutes/week were classified as “minimally active”. Respondents reporting <600 MET-minutes/week were classified as “inactive”.

Statistical Analysis

Descriptive statistics were computed to examine variable distributions. Correlations were evaluated using Pearson correlation. Age-adjusted logistic regression was used to assess associations between population characteristics, breast cancer-related variables (e.g. ET, time since diagnosis and cancer stage), intake of soy and cruciferous vegetable intake and reported symptoms. Cruciferous vegetable (<33.0, ≥ 33.0 to <70.8, ≥70.8 g/day), soy product (no intake, >0 to <24.0, ≥24.0 g/day) glucosinolate intake (≤20.4, >20.4 to <50.1, ≥50.1 mg/day) and isoflavone intake (no intake, >0 to <6.30, ≥6.30 mg/day) were categorized into tertiles.

Multivariable-adjusted logistic regression models were conducted to examine associations between dietary intake and treatment-related symptoms. Results were similar for the whole foods and associated bioactive food components; therefore, whole food results are presented in the primary results. Bioactive food component results are provided in supplementary materials. Models were adjusted for race/ethnicity, age (continuous), BMI (continuous), ET (none, AIs, tamoxifen), menopausal status (pre-, post-, peri-menopause, induced menopause), physical activity (HEPA active, minimally active, or inactive), time since diagnosis (<24, 24-36, >36 months), and cancer stage (0, I, II, III). Covariates were considered if previous research indicated that a variable may be associated with diet or treatment-related symptoms. While radiation and chemotherapy treatment was associated with treatment-related symptoms, it was not associated with dietary intakes nor did it change observed associations, so was not included in final study models. Alcohol intake was also not associated with symptoms in this study population, and therefore, not included in final models.

As consumption of both cruciferous vegetables and soy foods was higher in CA than NHW survivors, we replicated analyses stratified by race/ethnicity. Previous studies suggest possible interactions between ET usage and diet, so analyses were also conducted stratified by ET usage (non-user, tamoxifen user, AI user) [16,42]. Due to limited numbers within ET

usage strata, ET findings are presented only in supplementary materials. Tests for interactions between food groups and ethnicity or ET usage were conducted by including a cross product term in multivariable-adjusted models. All analyses were conducted by SAS 9.30 version with significance level defined as a p-value <0.05 or a 95% confidence interval that includes the null value of 1.0.

Results

A majority of women in this study were postmenopausal (47.6%) or perimenopausal (22.4%) (Table 1). The mean age was 57.1 years (SD=10.4). Most survivors were diagnosed with stage 0 (30.1%) or stage I (45.4%) breast cancer and 29.6% were < 2 years post-diagnosis, 30.4% were 24 to <36 months and 40.0% ≥36 months. Hormone receptor positive subtypes were most common (estrogen receptor positive: 62.2%; progesterone receptor positive: 53.7%). HER2 negative tumors were identified in 45.8% of participants, however, 42.2% had unknown HER2 status. Approximately, one quarter of the survivors received chemotherapy and 45.8% received radiation therapy. Endocrine therapy was utilized in 59.2% (34.5% tamoxifen, 24.9% AIs) of survivors. Cruciferous vegetable and soy food intakes ranged from no intake to 864 and 431 g/day, respectively. Mean intakes for cruciferous vegetables and soy foods were 17.1 g/day and 0 g/day in the lowest tertile, and 153.0 g/day and 98.5 g/day in the highest tertile, respectively. Among CA survivors, 44.8% were in the highest tertile for cruciferous vegetable intake and 49.5% for soy food intake, while 22.0% and 20.2% of NHW survivors were in the highest tertiles for each of the respective food types. Cruciferous vegetable intake and soy intake were modestly correlated with each other (r=0.35, p<0.001).

Age-adjusted associations between population characteristics, cancer-related variables, cruciferous vegetable and soy intake and treatment-related symptoms are reported on Table 2. NHW women were more likely to report experiencing menopausal symptoms, while CA were more likely to report fatigue, joint problems, hair loss/thinning and memory loss. Compared to postmenopausal women, premenopausal (OR=0.26, 95% CI: 0.09, 0.73) women were less likely to report menopausal symptoms while women with treatment-induced menopause were more likely to report both menopausal symptoms (OR=3.99, 95% CI: 1.40, 11.4) and hair thinning/loss (OR=2.28, 95% CI: 1.01, 5.13). Longer duration post-diagnosis was inversely associated with menopausal symptoms and fatigue. Chemotherapy was associated with all treatment related symptoms, while radiation therapy was associated with menopausal symptoms. Tamoxifen usage (compared to non-ET users) was significantly associated with menopausal symptoms (OR=3.95, 95% CI: 2.28, 6.82). AI usage was statistically significantly associated with reporting menopausal symptoms, fatigue and joint problems relative to non-ET users.

Soy intake tended to be inversely associated with treatment-related symptoms when compared to no intake, but in multivariable-adjusted models, only fatigue was statistically significantly in the overall population (≥ 24.0 versus 0 g/day, OR=0.43, 95% CI: 0.22, 0.84) (Table 3). In models stratified by race/ethnicity, associations with menopausal symptoms and fatigue only statistically significant in NHW survivors, however, tests for interaction were

not statistically significant. Results for isoflavones were similar to associations observed soy foods and treatment-related symptoms (Supplementary Table 1).

Cruciferous vegetable intake was inversely associated with menopausal symptoms in the overall population (≥ 70.8 versus <33.0 g/day, adjusted OR=0.50, 95% CI: 0.25, 0.97). (Table 4). When stratified by race/ethnicity, cruciferous vegetable intake remained inversely, but not statistically significantly, associated with menopausal symptoms. Cruciferous vegetable intake was not associated with other treatment-related symptoms in multivariable-adjusted models overall. Higher intake was significantly inversely associated with hair loss/thinning among CA, but not NHW survivors (P-interaction=0.08). Additionally, higher intake was positively associated (P-trend=0.03) with memory loss among NHW survivors, but inversely, though not statistically significantly (P-trend=0.31), associated with memory loss among CA survivors (P-interaction=0.02). However, few NHW survivors reported memory loss, so this result should be interpreted with caution. Associations between glucosinolate intake and symptoms were consistent with observed associations with cruciferous vegetable intake (Supplementary Table 2).

