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Healthy lifestyle impact on breast cancer-specific and all-cause mortality

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Abstract

Purpose—While several studies have evaluated the association of combined lifestyle factors on breast cancer-specific mortality, few have included Hispanic women. We constructed a "healthy behavior index" (HBI) and evaluated its associations with mortality in non-Hispanic White (NHW) and Hispanic women diagnosed with breast cancer from the southwestern U.S.

Methods—Diet and lifestyle questionnaires were analyzed for 837 women diagnosed with invasive breast cancer (1999–2004) in New Mexico as part of the 4-Corners Women's Health Study. An HBI score ranging from 0 to 12 was based on dietary pattern, physical activity, smoking, alcohol consumption, and body size and shape, with increasing scores representing less healthy characteristics. Hazard ratios for mortality over 14 years of follow-up were estimated for HBI quartiles using Cox proportional hazards models adjusting for education and stratified by ethnicity and stage at diagnosis.

Results—A significant increasing trend was observed across HBI quartiles among all women, NHW women, and those diagnosed with localized or regional/distant stage of disease for all-cause (AC) mortality (p-trend = 0.006, 0.002, 0.03, respectively). AC mortality was increased >2-fold for all women and NHW women in HBI Q4 versus Q1 (HR = 2.18, 2.65, respectively). The association was stronger in women with regional/distant than localized stage of disease (HR = 2.62, 1.94, respectively). Associations for Hispanics or breast cancer-specific mortality were not significant.

Conclusions—These findings indicate the associations between the HBI and AC mortality, which appear to differ by ethnicity and stage at diagnosis. Interventions for breast cancer survivors should address the combination of lifestyle factors on prognosis.

Kathy B. Baumgartner and Stephanie D. Boone were Co-senior authors.

Compliance with ethical standards

Conflict of interest

The authors declare that they have no conflict of interest.**Ethical standards**

This study complies with the current laws of the country in which it was performed.

Keywords

Breast cancer; Breast cancer-specific mortality; All-cause mortality; Lifestyle recommendations; Hispanic

Introduction

Despite advancements in detection and treatment, breast cancer remains the second leading cause of death for women in the US [1]. Modifiable lifestyle factors including diet [2–5], smoking status [6–8], physical activity [9–11], moderate/heavy alcohol consumption [12–14], as well as body size and shape [15–17] are associated with breast cancer risk, recurrence, and mortality. The American Cancer Society (ACS) Nutrition and Physical Activity Guidelines Advisory Committee has issued a comprehensive set of recommendations aimed at promoting health for cancer survivors through health behavior modifications [18].

Data suggest that many health behaviors occur in combination [19]; therefore, a composite variable may better capture how lifestyle factors act synergistically to influence breast cancer-specific and all-cause mortality. Consistent positive associations have been found in several studies between a composite lifestyle variable and both breast cancer risk [20–27] and all-cause mortality [20, 21, 28–31]. The combined effect of lifestyle factors on the inflammatory pathway may contribute to these associations [32–36]. Findings have been inconclusive, however, for breast cancer-specific mortality [20], and few studies have examined associations in racial/ethnic minorities. Evidence shows that Hispanic/Native Ameri-can (NA) women have a higher risk of breast cancer-specific mortality than non-Hispanic white (NHW) women [37–39] as well as less favorable prognostic factors [40–42].

The objective of this analysis was to construct a “healthy behavior index” (HBI) combining lifestyle and body size measures and to evaluate associations with all-cause and breast cancer-specific mortality in NHW and Hispanic women. Based on the findings of the previously described studies, we hypothesized that the HBI would be associated with breast cancer-specific and all-cause mortality in both racial/ethnic groups [2–17, 20, 21, 28–31], but that the association would be stronger in NHW than Hispanic women [37–42].

Methods

Study population

Data were from the New Mexico site of the 4-Corners Women’s Health Study (4-CWHS), a multi-site case–control study previously described in detail [43]. The main objective of 4-CWHS was to illuminate reasons for disparities in breast cancer incidence and survival between Hispanic and NHW women living in the US southwest. Controls were not included in the present analyses as the focus is on mortality in women diagnosed with breast cancer. Breast cancer cases were Hispanic and NHW women aged 25–79 years living in New Mexico with histologically confirmed first primary in situ (stage 0) or invasive (stages I–IIIA) breast cancer diagnosis between October 1999 and May 2004. Hispanic and NA women were combined for analysis due to the small number of women identifying as NA (*n*

= 6). Cases were ascertained from the New Mexico SEER cancer registry with ethnicity verified as described previously [44]. Cases considered as outliers (n = 4) or missing information for risk factor/outcome variables or covariates (n = 98) were excluded from analyses. In situ cases (n = 151) were excluded because of their high five-year relative survival rate (98.8%) [1]. The final analytic sample included 837 invasive cases, of which 64.5% (n = 540) identified as NHW and 35.5% (n = 297) identified as Hispanic/NA.

