Assessing Racial/Ethnic Disparities along the Breast Cancer Treatment Continuum

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THESIS

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DEDICATION

This work is dedicated to the breast cancer patients who took part in the Breast Cancer Care in Chicago study. Their participation is helping us gain insight into factors that perpetuate disparities in breast cancer care and outcomes. A better understanding of these factors should help inform interventions aimed at reducing these inequities in health.

I also dedicate this work to my wonderful husband and amazing daughters. Eduardo, your unconditional love, support, and patience allowed me to successfully complete my work. I am forever indebted. Gabriela and Cecilia, you make me happy by bringing utter joy to my world. May you follow your passion and may your passion be your life's work.

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BCCC	Breast Cancer Care in Chicago
CFI	Comparative Fit Index
CI	Confidence Interval
COC	Commission on Cancer
CT	Chemotherapy Treatment
ER	Estrogen Receptor
HER2	Human Epidermal Growth Factor Receptor 2
HT	Hormonal Treatment
ISCR	Illinois State Cancer Registry
MR	Medical Record
NAPBC	National Accreditation Program for Breast Centers
NCCN	National Comprehensive Cancer Network
NCI	National Cancer Institute
nH	non-Hispanic
PR	Progesterone Receptor
RD	Risk Difference
RT	Radiation Treatment
RMSEA	Root Mean Square Error of Approximation
RS	Recurrence Score
SEER	Surveillance Epidemiology and End Results
SR	Self-Report/s or Self-Reported
TLI	Tucker and Lewis Index
UIC	University of Illinois at Chicago

SUMMARY

Interventions aimed at ensuring equitable adjuvant treatment may help reduce the racial gap in breast cancer mortality; yet little is known about factors that facilitate or impede treatment. The study aims were to assess and examine racial/ethnic disparities in guideline-adherent adjuvant breast cancer treatment offered, accepted, and initiated.

The primary data came from a population-based study that included interview and medical record (MR) data (including state cancer registry) from 989 females living in Chicago, age 30 to 79 years, who were diagnosed with first primary breast cancer in 2005–2008. Logistic regression using model-based standardization was used to estimate age-adjusted risk differences (RD) and path analyses were conducted to help explain the disparities.

Chemotherapy treatment (CT) guidelines changed during the study period, and the association between race/ethnicity and treatment differed depending on which guideline was used to determine CT-eligibility. Among patients for whom CT became discretionary, minority patients were more likely than non-Hispanic (nH) White patients to receive a recommendation for CT but this was largely explained by tumor differences. There were no discernible racial/ethnic differences in radiation treatment (RT) recommendation and acceptance. However, among all RT-eligible patients, minority patients were less likely than nH White patients to receive RT (0.75 versus 0.74, p=0.01). This was explained by the higher use of mastectomy and lower breast tumor knowledge among minority patients. Compared to nH White patients (0.94), minority patients (0.80) were less likely to receive a recommendation for hormonal treatment (HT) (p=0.00). Tumor knowledge appears to be an important contributor of this disparity as well.

Mastectomy patients may not be receiving guideline-adherent RT. In addition, a patient's breast tumor knowledge may be protective against treatment under-use. These may present important avenues for disparity-reducing interventions.

I. INTRODUCTION AND SPECIFIC AIMS

Even though Black women in the United States have lower breast cancer incidence rates, they experience higher breast cancer mortality rates than White women (Smigal et al., 2006). The mortality disparity has been partly attributed to differences in the receipt of guideline-adherent treatment (Lund et al., 2008; Voti et al., 2006; Keating et al., 2009; Gross et al., 2008; Smith et al., 2005; Griggs et al., 2003; Griggs et al., 2007; Bickell et al., 2006).

It has been proposed that interventions aimed at ensuring equitable adjuvant treatment may help reduce the racial gap in breast cancer mortality (van Ravesteyn et al., 2011; Mandelblatt et al., 2004). However, little is known about factors that facilitate or impede treatment. For instance, treatment disparities may result from disparities in treatment recommendation and/or acceptance. In addition, racial/ethnic differences in cultural and psychosocial factors help explain breast cancer screening disparities (Alexandraki and Mooradian, 2010; Magai et al., 2004; Peek, Sayad, and Markwardt, 2008; Gerend and Pai, 2008; Lannin et al., 1998) and thus may also play a part in treatment disparities (Magai et al., 2007; Magai et al., 2008). Finally, most studies that examine treatment disparities do not carry out mediation analyses that have the potential to improve our understanding of factors that may be targeted for interventions aimed at reducing these disparities.

In order to address the causes of treatment disparities it is essential to understand which factors contribute most to the disparities along the treatment continuum. Therefore, the goal of this research was twofold: (1) determine the extent to which there are racial/ethnic disparities in guideline-adherent adjuvant (radiation, chemotherapy, hormonal) breast cancer treatment offered, accepted, and initiated (i.e., treatment continuum), and (2) explore sociocultural, health care, and tumor factors that may explain the variation along the treatment continuum.

This research has the following three primary aims:

1. Assessing and examining racial/ethnic disparities in CT among treatment-eligible patients.
2. Assessing and examining racial/ethnic disparities in RT among treatment-eligible patients.
3. Assessing and examining racial/ethnic disparities in HT among treatment-eligible patients.

