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The Association Of Smoking And Body Mass Index With Quality Of Life Among Breast Cancer Survivors

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Abstract

Objective: The associations of smoking and body mass index (BMI) with health-related quality of life (QoL) are not well understood among breast cancer survivors. We examined the QoL of breast cancer patients by smoking status and BMI (1) to determine if there are differences in physical and mental component summary (PCS and MCS) scores, (2) to evaluate whether there is an interaction between smoking and BMI on QoL, (3) to assess smoking pattern changes pre- and post-cancer diagnosis, and (4) to measure changes of physical and mental health by smoking status.

Methods: In this study, we included 6,756 breast cancer patients from the SEER-MHOS linkage database (1998-2011) who were 65 to 95 years old (inclusive) and did not present with any other types of cancer. A multivariate linear regression model was used to measure differences in PCS and MCS scores in different smoking statuses and BMI categories. A subgroup analysis was performed among 604 patients who responded to surveys pre- and post-diagnosis. We evaluated the patients' smoking behavior changes and assessed their mean PCS and MCS score changes by their smoking status.

Results: After adjusting for patient demographics, cancer characteristics, and comorbidities, smoking was significantly associated with reduced PCS and MCS scores in breast cancer patients. Being underweight, overweight or obese was negatively correlated with physical health, while being underweight was significantly associated with a lower mental health score. There was no significant interaction between smoking and BMI on QoL. In our subgroup population, only about 26.2% of the smokers quit after breast cancer diagnosis. In the unadjusted analysis, patients who quit smoking after cancer diagnosis showed greater physical health deterioration but less mental health decline compared to patients who continued smoking after diagnosis, or who never smoked.

Conclusions: Smoking and non-normal BMI were associated with poorer QoL, indicating the need to support breast cancer patients who wish to quit smoking and pursue a healthy BMI. The results also suggest that achieving a normal BMI may have greater impact on the mental health of underweight individuals than on those who are overweight or obese. Almost 73.8% of cancer patients did not quit smoking after their cancer diagnosis, indicating a need for encouraging smoking cessation among breast cancer survivors.

Keywords: breast cancer; smoking; BMI; smoking patterns; cancer diagnosis; quality of life

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Introduction

Breast cancer is the most commonly diagnosed cancer among women, and it is also the leading cause of cancer mortality in women worldwide (Parkin & Fernandez, 2006). Globally, there are an estimated 4.4 million women living with breast cancer who are within 5 years of their diagnosis (Parkin, Bray, Ferlay, & Pisani, 2005). Breast cancer incidence increases with age in women. The risk is low before the age of 30 (25 in 100,000), then it shows a linear increase and peaks and plateaus at 80 (around 500 in 100,000) (Kartal, Tezcan, & Canda, 2013). Twenty one percent of the 207,000 new invasive breast cancers (43,000) were predicted to be in women aged 75 or older in 2010 (Muss & Busby-Whitehead, 2011). Medical advances and technology progress have reduced overall mortality and increased human life-span (Cutler & McClellan, 2001). The rising life expectancy is increasing the number and proportion of elderly people, meaning the 65-and-over population is growing consistently (Cutler & McClellan, 2001). In 2012, the estimated number of the population aged 65 and over was 43.1 million, and this number will almost double by 2050, to 83.7 million (Ortman & Velkoff, 2014). Given the aging of the US population, it is important to improve the current health and future health outcomes of the elderly. A breast cancer survivor at the age of 65 or 75 years can be expected to live an additional 20 or 13 more years, respectively, if they do not die from breast cancer (Muss & Busby-Whitehead, 2011).

Smoking is associated with reduced effectiveness of cancer treatment and an increased risk of secondary cancer (Giovino, 2007). Furthermore, prior research indicates that smoking has a negative impact on the QoL of cancer survivors (National Cancer Institute, 2014), although the exact mechanisms are unclear. Smoking is associated with many other chronic diseases and depression (Stafford, Berk, & Jackson, 2013). Almost 50% of the women with early stage breast cancer had depression or anxiety (Burgess et al., 2005). In addition, smoking contributes to poor

physical function in elderly women (Nelson, Nevitt, Scott, Stone, & Cummings, 1994). Breast cancer patients who are current longtime smokers have worse prognosis than non-smokers, but those who quit after diagnosis do not (Ahmad Kiadaliri, Bastani, & Ibrahimipour, 2012). While smoking negatively impacts the QoL of patients with smoking-related cancers, whether smoking is associated with decreased QoL of breast cancer patients is under debate. In a recent study, although smoking negatively affected cognitive functioning of breast cancer patients and decreased their survival, there was a lack of evidence that smoking was associated with poor emotional or physical health in these patients (Ahmad Kiadaliri et al., 2012). Smoking also leads to various chronic conditions in older adults, and these conditions always cause pain and loss of function, decrease QoL, and increase costs for health care and long-term care (Centers for Disease Control and Prevention, 2009). It has been reported that people with smoking-related cancers are more likely to stop smoking or make serious efforts to quit at the time of diagnosis (Gritz, Nisenbaum, Elashoff, & Holmes, 1991; Ostroff et al., 1995). However, the overall smoking rates were similar between female cancer survivors and women who do not have cancer (Mayer & Carlson, 2011). Taken together, the current literature regarding the impact of smoking on the QoL of breast cancer survivors is limited.