Data collection

Data were collected via in-person interviewer-administered computerized questionnaires. Weight, height, and waist/hip circumference were measured. Participants reported information on dietary intake and lifestyle factors during the referent year, one year prior to breast cancer diagnosis. Stage at diagnosis was obtained from the New Mexico Tumor Registry (NMTR), as well as vital status and date and cause of death (via the National Death Index). Vital status information was available through December 31, 2009. Written informed consent was obtained prior to participation for all cases and the study was conducted under the approval of the Institutional Review Board at the University of Louisville.

Healthy behavior index

The HBI was constructed from smoking status, alcohol consumption, dietary pattern, vigorous physical activity, body mass index (BMI), and waist-to-hip ratio using the criteria shown in Table 1. BMI (kg/m^2) was based on the ACS recommendation "be as lean as possible throughout life without being underweight" [18] and categorized using standard cut-points. Alcohol consumption (standard drinks/day) was categorized based on the ACS recommendation that women consume no more than one standard drink (approximately 14 g of alcohol)/day [18]. Vigorous physical activity (minutes/week) was defined as "activities generally using large muscle groups and resulting in faster heart rate, deeper and faster breathing, and sweating" [18]; it was assessed in accordance with the ACS recommendation of 75 min/week [18]. Continuous variables, dietary pattern and waist-to-hip ratio (inches), were categorized into tertiles (T) based on the distribution in controls. Dietary pattern was defined using a "Western diet" variable developed previously in the 4-CWHS [45] in which higher scores reflected a diet high in dairy fat, refined grains, red meat, sugar, and fast foods, but low in fresh fruits and vegetables. Ever smoking was defined as 100 cigarettes or more in a lifetime, and categorized into current, former, and never smoking status.

Individual HBI components were assigned the scores of 0–2, with lower scores indicating a healthier lifestyle. Scores were assigned as defined in Table 1. An HBI summary score of 0–12 was calculated by summing the scores for the individual HBI components. The resulting HBI distribution was categorized into quartiles (Q) for analysis as follows: Q1 = 0–3, Q2 = 4–5, Q3 = 6–7, Q4 = 8–12 (Table 1).

Covariates, clinical characteristics, and outcome variables

Education was assessed as less than high school, high school/GED, and greater than high school. Women were classified as premenopausal if they were having periods or pregnant during the referent year. Women who reported natural menopause or menopause due to medical intervention were classified as postmenopausal. Race/ethnicity was self-reported as

NHW or Hispanic. Stage at diagnosis was assessed as localized (stage I), regional (stage II), and distant (stage IIIA). All-cause mortality was defined as death due to any cause, and breast cancer-specific mortality was defined using International Classification of Disease (ICD) code 50 [46] (Table 1).

Statistical analysis

Descriptive statistics were calculated by HBI quartiles for age, survival time, race, education, menopausal status, smoking status, BMI, alcohol consumption, vigorous physical activity, dietary pattern, waist-to-hip ratio, and stage at diagnosis. Differences between quartiles were assessed using analysis of variance (ANOVA) for continuous variables and the Mantel–Haenszel Chi-square test for categorical variables. Kaplan–Meier curves were constructed for breast cancer-specific survival and overall survival in years by HBI quartiles, and log-rank p values were calculated for differences between quartiles. Cox proportional hazards regression modeling was used to evaluate the association between the HBI and breast cancer-specific and all-cause mortality controlling for pertinent covariates. Hazard ratios (HR) and 95% confidence intervals (CI) were estimated for HBI quartiles with Q1 as the referent group and months from diagnosis to the end of the study or censor date as the time scale. All models were adjusted for education. Other covariates were retained in the models if their inclusion produced a change of ≥10% in the HR for HBI. Effect modification by self-reported ethnicity and stage at diagnosis was evaluated. Regional and distant stages of disease were combined due to the small number of women with distant stage of disease. The linear trend across HBI quartiles was estimated (p-trend) by entering HBI as a continuous variable in the models. Participants were censored if they were lost to follow-up, or in the analysis of breast cancer-specific mortality, if they died of causes not related to breast cancer. The proportional hazards assumption was tested graphically and statistically using an interaction of main effects and covariates with the log of survival time. All analyses met the proportional hazards assumption. Analyses were conducted using the SAS statistical package (version 9.4, SAS Institute, Cary, NC).