The primary data source was the University of Illinois at Chicago's (UIC) Center for Population Health and Health Disparities Breast Cancer Care in Chicago (BCCC) study (National Cancer Institute [NCI] grant 5 P50 CA 106743). The study included interview and MR data from 411 African American, 397 nH White, and 181 Hispanic female patients living in Chicago, age 30 to 79 years, who were diagnosed with first primary in situ or invasive breast cancer in 2005–2008.

II. BACKGROUND AND SIGNIFICANCE

A. Overview of Racial/Ethnic Disparities in Breast Cancer Outcomes

In the United States, breast cancer is the most common malignancy among women and the second leading cause of cancer death (Jemal et al., 2010). Racial/ethnic disparities in breast cancer incidence and mortality have been widely documented (Baquet et al., 2008; Newman and Martin, 2007; Smigal et al., 2006). Data from the Surveillance, Epidemiology, and End Results (SEER) program show that Black women have a lower age-adjusted incidence rate (per 100,000 population) than White women (118.3 and 126.5, respectively) but Black women have a higher mortality rate (32.4 versus 23.4) (Altekruse et al., 2010). To worsen matters, the Black/White breast cancer mortality disparity is increasing as a result of a steeper decrease in the White rate compared to the Black rate (Altekruse et al., 2010; Smigal et al., 2006; Orsi, Margellos-Anast, and Whitman, 2010). In comparison, Hispanic women have the lowest incidence (86.0) and mortality rate (15.3) of all three racial/ethnic groups (Altekruse et al., 2010). However, the breast cancer mortality rate among Hispanic women may be biased downward due to return (to birth country) migration and data linkage issues (e.g., missing social security number) (Pinheiro et al., 2011).

Minority women are also diagnosed at a later stage and experience lower relative survival. In a comprehensive analysis of 2000–2006 SEER data, Ooi and colleagues documented that 21% of nH Black and 18% of Hispanic women are diagnosed with stage III/IV breast cancer compared to 12% of nH White women (2010). Furthermore, the 5-year relative survival is 77% for Black women, 88% for nH White women, and 85% for Hispanic women (Altekruse et al., 2010; ACS, 2006).

B. The Role of Breast Cancer Treatment

The etiology of racial/ethnic disparities in breast cancer survival is multifactorial and challenging to unravel. Nonetheless, extensive research over the past two decades has identified some contributing

factors such as racial/ethnic differences in tumor stage and biology (Li, Malone, and Daling, 2003; Joslyn and West, 2000; Chlebowski et al., 2005; Carey et al., 2006; Morris and Mitchell, 2008; O'Brien et al., 2010), comorbidities (Tammemagi et al., 2005; Braithwaite et al., 2009), timeliness of treatment (Elmore et al., 2005; Gorin et al., 2006), and receipt of guideline-adherent treatment (Hershman et al., 2005; Chu, Lamar, and Freeman, 2003; Curtis et al., 2008; Wu et al., 2008). The literature with regard to adjuvant treatment disparities is particularly extensive. Adjuvant treatment refers to treatment after surgery such as RT, CT, and HT.

1. Disparities in chemotherapy treatment

The racial/ethnic disparity in breast cancer mortality may be due, in part to, differences in chemotherapy use (van Ravesteyn et al., 2011). However, it is not entirely clear if there are racial/ethnic disparities in CT. For instance, several studies have found that Black patients were less likely than White patients to receive chemotherapy (Freedman et al., 2011; Bickell et al., 2006) while others have not found such a disparity (Wu et al., 2011; Neugut et al., 2012a; Griggs et al., 2012). In addition, while a recent study revealed that Hispanic women were statistically significantly more likely to receive adjuvant chemotherapy than White women (Griggs et al., 2012), two other studies did not find any differences between Hispanic and nH White women (Wu et al., 2011; Freedman et al., 2011).

2. Disparities in radiation treatment

Studies have shown that radiation after surgery reduces recurrence and breast cancer mortality (Clarke et al., 2005). Despite the demonstrated benefits of adjuvant RT, it has been observed that, among patients who received breast-conserving surgery, Black and Hispanic women are less likely than White women to complete RT (Gross et al., 2008; Dragun et al., 2011; Bickell et al., 2006; Haggstrom, Quale, and Smith-Bindman, 2005; Joslyn, 2002; Lund et al., 2008). There is also some evidence that RT-eligible patients who received breast-conserving surgery are more likely to receive

radiation than those who had a mastectomy (Jagsi et al., 2010; Martinez et al., 2010). Among patients who received a mastectomy, racial/ethnic and economic disparities have been observed, whereby Black, Hispanic, and poor patients are less likely to receive guideline-adherent radiation (Martinez et al., 2010; Dragun et al., 2012).

3. Disparities in hormonal treatment

Among patients with hormone receptor-positive tumors, HT reduces their risk for recurrence and improves their disease-free and overall survival (EBCTCG, 1998, EBCTCG, 2005). The racial/ethnic disparities in breast cancer mortality may be due in part to disparities in HT (Wu et al., 2008; van Ravesteyn et al., 2011). Three studies have observed that Black and Hispanic patients were less likely than White patients to receive HT (Freedman et al., 2011; Bickell et al., 2006; Wu et al., 2011). Another study found that Hispanic (but not Black) women were less likely than White women to initiate HT (Livaudais et al., 2012). Conversely, two studies failed to find racial/ethnic disparities (Livaudais et al., 2012; Neugut et al., 2012b).