In models stratified by ET usage, soy food intake was statistically significantly inversely associated fatigue among non-ET users and joint problems in AI users. Among tamoxifen users, soy food intake was not associated with symptoms. Cruciferous vegetable intake was statistically significantly inversely associated with menopausal symptoms among AI users (≥70.8 versus <33.0 g/day, OR=0.13, 95% CI: 0.02, 0.62), whereas this inverse association was not statistically significant among non-users and tamoxifen users (P-interaction=0.20) (Supplementary Table 3). Tests for interaction were not statistically significant but numbers of participants in strata were small, so these results should be interpreted with caution.

Discussion

Presently, little is known of the effects of foods on menopausal symptoms or other treatment-related symptoms in breast cancer survivors [43,44]. In the combined population of CA and NHW breast cancer survivors, higher cruciferous vegetable was associated with lower odds of reporting experiencing menopausal symptoms and higher soy food intake was inversely associated with fatigue and menopausal symptoms. However, when stratified by race/ethnicity, soy intake associations with fatigue and menopausal symptoms were only statistically significant among NHW survivors. Associations between glucosinolates, isoflavones and treatment-related symptoms were consistent with observed associations for the corresponding food sources.

While the safety of soy intake has been questioned for breast cancer patients [45], several studies have reported lower risk of breast cancer recurrence [46–49] and mortality [50,51] among women with higher soy intakes. In our study, the intake of soy foods was linked to reduced prevalence of menopausal symptoms among breast cancer survivors. The exact biological mechanisms behind the menopausal symptoms are not well-understood, but may be due to the decrease in estrogen levels, and possibly, the corresponding impact on other hormones, such as gonadotropins [52]. Soy isoflavones are weakly estrogenic compounds, which may reduce menopausal symptoms by activating estrogen receptors in a low estrogen

environment, though the exact mechanism remains unclear [11,12]. Previous research suggests soy isoflavones may modestly reduce menopausal symptoms in healthy peri- and postmenopausal women [55]. However, among breast cancer survivors isoflavone supplementation for 4 to 12 weeks did not alleviate menopausal symptoms, which could be related to the duration, amount or type of soy supplementation product [18,20,56]. Conversely, an observational study among Chinese survivors found that higher soy isoflavone intake increased hot flashes at 36 months post-breast cancer diagnosis [16]. Possible explanations for the differences between our results and the previous observational study include: 1) the prior study involved Chinese women living in China and our study involved Chinese and NHW women living in the USA; 2) the former study assessed fewer menopausal symptoms, whereas our study measured multiple; and 3) patients in the prior study had a much higher soy intake than in our study sample. We additionally observed stronger associations among NHW (lower soy intake) compared to CA women (higher soy intake). It is possible that the benefits of soy intake are more evident in women with lower intakes relative to no intake, or that prevalence of women either reporting experiencing menopausal symptoms, no soy intake, or both were too low among the CA survivors to detect an association [54]. Of note, the prevalence of menopausal symptoms is reported to be lower in menopausal Asian women, which has been attributed to the higher soy content in their diet [54,53]. Alternatively, there may be differences in soy metabolism by race/ethnicity resulting in differential exposure to bioactive components in soy [57].

There was a suggestive inverse association between soy intake and fatigue. Research on soy and fatigue is limited, but a double-blind randomized placebo controlled trial of equol, a metabolite of another soy isoflavone (daidzein), observed statistically significant decreases in reported fatigue, among other psychosocial indicators, in Japanese women [58]. In our study, higher soy intake was inversely, albeit not statistically significantly, associated with joint problems, hair loss/thinning and memory loss. Isoflavones can increase secretion of insulin-like growth factor-1, which in turn promotes hair growth [59]. In animal studies, isoflavones have shown to preserve memory function [60,61], while a human study previous reported improvement in cognitive function with isoflavone intake [62].

In our study, cruciferous vegetable consumption was inversely associated with menopausal symptoms. While research on cruciferous vegetables and treatment-related symptoms is lacking, suggestive inverse associations between fruit and vegetable intake and night sweats and hot flashes were previously reported in a population of middle-aged Australian women [63]. One possible mechanism by which cruciferous vegetable intake might influence menopausal symptoms is via changes in regulation of estrogen metabolism enzymes, including cytochrome P450 1A1 (CYP1A1) [23,25–27]. Human trial data observed changes in estrogen metabolite profiles following supplementation of indole-3-carbinol, a metabolite of glucosinolates present in cruciferous vegetables [23]. We also observed a suggestive inverse association between higher cruciferous vegetable intake and hair loss/thinning among CA women. Long term ET-associated hair loss/thinning in breast cancer survivors is not well-studied and possible mechanisms by which cruciferous vegetable intake may limit them remain to be elucidated. One possible mechanism may be mediation of inflammation by compounds present in cruciferous vegetable [22,24], however, since this association was only present in CA survivors, this also may be chance association.

A strength of the present study was inclusion of both NHW and CA breast cancer survivors which provided a wide range of soy and cruciferous vegetable intake. A considerable additional strength is that this study provides important data on an understudied population: Asian American breast cancer survivors. Another strength was the data collection by phone, which allowed interviewers to follow-up on survey questions and were conducted in both English and Chinese. There are also several limitations, including the cross-sectional study design, which can result in temporality bias and limits causal inference. Dietary data were ascertained via FFQ, which has important limitations, including potential exposure misclassification. Although the FFQ ascertained detailed intake of selected vegetables and soy products, it was not a comprehensive FFQ. Therefore, we could not compute energy and individual nutrient intake and may have residual confounding from dietary factors not collected, including other types of fruits and vegetables. However, our analysis did control for two major determinants of energy intake, BMI and physical activity. Small sample size may have impacted our ability to detect associations, particularly for evaluating whether associations differ by race/ethnicity and endocrine-therapy usage. Finally, biospecimens were not collected in this population, so we were unable to measure estrogen and dietary-related biomarkers, which would have strengthened the study findings and provided possible mechanistic insights.