Results

The study population was predominantly NHW women compared to Hispanic women (64.5% vs. 35.5%, respectively) (Table 2). Race/ethnicity differed significantly between HBI quartiles ($p = 0.02$); the highest proportion of NHW women were in Q2 (34.6%), while the highest proportion of Hispanic women were in Q3 (35.4%). The mean age of women in Q1 was three years younger than in Q4 ($p = 0.02$). Education was inversely associated with HBI (e.g., 76.4% > high school in Q1 versus 55.9% in Q4, $p = 0.0002$). The majority of women were post-menopausal; however, healthier quartiles had a larger proportion of premenopausal women (46.2% in Q1 vs. 29.4% in Q4, $p = 0.005$). Stage at diagnosis did not differ significantly between HBI quartiles ($p = 0.53$). In all quartiles, the largest proportion of women were diagnosed with localized stage of disease (67.3, 69.0, 65.4, and 63.7%, respectively). However, the percentage of women with regional/distant stage of disease was higher in Q4 than in Q1–Q3 (36.3% vs. 32.2, 30.7, and 34.2%, respectively). All component variables of the HBI differed significantly by HBI quartile ($p < 0.0001$).

During the 14 years of follow-up, overall survival differed significantly by HBI quartile (p = 0.046) (Table 2). Comparing mean years of survival, women in HBI Q1 and Q2 lived 0.8 years longer than women in Q4. Survival rates did not significantly differ between quartiles for breast cancer survival (log-rank p value = 0.81) (Fig. 1). However, a decreasing trend in survival was observed as HBI quartile increased (84, 85, 86, and 77%, respectively). Survival rates significantly differed between quartiles of the HBI for overall survival (log-rank p value = 0.0005); the rate was similar across Q1–Q3 (70, 71, and 71%, respectively) but lower in Q4 (53%) (Fig. 2).

We evaluated the association between the HBI and breast cancer-specific and all-cause mortality for all women and stratified by race/ethnicity, adjusting for education level and stage at diagnosis (Tables 3 and 4). An increased risk of breast cancer-specific mortality was present for HBI Q3–Q4 compared to Q1, but was not statistically significant overall by race/ethnicity in crude or adjusted models. A significant increasing trend across HBI quartiles for all-cause mortality was observed among all women and NHW women (p-trend = 0.006 and 0.002, respectively), but not among Hispanic women. A significant > 2-fold increased risk of all-cause mortality was observed for all women and NHW women in HBI Q4 compared to Q1. Adjusting for education level and stage at diagnosis attenuated the results slightly (HR = 2.18 in all women, HR = 2.65 in NHW). Despite the observed differences in associations in racial/ethnic groups, the interaction between HBI quartile and race/ethnicity was not statistically significant (p-interaction = 0.60).

Results of analyses stratified by stage at diagnosis are shown in Table 5. HBI was not significantly associated with breast cancer-specific mortality in women with localized or regional/distant stage of disease. However, results differed by stage; women in Q2–Q4 with localized stage of disease had decreased risk compared to Q1, whereas women in Q2–Q4 with regional/distant stage of disease had increased risk compared to Q1. A significant increasing trend across HBI quartiles was observed among women diagnosed with regional/distant stage of disease for all-cause mortality (p-trend = 0.03). A significantly increased risk of all-cause mortality for HBI Q4 compared to Q1 was present for women with localized and regional/ distant stage of disease. However, this association was stronger in women with regional/distant than in localized stage of disease (HR = 2.49 and 1.94, respectively). The interaction between HBI quartile and stage of disease did not significantly influence risk of breast cancer-specific or all-cause mortality (p-interaction = 0.65 and 0.92, respectively).

Discussion

This analysis sought to evaluate the combined effect of lifestyle factors, in terms of a healthy behavior index, on breast cancer-specific and all-cause mortality in NHW and Hispanic women diagnosed with invasive breast cancer. We observed a statistically significant association between the HBI and all-cause mortality. An increased risk of breast cancer-specific mortality for HBI Q2–Q4 compared to Q1 was present, but was not statistically significant overall, by ethnicity, or by stage of disease. Risk was significantly increased >2-fold for HBI Q4 versus Q1 for all-cause mortality among all women and NHW women, but not in Hispanic women.

