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Post-diagnosis social networks, and lifestyle and treatment factors in the After Breast Cancer Pooling Project (ABCPP)

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Abstract

Objective—Larger social networks have been associated with better breast cancer survival. To investigate potential mediators, we evaluated associations of social network size and diversity with lifestyle and treatment factors associated with prognosis.

Methods—We included 9,331 women from the After Breast Cancer Pooling Project who provided data on social networks within approximately two years following diagnosis. A social network index was derived from information about the presence of a spouse or intimate partner, religious ties, community participation, friendship ties, and numbers of living relatives. Diversity was assessed as variety of ties, independent of size. We used logistic regression to evaluate associations with outcomes and evaluated whether effect estimates differed using meta-analytic techniques.

Results—Associations were similar across cohorts though analyses of smoking and alcohol included US cohorts only due to low prevalence of these behaviors in the Shanghai cohort. Socially isolated women were more likely to be obese (OR=1.21, 95% CI:1.03-1.42), have low physical activity (<10 MET-h/wk, OR=1.55, 95% CI:1.36-1.78), be current smokers (OR=2.77, 95% CI:2.09-3.68), and have high alcohol intake (≥15 g/d, OR=1.23, 95% CI:1.00-1.51), compared to socially integrated women. Among node positive cases from three cohorts, socially isolated women were more likely not to receive chemotherapy (OR=2.10, 95% CI:1.30-3.39);

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associations differed in a fourth cohort. Other associations (nonsignificant) were consistent with less intensive treatment in socially isolated women. Low social network diversity was independently associated with more adverse lifestyle, but not clinical, factors.

Conclusions—Small, less diverse social networks measured post-diagnosis were associated with more adverse lifestyle factors and less intensive cancer treatment.

Keywords

Social networks; social support; social ties; social diversity; breast cancer; survival; mortality; women

Introduction

Over 230,000 cases of breast cancer (BC) are diagnosed, and over 40,000 BC deaths occur each year[1]. Previous studies have reported that larger, supportive social networks, defined as the web of social relationships that surround an individual[2], are associated with better survival after a BC diagnosis[3-5]. In a theoretical model by Berkman and Glass[2], social networks influence health outcomes through functional social support, social norms, social engagement, access to resources, and subsequent effects on biology and behavior. However, in women with BC, no one has examined influences of social networks on lifestyle behaviors, i.e., daily habits over which a person has some control, such as diet, smoking, and physical activity, and little research has examined influences on treatment.

Social network members may influence lifestyle and treatment through instrumental, emotional, informational, and other types of social support[6]. Social norms and identification with SN members increase the likelihood of adopting lifestyle behaviors similar to those members[7, 8]. Low social network diversity, defined as the variety of social ties (connections) or roles, has been related to alcohol dependency, smoking, low levels of physical activity[9, 10] and poorer health generally[11]. Norms have been shown to influence screening[12]. Women's social relationships (e.g., spouse, family, friends) have also been shown to influence choice of mastectomy or lumpectomy[13], whether to pursue chemotherapy[14], and other treatment decisions[14]. Social relationships may also adversely affect health-related outcomes through relationship obligations or social strain, and related to this, reduced motivation for self-care and higher levels of psychological distress. Lifestyle risk factors, including poor diet quality[15], physical inactivity[16], smoking[17], and related to these, obesity[18], as well as suboptimal treatment, have each been associated with poorer BC-specific or overall survival and may be mechanisms through which social relationships influence BC outcomes.

Evaluating possible mechanisms may help draw inferences about how social relationships influence health outcomes in BC survivors, such as through social norms, support, or engagement and thus inform potential opportunities for developing effective social and clinical interventions. Therefore, we examined associations between social ties, and potential lifestyle and treatment mechanisms of BC survival in a pooled cohort of four studies of 9,331 women with invasive BC from the After Breast Cancer Pooling Project (ABCPP).

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METHODS

The After Breast Cancer Pooling Project

The ABCPP is an international collaboration of four prospective studies of 18,333 women[19] from multiple U.S. sites and Shanghai, China who were diagnosed with stages I-IV invasive BC. Three of the cohorts, the Shanghai Breast Cancer Survival Study (SBCSS) [20], the Life after Cancer Epidemiology (LACE) Study[21], and the Women's Healthy Eating and Living (WHEL) Study[22], specifically recruited BC patients. The fourth cohort included BC patients diagnosed in the Nurses' Health Study (NHS), a prospective study of female nurses[23]. Each cohort collected data on clinical, social, reproductive, and lifestyle factors. Data were harmonized into a common dataset. Individual cohort investigators received Institutional Review Board (IRB) approval from their respective institution(s) to participate in this collaboration. Details regarding cohort creation and characteristics have been published[19].

Study sample—Social data were collected in the SBCSS approximately six months post-diagnosis. In WHEL and LACE, data were collected on average about two years post-diagnosis. In the NHS, we used data collected between diagnosis and two years (mean, median=0.9 year) post-diagnosis; 26% provided data ≤6 months of diagnosis.