In conclusion, intake of soy and cruciferous vegetables may by associated with menopausal symptoms and fatigue in breast cancer survivors. Research on the role of diet and treatment-related effects in breast cancer survivors remains understudied, particularly in diverse study populations. To confirm study findings, additional research is needed that explores the possible relationship between diet and breast cancer treatment-related symptoms incorporating measurement of biomarkers and prospective data collection in a larger, diverse study population.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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References

1. Ganz PA. Monitoring the physical health of cancer survivors: a survivorship-focused medical history. J Clin Oncol. 2006; 24(32):5105–5111. DOI: 10.1200/JCO.2006.06.0541 [PubMed: 17093271]
2. U.S. National Cancer Institute. [Accessed August 17 2017] NCI Dictionary of Cancer Terms. 2017. https://www.cancer.gov/publications/dictionaries/cancer-terms?cdrid=390292
3. Cusack L, Brennan M, Baber R, Boyle F. Menopausal symptoms in breast cancer survivors: management update. British Journal of General Practice. 2013; 63(606):51–52. DOI: 10.3399/bjgp13X660977 [PubMed: 23336472]
4. Harris PF, Remington PL, Trentham-Dietz A, Allen CI, Newcomb PA. Prevalence and Treatment of Menopausal Symptoms Among Breast Cancer Survivors. Journal of Pain and Symptom Management. 2002; 23(6):501–509. doi:http://dx.doi.org/10.1016/S0885-3924(02)00395-0. [PubMed: 12067774]
5. Jim HS, Phillips KM, Chait S, Faul LA, Popa MA, Lee YH, Hussin MG, Jacobsen PB, Small BJ. Meta-analysis of cognitive functioning in breast cancer survivors previously treated with standard-dose chemotherapy. J Clin Oncol. 2012; 30(29):3578–3587. DOI: 10.1200/JCO.2011.39.5640 [PubMed: 22927526]
6. Gallicchio L, Calhoun C, Helzlsouer KJ. Aromatase inhibitor therapy and hair loss among breast cancer survivors. Breast Cancer Res Treat. 2013; 142(2):435–443. DOI: 10.1007/s10549-013-2744-2 [PubMed: 24197658]
7. Kenyon M, Mayer DK, Owens AK. Late and long-term effects of breast cancer treatment and surveillance management for the general practitioner. J Obstet Gynecol Neonatal Nurs. 2014; 43(3): 382–398. DOI: 10.1111/1552-6909.12300
8. Runowicz CD, Leach CR, Henry NL, Henry KS, Mackey HT, Cowens-Alvarado RL, Cannady RS, Pratt-Chapman ML, Edge SB, Jacobs LA, Hurria A, Marks LB, LaMonte SJ, Warner E, Lyman GH, Ganz PA. American Cancer Society/American Society of Clinical Oncology Breast Cancer Survivorship Care Guideline. J Clin Oncol. 2016; 34(6):611–635. DOI: 10.1200/JCO.2015.64.3809 [PubMed: 26644543]
9. Syrowatka A, Motulsky A, Kurteva S, Hanley JA, Dixon WG, Meguerditchian AN, Tamblyn R. Predictors of distress in female breast cancer survivors: a systematic review. Breast Cancer Res Treat. 2017; doi: 10.1007/s10549-017-4290-9
10. Wen KY, Fang CY, Ma GX. Breast cancer experience and survivorship among Asian Americans: a systematic review. J Cancer Surviv. 2014; 8(1):94–107. DOI: 10.1007/s11764-013-0320-8 [PubMed: 24214498]
11. Messina MJ, Loprinzi CL. Soy for Breast Cancer Survivors: A Critical Review of the Literature. The Journal of Nutrition. 2001; 131(11):3095S–3108S. [PubMed: 11694655]
12. Setchell KDR, Cassidy A. Dietary Isoflavones: Biological Effects and Relevance to Human Health. The Journal of Nutrition. 1999; 129(3):758.
13. Jacobs A, Wegewitz U, Sommerfeld C, Grossklaus R, Lampen A. Efficacy of isoflavones in relieving vasomotor menopausal symptoms - A systematic review. Mol Nutr Food Res. 2009; 53(9):1084–1097. DOI: 10.1002/mnfr.200800552 [PubMed: 19653225]
14. Kronenberg F, Fugh-Berman A. Complementary and alternative medicine for menopausal symptoms: a review of randomized, controlled trials. Ann Intern Med. 2002; 137(10):805–813. [PubMed: 12435217]
15. Messina M, Hughes C. Efficacy of soyfoods and soybean isoflavone supplements for alleviating menopausal symptoms is positively related to initial hot flush frequency. J Med Food. 2003; 6(1): 1–11. DOI: 10.1089/109662003765184697 [PubMed: 12804015]
16. Dorjgochoo T, Gu K, Zheng Y, Kallianpur A, Chen Z, Zheng W, Lu W, Shu XO. Soy intake in association with menopausal symptoms during the first 6 and 36 months after breast cancer diagnosis. Breast Cancer Res Treat. 2011; 130(3):879–889. DOI: 10.1007/s10549-010-1096-4 [PubMed: 20703939]
17. Gold EB, Flatt SW, Pierce JP, Bardwell WA, Hajek RA, Newman VA, Rock CL, Stefanick ML. Dietary factors and vasomotor symptoms in breast cancer survivors: the WHEL Study.

Menopause. 2006; 13(3):423–433. DOI: 10.1097/01.gme.0000185754.85328.44 [PubMed: 16735939]