Few studies have investigated the combined impact of lifestyle factors on breast cancer-specific mortality. Our results agree with those from the Women's Health Initiative (WHI) prospective cohort study, which did not find a significant association for a similar index with breast cancer-specific mortality [20]. However, a significant *p*-trend was reported in WHI for a positive association between adherence to ACS guidelines and breast cancer-specific mortality (*p*-trend = 0.049) [20], in contrast to our study. However, our study is smaller with less statistical power to detect small associations [20].

The relationship between a combination of lifestyle factors and all-cause mortality has been examined in six studies [20, 21, 28–31], although not all of these studies included women diagnosed with breast cancer. Consistent reductions in risk ranging from 27 to 68% over 10.5–24 years of follow-up were reported in those with the highest adherence to cancer prevention guidelines compared to the lowest adherence [20, 21, 28–31]. Similarly, a significant *p*-trend was reported as adherence to cancer prevention guidelines increased in several studies [20, 29, 30]. A large proportion of all-cause mortality in cancer patients consists of deaths due to cardiovascular and pulmonary diseases [47]. Since these outcomes have consistently been linked to individual lifestyle factors [48, 49], it is likely that they may also be associated with the combination of lifestyle factors. Several prospective cohort studies have reported a significantly reduced risk of death due to cardiovascular disease (HR = 0.21–0.59) among those displaying the greatest adherence to cancer prevention guidelines compared to those displaying the lowest adherence [28–31, 50].

Race/ethnicity is a significant predictor of both all-cause and breast cancer-specific mortality [51–54]. An unresolved question is that to which extent race/ethnicity modifies the associations of lifestyle factors with mortality. We detected no effect modification by race/ethnicity for breast cancer-specific mortality. To our knowledge, this is the first combined lifestyle factor study to evaluate race/ ethnicity as an effect modifier for breast cancer-specific mortality. We did detect effect modification by race/ethnicity for all-cause mortality, which is consistent with the findings of Thomson et al. [20]. However, there was a stronger association between all-cause mortality and adherence to ACS guidelines for Hispanic women than for NHW women (HR = 0.56 and 0.73, respectively) in their study, whereas a statistically significant association was found in NHW women but not in Hispanic women in the present study.

Stage at diagnosis is a strong predictor of breast cancer survival [1]. To our knowledge, this is the first combined lifestyle factor study to evaluate stage at diagnosis as an effect modifier for breast cancer-specific mortality or all-cause mortality. We detected no effect modification by stage at diagnosis for breast cancer-specific mortality. However, we did detect differences by stage at diagnosis for all-cause mortality; the association was stronger for regional/distant stage of disease than localized stage of disease, and a larger proportion of deaths took place in regional/distant than localized (33.8% vs. 45.9%). Comorbid conditions may have played a role in this relationship. Research suggests that women with comorbid conditions tend to be diagnosed with breast cancer at a later stage of disease [55] and have lower rates of cancer screening than women without comorbidities [56, 57]. Women with advanced disease may also receive more intensive treatment with

chemotherapeutic drugs and radiotherapy that may exacerbate the underlying non-cancer diseases such as cardiovascular disease [58, 59].

Inconsistencies among studies could partially be explained by differences in the construction of the composite lifestyle variable. The majority of the studies used women displaying the poorest adherence to lifestyle recommendations as the referent group [20–27, 29–31, 50], while we used the quartile with the healthiest lifestyle factors. Several studies constructed the composite variable based on different sets of cancer prevention guidelines [22–24, 26, 27, 30, 50], which differed from our HBI as well as other indices constructed based on ACS guidelines [20, 21, 29]. Scoring for the individual components of the composite variable also differed between studies.

No studies have evaluated the mechanism by which the combination of lifestyle factors might affect breast cancer-specific mortality; however, these lifestyle factors may individually act through several mechanisms that could operate synergistically to increase risk of breast cancer-specific mortality. Obesity is associated with chronic inflammation, increased plasma estrogen, insulin-like growth factor 1 (IGF-1), and insulin levels [32, 60–63]. Obesity-induced chronic inflammation has been associated with increased tumor size, high tumor grade, and increased tumor metastasis [32]. Physical activity modulates serum estrogen levels and immune function [64, 65] as well as insulin levels [66, 67]. Diets low in fruits and vegetables and high in red meat have been linked to increased risk of weight gain and/or obesity [68, 69]. Additionally, diets high in fruits and vegetables may exert a protective effect against breast cancer-specific mortality [70], and some components of cooked meat may increase invasiveness of breast cancer cells [71, 72]. Alcohol consumption has been linked to increases in tumor progression, serum estrogen levels, and expression of growth factors that promote tumor angiogenesis [73–76]. Smoking is reported to increase the production of inflammatory mediators and suppress immune function [33, 77], and has been associated with larger tumor size [78], increased risk of cancer metastasis [78, 79], and hormone receptor-negative cancers [80].