To derive the study sample, we considered the significance of missing data in each cohort. Because of the complexity of the social network measures, we considered that failure to complete specific survey items may denote a lack of a social tie and sought to avoid excluding these women since the requirement of complete data has been shown to lead to bias[24]. In three of the cohorts (NHS, SBCSS, WHEL), most of the women with any missing information were missing information for only one tie (data not shown). In the LACE cohort, women tended to have more missing data because questions about religious and community participation were derived from a lengthy time use survey designed to assess physical activity. Thus, when data on physical activity were available but when women omitted questions on religious or community participation, we assumed that this meant they did not participate in that activity. However, when physical activity and religious and community participation data were both missing, we assumed that women did not complete the questionnaire because of the level of burden and did not make assumptions about their participation.

If women were missing information for 2 or fewer ties, we assumed that missing data signified a lack of a social tie. Women were excluded if they were missing data on more than 2 ties (5.2%). We included 1,947 women from the LACE cohort, 2,223 from the NHS cohort, 2,194 from the SBCSS cohort, and 2,967 from the WHEL cohort (N=9,331).

Data Collection

Social networks and social diversity—The ABCPP Social Network Index (ABCPP-SNI) (Supplemental Table 1) used in this analysis was adapted from the Berkman-Syme Social Networks Index[25] (B-SNI) which is frequently used in epidemiological research and includes five components: a spouse or intimate partner, number of relatives, friendship

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ties, religious/social ties, and community ties. Approximate tertiles of friendship ties were generated from single items about numbers of, time with, support from, or ability to maintain activities with, friends. The number of relatives was summed based on available questions in each cohort about the number of living children and relatives. To incorporate supportiveness into the computation of numbers of relatives in WHEL, LACE, and SBCSS, we assigned an extra point to those in the middle category of relatives with high levels of support; higher supportiveness did not further distinguish risk in socially isolated and integrated women. We did this to better approximate the B-SNI and generate comparable results across cohorts; the NHS built "closeness" into questions about relatives.

Women were assigned 1 or 0 points depending on whether or not they were married/in an intimate relationship, engaged or not in community participation, or engaged or not in religious participation, and 1, 2, or 3 points for cohort-specific tertiles of the sum of relatives or tertiles of friends. A higher score signifies greater social integration. Results using similar approaches have been published[26-28].

Information on religious participation was not available in the Shanghai cohort. Therefore, we calculated the ABCPP-SNI separately in each cohort and divided the index into cohort-specific tertiles of women before pooling data, representing those who were socially isolated, moderately integrated, and socially integrated. We standardized the continuous social network score (mean=0, standard deviation=1) for analyses of trend. The questions and measures used to derive the social network index in each cohort are presented in Supplemental Table 1.

To examine social network diversity, independent of social network size, we generated a variable from the sum of the different types of ties, with a point added for medium or large friend networks rather than using the binary any vs. no friends, since almost all women reported at least one close friend and larger friendship networks may be more diverse[29]. To ensure independence of the diversity and size variables, we categorized the diversity variable into a dichotomous "high" vs. "low" diversity variable within each cohort and each social network size category; this variable had a similar distribution within each social network category.

Sociodemographic and reproductive characteristics—Available sociodemographic and reproductive data included race/ethnicity (Non-Hispanic White, Non-Hispanic Black, Asian, Hispanic, Other) and education (< high school, high school, some college, college graduate). Data on menopausal status at diagnosis (premenopausal, postmenopausal, unknown), parity, and age at first birth were also available.

Lifestyle factors and body mass index—Lifestyle factors were measured at the time of the assessment of social variables. Smoking history was self-reported (never, past, current). Recreational physical activity in metabolic equivalents (MET-hours/week) was determined from validated semi-quantitative questionnaires[30]. Weight was self-reported. Height was self-reported in LACE, WHEL, and the NHS; in the SBCSS, height was measured by an interviewer at baseline. Body mass index (BMI) in kg/m^2 was derived from

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weight and height. Information on alcohol intake (g/d) was derived from validated food frequency questionnaires[31].

Clinical characteristics and breast cancer treatment—Available clinical and treatment data included age at diagnosis (years), American Joint Committee on Cancer (AJCC) stage (I, II, III, IV), estrogen receptor (ER)/progesterone receptor (PR) status (ER +/PR+, ER+/PR−, ER−/PR), nodal status (cancer spread to lymph nodes or not), HER2 status (positive, negative), and any comorbidity (diabetes, hypertension, myocardial infarction [MI], or stroke).

Treatment information included data on surgery (none, lumpectomy, mastectomy, unknown), chemotherapy (no, yes), radiation therapy (no, yes), and hormonal therapy (no, yes).

Outcome variables—From data on lifestyle factors and BMI, we generated dichotomous outcomes. These included weight variables (overweight, BMI≥25 kg/m^2 (yes vs. no) and obesity, BMI≥30 kg/m^2 (yes vs. no)), high alcohol intake (alcohol consumption≥15 g/d vs. not), low physical activity (<10 vs. ≥10 MET-hrs/week), and current smoking (yes vs. no).

From clinical data, we generated outcomes including receipt of chemotherapy (yes vs. no) among women with node-positive cancers, radiation (yes vs. no) among those obtaining lumpectomy, and hormonal therapy (yes vs. no) among those with hormone receptor positive cancers. We also generated a variable among women who had surgery—lumpectomy vs. mastectomy—to evaluate whether social networks were related to less invasive surgery.

Statistical analyses

Using analysis of covariance and Mantel-Haenszel chi-square tests, we examined age-adjusted associations between social network categories and potential confounding variables.