BMI has long been linked to QoL (Finkelstein, 2000). A higher BMI was associated with poor QoL among survivors of uterine cancer and endometrial cancer (Fader, Frasure, Gil, Berger, & von Gruenigen, 2011; Lin, Brown, Segal, & Schmitz, 2014), as well as decreased overall survival in prostate cancer patients receiving radiotherapy (Smyth, 2015). BMI impacts physical function, which, in turn, influences mood. Previous research shows that obese or overweight women are more likely to have anxiety, depression and lower well-being (Jorm et al., 2003). Little is known about whether such associations exist within breast cancer survivors.

Prior literature has demonstrated a strong relationship between smoking and BMI (Sneve & Jorde, 2008). However, research examining how smoking and BMI influence the QoL of elderly breast cancer survivors is limited. Understanding whether there is a synergetic effect of smoking and BMI on QoL has the potential to provide valuable information to policymakers, healthcare providers, and patients and their families, possibly leading to effective interventions that allow patients to live longer with a higher QoL.

The objective of this study is to assess self-reported QoL among 65 to 95 year-old Medicare-enrolled breast cancer patients by smoking status and BMI, and to evaluate whether there is an interaction between smoking and BMI on QoL. We also aim to assess smoking patterns and behavior changes of breast cancer patients before and after diagnosis and measure the changes in their physical health and mental health according to their smoking status.

Methods

Data Source

We used linked data from the Center of Medicare and Medicaid Services (CMS) Medicare Health Outcomes Survey (MHOS) and the National Cancer Institute's Surveillance, Epidemiology and End Results (SEER) program. The SEER program includes nearly 28% of the US population and provides authoritative data on cancer incidence and survival in the US. Out of the 18 population-based cancer registries affiliated with SEER, 14 participated in the SEER-MHOS linkage. The MHOS was designed as an ongoing, 2-year longitudinal cohort survey of Medicare beneficiaries enrolled in managed-care plans nationwide, starting in 1998 (Ambs et al., 2008), and it included more than 400 Medicare Advantage managed-care plans (National Cancer Institute,

2015). The survey was administered to a random sample of 1,000 Medicare beneficiaries from each managed care plan under contract with CMS. It was designed to measure the health status and outcomes within each participating Medicare + Choice (M+C) managed care plan in order to provide risk-adjusted measures of plan performance as well as to assess population-based outcomes of care (Stevic et al., 2000). The current linked SEER-MHOS database includes twelve cohorts of MHOS data (baseline and follow up) collected between 1998 and 2011.

Study Sample

A total of 20,021 female breast cancer patients were initially identified by the SEER program from 1998 – 2011. Of these patients, we first selected 10,165 between the ages of 65 and 95 years (inclusive) who did not present with any other types of cancer. We then excluded 3,409 patients for missing one or more of the following covariates: smoking status, age, race, education, marital status, region, high blood pressure, heart disease, stroke, chronic obstructive pulmonary disease (COPD), gastrointestinal (GI) disease, arthritis, diabetes, vision problems, hearing problems, or time since diagnosis. As a result, the final sample size for this study was 6,756 (**Figure 1**).

Variables of Interest

Dependent variables

QoL was assessed by PCS and MCS scores using validated measures of SF-12, which is a 12-item questionnaire measuring physical and mental health. As one of the most widely used instruments for assessing QoL (Nachar et al., 2013), SF-12 evaluates eight dimensions of health

(physical functioning, role physical, bodily pain, general health, vitality, social functioning, role emotional, and mental health). PCS and MCS summary scores are standardized and normalized to the US general population and scaled from 0 to 100. The mean score is 50 and the standard deviation is 10. A higher PCS or MCS score represents better QoL in physical health or mental health, respectively (Boele et al., 2015). This standard-based scoring makes it possible to interpret scores by comparing them to those of a reference population.

Independent variables

The primary independent variables of this study were smoking status (smokers or non-smokers) and BMI. BMI was categorized into 5 categories: underweight (BMI<18.5), normal (18.5≤BMI<25), overweight (25≤BMI<30), obese (BMI≥30), and unknown. We additionally examined cancer specific variables including time since cancer diagnosis (<2 years, 3-5 years, 6-10 years, ≥11 years), breast cancer stage (Stage 0, Stage 1, Stage 2, Stage 3, Stage 4, unknown), and surgical treatment (breast-conserving surgery (BCS) only, BCS and radiotherapy, mastectomy with or without radiotherapy, unknown). The non-cancer specific variables we examined were: age (65 to <70, 70 to <75, 75 to <80, 80 to <85, 85 to <90, 90 to ≤95), race (white, black, other race), region (Northeast, Midwest, South, West), education level (less than high school, high school, college or higher education), household income (<$30,000, $30,000 to <$50,000, $50,000 to <$100,000, ≥100,000, unknown), marital status (married, widowed, divorced/separated, never married), and medical comorbidity (including high blood pressure, heart disease, stroke, COPD, GI disease, arthritis, diabetes, vision problems, and hearing problems).