18. MacGregor CA, Canney PA, Patterson G, McDonald R, Paul J. A randomised double-blind controlled trial of oral soy supplements versus placebo for treatment of menopausal symptoms in patients with early breast cancer. Eur J Cancer. 2005; 41(5):708–714. DOI: 10.1016/j.ejca.2005.01.005 [PubMed: 15763646]
19. Nikander E, Kilkkinen A, Metsa-Heikkila M, Adlercreutz H, Pietinen P, Tiitinen A, Ylikorkala O. A randomized placebo-controlled crossover trial with phytoestrogens in treatment of menopause in breast cancer patients. Obstet Gynecol. 2003; 101(6):1213–1220. [PubMed: 12798527]
20. Van Patten CL, Olivotto IA, Chambers GK, Gelmon KA, Hislop TG, Templeton E, Wattie A, Prior JC. Effect of soy phytoestrogens on hot flashes in postmenopausal women with breast cancer: a randomized, controlled clinical trial. J Clin Oncol. 2002; 20(6):1449–1455. DOI: 10.1200/JCO.2002.20.6.1449 [PubMed: 11896091]
21. Keck AS, Finley JW. Cruciferous vegetables: cancer protective mechanisms of glucosinolate hydrolysis products and selenium. Integrative Cancer Therapies. 2004; 3:5–12. [PubMed: 15035868]
22. Fuentes F, Paredes-Gonzalez X, Kong AT. Dietary Glucosinolates Sulforaphane, Phenethyl Isothiocyanate, Indole-3-Carbinol/3,3′-Diindolylmethane: Anti-Oxidative Stress/Inflammation, Nrf2, Epigenetics/Epigenomics and In Vivo Cancer Chemopreventive Efficacy. Curr Pharmacol Rep. 2015; 1(3):179–196. DOI: 10.1007/s40495-015-0017-y [PubMed: 26457242]
23. Higdon JV, Delage B, Williams DE, Dashwood RH. Cruciferous vegetables and human cancer risk: epidemiologic evidence and mechanistic basis. Pharmacol Res. 2007; 55(3):224–236. DOI: 10.1016/j.phrs.2007.01.009 [PubMed: 17317210]
24. Navarro SL, Schwarz Y, Song X, Wang CY, Chen C, Trudo SP, Kristal AR, Kratz M, Eaton DL, Lampe JW. Cruciferous vegetables have variable effects on biomarkers of systemic inflammation in a randomized controlled trial in healthy young adults. J Nutr. 2014; 144(11):1850–1857. DOI: 10.3945/jn.114.197434 [PubMed: 25165394]
25. Steinkellner H, Rabot S, Freywald C, Nobis E, Scharf G, Chabicovsky M, Knasmuller S, Kassie F. Effects of cruciferous vegetables and their constituents on drug metabolizing enzymes involved in the bioactivation of DNA-reactive dietary carcinogens. Mutat Res. 2001; 480–481:285–297.
26. Tsuchiya Y, Nakajima M, Yokoi T. Cytochrome P450-mediated metabolism of estrogens and its regulation in human. Cancer Lett. 2005; 227(2):115–124. DOI: 10.1016/j.canlet.2004.10.007 [PubMed: 16112414]
27. Zhang Y. The molecular basis that unifies the metabolism, cellular uptake and chemopreventive activities of dietary isothiocyanates. Carcinogenesis. 2012; 33(1):2–9. DOI: 10.1093/carcin/bgr255 [PubMed: 22080571]
28. Portenoy RK, thaler HT, Kornblith AB, Lepore JM, Friedlander-Klar H, Kiyasu E, Sobel K, Coyle N, Kemeny N, Norton L. The Memorial Symptom Assessment Scale: an instrument for the evaluation of symptom prevalence, characteristics and distress. European Journal of Cancer. 1994; 30A:1326–1336. [PubMed: 7999421]
29. Cella D, Land SR, Chang C-H, Day R, Costantino JP, Wolmark N, Ganz PA. Symptom measurement in the Breast Cancer Prevention Trial (BCPT) (P-1): psychometric properties of a new measure of symptoms for midlife women. Breast Cancer Res Treat. 2007; 109(3):515–526. DOI: 10.1007/s10549-007-9682-9 [PubMed: 17851765]
30. Lam WWT, Law CC, Fu YT, Wong KH, Chang VT, Fielding R. New Insights in Symptom Assessment: The Chinese Versions of the Memorial Symptom Assessment Scale Short Form (MSAS-SF) and the Condensed MSAS (CMSAS). Journal of Pain and Symptom Management. 2008; 36(6):584–595. DOI: 10.1016/j.jpainsymman.2007.12.008 [PubMed: 18434076]
31. Epplein M, Shu XO, Xiang YB, Chow WH, Yang G, Li HL, Ji BT, Cai H, Gao YT, Zheng W. Fruit and vegetable consumption and risk of distal gastric cancer in the Shanghai Women's and Men's Health studies. Am J Epidemiol. 2010; 172(4):397–406. DOI: 10.1093/aje/kwq144 [PubMed: 20647333]
32. Fred Hutchinson Cancer Research Center. Food Frequency Questionnaires. Fred Hutchinson Cancer Research Center; 2010. http://sharedresources.fhcrc.org/services/food-frequency-questionnaires-ffq [Accessed May 2 2012]

33. Hakim IA, Hartz V, Harris RB, Balentine D, Weisgerber UM, Graver E, Whitacre R, Alberts D. Reproducibility and relative validity of a questionnaire to assess intake of black tea polyphenols in epidemiological studies. Cancer Epidemiol Biomarkers Prev. 2001; 10(6):667–678. [PubMed: 11401918]
34. Thomson CA, Newton TR, Graver EJ, Jackson KA, Reid PM, Hartz VL, Cussler EC, Hakim IA. Cruciferous vegetable intake questionnaire improves cruciferous vegetable intake estimates. J Am Diet Assoc. 2007; 107(4):631–643. DOI: 10.1016/j.jada.2007.01.016 [PubMed: 17383269]
35. Martinez ME, Marshall JR, Graver E, Whitacre RC, Woolf K, Ritenbaugh C, Alberts DS. Reliability and validity of a self-administered food frequency questionnaire in a chemoprevention trial of adenoma recurrence. Cancer Epidemiol Biomarkers Prev. 1999; 8(10):941–946. [PubMed: 10548325]
36. Thomson CA, Giuliano A, Rock CL, Ritenbaugh CK, Flatt SW, Faerber S, Newman V, Caan B, Graver E, Hartz V, Whitacre R, Parker F, Pierce JP, Marshall JR. Measuring dietary change in a diet intervention trial: comparing food frequency questionnaire and dietary recalls. Am J Epidemiol. 2003; 157(8):754–762. [PubMed: 12697580]
37. Bhagwat, SHD., Holden, JM. USDA Database for the Isoflavone Content of Selected Foods, Release 2.0. U.S. Department of Agriculture; 2008. https://www.ars.usda.gov/northeast-area/beltsville-md/beltsville-human-nutrition-research-center/nutrient-data-laboratory/docs/usda-database-forthe-isoflavone-content-of-selected-foods-release-20/ [Accessed August 15 2016]
38. McNaughton SA, Marks GC. Development of a food composition database for the estimation of dietary intakes of glucosinolates, the biologically active constituents of cruciferous vegetables. British Journal of Nutrition. 2003; 90(03):687–697. DOI: 10.1079/BJN2003917 [PubMed: 13129476]
39. Craig CL, Marshall AL, Sjostrom M, Bauman AE, Booth ML, Ainsworth BE, Pratt M, Ekelund U, Yngve A, Sallis JF, Oja P. International Physical Activity Questionnaire: 12-Country Reliability and Validity. Medicine & Science in Sports & Exercise. 2003; 35:1381–1395. [PubMed: 12900694]
40. Macfarlane DJ, Lee CCY, Ho EYK, Chan KL, Chan DTS. Reliability and validity of the Chinese version of IPAQ (short, last 7 days). Journal of Science and Medicine in Sport. 2007; 10(1):45–51. doi:http://dx.doi.org/10.1016/j.jsams.2006.05.003. [PubMed: 16807105]
41. Group TI. IPAQ scoreing protocol. 2004
42. Thomson C, Rock C, Thompson P, Caan B, Cussler E, Flatt S, Pierce J. Vegetable intake is associated with reduced breast cancer recurrence in tamoxifen users: a secondary analysis from the Women's Healthy Eating and Living Study. Breast Cancer Research and Treatment. 2011; 125(2): 519–527. DOI: 10.1007/s10549-010-1014-9 [PubMed: 20607600]
43. Comhaire FH, Depypere HT. Hormones, herbal preparations and nutriceuticals for a better life after the menopause: part II. Climacteric. 2015; 18(3):364–371. DOI: 10.3109/13697137.2014.985646 [PubMed: 25668332]
44. Comhaire FH, Depypere HT. Hormones, herbal preparations and nutriceuticals for a better life after the menopause: part I. Climacteric. 2015; 18(3):358–363. DOI: 10.3109/13697137.2014.985645 [PubMed: 25668235]
45. Medina D. Mammary developmental fate and breast cancer risk. Endocrine-Related Cancer. 2005; 12(3):483–495. DOI: 10.1677/erc.1.00804 [PubMed: 16172188]
46. Fritz H, Seely D, Flower G, Skidmore B, Fernandes R, Vadeboncoeur S, Kennedy D, Cooley K, Wong R, Sagar S, Sabri E, Fergusson D. Soy, Red Clover, and Isoflavones and Breast Cancer: A Systematic Review. PLoS ONE. 2013; 8(11):e81968.doi: 10.1371/journal.pone.0081968 [PubMed: 24312387]
47. Nechuta SJ, Caan BJ, Chen WY, Lu W, Chen Z, Kwan ML, Flatt SW, Zheng Y, Zheng W, Pierce JP, Shu XO. Soy food intake after diagnosis of breast cancer and survival: an in-depth analysis of combined evidence from cohort studies of US and Chinese women. The American Journal of Clinical Nutrition. 2012; 96(1):123–132. DOI: 10.3945/ajcn.112.035972 [PubMed: 22648714]
48. Kang X, Zhang Q, Wang S, Huang X, Jin S. Effect of soy isoflavones on breast cancer recurrence and death for patients receiving adjuvant endocrine therapy. Canadian Medical Association Journal. 2010; 182(17):1857–1862. DOI: 10.1503/cmaj.091298 [PubMed: 20956506]