Validation of the ABC social networks index—The original B-SNI[25] has four levels—socially integrated, moderately integrated, moderately isolated, and socially isolated. To compare the B-SNI to the ABCPP-SNI, both which we were able to derive in the NHS (only), we categorized scores for the ABCPP-SNI based on the distribution of the scores of the original B-SNI. Then we computed the Spearman correlation between the ABCPP-SNI and the B-SNI for the NHS women, evaluated the concordance between the measures using the weighted kappa statistic, and compared the indexes in terms of the magnitude of associations with outcomes.

Analyses of social networks and clinical and lifestyle factors—Our goal was to examine cross-sectional associations between social networks assessed within approximately two years following diagnosis and lifestyle and clinical variables. First, we evaluated categories of social network size with clinical and lifestyle factors. We also evaluated additional models for social network diversity, adjusted simultaneously for social network size. We subsequently evaluated associations between each type of social tie (e.g., married/intimate partner, friends, relatives, community participation, religious participation), adjusted simultaneously for other ties, and outcome variables.

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Each analysis involved three steps. First, multiple logistic regression models were used to estimate study-specific adjusted odds ratios (ORs) and 95% confidence intervals (CI) for associations of social networks with each outcome variable (i.e., weight, current smoking, physical activity, alcohol consumption, treatment). Second, a meta-analysis was conducted, combining study-specific ORs using inverse-variance weights in random-effects models[32]. The Q test statistic was used to assess heterogeneity in risk estimates across studies[33]. When evidence for heterogeneity was not observed (P>0.05; this was the case for all associations but one), the studies were pooled and associations between social networks and clinical and lifestyle variables were evaluated using logistic regression adjusted for study in addition to the covariates listed below. Otherwise, the Q test statistic and separate results were reported. Tests for linear trend of social network size were conducted using the standardized, continuous measure. In analyses with simultaneous adjustment for social network size and diversity, we evaluated significance for diversity using the Wald $\chi 2$ test for the dichotomous variable.

In analyses of treatment, since chemotherapy and hormonal therapy are not indicated for all women with BC, our analyses of the likelihood of chemotherapy were limited to women with node positive cancers, and analyses of hormonal therapy were restricted to those with ER+ BC. Though there is latitude for choice in surgery, we examined lumpectomy vs. mastectomy for additional insight but without making an assumption as to expected therapy. We attempted to examine associations with radiotherapy among those with lumpectomy, but only 70 women (2%) who had lumpectomy didn't have radiotherapy so we had insufficient power to examine this treatment outcome.

Covariates in multivariable-adjusted models were chosen based on *a priori* determination from literature review. These included age at diagnosis, time between diagnosis and social network assessment, study, education, race/ethnicity, AJCC stage, hormone receptor status, Her2 neu status, parity, menopausal status at diagnosis, comorbidity, treatment (types of treatment other than the outcome including chemotherapy, radiation, surgery, hormone therapy), and lifestyle and related factors (factors other than the outcome including smoking, physical activity, BMI, alcohol) were included. We allowed missing categories for all covariates; this approach produced qualitatively similar findings to those obtained in sensitivity analyses employing multiple imputation or requiring complete case ascertainment (data not shown).

Finally, we stratified by education (< vs. any college education), age (≥ vs. < median=56 years), and comorbidity (no vs. any). However, we were limited in our ability to examine associations by race/ethnicity. We computed interaction terms based on the cross product of the continuous social networks variable and each of these dichotomous variables when associations differed by strata and evaluated interactions with Wald $\chi 2$ tests. Finally, we conducted sensitivity analyses excluding data provided ≤6 months since diagnosis, since associations may differ among those undergoing initial treatment.

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RESULTS

Women from the LACE (median=58.9, IQR:50.8, 67.1) and NHS (median=65.1, IQR:59.3, 70.5) cohorts were older than women from the SBCSS (median=51.0, IQR:45.9, 61.5) and WHEL (median=50.7, IQR:45.4, 57.6) cohorts. Women with smaller social networks had higher levels of education and a larger interval between diagnosis and social networks assessment. They were younger and more likely to be White and nulliparous, and they were less likely to have a Her2 neu positive cancer. Age, menopausal status at diagnosis, cancer stage, and ER status were not related to social network size (Table 1).

Validation of the ABC social networks index

Correlation between the social network indexes was high, $r=0.72$, $p<0.001$ and the $\kappa=0.60$ was moderately high, suggesting fairly good concordance between the two measures. The SNI measures were similarly predictive (data not shown).

Social networks and lifestyle factors

Associations between social networks and lifestyle factors did not differ by cohort and were pooled. After adjustment for potential confounding variables, socially isolated women were more likely to be current smokers (US cohorts) (OR=2.77, 95% CI:2.09-3.68), have low levels of physical activity (OR=1.55, 95% CI:1.36-1.78), have a BMI≥30 kg/m^2 (OR=1.21, 95% CI:1.03-1.42), and consume ≥15 g/d alcohol (OR=1.23, 95% CI:1.00-1.51), compared with socially integrated women. Social isolation was not associated with overweight (BMI≥25 kg/m^2) status (data not shown), though moderately integrated women had a lower odds of overweight compared with socially integrated women (OR=0.89, 95% CI: 0.80-0.98).

Social network size and social network diversity were independently associated with each lifestyle factor (Tables 2, 3). Specifically, adjusted for social network size, low social network diversity was associated with low levels of physical activity (OR=1.23, 95% CI: 1.12-1.36), a BMI≥30 kg/m^2 (OR=1.13, 95% CI:1.00-1.28), current smoking (OR=1.96, 95% CI:1.58-2.43), and ≥15g/d alcohol consumption (OR=1.18, 95% CI:1.01-1.38).