4. Treatment disparities and mortality

Some studies show that unequal receipt of guideline-adherent treatment is an important cause of disparities in breast cancer outcomes. For instance, using SEER data, Li et al. (2003) found that Black women and Hispanic women, particularly Mexican and Puerto Rican, were less likely than White women to receive appropriate breast cancer treatment as defined by national guidelines. Racial/ethnic disparities in mortality were attenuated after adjusting for treatment, hormone-receptor status, stage, and age. In an updated analysis that used a more recent cohort, the authors found comparable results (Ooi, Martinez, and Li, 2010). Wu et al. (2008) investigated the Black/White adjuvant treatment disparity among women with localized breast cancer by using data from seven population-based state cancer registries. They concluded that racial differential in guideline-adherent treatment

helped explain the disparity in mortality. Similarly, Hershman and colleagues (2005) demonstrated that Black patients were less likely than White patients to complete their CT and thus had poorer overall survival. Finally, using simulation models, studies have shown that optimizing adjuvant treatment can greatly reduce breast cancer mortality in the population (Mandelblatt, Tosteson, and van Ravesteyn, 2013; van Ravesteyn et al., 2011). These findings suggest that interventions aimed at reducing the racial gap in adjuvant treatment may effectively reduce the mortality disparity (van Ravesteyn et al., 2011; Mandelblatt et al., 2004).

C. Potential Explanatory Factors of the Treatment Disparities

While there is increasing evidence of disparities in breast cancer treatment, the literature on factors that facilitate or impede treatment has not been substantially developed and many questions remain. For instance, treatment disparities may result from disparities in treatment recommendation and/or acceptance. In addition, health care is delivered in a multi-level context and so disparities are likely influenced by interactions between patient, provider, and health system factors (Blackman and Masi, 2006; Taplin et al., 2010). However, most studies to date have often focused on the contribution of one level of factors (e.g., patient, provider, hospital) in an attempt to explain racial/ethnic breast cancer treatment disparities. Furthermore, racial/ethnic differences in cultural and psychosocial factors help explain breast cancer screening disparities (Alexandraki and Mooradian, 2010; Magai et al., 2004; Peek, Sayad, and Markwardt, 2008; Gerend and Pai, 2008; Lannin et al., 1998) and they may also play a part in treatment disparities (Magai et al., 2007; Magai et al., 2008).

1. Treatment continuum

In order for treatment to occur, patients must first be offered the treatment and then accept it. Variation in breast cancer treatment recommendation has been documented and may contribute to racial/ethnic differences in treatment. For instance, one study found that among patients

with a strong indication for post-mastectomy radiation, 18 out of 25 patients did not receive RT due to lack of provider recommendation (Jagsi et al., 2010). Another study found that three-quarters of patients who failed to receive CT reported that their provider did not discuss or recommend the treatment (Griggs et al., 2012). Finally, Neugut and colleagues (2012b) recently noted that, compared to patients who initiated HT, non-initiators were less likely to have discussed the treatment with their physicians. Less is known about breast cancer treatment acceptance. Bickell and colleagues (2007) observed that one-third of adjuvant breast cancer treatment underuse was due to patient refusal although they did not find racial/ethnic differences in refusal rates. A study of African American women with Stage III breast cancer also found that approximately a quarter of the patients refused adjuvant treatment (Rizzo et al., 2009). In short, while there is evidence of racial/ethnic disparities in guideline-adherent breast cancer treatment, disparities in treatment recommendation and acceptance need to be further examined.

2. Patient factors

Racial differences in socioeconomic status and health insurance help explain disparities in breast cancer screening and late-stage presentation and perhaps can help explain treatment disparities (Harlan et al., 2005; Alexandraki and Mooradian, 2010; Lannin et al., 1998; Peek, Sayad, and Markwardt, 2008; Hahn et al., 2007; Halpern et al., 2007). Indeed, some studies have demonstrated that insurance status and area-level socioeconomic indicators (e.g., poverty level, income, and education) contribute to the racial disparity in breast cancer treatment (Berz et al., 2009; Michalski and Nattinger, 1997; Bhargava and Du, 2009). On the other hand, a recent analysis by Freeman and colleagues failed to show any reduction in racial/ethnic treatment disparity when they adjusted for health insurance and area-level education and income (Freedman et al., 2011). Nonetheless, several studies have observed that insurance status independently predicts receipt of guideline-adherent cancer treatment (Freedman et al., 2011; Royak-Schaler et al., 2011; Voti et al., 2006). Furthermore, there is some suggestion that

cancer treatment costs may influence treatment recommendation and adherence (Schrag and Hanger, 2007; Neumann et al., 2010; Neugut et al., 2011; Sedjo and Devine, 2011). Interestingly, one study reported that Black patients with lung and colorectal cancer were more likely than non-Black patients to drain their financial resources in exchange for life-prolonging cancer treatment (Martin et al., 2011).