These lifestyle factors also may influence risk of all-cause mortality through cardiovascular and pulmonary conditions. Obesity and increased waist-to-hip ratio are associated with increased cardiac demand of adipose tissue [81, 82] and metabolic syndrome [83], which includes such risk factors as hypertension, glucose intolerance, and dyslipidemia [34, 84]. Increased leptin and IGF-1 concentrations are associated with inflammation, prothrombotic state, endothelial damage, and vascular hypertrophy [85, 86]. Physical activity exerts a protective effect against cardiovascular disease by creating favorable changes in inflammatory markers, lipids, cholesterol, and hypertension [87]. It also contributes to “vascular conditioning” and improvements in the function of vessel walls [88]. Recent research has focused on the importance of dietary pattern in cardiometabolic risk [89, 90]. Diets high in fruits and vegetables and whole grains and low in animal fats have been linked to decreased risk of obesity and reduced cardiac events [69, 91], which may be explained by favorable effects on blood pressure, serum insulin levels, inflammation, blood lipoproteins and lipids, and endothelial function [35]. Although light alcohol consumption has been shown to exert a protective effect against all-cause mortality and cardiovascular disease [92], heavy drinking has been associated with hypertension [93] and increased risk of mortality

due to stroke, cancer, cirrhosis, and alcoholic cardiomyopathy [94–96]. Oxidant chemicals found in cigarette smoke have been linked to inflammation, thrombosis, and endothelial dysfunction, while exposure to nicotine is associated with hypertension [36, 97]. An association has also been found between smoking and higher serum triglyceride, higher low-density lipoprotein (HDL), and lower high-density lipoprotein (LDL) [98]; it has been hypothesized that these changes may contribute to the development of insulin resistance [99].

Our study has a number of strengths. The population-based study design allowed for the recruitment of a large number of participants, and cases were ascertained through a SEER cancer registry. This study is one of the first to investigate the association of combined lifestyle factors on breast cancer-specific and all-cause mortality in a Hispanic population within the U.S. The collection of comprehensive diet and lifestyle data through in-person interviews allowed for all ACS guidelines to be included in the construction of the HBI. The 14-year follow-up period increased the likelihood for mortality events for both localized and regional/distant stages of disease. The likelihood of misclassification was reduced through ascertainment of vital status and cause of death data from the National Death Index and the New Mexico Tumor Registry.

There are several limitations related to our study. Statistical power was limited due to the low number of events within each quartile of the HBI, particularly in terms of breast cancer-specific mortality. Since data were collected retrospectively and self-reported, it is possible that the data could have been subject to recall bias. An additional vital status update could increase the number of deaths per quartile of the HBI, resulting in an increase in statistical power. The analysis did not account for lifestyle changes that may have taken place over the course of follow-up since HBI scores were based on the data reported for lifestyle in the referent year.

In summary, these data indicate that the combination of unhealthy lifestyle factors is significantly associated with risk of all-cause mortality and may be associated with risk of breast cancer-specific mortality. Further research is necessary on the association between the combination of lifestyle factors and breast cancer-specific mortality, particularly in racial/ethnic minorities. Since these factors are associated with poorer outcomes both individually and in combination, interventions for breast cancer survivors should address the combination of lifestyle factors and their effect on prognosis, recurrence, and second primaries.