Looking separately at the different types of ties, women who were married or in an intimate relationship were less likely to be current smokers. Women with few friendship ties were more likely to have low levels of physical activity and to be obese, but were less likely to have high alcohol intake. Women engaged in community participation were less likely to report low levels of physical activity or current smoking, but community participation was not associated with other lifestyle variables. Those who did not participate in religious organizations were more likely to report current smoking and high alcohol intake. Small networks of relatives predicted higher alcohol intake but a lower risk of obesity (Supplemental Table 2).

Social networks and BC treatment

Associations between social networks and surgery and hormonal therapy did not differ by cohort and associations were pooled. However, associations of social isolation with odds of

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chemotherapy differed for the WHEL cohort compared with the other three cohorts (*Q* test statistic=8.39, p=0.04), explained by a greater likelihood of receiving chemotherapy among those without religious ties (data not shown), and overall results for WHEL were presented separately.

As indicated, stage was unrelated to social network size (Table 1). However, among women (LACE, NHS, SBCSS) with node positive cancers, those who were socially isolated were more likely not to receive chemotherapy (OR=2.10, 95% CI:1.30-3.39), compared with socially integrated women (no association in WHEL). Associations with hormonal therapy (ER+ cases only, OR=1.09, 95% CI:0.95-1.25), and lumpectomy vs. mastectomy (OR=1.22, 95% CI:0.97-1.55) were in the same direction (socially isolated women more likely not to receive treatment) but were nonsignificant (Table 2). Social network diversity was unrelated to odds of treatment (Table 3).

Regarding different types of social ties, women who were unmarried/not in an intimate relationship were more likely not to receive chemotherapy (OR=1.44, 95% CI:1.03-2.00) or hormonal therapy (OR=1.18, 95% CI:0.99-1.40). Women with few friendship ties were also more likely not to receive chemotherapy (OR=1.54, 95% CI:1.02-2.31) or hormonal treatment (OR=1.32, 95% CI:1.11-1.58). No tie was related to type of surgery. Women with few ties to relatives were also more likely not to receive chemotherapy (OR=1.57, 95% CI: 1.11-2.23), though ties to relatives were unrelated to other types of treatment. Neither community nor religious participation was related to treatment (Supplemental Table 3).

In stratified analysis, associations did not differ by education level. The association with chemotherapy differed somewhat by median age (p-test for interaction=0.06) with the association appearing stronger in older women. There was a significant interaction by comorbidity for type of surgery, with a significantly higher odds of lumpectomy with low social integration (OR=1.35, 95% CI:1.06-1.74) among those without comorbidity and a significantly lower odds of lumpectomy (OR=0.24, 95% CI:0.08-0.69) among those with comorbidity (p-test for interaction=0.002), but only 8% of women in the cohort had any comorbidity. Associations were not qualitatively different when we restricted analyses to those with data provided ≥6 months post-diagnosis.

DISCUSSION

Consistent with our hypothesis, social isolation in BC survivors was related to less favorable post-diagnosis lifestyle factors and less intensive BC treatment. Specifically, socially isolated women were more likely to be current smokers, have low physical activity, have high alcohol intake, and be obese. They were also less likely to receive chemotherapy. Women with low social network diversity also had worse lifestyle, but social network diversity was not independently related to treatment. Types of ties were differently predictive of lifestyle, but friends, relatives, and a spouse/intimate partner were the only significant predictors of treatment. Associations were independent of disease severity, age, obesity, or comorbidity status. To our knowledge, this is the first study examining associations between social networks, social network diversity, and lifestyle and treatment following a BC

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diagnosis. Findings provide evidence for the influence of social environment on lifestyle and clinical factors, which may have implications for survival in women with BC.

Findings for social network size, but not diversity, and chemotherapy suggest that close relationships are important to the ability to undergo chemotherapy. Large social networks may increase the odds that women have friends and family to rely on for instrumental (e.g., rides to the hospital, trips to the pharmacy, assistance with exercise, or provision of healthy meals) and social-emotional support[6]. Having someone to assist with needs may also influence decisions about whether to pursue more intensive treatment, given latitude in treatment decision-making[34]. Nonsignificant associations with hormonal therapy and surgery were in the same direction; women with small social networks consistently received less treatment than did those who were socially integrated. While multiple considerations influence the development of treatment plans, these findings suggest that some women who would benefit from more intensive treatment may not receive it, predicted by level of social integration. Potentially, in the face of side effects, as well as daily responsibilities, women with small social networks may lack adequate support to persist with intensive treatment. Since women with smaller social networks are less healthy and engage in less healthy behavior, social networks could be an indicator of conditions predictive of less intensive treatment such as older age, frailty, or obesity. However, adjustment for age, comorbidity, and BMI did not attenuate associations with clinical factors.

Additional research is needed to determine whether the absence of social support or existence of social strain/obligation leads to different decisions, by the patient or provider, about level of treatment. Collecting data on social ties within health care settings would help identify BC patients at potential risk. Additional work is also needed to determine appropriate intervention strategies in those who differ with regard to the cause of their social isolation including demographic, personality, mental health, and other factors.