Medical mistrust and fatalism seem to pose barriers to screening and diagnosis (Mohamed et al., 2005; Alexandraki and Mooradian, 2010; Lannin et al., 2002; Lannin et al., 1998; Peek, Sayad, and Markwardt, 2008; Holt, Lukwago, and Kreuter, 2003), yet their role in breast cancer treatment remains largely unexplored. In a survey of breast cancer patients, Bickell and colleagues (2009) found that compared to women who received adjuvant treatment, untreated women had greater medical mistrust. Furthermore, among the undertreated, Black and Hispanic women reported higher levels of mistrust compare to White women. In a recent qualitative study, Masi and Gehlert (2009) reported that African American adults voiced concern over being able to access high-quality breast cancer care due to racism and their lack of resources (e.g., financial, health insurance). With regard to fatalism, Lannin et al., (1998) found that Black women were more likely than White women to harbor fatalistic attitudes about breast cancer. These fatalistic attitudes were associated with an increased likelihood of presenting with late stage breast cancer. Mohamed and colleagues (2005) also reported an association between fatalism and late stage breast cancer. Another study did not find any racial differences in fatalistic attitudes between their Black and White breast cancer patient populations; however, they did find that fatalism independently predicted all-cause mortality (Soler-Vila, Kasl, and Jones, 2005).

Adequate knowledge of the risks and benefits of breast cancer treatment is critical when it comes to making decisions around treatment (Sepucha, Ozanne, and Mulley, 2006; Polacek, Ramos, and Ferrer, 2007; Rimer et al., 2004). A study by Hawley and colleagues (2008) found that, even after adjusting for education, minority breast cancer patients had less treatment knowledge than their White counterparts with regard to the effect of mastectomy and breast-conserving surgery on recurrence and survival. Soler-Vila et al. (2005) found that African American breast cancer patients were more likely

than White patients to believe that surgery can spread the cancer. Finally, one study found that adjuvant treatment underuse was associated with lower treatment knowledge but did not find a racial/ethnic difference in knowledge (Bickell et al., 2009).

Social support is a documented protective factor in medical treatment adherence (DiMatteo, 2004), cancer mortality (Pinquart and Duberstein, 2010), and breast cancer screening and survival (Soler-Vila, Kasl, and Jones, 2003; Katapodi et al., 2002; Messina et al., 2004; Kroenke et al., 2006; Reynolds et al., 1994). The literature on the relationship between social support and breast cancer treatment (adherence) is scant but informative. Bickell et al. (2009) found that women who received adjuvant treatment reported more social support than untreated women. In qualitative studies of minority breast cancer survivors, women have reported that family support was important to their emotional well-being and treatment adherence (Ashing-Giwa et al., 2004; Ashing-Giwa et al., 2006). A randomized, controlled pilot study offers further insight into the important role that social support may play in treatment adherence (Rosenzweig et al., 2011). This study showed that African American breast cancer patients that participated in a supportive, one-time psycho-educational intervention demonstrated better CT initiation and overall adherence than those in the control group.

Spirituality appears to play an important role in coping with breast cancer and may also influence treatment acceptance and adherence. The qualitative work by Ashing-Giwa and colleagues (2004; 2006) informs us that minority breast cancer survivors find comfort and strength in their spiritual beliefs and practices. However, there is concern that too much reliance on faith to cure may delay breast cancer screening, diagnosis, and treatment (Mitchell et al., 2002; Ashing-Giwa et al., 2006; Lannin et al., 1998; Peek, Sayad, and Markwardt, 2008).

The racial/ethnic disparity in comorbidity among breast cancer patients has been associated with disparities in survival (Tammemagi et al., 2005; Mell et al., 2010; Braithwaite et al., 2009). The influence of comorbidity along the breast cancer treatment continuum has not been fully explored although several studies have shown that women of color are more likely than White women to have

one or more comorbid conditions and women with comorbidities are less likely to receive adjuvant treatment (Hershman et al., 2008; Banerjee et al., 2007; Bickell et al., 2006; Livaudais et al., 2012). In addition, one study noted that surgeons did not recommend adjuvant treatment in 11% of cases because of a patient's comorbid condition (Bickell et al., 2007).

3. Provider factors

Providers may contribute to racial/ethnic treatment disparities in several ways such as through personal beliefs, bias, practice style, resources, expertise, and the patient-provider communication/relationship (van Ryn, 2002; van Ryn and Fu, 2003; Haider et al., 2011).

Research suggests that surgeons with a high breast cancer case volume produce more favorable outcomes (Pass, Klimberg, and Copeland, 2008). Several studies have reported better survival for patients who were treated by high cancer case volume surgeons compared to those seen by low volume surgeons (Skinner et al., 2003; Chen, Liu et al., 2008; Stefoski Mikeljevic et al., 2003). However, one study found this association to be true only for non-breast cancer mortality (Nattinger et al., 2007). Surgeon case volume is also predictive of less aggressive surgery and guideline-adherent adjuvant treatment (Hershman et al., 2008; Gilligan et al., 2007a; Hershman et al., 2009a). In addition, research shows that surgeons with a higher volume of breast cancer patients had a higher propensity for breast-conserving surgery (versus mastectomy) (Mandelblatt et al., 2001; Katz et al., 2005).

Some studies have found an association between surgeon expertise and breast cancer treatment and outcomes. For example, one study reported that, compared to patients treated by surgeons who were not specialists, those treated by specialists (defined as a member of a multidisciplinary cancer care team who also participated in clinical trials) had a lower risk of receiving inadequate axillary staging, non-guideline adherent loco-regional, and non-definitive axillary treatment (Kingsmore, Hole, and Gillis, 2004). Perhaps not surprising, patients of specialist surgeons also had lower rates of local recurrence and breast cancer mortality. Zork et al. (2008) reported that patients who were

treated by breast cancer surgeons were less likely to have excisional biopsies, close or positive surgical margins, and re-excisions. In addition, they found that patients of breast surgeons were more likely to receive sentinel lymph node procedures, breast-conserving surgery, and HT.