49. Shu XO, Zheng Y, Cai H, Gu K, Chen Z, Zheng W, Lu W. Soy foods intake and breast cancer survival. JAMA. 2009; 302:2437–2443. [PubMed: 19996398]
50. Fink BN, Steck SE, Wolff MS, Britton JA, Kabat GC, Gaudet MM, Abrahamson PE, Bell P, Schroeder JC, Teitelbaum SL, Neugut AI, Gammon MD. Dietary Flavonoid Intake and Breast Cancer Survival among Women on Long Island. Cancer Epidemiology Biomarkers & Prevention. 2007; 16(11):2285–2292. DOI: 10.1158/1055-9965.epi-07-0245
51. Zhang YF, Kang HB, Zhang RM. Positive effects of soy isoflavone food on survival of breast cancer patients in China. Asian Pacific Journal of Cancer Prevention. 2012; 13:479–482. [PubMed: 22524810]
52. Freedman RR. Menopausal hot flashes: mechanisms, endocrinology, treatment. J Steroid Biochem Mol Biol. 2014; 142:115–120. DOI: 10.1016/j.jsbmb.2013.08.010 [PubMed: 24012626]
53. Liu ZM, Ho SC, Woo J, Chen YM, Wong C. Randomized controlled trial of whole soy and isoflavone daidzein on menopausal symptoms in equol-producing Chinese postmenopausal women. Menopause. 2014; 21(6):653–660. DOI: 10.1097/GME.0000000000000102 [PubMed: 24149925]
54. Ye YB, Wang ZL, Zhuo SY, Lu W, Liao HF, Verbruggen M, Fang S, Mai HY, Chen YM, Su YX. Soy germ isoflavones improve menopausal symptoms but have no effect on blood lipids in early postmenopausal Chinese women: a randomized placebo-controlled trial. Menopause. 2012; 19(7): 791–798. DOI: 10.1097/gme.0b013e31823dbeda [PubMed: 22278344]
55. Franco OH, Chowdhury R, Troup J, et al. Use of plant-based therapies and menopausal symptoms: A systematic review and meta-analysis. JAMA. 2016; 315(23):2554–2563. DOI: 10.1001/jama.2016.8012 [PubMed: 27327802]
56. Quella SK, Loprinzi CL, Barton DL, Knost JA, Sloan JA, LaVasseur BI, Swan D, Krupp KR, Miller KD, Novotny PJ. Evaluation of Soy Phytoestrogens for the Treatment of Hot Flashes in Breast Cancer Survivors: A North Central Cancer Treatment Group Trial. Journal of Clinical Oncology. 2000; 18(5):1068. [PubMed: 10694559]
57. Adlercreutz H, Fotsis T, Bannwart C, Wahala K, Makela T, Brunow G, Hase T. Determination of urinary lignans and phytoestrogen metabolites, potential antiestrogens and anticarcinogens, in urine of women on various habitual diets. J Steroid Biochem. 1986; 25(5B):791–797. [PubMed: 3027456]
58. Ishiwata N, Melby MK, Mizuno S, Watanabe S. New equol supplement for relieving menopausal symptoms: Randomized, placebo-controlled trial of Japanese women. Menopause-the Journal of the North American Menopause Society. 2009; 16(1):141–148. DOI: 10.1097/gme.0b013e31818379fa
59. Zhao J, Harada N, Kurihara H, Nakagata N, Okajima K. Dietary isoflavone increases insulin-like growth factor-I production, thereby promoting hair growth in mice. Journal of Nutritional Biochemistry. 22(3):227–233. DOI: 10.1016/j.jnutbio.2010.01.008
60. Ding J, Xi Y-D, Zhang D-D, Zhao X, Liu J-M, Li C-Q, Han J, Xiao R. Soybean isoflavone ameliorates β-amyloid 1–42-induced learning and memory deficit in rats by protecting synaptic structure and function. Synapse. 2013; 67(12):856–864. DOI: 10.1002/syn.21692 [PubMed: 23766238]
61. Yuan-Di X, Xiao-Ying L, Juan D, Huan-Ling Y, Wei-Wei M, Lin-Hong Y, Jian W, Rong X. Soy Isoflavone Alleviates Aβ1–42-Induced Impairment of Learning and Memory Ability Through the Regulation of RAGE/LRP-1 in Neuronal and Vascular Tissue. Current Neurovascular Research. 2013; 10(2):144–156. doi:http://dx.doi.org/10.2174/1567202611310020007. [PubMed: 23469956]
62. Cheng PF, Chen JJ, Zhou XY, Ren YF, Huang W, Zhou JJ, Xie P. Do soy isoflavones improve cognitive function in postmenopausal women? A meta-analysis. Menopause. 2015; 22:198–206. [PubMed: 25003621]
63. Herber-Gast GC, Mishra GD. Fruit, Mediterranean-style, and high-fat and -sugar diets are associated with the risk of night sweats and hot flushes in midlife: results from a prospective cohort study. Am J Clin Nutr. 2013; 97(5):1092–1099. DOI: 10.3945/ajcn.112.049965 [PubMed: 23553160]