Statistical Analysis

The baseline characteristics of the subjects were summarized using mean (SD) for continuous variables, and N (proportion) for categorical variables. We used chi-square tests to compare baseline categorical characteristics and t-tests to compare baseline continuous variables between breast cancer patients who were smokers and those who were non-smokers. To study the association between smoking status and QoL (PCS and MCS), multivariate linear regression models adjusted for the baseline variables mentioned above were used. We also examined whether adding interaction terms between smoking and BMI affected PCS and MCS scores, and the results were presented as the least squares mean ± SD of PCS and MCS scores with p values. Statistical significance was considered at $p < 0.05$.

In order to understand whether smoking patterns had changed due to breast cancer diagnosis, we created a subgroup including patients who had responded to surveys both before and after cancer diagnosis and obtained data on their smoking behaviors from both surveys. The surveys they took closest to their diagnosis dates were the ones used for analysis. Patients included in this subgroup analysis were divided into 4 categories: (1) smoker both before and after diagnosis (smokers); (2) smoker before diagnosis but non-smoker after diagnosis (quitters); (3) non-smoker before diagnosis but smoker after diagnosis (starters); (4) non-smoker both before and after diagnosis (non-smokers). Furthermore, we assessed the PCS and MCS scores of these 4 groups of patients based on their pre- and post-diagnosis surveys. Because only very few non-smokers would be expected to start smoking after diagnosis, we combined starters and non-smokers into one group as non-smokers. Smokers, quitters, and non-smokers are the ones in which we are most interested. Therefore, the changes in PCS and MCS scores before and after cancer diagnosis of these 3 groups were plotted in 2 graphs.

All analyses were performed by using SAS (version 9.3, the SAS Institute, Cary, North Carolina).

Results

Patient Characteristics

Among the 6,756 breast cancer patients who had been diagnosed from 1998 to 2011 and had responded to surveys after cancer diagnosis, 619 were smokers and 6,137 were non-smokers (**Table 1**). Smokers were more likely to be underweight and less likely to be overweight or obese compared to nonsmokers (2.6%, 14.1%, and 6.5% of smokers vs. 1.5%, 17.4%, and 14.3% of non-smokers). Smokers had worse PCS and MCS scores compared to non-smokers (37.1 and 50.1 vs. 38.2 and 51.6, respectively). The mean age of smokers was younger than that of non-smokers (73.8 vs. 76.3, $p<0.001$). Smokers had a lower proportion of 85-to-<95 year-olds than non-smokers (4.4% vs. 11.6%). Education level was lower in smokers compared to non-smokers (35.1% vs. 42.2% received a college education or higher). Compared to non-smokers, smokers were more likely to have lower household income, be unmarried, and have a shorter time since diagnosis. There was no significant difference in race, region, cancer stage or surgical treatment between smokers and non-smokers. A lower percentage of smokers had high blood pressure, arthritis, and diabetes compared to non-smokers. However, the proportion of individuals who had COPD in the smoker group was approximately twice that of the non-smoker group (24.23% vs 12.99%). The distributions of heart disease, stroke, GI disease, vision, and hearing problems were very similar in the two groups.

Factors Associated with PCS and MCS

In multivariate analyses, smoking status and BMI were significantly associated with PCS and MCS scores in patients who had responded to surveys after breast cancer diagnosis, controlling for other covariates mentioned above (**Table 2**). The PCS score and MCS score were 2.02 units and 1.10 units lower, on average, in smokers compared with non-smokers ($p<0.001$ and $p=0.013$, respectively). In contrast to normal weight patients, individuals who were underweight, overweight, obese, or who had an unknown BMI had worse physical health. The underweight, overweight, and obese groups had 3.08, 1.55, and 4.83 lower PCS average scores respectively than the normal weight group. Underweight patients had MCS scores that were 3.43 units lower on average compared to normal weight individuals. Overweight and obese individuals had similar MCS scores to normal weight patients. People living in the South and the West showed significantly lower PCS scores than those residing in the Northeast. A higher level of education or household income was associated with better physical and mental health in the study population. Never married patients demonstrated greater PCS and MCS scores compared to married people. Physical function was better among those who were diagnosed 11 years or more prior to the survey compared to those who were diagnosed less than 2 years ago. However, race and surgical treatment did not appear to be associated with QoL in breast cancer patients.

We also examined whether there were interactions between smoking status and BMI on the physical health and mental health of breast cancer patients. The results were not statistically significant ($p>0.05$).