Every type of social tie was important to lifestyle factors, depending on the risk factor, whereas only ties to a spouse, friends, or relatives predicted treatment. Differences in the nature and direction of relationships suggest that the roles of social network ties differ; this is consistent with previous literature showing that partners, family, and friends are more important than other ties to provision of informal caregiving[35].

Religious participation was strongly related to lower smoking and alcohol consumption, consistent with previous studies and norms of participation[36]. More favorable lifestyle with community participation suggests that participation helps to maintain better health or that better health enables women to participate. Volunteering and community participation have been related to higher physical activity[37], lower blood pressure and better cardiovascular health. Also consistent with our findings, previous literature has repeatedly shown the salutary effects of being married, including better BC survival[38], though effects may depend on the quality of relationships[39]. The roles of social ties to lifestyle and treatment in BC survivors differed, but in general, larger, more diverse social networks were related to lifestyle and clinical factors associated with better prognosis.

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A major strength of the current analysis was the ability to examine associations in a very large cohort of ethnically, socioeconomically, and geographically diverse BC survivors. Related to this, another strength was the ability to harmonize the studies to develop a valid measure of social networks assessed in each of the cohorts post-diagnosis. In addition, we minimized confounding by adjusting for variables related to BC severity, including stage, hormone receptor status, and HER2 status; reproductive history; and lifestyle, demographic, and socioeconomic variables.

One limitation was the lack of complete social networks information across cohorts. However, generating study-specific tertiles helped to overcome this limitation. Additionally, our results may not generalize to women of lower socioeconomic status (SES), who were not well represented in this population; this may lead to an underestimate of the association since women of low SES have smaller social networks[40]. Strikingly, associations did not differ in the Shanghai vs. the US cohorts. Also, though we had limited power, associations did not appear to differ by white/non-white race/ethnicity within the US (data not shown). Nonetheless, future studies should include a larger number of non-white participants.

Of concern, associations were cross-sectional and disease severity could influence social network size. However, there is evidence that social networks may not change dramatically across diagnosis[4]. Additionally, social networks were not associated with BC stage in this study, notable given that the large sample size can increase the chance of significant associations. Also, while there may be bi-directional influences between social networks and lifestyle factors in BC patients, it is unlikely that treatment would substantially influence marital status or numbers of relatives or living children in this population. We also adjusted for education as a measure of socioeconomic status, a potentially important predictor of both social network variables and lifestyle factors. Of benefit, post-diagnosis data may most accurately reflect the level of support available during and following treatment.

Other limitations include different timing of social networks measures across the cohorts, missing covariate data, and dichotomous treatment outcomes. Despite these limitations, associations were similar across cohorts and sensitivity analyses suggested robust associations. Future work should more carefully look at treatment delays, decisions, and adherence to treatment.

To summarize, smaller, less diverse social networks were related to a higher risk of adverse lifestyle and less intensive treatment in BC survivors. Given the rising costs of health care and the aging of the population, there is a growing need to understand how social relationships influence disease progression.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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REFERENCES