Table 1

Population characteristics

	Total Population	Non-Hispanic White	Chinese American
Total N (%)	365 (100)	173 (47.4)	192 (52.6)
Age in years (mean, SD)	57.1 (10.4)	57.2 (10.5)	56.9 (10.4)
Menopausal status (N, %)			
Premenopause	47 (13.0)	21 (12.3)	26 (13.7)
Induced Menopause	61 (16.9)	30 (17.5)	31 (16.3)
Perimenopause	81 (22.4)	35 (20.5)	46 (24.2)
Postmenopause	172 (47.6)	85 (49.7)	87 (45.8)
BMI (kg/m^2) (mean, SD)	24.0 (4.4)	25.2 (5.1)	22.9 (3.1)
Physical activity (N, %)[a]			
Active	110 (30.1)	77 (44.5)	33 (17.2)
Inactive	119 (32.6)	38 (22.0)	81 (42.2)
Minimally active	136 (37.3)	58 (33.5)	78 (40.6)
Cancer stage (N, %)			
Stage 0	110 (30.1)	64 (37.0)	46 (24.0)
Stage I	166 (45.4)	77 (44.5)	89 (46.4)
Stage II	47 (12.9)	22 (12.7)	25 (13.0)
Stage III	42 (11.5)	10 (5.8)	32 (16.7)
Endocrine therapy (N, %)			
None	148 (40.8)	74 (42.8)	74 (38.5)
Tamoxifen	126 (34.5)	60 (34.7)	66 (34.4)
Aromatase inhibitor	91 (24.9)	39 (22.5)	52 (27.1)
Lumpectomy (N, %)			
No	141 (38.6)	59 (34.1)	82 (42.5)
Yes	224 (61.4)	114 (65.9)	110 (57.3)
Mastectomy (N, %)			
No	228 (62.5)	114 (65.9)	114 (59.4)
Yes	137 (37.5)	59 (34.1)	78(40.6)
Chemotherapy (N, %)			
No	257 (76.3)	127 (80.4)	130 (72.6)
Yes	80 (23.7)	31 (19.6)	49 (27.4)
Radiation therapy (N, %)			
No	198 (54.2)	88 (50.9)	110 (57.3)
Yes	167 (45.8)	85 (49.1)	82 (42.7)
Time since diagnosis (N, %)			
<24 months	108 (29.6)	48 (27.7)	60 (31.3)
24–36 months	111 (30.4)	49 (28.3)	62 (32.3)
>36 months	146 (40.0)	76 (43.9)	70 (36.5)
Estrogen receptor (N, %)			
Positive	227 (62.2)	109 (63.0)	118 (61.5)

	Total Population	Non-Hispanic White	Chinese American
Negative	49 (13.4)	19 (11.0)	30 (15.6)
Unknown	89 (24.4)	45 (26.0)	44 (22.9)
Progesterone receptor (N, %)			
Positive	196 (53.7)	91 (52.6)	105 (54.7)
Negative	80 (21.9)	37 (21.4)	43 (22.4)
Unknown	89 (24.4)	45 (26.0)	44 (22.9)
HER2 (N, %)			
Positive	44 (12.1)	18 (10.4)	26 (13.5)
Negative	167 (45.8)	74 (42.8)	93 (48.4)
Unknown	154 (42.2)	81 (46.8)	73 (28.0)
Soy products (N, %)[b]			
No intake	104 (28.5)	73 (42.2)	31 (16.1)
>0 – <24.0 g/day	131 (35.9)	65 (37.6)	66 (34.4)
≥24.0 g/day	130 (35.6)	35 (20.2)	95 (49.5)
Isoflavones (N, %)[b]			
No intake	104 (28.5)	73 (42.2)	31 (16.1)
>0 – <6.3 mg/day	129 (35.3)	62 (35.8)	67 (34.9)
≥6.3 mg/day	132 (36.2)	38 (22.0)	94 (49.0)
Cruciferous vegetable (N, %)[b]			
<33.0 g/day	121 (33.2)	77 (44.5)	44 (22.9)
≥33.0 – <70.8 g/day	120 (32.9)	58 (33.5)	62 (32.3)
≥70.8 g/day	124 (33.9)	38 (22.0)	86 (44.8)
Glucosinolates (N, %)[b]			
≤20.4 mg/day	121 (33.2)	70 (40.5)	51 (26.6)
>20.4 – <50.1 mg/day	120 (32.9)	55 (31.8)	65 (33.9)
≥50.1 mg/day	124 (33.9)	48 (27.7)	76 (39.6)

[a]Active: vigorous physical activity ≥ 3 days/week + ≥1500 MET-minutes/week or ≥3,000 MET-minutes/week engaged in any intensity levels of physical activity; Minimally active: < Active cut-points and ≥600 MET-minutes/week; Inactive: <600 MET-minutes/week.

[b]Tertiles.

Table 2

Age-adjusted associations between selected population characteristics and treatment-related symptoms among breast cancer survivors