Subgroup Analysis

In the subgroup of 604 breast cancer patients who responded to pre- and post-diagnosis surveys, 61 were smokers and 543 were non-smokers before cancer diagnosis. After cancer diagnosis, 16 out of 61 had quit smoking, and 6 out of 543 had started smoking. Other people maintained their smoking behavior after diagnosis (**Table 3**).

Among 602 patients who reported their PCS scores before and after cancer diagnosis, the unadjusted average PCS scores for the smokers, quitters, and non-smokers were 42.51, 41.98, and 40.04 prior to diagnosis, and 39.74, 33.88, and 37.10 after diagnosis, respectively (**Figure 2**). The unadjusted average MCS scores for smokers, quitters, and non-smokers were 52.50, 52.88, and 52.85 prior to diagnosis, and 49.26, 52.04, and 50.90 after diagnosis, respectively (**Figure 3**).

Discussion

The results of this study indicate that smoking was significantly associated with poor self-reported physical and mental health in breast cancer survivors, after controlling for patient demographics, breast cancer-related characteristics, and comorbidities. The study provides evidence that smoking negatively impacts the health of breast cancer survivors, although smoking is not considered an important risk factor for breast cancer incidence (Roddam et al., 2007).

Our results showed that non-normal BMI was linked to decreased health outcomes of breast cancer patients. When evaluating BMI-related health outcomes in breast cancer patients, we controlled for smoking and other demographic, geographic and clinical characteristics. This, to our knowledge, has rarely been performed in previous studies (Wong, Lo, Wong, & Fung, 2013). Both physical and mental health were significantly worse in the underweight group than in the

normal weight group. Overweight and obese individuals had significantly lower PCS scores in contrast to normal weight people measured by SF-12, but their MCS scores were not significantly different. These findings might be explained by the effects of BMI on the physiological function of body systems, body structures and functional mobility. An abnormally high BMI would reduce postural control and stability during walking, increase weight exertion on the knee, decrease neurocognitive function, and cause chronic pain (Forhan & Gill, 2013). Overweight and obese additionally impacts patients' physical health by slowing walking speed and limiting adaptability and mobility. An increased risk of depression from being overweight or obese indicated by previous studies was not observed in breast cancer patients (Luppino et al., 2010). The physical functional limitation of underweight individuals may be caused by a smaller amount of muscle mass leading to lower muscle strength (Ahmed & Haboubi, 2010; Kikafunda & Lukwago, 2005; Sergi et al., 2007) and reduced physical activity (Sergi et al., 2007). Mental health impairment in underweight female cancer patients can be caused by reduced consumption of certain types of nutrients that are helpful in preventing depressive symptoms (Crisp & McGuiness, 1976; Crisp, Queenan, Sittampaln, & Harris, 1980). It is also possible that dietary patterns such as periodic eating protect against depression, anxiety and stress (Crisp & McGuiness, 1976; Crisp et al., 1980). On the other hand, mental health disorders may bi-directionally cause or aggravate body weight loss through anorexia nervosa (Crisp & McGuiness, 1976; Crisp et al., 1980). Therefore, being underweight is closely related to negative emotional health outcomes.

There were 604 patients in total who had indicated their smoking status in surveys pre- and post-diagnosis, and 26.2% smokers quit smoking after they were diagnosed with breast cancer (16 out of 61). In order to assess how physical and mental health changed after cancer diagnosis in patients with different smoking statuses, their PCS and MCS scores before and after diagnosis

were compared. The pre-cancer diagnosis PCS scores were 42.51, 41.98, and 40.04 for the smokers, quitters, and non-smokers respectively. At baseline, the smoking group had the best physical health, while the non-smokers had the worst. After cancer diagnosis, the quitters had a much greater decrease of PCS scores compared to the smokers and non-smokers (8.10 vs 2.77 and 2.94). The unadjusted analysis showed that quitting smoking negatively affected the physical health of breast cancer patients. However, those patients who quit smoking might have had worse health compared to others, which forced them to stop smoking. The MCS scores were very similar across these three groups of people before cancer diagnosis. After cancer diagnosis, quitters had the lowest decrease of MCS scores (0.84), while smokers had the highest decrease (3.24). Therefore, smoking cessation probably had beneficial effects on preventing or reducing depression, anxiety, and stress caused by breast cancer. The effect size could be larger in patients with psychiatric disorders (Taylor et al., 2014). Through subgroup analysis, we found that smoking cessation was protective for mental health after cancer diagnosis in breast cancer patients. Therefore, it might be helpful to encourage smoking cessation in breast cancer patients to promote mental health. Further research on smoking cessation and physical health should be conducted, as our finding regarding physical health appeared counterintuitive.

Major strengths of the current study include a population-based study design, a clearly-defined target population (only primarily diagnosed breast cancer patients), and comprehensive covariate adjustment. The population-based study design enhances the validity and generalizability of the findings (Sorlie & Wei, 2011). Our target study population was breast cancer patients without any other types of cancer. This prevented the possible effects of other cancers on patients' health. In order to accurately measure the association between smoking status, BMI and QoL, detailed demographic information, geographic variables, and clinical factors were

adjusted in the regression models. In addition, our study provided novel data regarding changes in smoking patterns among breast cancer patients after diagnosis, which had not been evaluated in previous studies. The analysis of the changes in PCS and MCS scores among the smokers, quitters, and non-smokers sheds lights on how physical and mental health might be related to smoking status.