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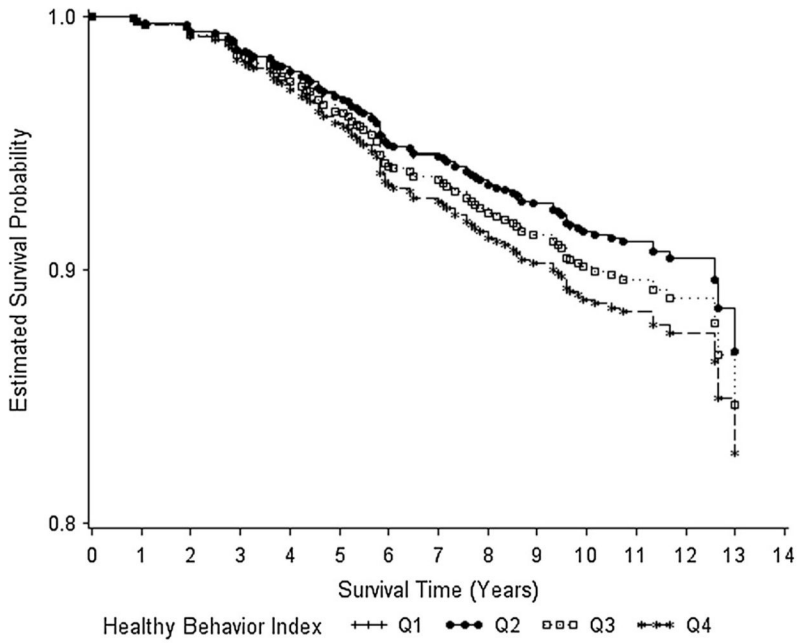

Fig. 1.

Breast cancer survival by healthy behavior index quartiles (Q). Survival curves adjusted for stage at diagnosis and education level; Q1 and Q2 overlap

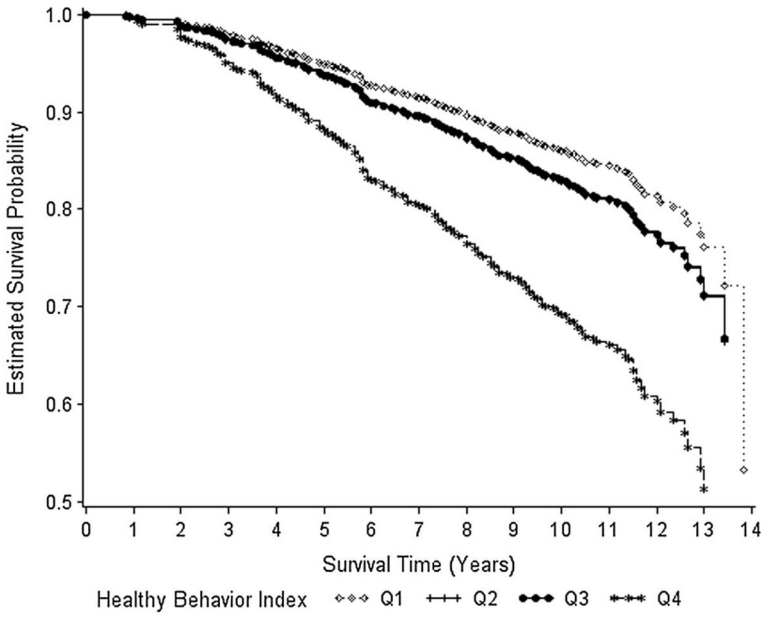

Fig. 2.

Overall survival by healthy behavior index quartiles (Q). Survival curves adjusted for stage at diagnosis and education level; Q2 and Q3 overlap

Table 1

Summary of outcome and healthy behavior index variables

Variable	Definition
All-cause mortality	Deceased any cause
Breast cancer-specific mortality	ICD C50 COD
Smoking status	0 = Never
	1 = Former
	2 = Current
Body mass index (kg/m^2)	0 = Normal, <25
	1 = Overweight, 25–30
	2 = Obese, ≥30
Waist-to-hip ratio (inches)	0 = <0.775
	1 = 0.775–0.84
	2 = ≥0.84
Alcohol consumption (std drinks/day)	0 = ≤0.5
	1 = 0.5–1
	2 = > 1
Dietary pattern *	0 = T1
	1 = T2
	2 = T3
Vigorous physical activity (min/week)	0 = > 75
	1 = ≤75
	2 = none
Healthy behavior index	Q1 = 0–3
	Q2 = 4–5
	Q3 = 6–7
	Q4 = 8–12

Q quartiles, *T* tertiles, *HBI* healthy behavior index

* High in dairy fat, refined grains, snacks, gravies and sauces, potatoes, bacon, beef, sugary drinks and desserts, prepared foods, and fast foods; low in fresh fruits and vegetables

Table 2

Descriptive statistics for demographic and prognostic variables by healthy behavior index quartiles, New Mexico site of 4-Corners Women's Health Study (N = 837)