Other surgeon characteristics also seem to influence breast cancer treatment. For instance, some studies report that patients of female surgeons were more likely than patients of male surgeons to receive breast-conserving surgery, adjuvant radiation, loco-regional treatment, and systemic treatment (Hershman et al., 2008; Hershman et al., 2009b; Silliman, Demissie, and Troyan, 1999). However, one study did not find a gender effect with regard to CT, and another study found that female surgeons were less likely to provide guideline-adherent treatment (Gilligan et al., 2007a; Hershman et al., 2009a). Patients seen by US-trained surgeons were also more likely to receive breast-conserving surgery and adjuvant radiation (Hershman et al., 2009a; Hershman et al., 2008). Finally, one study found that surgeons with the strongest belief in patient participation in treatment decisions were more likely to perform breast-conserving surgery (Mandelblatt et al., 2001).

Racial/ethnic treatment disparities may also be partly explained by the patient-provider interaction. Studies have shown that the interaction affects patient satisfaction and recommendation adherence (Ashton et al., 2003). In a qualitative study with Black breast cancer patients, Sheppard and colleagues (2010) reported that the patient-provider relationship was the most important factor influencing treatment decision-making. The relationship influenced the patient's knowledge about their diagnosis and treatment options and played a role in treatment adherence. Another study also found that the patient-provider communication was associated with a patient's knowledge of treatment risk and benefit (Hawley et al., 2008). However, this did not help explain the racial/ethnic disparity in knowledge. A compelling study by Siminoff et al. (2006) documented that providers communicated differently depending on a breast cancer patient's age, income, education, and race. Compared to non-White patients, White patients received more education or counseling and were more often engaged in

emotional talk as well as partnership building behavior. White patients were also more likely to provide the physician with biomedical information and ask biomedical or psychosocial questions.

4. Hospital factors

Studies have linked some hospital factors, such as case volume, teaching status, and research expertise to breast cancer care and outcomes. Indeed, it has been suggested that treatment disparities may be due, in part, to where minority women obtain care (Hasnain-Wynia et al., 2007; Bach et al., 2004; Bach, 2005; Jha et al., 2007; Keating et al., 2009).

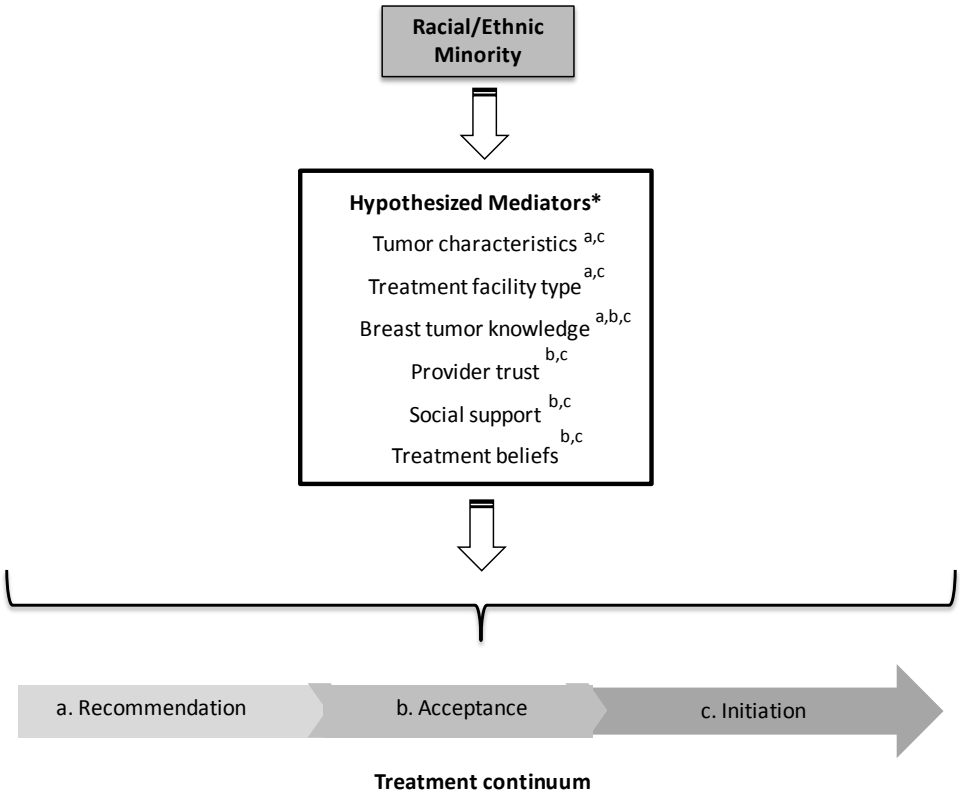
Several studies have shown that, compared to low breast cancer case volume hospitals, high-volume hospitals are associated with lower post-operative morbidity, less treatment delay, more breast-conserving surgeries, and better overall and breast cancer-specific survival (Skinner et al., 2003; Peltoniemi et al., 2011; Gilligan et al., 2007; Gooiker et al., 2010; Chen, Liu, et al., 2008; Guller et al., 2005; Fedewa et al., 2010). In addition, Kong and colleagues (2011) also found that Black and Hispanic breast cancer patients are more likely than White patients to be treated at low-volume hospitals.