This study also has several limitations. The analysis of cross-sectional data makes it difficult to assess the temporal relationship of different variables. Some of the data were obtained from self-reported surveys and could be subject to information bias. Some patients had missing data on BMI, household income, and cancer stage, reducing the statistical power and possibly even affecting the validity of the results. In addition, we only categorized smoking status based on cigarette use at the time of the survey. Among the non-smokers, it is possible that those who never smoked in their lifetime may have different PCS and MCS scores than former smokers. Furthermore, although our overall sample size was rather large, the power for some of the analyses, such as the analysis of potential interactions between smoking status and BMI, might have been limited.

In the subgroup analysis, only 16 patients quit smoking after breast cancer diagnosis. The small sample size might have led to difficulty in measuring the changes in PCS and MCS scores after diagnosis. In addition, changes in physical and mental health pre- and post-diagnosis were assessed without adjusting for other covariates. Therefore, the negative effects of smoking cessation on PCS scores could have been influenced by other factors. It is possible that quitters had more severe cancer progression (Stage 3 or Stage 4) compared to other groups of patients. Other factors such as socioeconomic status and comorbidity also could have contributed to the observed associations. For each patient, we only used two surveys that were taken around the date

of diagnosis (before and after). Analyzing longitudinal data over an extended period of time and analyzing a larger sample would be helpful in understanding how smoking cessation affects breast cancer patients' health in the long term.

Future research should focus on identifying the optimal strategies for supporting those who would like to quit smoking and those who hope to maintain a healthy BMI in order to achieve positive health outcomes in the long term. Prospective studies designed to better understand the QoL of breast cancer patients are desired. Healthcare providers and policy-makers should pay attention to the effects of smoking and BMI on the QoL of breast cancer patients, and seek the best ways to communicate such information to patients.

Conclusions

In this study, smoking and BMI were significantly associated with the QoL of breast cancer patients. Cigarette smoking was related to lower PCS and MCS scores. Being underweight, overweight or obese was negatively correlated with physical health, while being underweight was significantly associated with poorer mental health. Only a small proportion of breast cancer patients (26.2%) stopped smoking after cancer diagnosis. Greater efforts need to be made to inform patients about the harmful effects of smoking and help them quit early.

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Figures and Tables

Figure 1. Study Flow Diagram:

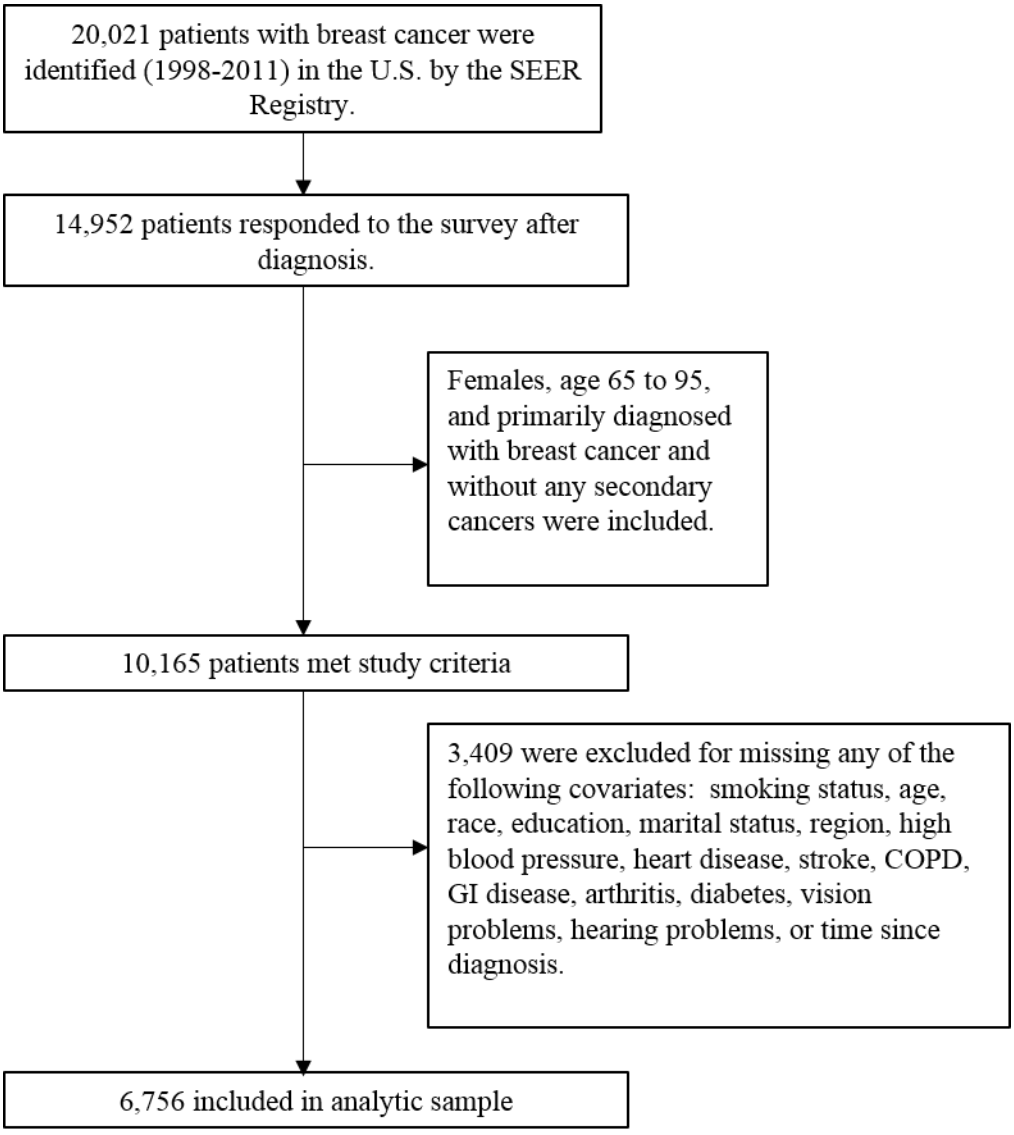

Figure 2. PCS Change by Smoking Status

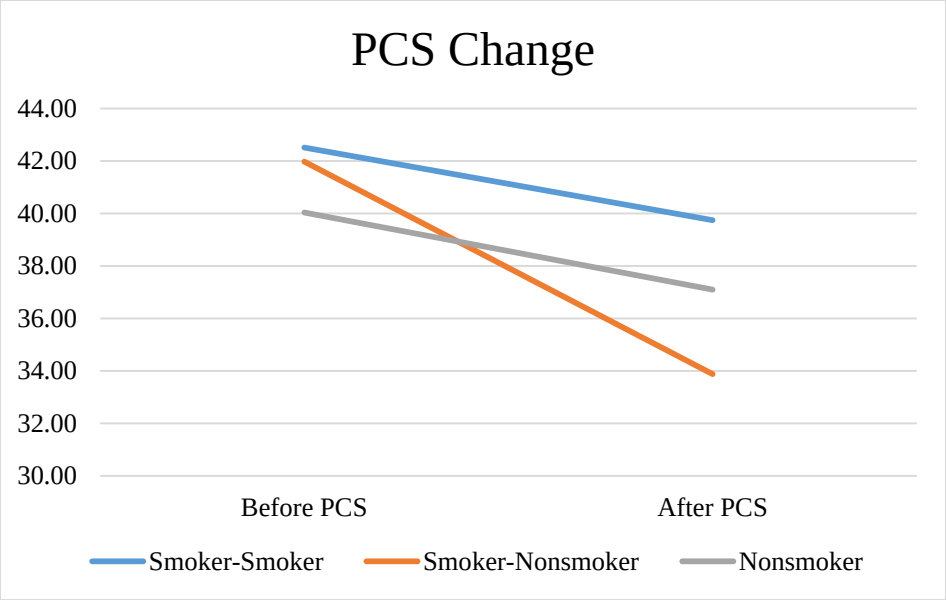

Figure 3. MCS Change by Smoking Status

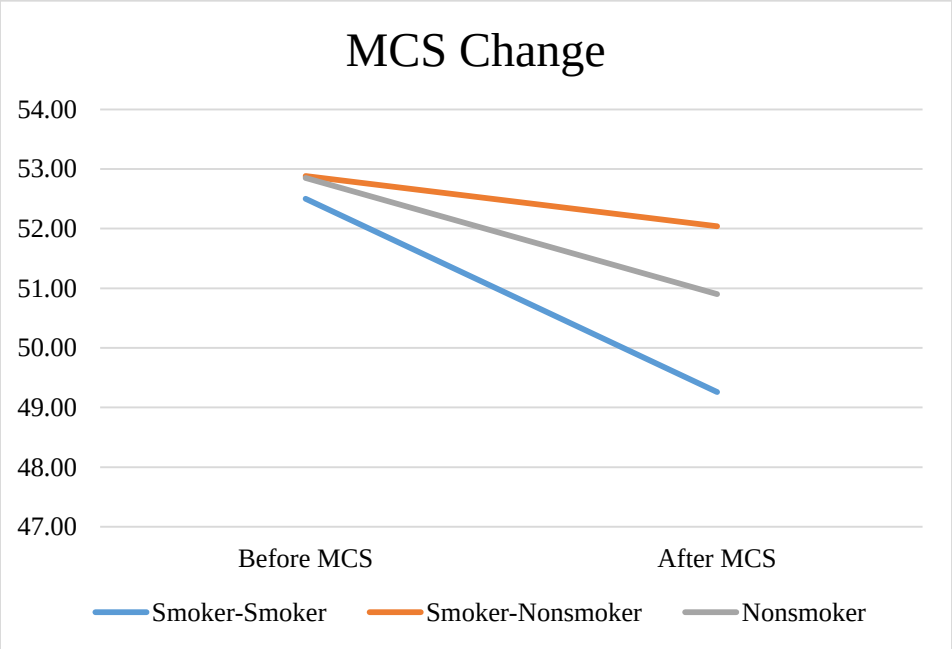

Table 1. Characteristics of 6,756 Breast Cancer Patients Diagnosed between 1998 and 2011, by Smoking Status