	Menopausal symptoms[b]		Fatigue		Joint problems[c]		Hair loss or thinning		Memory loss	
	N Yes/No	Age-adjusted OR (95% CI)[d]	N Yes/No	Age-adjusted OR (95% CI)[d]	N Yes/No	Age-adjusted OR (95% CI)[d]	N Yes/No	Age-adjusted OR (95% CI)[d]	N Yes/N o	Age-adjusted OR (95% CI)[d]
Race/ethnicity										
Chinese American	95/97	Reference	116/76	Reference	110/82	Reference	86/105	Reference	77/115	Reference
Non-Hispanic White	108/65	1.77 (1.14, 2.75)	80/93	0.54 (0.35, 0.82)	76/97	0.57 (0.37, 0.86)	59/114	0.61 (0.39, 0.94)	37/136	0.38 (0.24, 0.60)
Menopause status										
Postmenopause	74/98	Reference	76/98	Reference	82/90	Reference	53/119	Reference	47/125	Reference
Perimenopause	48/33	0.86 (0.44, 1.68)	48/33	1.13 (0.59, 2.18)	39/42	0.79 (0.41, 1.51)	35/46	1.40 (0.72, 2.73)	30/51	1.51 (0.75, 3.02)
Induced menopause	55/6	3.99 (1.40, 11.4)	55/6	1.78 (0.78, 4.07)	37/24	1.18 (0.53, 2.62)	35/26	2.28 (1.01 5.13)	21/40	1.32 (0.56, 3.10)
Premenopause	23/24	0.26 (0.09, 0.73)	23/24	0.68 (0.25, 1.81)	25/22	0.76 (0.29, 2.01)	21/25	1.28 (0.47, 3.49)	14/33	1.05 (0.36, 3.03)
Chemotherapy										
No	126/131	Reference	116/141	Reference	118/139	Reference	86/171	Reference	69/188	Reference
Yes	102/65	2.18 (1.22, 3.90)	63/17	3.80 (2.08, 6.94)	55/25	2.44 (1.41, 4.21)	47/33	2.48 (1.46, 4.21)	41/39	2.88 (1.68, 4.93)
Radiation therapy										
No	101/97	Reference	105/93	Reference	100/98	Reference	82/116	Reference	60/138	Reference
Yes	102/65	2.20 (1.37, 3.54)	91/76	1.34 (0.86, 2.10)	86/81	1.05 (0.68, 1.63)	63/103	1.01 (0.64, 1.58)	54/113	1.14 (0.72, 1.81)
Endocrine therapy										
None	59/89	Reference	67/81	Reference	68/80	Reference	55/93	Reference	43/105	Reference
Tamoxifen	9630	3.95 (2.28, 6.82)	77/49	1.51 (0.91, 2.50)	62/64	0.84 (0.57, 1.12)	53/72	1.06 (0.64, 1.77)	40/86	1.06 (0.62, 1.80)
Aromatase Inhibitor	48/42	2.46 (1.39, 4.36)	52/39	2.17 (1.24, 3.80)	56/35	2.32 (1.33, 4.06)	37/54	1.50 (0.85, 2.63)	31/60	1.40 (0.78, 2.51)
Time since diagnosis										
<24 months	71/37	Reference	75/33	Reference	63/45	Reference	46/62	Reference	40/68	Reference
24–36 months	52/59	0.44 (0.25, 0.79)	50/61	0.35 (0.20, 0.63)	52/59	0.65 (0.38, 1.12)	48/62	1.11 (0.64, 1.92)	33/78	0.75 (0.43, 1.32)
>36 months	80/66	0.52 (0.30, 0.90)	71/75	0.36 (0.21, 0.62)	71/75	0.64 (0.38, 1.07)	51/95	0.71 (0.42, 1.20)	41/105	0.66 (0.38, 1.13)
Cancer stage										
Stage 0	48/62	Reference	47/63	Reference	45/65	Reference	29/80	Reference	18/92	Reference
Stage 1	97/69	2.26 (1.34, 3.80)	90/76	1.80 (1.09, 2.98)	86/80	1.66 (1.01, 2.72)	63/103	1.73 (1.01, 2.97)	52/114	2.43 (1.31, 4.50)
Stage II	29/18	2.03 (0.97, 4.24)	30/17	2.31 (1.12, 4.76)	27/20	1.90 (0.94, 3.84)	28/19	3.72 (1.79, 7.75)	21/26	4.06 (1.86, 8.86)

	Menopausal symptoms[b]		Fatigue		Joint problems[c]		Hair loss or thinning		Memory loss	
	N Yes/No	Age-adjusted OR (95% CI)[d]	N Yes/No	Age-adjusted OR (95% CI)[d]	N Yes/No	Age-adjusted OR (95% CI)[d]	N Yes/No	Age-adjusted OR (95% CI)[d]	N Yes/N o	Age-adjusted OR (95% CI)[d]
Stage III	29/13	2.25 (1.03, 4.94)	29/13	2.55 (1.18, 5.53)	28/14	2.74 (1.28, 5.84)	25/17	3.37 (1.57, 7.21)	23/19	6.30 (2.81, 14.1)
Soy products[a]										
No intake	66/38	Reference	59/45	Reference	54/50	Reference	41/63	Reference	33/71	Reference
>0 – <24.0 g/day	74/57	0.56 (0.32, 0.99)	72/59	0.79 (0.46, 1.36)	68/63	0.94 (0.56, 1.59)	58/73	1.12 (0.65, 1.92)	43/88	1.03 (0.58, 1.80)
≥24.0 g/day	63/67	0.41 (0.23, 0.72)	65/65	0.66 (0.38, 1.12)	64/66	0.84 (0.50, 1.42)	46/83	0.78 (0.45, 1.35)	38/92	0.89 (0.51, 1.58)
Cruciferous vegetables[a]										
<33.0 g/day	72/49	Reference	60/61	Reference	59/62	Reference	45/76	Reference	30/91	Reference
≥33.0 – <70.8 g/day	73/47	1.08 (0.63, 1.85)	65/55	1.22 (0.73, 2.05)	61/59	1.09 (0.66, 1.82)	56/64	1.51 (0.89, 2.55)	42/78	1.58 (0.90, 2.77)
≥70.8 g/day	58/66	0.54 (0.32, 0.93)	71/53	1.36 (0.81, 2.27)	66/58	1.20 (0.72, 1.99)	44/79	0.89 (0.52, 1.52)	42/82	1.51 (0.86, 2.63)

[a] Tertiles.

[b] Menopausal symptoms: Hot flashes or night/cold sweats, vaginal dryness/pain with intercourse, vaginal discharge.

[c] Joint problems: muscle pain, joint stiffness, joint pain, bone thinning.

[d] Age-adjusted logistic regression.