1. American Cancer Society. Cancer Facts & Figures 2015. American Cancer Society; Atlanta, GA: 2015.
2. Berkman, L., Glass, TA. Social integration, social networks, social support, and health. In: Berkman, L., Kawachi, I., editors. Social epidemiology. Oxford University Press; New York, NY: 2000.
3. Chou AF, Stewart SL, Wild RC, Bloom JR. Social support and survival in young women with breast carcinoma. Psychooncology. 2010; 21(2):125–133. [PubMed: 20967848]
4. Kroenke CH, Kubzansky LD, Schernhammer ES, Holmes MD, Kawachi I. Social networks, social support, and survival after breast cancer diagnosis. J Clin Oncol. 2006; 24(7):1105–1111. [PubMed: 16505430]
5. Reynolds P, Boyd PT, Blacklow RS, Jackson JS, Greenberg RS, Austin DF, Chen VW, Edwards BK. The relationship between social ties and survival among black and white breast cancer patients. National Cancer Institute Black/White Cancer Survival Study Group. Cancer Epidemiol Biomarkers Prev. 1994; 3(3):253–259. [PubMed: 8019376]
6. Sherbourne CD, Stewart AL. The MOS social support survey. Soc Sci Med. 1991; 32(6):705–714. [PubMed: 2035047]
7. Christakis NA, Fowler JH. The spread of obesity in a large social network over 32 years. N Engl J Med. 2007; 357(4):370–379. [PubMed: 17652652]
8. Pachucki MA, Jacques PF, Christakis NA. Social network concordance in food choice among spouses, friends, and siblings. Am J Public Health. 101(11):2170–2177. [PubMed: 21940920]
9. Mowbray O, Quinn A, Cranford JA. Social networks and alcohol use disorders: findings from a nationally representative sample. Am J Drug Alcohol Abuse. 2014; 40(3):181–186. [PubMed: 24405256]
10. Cohen S, Doyle WJ, Skoner DP, Rabin BS, Gwaltney JM Jr. Social ties and susceptibility to the common cold. JAMA. 1997; 277(24):1940–1944. [PubMed: 9200634]
11. Barefoot JC, Gronbaek M, Jensen G, Schnohr P, Prescott E. Social network diversity and risks of ischemic heart disease and total mortality: findings from the Copenhagen City Heart Study. Am J Epidemiol. 2005; 161(10):960–967. [PubMed: 15870160]
12. Allen JD, Stoddard AM, Sorensen G. Do social network characteristics predict mammography screening practices? Health Educ Behav. 2008; 35(6):763–776. [PubMed: 17620665]
13. Hawley ST, Griggs JJ, Hamilton AS, Graff JJ, Janz NK, Morrow M, Jagsi R, Salem B, Katz SJ. Decision involvement and receipt of mastectomy among racially and ethnically diverse breast cancer patients. J Natl Cancer Inst. 2009; 101(19):1337–1347. [PubMed: 19720966]
14. Shelton RC, Clarke Hillyer G, Hershman DL, Leoce N, Bovbjerg DH, Mandelblatt JS, Kushi LH, Lamerato L, Nathanson SD, Ambrosone CB, et al. Interpersonal influences and attitudes about adjuvant therapy treatment decisions among non-metastatic breast cancer patients: an examination of differences by age and race/ethnicity in the BQUAL study. Breast Cancer Res Treat. 2013; 137(3):817–828. [PubMed: 23263696]
15. Kroenke CH, Fung TT, Hu FB, Holmes MD. Dietary patterns and survival after breast cancer diagnosis. J Clin Oncol. 2005; 23(36):9295–9303. [PubMed: 16361628]
16. Holmes MD, Chen WY, Feskanich D, Kroenke CH, Colditz GA. Physical activity and survival after breast cancer diagnosis. JAMA. 2005; 293(20):2479–2486. [PubMed: 15914748]
17. Holmes MD, Murin S, Chen WY, Kroenke CH, Spiegelman D, Colditz GA. Smoking and survival after breast cancer diagnosis. Int J Cancer. 2007; 120(12):2672–2677. [PubMed: 17278091]
18. Kroenke CH, Chen WY, Rosner B, Holmes MD. Weight, weight gain, and survival after breast cancer diagnosis. J Clin Oncol. 2005; 23(7):1370–1378. [PubMed: 15684320]
19. Nechuta SJ, Caan BJ, Chen WY, Flatt SW, Lu W, Patterson RE, Poole EM, Kwan ML, Chen Z, Weltzien E, et al. The After Breast Cancer Pooling Project: rationale, methodology, and breast cancer survivor characteristics. Cancer Causes Control. 2011; 22(9):1319–1331. [PubMed: 21710192]
20. Shu XO, Zheng Y, Cai H, Gu K, Chen Z, Zheng W, Lu W. Soy food intake and breast cancer survival. JAMA. 2009; 302(22):2437–2443. [PubMed: 19996398]

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21. Caan B, Sternfeld B, Gunderson E, Coates A, Quesenberry C, Slattery ML. Life After Cancer Epidemiology (LACE) Study: a cohort of early stage breast cancer survivors (United States). Cancer Causes Control. 2005; 16(5):545–556. [PubMed: 15986109]
22. Pierce JP, Faerber S, Wright FA, Rock CL, Newman V, Flatt SW, Kealey S, Jones VE, Caan BJ, Gold EB, et al. A randomized trial of the effect of a plant-based dietary pattern on additional breast cancer events and survival: the Women's Healthy Eating and Living (WHEL) Study. Control Clin Trials. 2002; 23(6):728–756. [PubMed: 12505249]
23. Colditz GA, Hankinson SE. The Nurses' Health Study: lifestyle and health among women. Nat Rev Cancer. 2005; 5(5):388–396. [PubMed: 15864280]
24. Demissie S, LaValley MP, Horton NJ, Glynn RJ, Cupples LA. Bias due to missing exposure data using complete-case analysis in the proportional hazards regression model. Stat Med. 2003; 22(4): 545–557. [PubMed: 12590413]
25. Berkman LF, Syme SL. Social networks, host resistance, and mortality: a nine-year follow-up study of Alameda County residents. Am J Epidemiol. 1979; 109(2):186–204. [PubMed: 425958]
26. Ye J, Williams SD, Xu Z. The association between social networks and colorectal cancer screening in American males and females: data from the 2005 Health Information National Trends Survey. Cancer Causes Control. 2009; 20(7):1227–1233. [PubMed: 19350400]
27. Kroenke CH, Quesenberry C, Kwan ML, Sweeney C, Castillo A, Caan BJ. Social networks, social support, and burden in relationships, and mortality after breast cancer diagnosis in the Life After Breast Cancer Epidemiology (LACE) study. Breast Cancer Res Treat. 2013; 137(1):261–271. [PubMed: 23143212]
28. Loucks EB, Berkman LF, Gruenewald TL, Seeman TE. Relation of social integration to inflammatory marker concentrations in men and women 70 to 79 years. Am J Cardiol. 2006; 97(7):1010–1016. [PubMed: 16563907]
29. Hampton, K., Goulet, LS., Rainie, L., Purcell, K. Pew Research Internet Project. Pew Research Center; Washington, D.C.: 2011. Social networking sites and our lives.
30. Beasley JM, Kwan ML, Chen WY, Weltzien EK, Kroenke CH, Lu W, Nechuta SJ, Cadmus-Bertram L, Patterson RE, Sternfeld B, et al. Meeting the physical activity guidelines and survival after breast cancer: findings from the after breast cancer pooling project. Breast Cancer Res Treat. 2011
31. Kwan ML, Chen WY, Flatt SW, Weltzien EK, Nechuta SJ, Poole EM, Holmes MD, Patterson RE, Shu XO, Pierce JP, et al. Postdiagnosis alcohol consumption and breast cancer prognosis in the after breast cancer pooling project. Cancer Epidemiol Biomarkers Prev. 2013; 22(1):32–41. [PubMed: 23150063]
32. Smith-Warner SA, Spiegelman D, Ritz J, Albanes D, Beeson WL, Bernstein L, Berrino F, van den Brandt PA, Buring JE, Cho E, et al. Methods for pooling results of epidemiologic studies: the Pooling Project of Prospective Studies of Diet and Cancer. Am J Epidemiol. 2006; 163(11):1053–1064. [PubMed: 16624970]
33. DerSimonian R, Laird N. Meta-analysis in clinical trials. Control Clin Trials. 1986; 7(3):177–188. [PubMed: 3802833]
34. National Comprehensive Cancer Network. NCCN Guidelines for Patients, Reports, Stages 0-IV. NCCN; Fort Washington, PA: 2014.
35. Romito F, Goldzweig G, Cormio C, Hagedoorn M, Andersen BL. Informal caregiving for cancer patients. Cancer. 2013; 119(Suppl 11):2160–2169. [PubMed: 23695928]
36. Strawbridge WJ, Shema SJ, Cohen RD, Kaplan GA. Religious attendance increases survival by improving and maintaining good health behaviors, mental health, and social relationships. Ann Behav Med. 2001; 23(1):68–74. [PubMed: 11302358]
37. Tan EJ, Xue QL, Li T, Carlson MC, Fried LP. Volunteering: a physical activity intervention for older adults--The Experience Corps program in Baltimore. J Urban Health. 2006; 83(5):954–969. [PubMed: 16763775]
38. Aizer AA, Chen MH, McCarthy EP, Mendu ML, Koo S, Wilhite TJ, Graham PL, Choueiri TK, Hoffman KE, Martin NE, et al. Marital Status and Survival in Patients With Cancer. J Clin Oncol. 2013; 31(31):3869–3876. [PubMed: 24062405]