Characteristic	Healthy behavior index								p^a
	Q1 (0–3) *n* = 208		Q2 (4–5) *n* = 284		Q3 (6–7) *n* = 243		Q4 (8–12) *n* = 102		
	n	%	*n*	%	*n*	%	*n*	%	
Age (years; mean ± SD)	53.1 ± 11.3		56.2 ± 11.7		55.5 ± 12.1		56.1 ± 11.2		0.02
Survival (years; mean ± SD)	10.3 ± 2.5		10.3 ± 2.7		10.1 ± 2.6		9.5 ± 3.4		0.046
Race									0.02
Non-Hispanic White	145	69.7	187	65.9	138	56.8	70	68.6	
Hispanic	63	30.3	97	34.2	105	43.2	32	31.4	
Education									
<High school	13	6.3	29	10.2	38	15.6	17	16.7	0.0002
High school/GED	36	17.3	70	24.7	70	28.8	28	27.5	
>High school	159	76.4	183	64.4	135	55.6	57	55.9	
Menopausal status									0.005
Premenopausal	96	46.2	93	32.8	83	34.2	30	29.4	
Postmenopausal	112	53.9	191	67.3	160	65.8	72	70.6	
Smoking status									<0.0001
Never	153	73.6	164	57.8	125	51.4	17	16.7	
Former	48	23.1	86	30.3	70	28.8	42	41.2	
Current	7	3.4	34	12.0	48	19.8	43	42.2	
Body mass index (kg/m^2)									<0.0001
Normal, <25	165	79.3	136	47.9	50	20.6	11	10.8	
Overweight, 25–30	41	19.7	113	39.8	96	39.5	35	34.3	
Obese, ≥30	2	0.96	35	12.3	97	39.9	56	54.9	
Alcohol consumption (std drinks/day)									<0.0001
≤0.5	186	89.4	237	83.5	199	81.9	65	63.7	
0.5–1	19	9.1	26	9.2	19	7.8	13	12.8	
>1	3	1.4	21	7.4	25	10.3	24	23.5	
Vigorous physical activity (min/wk)									<0.0001

Characteristic	Healthy behavior index								p^a
	Q1 (0–3) *n* = 208		Q2 (4–5) *n* = 284		Q3 (6–7) *n* = 243		Q4 (8–12) *n* = 102		
	n	%	*n*	%	*n*	%	*n*	%	
>75	110	52.9	68	23.9	32	13.2	2	2.0	
≤75	64	30.8	107	37.7	79	32.5	15	14.7	
None	34	16.4	109	38.4	132	54.3	85	83.3	
Dietary pattern									<0.0001
T1	107	51.4	88	31.0	30	12.4	2	2.0	
T2	82	39.4	118	41.6	90	37.0	26	25.5	
T3	19	9.1	78	27.5	123	50.6	74	72.6	
Waist-to-hip ratio (inches)									<0.0001
<0.775	130	62.5	70	24.7	24	9.9	3	2.9	
0.775–0.84	67	32.2	140	49.3	78	32.1	18	17.7	
≥0.84	11	5.3	74	26.1	141	58.0	81	79.4	
Stage									0.53
Localized	140	67.3	196	69.0	159	65.4	65	63.7	
Regional	64	30.8	84	29.6	77	31.7	37	36.3	
Distant	3	1.4	3	1.1	6	2.5	0	0	

Q quartile, *T* tertile. Column percentages (%) may not add up to 100% due to rounding or missing observations. Column totals (n) may not add up to total due to missing observations: education (*n* = 2) stage (*n* = 3)

[a]Comparisons between healthy behavior index quartiles; *p* values reported for Mantel–Haenszel Chi-square (categorical) and ANOVA (continuous)

Table 3

Associations between healthy behavior index and breast cancer-specific and all-cause mortality among all women

Healthy behavior index	Deaths/No	Crude HR (95% CI)	Adjusted HR[a] (95% CI)
Breast cancer-specific mortality			
Q1 (0–3)	23/207	1.00	1.00
Q2 (4–5)	31/282	1.00 (0.58–1.71)	0.98 (0.57–1.68)
Q3 (6–7)	31/242	1.19 (0.69–2.04)	1.04 (0.60–1.81)
Q4 (8–12)	13/102	1.27 (0.65–2.52)	1.15 (0.58–2.28)
p-trend		*0.79*	*0.68*
All-cause mortality			
Q1 (0–3)	36/207	1.00	1.00
Q2 (4–5)	63/283	1.28 (0.85–1.93)	1.19 (0.79–1.80)
Q3 (6–7)	51/242	1.27 (0.83–1.95)	1.11 (0.72–1.72)
Q4 (8–12)	39/102	2.44 (1.55–3.85)	2.18 (1.37–3.44)
p-trend		*0.0008*	*0.006*