	Smoking Status				P value
	Smoker (N=619)		Non-smoker (N=6137)		
PCS (SD)[a]	37.1 (11.9)		38.2 (12.1)		0.039
MCS (SD)[b]	50.1 (10.8)		51.6 (10.9)		0.001
BMI					<0.001
Underweight	16	2.6	91	1.5	
Normal	98	15.8	1250	20.4	
Overweight	87	14.1	1067	17.4	
Obese	40	6.5	875	14.3	
Unknown	378	61.1	2854	46.5	
Demographics					
Mean Age (SD)	73.8 (5.6)		76.3 (6.7)		<0.001
Age					<0.001
65-<70	186	30.1	1291	21.0	
70-<75	208	33.6	1600	26.1	
75-<80	143	23.1	1494	24.3	
80-<85	55	8.9	1041	17.0	
85-<95	27	4.4	711	11.6	
Race					0.100
White	517	83.5	5008	81.6	
Black	42	6.8	362	5.9	
Other	60	9.7	767	12.5	
Region					0.271
Northeast	88	14.2	866	14.1	
Midwest	62	10.0	604	9.8	
South	97	15.7	796	13.0	
West	372	60.1	3871	63.1	
Education					0.002
Less than high school	138	22.3	1272	20.7	
High School	264	42.7	2276	37.1	

	Smoking Status				P value
	Smoker (N=619)		Non-smoker (N=6137)		
College or higher	217	35.1	2589	42.2	
Income					<0.001
<30K	370	59.8	2999	48.9	
30K-<50K	92	14.9	1088	17.7	
50K-<100K	31	5.0	609	9.9	
≥100K	10	1.6	135	2.2	
Unknown	116	18.7	1306	21.3	
Marital Status					<0.001
Married	212	34.3	2751	44.8	
Widowed	254	41.0	2462	40.1	
Divorced/Separated	139	22.5	733	11.9	
Never Married	14	2.3	191	3.1	
Clinical factors					
Surgical Treatment					0.081
BCS only	23	3.7	203	3.3	
BCS and Radiotherapy	73	11.8	631	10.3	
Mastectomy with/without Radiotherapy	155	25.0	1333	21.7	
Unknown	368	59.5	3970	64.7	
Stage					0.450
Stage 0	71	11.5	651	10.6	
Stage 1	170	27.5	1720	28.0	
Stage 2	108	17.5	907	14.8	
Stage 3 & 4	11	1.8	94	1.5	
Unknown	259	41.8	2765	45.1	
High Blood Pressure					0.001
No	262	42.3	2195	35.8	
Yes	357	57.7	3942	64.2	
Heart Disease					0.093
No	451	72.9	4272	69.6	
Yes	168	27.1	1865	30.4	

	Smoking Status				P value
	Smoker (N=619)		Non-smoker (N=6137)		
Stroke					0.300
No	565	91.3	5673	92.4	
Yes	54	8.7	464	7.6	
COPD					<0.001
No	469	75.8	5340	87.0	
Yes	150	24.2	797	13.0	
GI Disease					0.583
No	585	94.5	5831	95.0	
Yes	34	5.5	306	5.0	
Arthritis					0.003
No	250	40.4	2111	34.4	
Yes	369	59.6	4026	65.6	
Diabetes					<0.001
No	528	85.3	4863	79.2	
Yes	91	14.7	1274	20.8	
Vision Problem					0.807
No	578	93.4	5746	93.6	
Yes	41	6.6	391	6.4	
Hearing Problem					0.132
No	565	91.3	5482	89.3	
Yes	54	8.7	655	10.7	
Time since Diagnosis					0.049
<2 years	128	20.7	1320	21.5	
3-5 years	183	29.6	1560	25.4	
6-10 years	154	24.9	1463	23.8	
≥11 years	154	24.9	1794	29.2	

[a] For the PCS, **N = 6,754**.

[b] For the MCS, **N = 6,726**.