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39. Yang HC, Schuler TA. Marital quality and survivorship: slowed recovery for breast cancer patients in distressed relationships. Cancer. 2009; 115(1):217–228. [PubMed: 18951520]

40. Ajrouch KJ, Blandon AY, Antonucci TC. Social networks among men and women: the effects of age and socioeconomic status. J Gerontol B Psychol Sci Soc Sci. 2005; 60(6):S311–S317. [PubMed: 16260713]

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Table 1

Selected baseline characteristics* by category of social network size, in the After Breast Cancer Pooling Project (N=9,331)

	Size of social networks			
	Socially isolated	**Moderately integrated**	**Socially integrated**	**p-value****
N	**1,965**	**4,184**	**3,182**	
Mean time from diagnosis to post-diagnosis assessment (days)	506	497	491	<0.001
Low social diversity (%)	50.5	50.7	57.4	<0.001
Comorbidity (%)	8.7	8.2	8.2	0.36
Study (%)				
LACE	16.0	20.7	24.1	<0.001
NHS	23.8	23.8	23.9	
SBCSS	19.0	23.8	25.9	
WHEL	41.2	31.7	26.2	
Demographic variables				
Age at diagnosis (mean years)	56	57	57	<0.001
Ethnicity (%)				
Caucasian	71.2	66.1	64.3	<0.001
African-American	2.1	2.3	2.6	
Asian	21.4	26.5	27.9	
Hispanic/Latino	3.3	3.3	3.0	
Other	2.1	1.9	2.3	
Education				
Less than HS	11.0	12.8	14.0	<0.001
HS	16.0	17.7	18.6	
Some college	19.2	19.9	18.9	
College degree or greater	53.8	49.4	48.5	
Severity of disease				
Stage (%)				
I	43.6	44.7	45.6	0.63
II	42.1	41.8	40.6	
III	14.1	13.1	13.4	
IV	0.2	0.4	0.5	
ER positive tumor (%)	76.3	76.0	75.0	0.20
HER-2-neu positive (%) (N=5930)	16.2	18.5	19.6	0.04
Reproductive factors				
Postmenopausal at diagnosis (%)	59.9	62.6	64.5	0.17
Nulliparous (%)	27.4	12.7	5.2	<0.001

* Except for age, all variables age-adjusted

** p-value, continuous variable, or p-value, Mantel-Haenszel $\chi 2$ test for categorical variables

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Table 2

Relative adjusted odds of adverse lifestyle and related factors by level of social integration in the ABCPP (N=9,331).