Table 3

Multivariable-adjusted associations between soy intake and treatment-related symptoms among Chinese and non-Hispanic White breast cancer survivors

	Menopausal symptoms[b]		Fatigue		Joint problems[c]		Hair loss or thinning		Memory loss	
	N Yes/No	Age-adjusted OR (95% CI)[d]	N Yes/No	Age-adjusted OR (95% CI)[d]	N Yes/No	Age-adjusted OR (95% CI)[d]	N Yes/No	Age-adjusted OR (95% CI)[d]	N Yes/N o	Age-adjusted OR (95% CI)[d]
Soy Products[a]										
Overal										
No intake	66/38	Reference	59/45	Reference	54/50	Reference	41/63	Reference	33/71	Reference
>0 – <24.0 g/day	74/57	0.47 (0.23, 0.93)	72/59	0.62 (0.33, 1.16)	68/63	0.79 (0.43, 1.44)	58/73	0.89 (0.48, 1.65)	43/88	0.82 (0.43, 1.58)
≥24.0 g/day	63/67	0.51 (0.25, 1.03)	65/65	0.43 (0.22, 0.84)	64/66	0.56 (0.29, 1.06)	46/83	0.66 (0.34, 1.26)	38/92	0.53 (0.26, 1.06)
P-trend		0.08		0.01		0.08		0.21		0.07
Non-Hispanic White										
No intake	51/22	Reference	39/34	Reference	35/38	Reference	23/50	Reference	15/58	Reference
>0 – <24.0 g/day	39/26	0.36 (0.13, 1.01)	29/36	0.47 (0.20, 1.09)	27/38	0.49 (0.21, 1.15)	24/41	0.87 (0.35, 2.13)	16/49	1.17 (0.47, 2.90)
≥24.0 g/day	18/17	0.29 (0.09, 0.96)	12/23	0.25 (0.09, 0.72)	14/21	0.49 (0.18, 1.31)	12/23	0.89 (0.32, 2.45)	6/29	0.68 (0.21, 2.14)
P-trend		0.03		0.008		0.11		0.80		0.62
Chinese										
No intake	15/16	Reference	20/11	Reference	19/12	Reference	18/13	Reference	18/13	Reference
>0 – <24.0 g/day	35/31	0.52 (0.17, 1.61)	43/23	0.94 (0.31, 2.77)	41/25	1.27 (0.46, 3.50)	34/32	0.60 (0.22, 1.65)	27/39	0.56 (0.20, 1.61)
≥24.0 g/day	45/50	0.61 (0.21, 1.76)	53/42	0.68 (0.24, 1.90)	50/45	0.71 (0.27, 1.85)	34/60	0.44 (0.16, 1.16)	32/63	0.38 (0.14, 1.05)
P-trend		0.54		0.38		0.26		0.10		0.06
P-interaction[e]		0.71		0.31		0.60		0.55		0.35

[a] Tertiles.

[b] Menopausal symptoms: Hot flashes or night/cold sweats, vaginal dryness/pain with intercourse, vaginal discharge.

[c] Joint problems: muscle pain, joint stiffness, joint pain, bone thinning.

[d] Multivariable logistic regression adjusted for age (continuous), ethnicity (Chinese American, non-Hispanic White), menopausal status (premenopause, treatment induced menopause, perimenopause, postmenopause), BMI (continuous), physical activity (active, minimally active, inactive), endocrine therapy (none, tamoxifen, aromatase inhibitor), time since diagnosis (<24 months, 24-36 months, >36 months), and cancer stage (0, I, II, III).

[e] Test for interaction between soy intake and ethnicity. Logistic regression models additionally including cross-product interaction term for soy intake and ethnicity.

Table 4

Multivariable-adjusted association between cruciferous vegetable intake and treatment-related symptoms among Chinese and non-Hispanic White breast cancer survivors

	Menopausal symptoms[b]		Fatigue		Joint problems[c]		Hair loss or thinning		Memory loss	
	N Yes/No	Age-adjusted OR (95% CI)[d]	N Yes/No	Age-adjusted OR (95% CI)[d]	N Yes/No	Age-adjusted OR (95% CI)[d]	N Yes/No	Age-adjusted OR (95% CI)[d]	N Yes/N o	Age-adjusted OR (95% CI)[d]
Cruciferous vegetables[a]										
Overall										
<33.0 g/day	72/49	Reference	60/61	Reference	59/62	Reference	45/76	Reference	30/91	Reference
≥33.0 – <70.8 g/day	73/47	0.90 (0.46, 1.74)	65/55	0.97 (0.53, 1.75)	61/59	0.88 (0.50, 1.57)	56/64	1.41 (0.78, 2.54)	42/78	1.32 (0.70, 2.48)
≥70.8 g/day	58/66	0.50 (0.25, 0.97)	71/53	1.26 (0.68, 2.32)	66/58	1.08 (0.59, 1.95)	44/79	0.68 (0.37. 1.28)	42/82	1.24 (0.56, 2.39)
P-trend		0.04		0.46		0.80		0.26		0.51
Non-Hispanic White										
<33.0 g/day	50/27	Reference	34/43	Reference	30/47	Reference	21/56	Reference	10/67	Reference
≥33.0 – <70.8 g/day	37/21	1.44 (0.53, 3.92)	29/29	1.22 (0.53, 2.78)	28/30	1.20 (0.52, 2.75)	23/35	2.47 (1.00 6.11)	15/43	2.40 (0.92, 6.30)
≥70.8 g/day	21/17	0.72 (0.23, 2.22)	17/21	0.99 (0.39, 2.51)	18/20	1.20 (0.47, 3.03)	15/23	1.55 (0.57, 4.19)	12/26	2.00 (1.03, 8.74)
P-trend		0.71		0.93		0.65		0.25		0.03
Chinese										
<33.0 g/day	22/22	Reference	26/18	Reference	29/15	Reference	24/20	Reference	20/24	Reference
≥33.0 – <70.8 g/day	36/26	0.96 (0.35, 2.62)	36/26	0.82 (0.31, 2.13)	33/29	0.76 (0.31, 1.85)	33/29	0.83 (0.33, 2.04)	27/35	0.71 (0.28, 1.81)
≥70.8 g/day	37/49	0.42 (0.16, 1.09)	54/32	1.27 (0.51, 3.14)	48/38	1.00 (0.42, 2.37)	29/56	0.31 (0.13, 0.75)	30/56	0.61 (0.25, 1.51)
P-trend		0.05		0.53		0.89		0.006		0.31
P-interaction[e]		0.86		0.76		0.63		0.08		0.02

[a] Tertiles.

[b] Menopausal symptoms: Hot flashes or night/cold sweats, vaginal dryness/pain with intercourse, vaginal discharge.

[c] Joint problems: muscle pain, joint stiffness, joint pain, bone thinning.

[d] Multivariable logistic regression adjusted for age (continuous), ethnicity (Chinese American, non-Hispanic White), menopausal status (premenopause, treatment induced menopause, perimenopause, postmenopause), BMI (continuous), physical activity (active, minimally active, inactive), endocrine therapy (none, tamoxifen, aromatase inhibitor), time since diagnosis (<24 months, 24-36 months, >36 months), and cancer stage (0, I, II, III).

[e] Test for interaction between cruciferous vegetable intake and ethnicity. Logistic regression model additionally including cross-product interaction term for cruciferous vegetable intake and ethnicity.