Other characteristics of the treating hospital seem to influence breast cancer care and outcomes. For instance, compared to other hospitals, patients treated at teaching hospitals are more likely to undergo sentinel lymph node biopsies and breast-conserving surgeries, receive multimodal therapy, and experience improved survival (Chen, Halpern, et al., 2008; Chaudhry, Goel, and Sawka, 2001; Gutierrez et al., 2008; Hebert-Croteau et al., 2005). In addition, breast cancer patients who received care at institutions affiliated with cancer research networks were more likely to receive a sentinel lymph node biopsy and guideline-adherent loco-regional treatment (Carpenter et al., 2011; Reeder-Hayes et al., 2011; Laliberte, Fennell, and Papandonatos, 2005). Finally, Keating et al. (2009) found that Black patients were less likely than White patients to attend higher quality hospitals (top quartile rates of post breast-conserving radiation) but not higher volume hospitals (top quartile). In turn, hospital quality largely explained the Black/White disparity in definitive breast cancer treatment.

III. GUIDING CONCEPTUAL FRAMEWORK

In order to begin fully addressing the causes of adjuvant treatment disparities it is essential to understand which factors contribute most to the disparities along the treatment continuum. To that end, the goal of this research is twofold: (1) determine the extent to which there are racial/ethnic disparities in guideline-adherent adjuvant (radiation, chemotherapy, hormonal) breast cancer treatment offered, accepted, and initiated (i.e., treatment continuum), and (2) identify the pathways by which these disparities are allowed to occur.

Figure 1 summarizes the conceptual framework guiding the research analysis. There are two key components to the model that reflect the two main goals of the research. First, the model recognizes that there is a treatment continuum, and second, that the racial/ethnic treatment disparity may be explained by several potential mediating factors. The influence of each set of factors may differ as one moves along the continuum. For instance, one can hypothesize that social support plays a more important role in treatment initiation while it is unlikely to influence treatment recommendation.



**Potential confounders of the association among mediators and between mediators and outcome includesociodemographic (e.g., age, income) and health care access (e.g., health insurance, regular provider) factors.*

Figure 1. The conceptual framework.

The hypothesized mediators outlined in the figure include factors that were identified in the literature as potential contributors to treatment disparities, and available in the study data sources. The absence of other possible explanatory factors such as patient-provider communication and provider cancer treatment expertise were not measured and thus could not be considered. This, however, is not intended to diminish the potentially important contributing role of these factors in explaining treatment disparities.

A. Hypothesized Mediators

Tumor characteristics (e.g., tumor size, node-status, receptor-status) largely influence the type of surgery and adjuvant treatment a patient should receive. However, some treatment-eligible patients

with certain tumor characteristics may be undertreated such as in the case of RT underutilization among mastectomy patients with large and node-positive tumors (Jagsi et al., 2010; Dragun et al., 2011). Treatment facility characteristics, such as research and care expertise, have been found to be associated with breast cancer treatment (Wu et al., 2011; Reeder-Hayes et al., 2011; Laliberte, Fennell, and Papandonatos, 2005). In turn, treatment disparities may be due, in part, to where minority women obtain care (Hasnain-Wynia et al., 2007; Bach et al., 2004; Bach, 2005; Jha et al., 2007). Breast tumor knowledge may play a role in treatment initiation in so far as patients with higher knowledge about their tumor characteristics may be more engaged in the treatment decision-making process and thus better understand the importance of promptly initiating and completing treatment (Sepucha, Ozanne, and Mulley, 2006; Polacek, Ramos, and Ferrer, 2007; Rimer et al., 2004). Provider trust may explain the disparity in treatment as those with greater trust are more likely to accept and follow recommendations (Freedman, 2003; Bickell et al., 2009; Hillen, de Haes, and Smets, 2011). Indeed, Bickell and colleagues (2009) recently noted that compared to breast cancer patients who received adjuvant treatment, untreated patients had greater medical mistrust. Furthermore, among the undertreated, Black and Hispanic women reported higher levels of mistrust compare to White women. Social support also appears to play a critical role in breast cancer treatment adherence, as Bickell et al. (2009) found that women who received adjuvant treatment reported more social support than untreated women. In addition, qualitative studies involving minority breast cancer survivors found that family support was important to emotional well-being and treatment adherence (Ashing-Giwa et al., 2004; Ashing-Giwa et al., 2006). Finally, treatment beliefs, such as fatalistic attitudes or misconceptions about cancer treatment, may present a barrier to treatment. For instance, a recent study found that patients who believed that adjuvant treatments were harmful were more likely to underuse treatment (Bickell et al., 2009).

B. Potential Confounders

Racial/ethnic differences in socioeconomic status (e.g., income, neighborhood disadvantage) and healthcare access (e.g., insurance type, regular provider) have been linked to treatment disparities (Freedman et al., 2011; Wu et al., 2011). Rather than examining these factors as potential mediators, it can be argued that these upstream factors should be treated as confounders in the association between/among hypothesized mediators and the treatment outcome. For instance, a patient's tumor aggression (e.g., grade, receptor-status) and progression (e.g., stage) can result from social disadvantage and poor access to care (Schlichting et al., 2012a; Schlichting et al., 2012b; Vona-Davis and Rose, 2009; Gerend and Pai, 2008). At the same time, lower socioeconomic access and lack of health insurance may pose barriers to treatment (Berz et al., 2009; Bhargava and Du, 2009; Michalski and Nattinger, 1997). Similarly, a patient's educational status may be associated with her treatment (mis-) beliefs as well as with her ability to understand and obtain the recommended treatment (Lannin et al., 2002). As such, socioeconomic and health care access factors are conceptualized as confounders along the pathways between race/ethnicity and treatment.