	Socially integrated	Moderately integrated	Socially isolated	p-value*
N	2,619	3,428	1,573	
<10 MET-hrs physical activity/wk	1,126	1,659	845	
OR	1.00	**1.29**	**1.55**	**<0.001**
95% CI		**(1.16, 1.44)**	**(1.36, 1.78)**	
N	2,763	3,581	1,656	
Obesity (BMI ≥ 30 kg/m2)	545	701	404	
OR	1.00	0.97	**1.21**	**0.03**
95% CI		(0.85, 1.10)	**(1.03, 1.42)**	
N	2,354	3,185	1,588	
Current smoking (US cohorts) *	89	209	149	
OR	1.00	**1.63**	**2.77**	**<0.001**
95% CI		**(1.26, 2.12)**	**(2.09, 3.68)**	
N	2,289	3,052	1,527	
Alcohol intake ≥15 g/d (US cohorts) *	258	386	222	
OR	1.00	1.04	**1.23**	**0.03**
95% CI		(0.88, 1.25)	**(1.00, 1.51)**	
N, LACE, NHS, SBCSS **	744	877	341	
No chemotherapy (Node+ cases) (%)	71	105	56	
OR	1.00	**1.59**	**2.10**	**<0.001**
95% CI		**(1.06, 2.38)**	**(1.30, 3.39)**	
N, WHEL	348	564	345	
No chemotherapy (Node+ cases) (%)	24	54	20	
OR	1.00	1.05	0.76	0.14
95% CI		(0.57, 1.91)	(0.36, 1.59)	
N	2,306	3,067	1,428	
No hormone therapy (ER+ cases) (%)	345	493	256	
OR	1.00	1.05	1.09	0.11
95% CI		(0.90, 1.22)	(0.95, 1.25)	
N	3,182	4,184	1,965	
Lumpectomy vs. mastectomy (%)	1,157	1,597	796	
OR	1.00	1.04	1.22	0.21
95% CI		(0.86, 1.26)	(0.97, 1.55)	

Adjusted for age (continuous), time between diagnosis and social network assessment (continuous), study (LACE, NHS (ref), WHEL, SBCSS), education (<HS, HS, some college, college degree or greater (ref)), race (White (ref), Black, Asian, Hispanic, other), stage (I (ref), II, III, IV), estrogen receptor status (no (ref), yes), Her2 neu status (no (ref), yes), parity (nulliparous, 1 pregnancy>20 weeks and age at first birth<20, 1 pregnancy>20 weeks and age at first birth≥20, 2+ and age at first birth<20, 2+ and age at first birth≥20), menopausal status (premenopausal, postmenopausal (ref)), comorbidity (no (ref), yes), chemotherapy (no (ref), yes), radiation (no (ref), yes), surgery (no, lumpectomy, mastectomy (ref), other), hormonal therapy (none (ref), tamoxifen, aromatase inhibitors, or both), alcohol intake (none (ref), >0-<1.7, 1.7-<15, 15+ g/d), smoking (never (ref), past, current), physical activity (0-<10 (ref), 10-<20, 20+ METS/wk), body mass index (<18.5, 18.5-25 (ref), 25-<30, 30+ kg/

m2), and simultaneously for social network diversity (high (ref), low). Analyses adjusted for variables other than those specifically analyzed or restricted.

*p-value, standardized, continuous measure of social network size

**Q test statistic=8.39, p=0.04, for test whether the association for social isolation and odds of chemotherapy differed by cohort and so results for WHEL presented separately.

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Table 3

Relative adjusted odds of adverse lifestyle and related factors by level of social network diversity in the ABCPP (N=9,331).

	Higher diversity network	Lower diversity social network	p-value*
N	3,505	4,115	
<10 MET-hrs physical activity/wk	1,562	2,068	
OR	1.00	**1.23**	**<0.001**
95% CI		**(1.12, 1.36)**	
N	3,770	4,230	
Obesity (BMI ≥ 30 kg/m2)	736	914	
OR	1.00	**1.13**	**0.04**
95% CI		**(1.00, 1.28)**	
N	3,425	3,702	
Current smoking (US cohorts)*	149	298	
OR	1.00	**1.96**	**<0.001**
95% CI		**(1.58, 2.43)**	
N	3,297	3,571	
Alcohol intake ≥15 g/d (US cohorts)*	389	477	
OR	1.00	**1.18**	**0.03**
95% CI		**(1.01, 1.38)**	
N	1,553	1,666	
No chemotherapy (Node+ cases) (%)	166	164	
OR	1.00	0.84	0.25
95% CI		(0.63, 1.13)	
N	3,206	3,595	
No hormone therapy (ER+ cases) (%)	522	572	
OR	1.00	1.09	0.25
95% CI		(0.95, 1.25)	
N	4,394	4,937	
Lumpectomy vs. mastectomy (%)	1,709	1,841	
OR	1.00	0.92	0.36
95% CI		(0.78, 1.10)	

Adjusted for age (continuous), time between diagnosis and social network assessment (continuous), study (LACE, NHS (ref), WHEL, SBCSS), education (<HS, HS, some college, college degree or greater (ref)), race (White (ref), Black, Asian, Hispanic, other), stage (I (ref), II, III, IV), estrogen receptor status (no (ref), yes), Her2 neu status (no (ref), yes), parity (nulliparous, 1 pregnancy>20 weeks and age at first birth<20, 1 pregnancy>20 weeks and age at first birth≥20, 2+ and age at first birth<20, 2+ and age at first birth≥20), menopausal status (premenopausal, postmenopausal (ref)), comorbidity (no (ref), yes), chemotherapy (no (ref), yes), radiation (no (ref), yes), surgery (no, lumpectomy, mastectomy (ref), other), hormonal therapy (none (ref), tamoxifen, aromatase inhibitors, or both), alcohol intake (none (ref), >0-<1.7, 1.7-<15, 15+ g/d), smoking (never (ref), past, current), physical activity (0-<10 (ref), 10-<20, 20+ METS/wk), body mass index (<18.5, 18.5-25 (ref), 25-<30, 30+ kg/m2), and simultaneously for level of social integration (socially integrated (ref), moderately integrated, socially isolated). Analyses adjusted for variables other than those specifically analyzed or restricted.

*p-value, continuous ordinal variable