Q quartile, *HR* hazard ratio, *CI* confidence interval

[a] Adjusted for education and stage at diagnosis

Table 4

Associations between healthy behavior index and breast cancer-specific and all-cause mortality, stratified by race

	Non-Hispanic WhiteDS			Hispanic		
Healthy behavior index	**Deaths/No**	**Crude HR (95% CI)**	**Adjusted HR[a] (95% CI)**	**Deaths/No**	**Crude HR (95% CI)**	**Adjusted HR[a] (95% CI)**
Breast cancer-specific mortality						
Q1 (0–3)	15/144	1.00	1.00	8/63	1.00	1.00
Q2 (4–5)	17/186	0.89 (0.44–1.78)	0.91 (0.45–1.82)	14/97	1.17 (0.49–2.79)	1.13 (0.47–2.70)
Q3 (6–7)	16/137	1.91 (0.59–2.41)	1.19 (0.58–2.45)	15/105	1.12 (0.47–2.64)	0.97 (0.41–2.31)
Q4 (8–12)	8/70	1.30 (0.55–3.06)	1.25 (0.52–2.98)	5/32	1.28 (0.42–3.91)	1.27 (0.41–3.88)
p-trend		*0.43*	*0.50*		*0.73*	*0.89*
p-interaction[b]						*0.94*
All-cause mortality						
Q1 (0–3)	26/144	1.00	1.00	10/63	1.00	1.00
Q2 (4–5)	40/186	1.21 (0.74–1.98)	1.19 (0.72–1.95)	23/97	1.51 (0.72–3.17)	1.29 (0.61–2.74)
Q3 (6–7)	27/137	1.20 (0.70–2.07)	1.14 (0.66–1.98)	24/105	1.42 (0.68–2.98)	1.18 (0.56–2.50)
Q4 (8–12)	30/70	2.90 (1.71–4.91)	2.65 (1.54–4.55)	9/32	1.75 (0.71–4.31)	1.63 (0.66–4.03)
p-trend		*0.0005*	*0.002*		*0.2887*	*0.43*
p-interaction[b]						*0.60*

Q quartile, *HR* hazard ratio, *CI* confidence interval

[a] Adjusted for education and stage at diagnosis

[b] Interaction for HBI quartile and race

Table 5

Associations between healthy behavior index and breast cancer-specific and all-cause mortality, stratified by stage at diagnosis

Healthy behavior index	Localized			Regional/distant		
	Deaths/No	Crude HR (95% CI)	Adjusted HR[a] (95% CI)	Deaths/No	Crude HR (95% CI)	Adjusted HR[a] (95% CI)
Breast cancer-specific mortality						
Q1 (0–3)	10/140	1.00	1.00	13/67	1.00	1.00
Q2 (4–5)	11/196	0.79 (0.34–1.86)	0.72 (0.30–1.70)	20/87	1.21 (0.60–2.43)	1.18 (0.57–2.39)
Q3 (6–7)	11/159	0.98 (0.42–2.31)	0.83 (0.35–2.00)	20/83	1.33 (0.66–2.67)	1.21 (0.59–2.48)
Q4 (8–12)	3/65	0.68 (0.19–2.47)	0.56 (0.15–2.05)	10/37	1.66 (0.73–3.79)	1.59 (0.70–3.65)
p-trend		*0.7349*	*0.48*		*0.2252*	*0.32*
p-interaction[b]						*0.65*
All-cause mortality						
Q1 (0–3)	22/140	1.00	1.00	14/67	1.00	1.00
Q2 (4–5)	37/196	1.21 (0.72–2.06)	1.09 (0.64–1.87)	26/87	1.43 (0.75–2.75)	1.38 (0.72–2.66)
Q3 (6–7)	26/159	1.10 (0.62–1.94)	0.97 (0.54–1.72)	25/83	1.53 (0.79–2.94)	1.36 (0.70–2.67)
Q4 (8–12)	22/65	2.29 (1.27–4.14)	1.94 (1.06–3.57)	17/37	2.62 (1.29–5.31)	2.49 (1.22–5.08)
p-trend		*0.0287*	*0.099*		*0.0130*	*0.03*
p-interaction[b]						*0.92*

Q quartile, *HR* hazard ratio, *CI* confidence interval

[a] Adjusted for education

[b] Interaction reported for HBI quartile and stage at diagnosis