More information about these mediator and confounder variables, including their source, will be presented in Chapter IV and Appendix A.

IV. METHODS

A. Data Sources

1. The Breast Cancer Care in Chicago study

The primary data source is the UIC Center for Population Health and Health Disparities BCCC study *(*NCI grant 5 P50 CA 106743). The BCCC study includes a population-based sample of 989 patients living in Chicago, age 30 to 79 years, who were diagnosed with first primary in situ or invasive breast cancer in 2005–2008. The study sample is racially/ethnically diverse as it includes 411 African American, 397 nH White, and 181 Hispanic female patients. Patients were identified through rapid case ascertainment via the Illinois State Cancer Registry (ISCR). Certified tumor registrars from ISCR reviewed pathology records and/or hospital tumor registries to ascertain newly diagnosed and eligible patients. Potentially eligible and interested patients were referred by ISCR staff to UIC's Survey Research Laboratory (SRL).

The SRL screened potentially eligible women and conducted face-to-face interviews with all consenting women a median of 3.5 months post-diagnosis. All participants answered questions on various topics including: sociodemographics, breast cancer screening, cultural beliefs, health care access, social support, health care providers, stress, medical trust, and cancer treatment. Of the 989 study participants, 849 additionally consented to a review of their MRs. An attempt was made to abstract MRs from all facilities reported by the patient during the interview as places where they received breast cancer screening diagnostic and treatment-related care. Using structured forms, the following type of information was abstracted from the MR: comorbidities, diagnostic results, tumor characteristics, and treatment planned and received.

More detailed information about this study has been published elsewhere (Rauscher et al., 2010).

2. Linkage with the Illinois State Cancer Registry

The ISCR is a statewide population-based cancer surveillance system that gathers the following information about almost all cancers diagnosed or treated in Illinois: patient demographics, tumor characteristics, methods of diagnosis, and information on first course of treatment (e.g., type, date).

In an effort to improve the tumor, diagnostic, and treatment information on BCCC study participants, an attempt was made to obtain cancer registry data for the women who consented to MR review. To that end, the principle investigator of the BCCC study provided ISCR with the following information on the 849 consenting participants: first name, last name, middle name, middle name initial, birth date, race, address, zip code, home phone, cell phone, date of diagnosis, biopsy dates, international Classification of Diseases codes, tumor site. A deterministic match was carried out as follows:

- A "perfect" match was one that matched on last name, first name, date of birth, and gender.
- Successive match passes were run on those cases that weren't contained in the "perfect" match group. For each pass, ISCR staff reviewed whatever data elements weren't matching. If they determined that the case was truly a match, then it was marked as such.

Of the 849 BCCC participants, a match was found for 846. Among those matches, 824 patients had a single primary tumor while 22 had multiple primary tumors. Demographic, type of payer, tumor, and treatment information was obtained for the patients for whom a match was found.

B. Study Population

Overall, 87% of the 989 study participants consented to having their tumor, diagnostic, and treatment information abstracted from MR, including the ISCR. There were no differences in medical consent rates by race/ethnicity, age, primary language, annual household income, type of treatment facility, and time from diagnosis to interview (Table I). However, participants with a high school

education were less likely to provide MR consent than participants with less education (90% versus 83%, respectively).

Table I

MEDICAL CONSENT RATE BY SELECTED CHARACTERISTICS

	n	*(%)*	
Race/Ethnicity			
nH Black	411	86	
nH White	397	85	
Hispanic	181	87	
Age			
<50 years old	317	86	
50–59 years old	308	86	
>=60 years old	365	86	
Primary language			
English primary language	850	86	
English not primary language	123	86	
Annual household income			
<=$30,000	365	88	
>$30,000	595	86	
Education			*
<= High school education	369	90	
> High school education	620	83	
Treatment Facility Type			
NCI[a]/Academic Facility	656	85	
Other Facility	274	86	
Time from diagnosis to interview			
<90 days	323	86	
>=90 days	666	86	
Total	989	87	

†p<0.20, *p<0.10, **p<0.01, ***p<0.001

[a]National Cancer Institute-designated cancer center

Table II illustrates some characteristics of the 824 study participants that consented to the MR and had single primary tumors. While there were no racial/ethnic differences in terms of age at diagnosis, minority patients had lower levels of education, income, and health insurance as compared to nH White patients. In addition, minority patients were more likely to be diagnosed at a later stage and with higher grade tumors. Given their more unfavorable tumor characteristics, it is perhaps not surprising that minority patients received more aggressive surgery (mastectomy as opposed to breast-conserving surgery).