Table 2. Multivariate linear regression models predicting the Physical (PCS) and Mental (MCS) Component Summary scores among persons with breast cancer

	PCS (N=6,754)		MCS (N=6,726)	
Characteristic	Score (SE)	p	Score (SE)	p
Smoking status				
Non-smoker	Reference	---	Reference	---
Smoker	-2.015 (0.443)	<0.001	-1.098 (0.442)	0.013
BMI				
Normal weight	Reference	---	Reference	---
Underweight	-3.076 (1.036)	0.003	-3.425 (1.030)	0.001
Overweight	-1.553 (0.416)	<0.001	0.280 (0.414)	0.498
Obese	-4.834 (0.456)	<0.001	0.658 (0.454)	0.147
Unknown	-2.582 (0.354)	<0.001	-0.785 (0.353)	0.026
Age (years)				
65-<70	Reference	---	Reference	---
70-<75	-1.225 (0.362)	0.001	-0.102 (0.361)	0.777
75-<80	-2.849 (0.380)	<0.001	-0.201 (0.378)	0.595
80-<85	-5.652 (0.434)	<0.001	-0.453 (0.432)	0.295
85-<90	-6.463 (0.546)	<0.001	-0.922 (0.545)	0.091
90-<85	-8.533 (0.856)	<0.001	-1.466 (0.855)	0.086
Race/ethnicity				
White	Reference	---	Reference	---
Black	-0.077 (0.555)	0.890	-0.048 (0.554)	0.930
Other	0.221 (0.399)	0.579	0.020 (0.397)	0.960
Region				
Northeast	Reference	---	Reference	---
Midwest	-0.870 (0.525)	0.098	1.256 (0.523)	0.016
South	-1.414 (0.486)	0.004	-0.222 (0.484)	0.647
West	-1.494 (0.385)	<0.001	0.450 (0.385)	0.242
Educational level (years)				
Less than high school	Reference	---	Reference	---
High school	0.960 (0.348)	0.006	2.815 (0.347)	<0.001
College or higher	2.146 (0.361)	<0.001	3.770 (0.360)	<0.001
Income				
<30K	Reference	---	Reference	---
30K-<50K	0.626 (0.367)	0.088	0.827 (0.365)	0.024
50K-<100K	2.018 (0.468)	<0.001	1.866 (0.467)	<0.001
≥100K	2.218 (0.888)	0.013	2.339 (0.883)	0.008
Unknown	0.372 (0.328)	0.257	0.643 (0.327)	0.049
Marital status				
Married	Reference	---	Reference	---
Widowed	0.492 (0.301)	0.102	-0.089(0.300)	0.768
Divorced/Separated	0.151 (0.409)	0.713	-0.514 (0.407)	0.207
Never Married	1.708 (0.748)	0.023	1.447 (0.746)	0.052
Surgical Treatment				
BCS	Reference	---	Reference	---
BCS + radiotherapy	0.492 (0.791)	0.534	0.799 (0.789)	0.311
Mastectomy +/- radiotherapy	-0.876 (0.744)	0.239	0.650 (0.743)	0.381

Unknown	-0.507 (0.730)	0.487	0.570 (0.730)	0.435
Stage				
0	Reference	---	Reference	---
1	-0.971 (0.452)	0.032	-1.094 (0.451)	0.015
2	-1.877 (0.503)	<0.001	-1.148 (0.501)	0.022
3	-2.309 (1.213)	0.057	-2.063 (1.206)	0.087
4	-9.130 (2.087)	<0.001	-1.614 (2.075)	0.437
Unknown	-1.270 (0.436)	0.004	-1.068 (0.435)	0.014
High blood pressure				
Yes	-2.283 (0.274)	<0.001	-0.711 (0.273)	<0.001
No	Reference	---	Reference	---
Heart disease				
Yes	-3.646 (0.283)	<0.001	-1.513 (0.282)	<0.001
No	Reference	---	Reference	---
Stroke				
Yes	-3.846 (0.483)	<0.001	-2.905 (0.481)	<0.001
No	Reference	---	Reference	---
COPD				
Yes	-3.942 (0.366)	<0.001	-1.980 (0.365)	<0.001
No	Reference	---	Reference	---
GI disease				
Yes	-2.292 (0.576)	<0.001	-4.024 (0.576)	<0.001
No	Reference	---	Reference	---
Arthritis				
Yes	-5.894 (0.268)	<0.001	-2.290 (0.266)	<0.001
No	Reference	---	Reference	---
Diabetes				
Yes	-2.659 (0.326)	<0.001	-1.482 (0.325)	<0.001
No	Reference	---	Reference	---
Vision				
Yes	-3.627 (0.528)	<0.001	-5.237 (0.530)	<0.001
No	Reference	---	Reference	---
Hearing				
Yes	-1.504 (0.419)	<0.001	-2.693 (0.418)	<0.001
No	Reference	---	Reference	---
Time since diagnosis (years)				
<2	Reference	---	Reference	---
3-5	0.207 (0.371)	0.577	0.069 (0.370)	0.852
6-10	0.635 (0.398)	0.111	0.572 (0.396)	0.149
≥11	0.910 (0.459)	0.048	0.366 (0.458)	0.424

Table 3. Distribution of Subjects by Smoking Status Pre- and Post-Cancer Diagnosis

		Survey after diagnosis		Total
		Smoker	Non-smoker	
Survey before diagnosis	Smoker	45	16	61
	Non-smoker	6	537	543
	Total	51	553	604