Table II

SELECTED CHARACTERISTICS OF THE STUDY POPULATION

	nH White	*nH Black*	*Hispanic*	
	n=325	*n=347*	*n=152*	
	%	*%*	*%*	
Age				
<50 years old	31	32	38	
>=50 years old	69	68	63	
Household income				***
<=$30,000	17	53	52	
>$30,000	83	47	48	
Education				***
<= High school	19	45	68	
> High school	91	55	32	
Health insurance				***
None	6	15	26	
Public	5	27	20	
Private	90	58	54	
Stage				**
0, I	35	45	48	
II–IV	65	55	52	
Tumor grade				***
Low	31	15	15	
Moderate-high	69	85	85	
Surgery type				*
Breast-conserving	68	58	58	
Mastectomy	32	42	42	
None				

†p<0.20, *p<0.10, **p<0.01, ***p<0.001

C. Treatment Eligibility

The National Comprehensive Cancer Network (NCCN) Clinical Practice Guidelines were used to determine treatment eligibility because they are based on the best available evidence and are widely used by clinicians and patients to make informed treatment decisions. The 2005, 2006, and 2007 guidelines were used because 90% of the study population was diagnosed during those three years.

Treatment-eligible patients were those for whom treatment was strongly recommended. Patients for whom treatment was discretionary or not recommended were not considered treatment-eligible.

1. Chemotherapy treatment eligibility

During the study period (2005–2008), the NCCN guidelines for CT changed between 2005/2006 and 2007 (Figure 2). Per the 2005/2006 guidelines, CT was strongly recommended for patients with Stage I–II node-positive or large (greater than 1 cm) tumors as well as for Stage III patients. However, according to the 2007 guidelines, CT became discretionary for patients with Stage I–II node-negative and large tumors that were estrogen-receptor (ER)-/progesterone-receptor (PR)-positive but human epidermal growth factor receptor 2 (HER2)-negative.

	2005-2006 [a]	*2007* [a]
Stage I–II	- positive node - negative node and tumor>1cm	- positive node - negative node and tumor>1cm and ER/PR-negative - negative node and tumor>1cm and ER/PR-positive and HER2-positive
Stage III	- all	-all

[a]Excludes tumors with favorable histology (tubular or colloid) and women age >70.

Figure 2. 2005–2007 Chemotherapy treatment guidelines for Stage I–III breast cancer.

2. Radiation treatment eligibility

Radiation is recommended for Stage I–II patients who receive breast-conserving surgery as well as for some that receive a mastectomy (Figure 3). All patients with Stage III tumors who undergo surgery should also receive RT.

Stage I–II - had a lumpectomy OR -had a mastectomy and >=4 positive lymph nodes OR -had a mastectomy and tumor >5cm with negative lymph nodes OR -had a mastectomy with positive margins
Stage III - had a lumpectomy OR mastectomy

Figure 3. 2005–2007 Radiation treatment guidelines for Stage I–III breast cancer.

3. Hormonal treatment eligibility

Patients who are diagnosed with Stage I–II cancer that is ER/PR-positive are eligible for HT if their tumors are large (greater than 1 cm) or node-positive (Figure 4).

Stage I–II[a]	- ER/PR-positive with >=1 positive node/s OR - ER/PR-positive with tumor>1cm

[a]Excludes tumors with favorable histology (tubular or colloid)

Figure 4. 2005–2007 Hormonal treatment guidelines for Stage I–III breast cancer.

It should be noted that patients may be eligible for one or more adjuvant treatment(s) and thus may be included in one or more primary research aim(s). For example, approximately 30% of the treatment-eligible study population are eligible for CT, RT, and HT. As a result, such patients are included in all three research aims. On the other hand, another 30% of the treatment-eligible population are only

eligible for RT and thus only included in one of the research aims (i.e., Assess and examine racial/ethnic disparities in RT among treatment-eligible patients).

D. Consistency Between Self-reported and Documented Breast Cancer Treatment Information

The main outcome variables for the primary aims include treatment recommendation, acceptance, and initiation. The BCCC study contains three sources of treatment data: interviews, MR abstractions, and ISCR records. As a result, an understanding of the strengths and weaknesses of these treatment data sources was imperative in order to make an informed decision on how best to define the treatment variables. To that end, a detailed analysis included: (1) an estimation of the sensitivity, specificity, and accuracy of self-reports with regard to adjuvant treatments recommended, accepted, and initiated; (2) a quantification of the level of potential over- and under-reporting; (3) an examination of the treatment prevalence by data source (e.g., self-report, MR); and (4) an exploration of factors (e.g., sociodemographics, time from diagnosis to interview) associated with potential over- and under-reporting.

1. Methods

Patients who provided MR consent and had single invasive primary tumors were included in this analysis (n=824).

All interview treatment questions follow the same general structure (Figure 5). For example, with regard to RT, patients were asked a series of yes/no questions: “Were you offered radiation therapy or was it suggested that you accept this treatment?; If yes, Have you agreed to have radiation therapy?; If yes, Have you begun radiation therapy yet?”

Radiation Treatment

Radiation therapy is treatment that uses X-ray beams to kill cancer cells. It is a local treatment, which means that it only works where you aim it. Were you offered radiation therapy or was it suggested that you accept this treatment?

Radiation treatment status

Recommended?	Yes/No
Accepted?	Yes/No
Initiated?[a]	Yes/No
(If yes,) Have you agreed to have radiation therapy?	Yes/No
(If yes,) Have you begun radiation therapy yet?	

Current status of radiation treatment (completed, ongoing, discontinued)

Date of first radiation treatment (MM/DD/YY)

Total radiation dose delivered (e.g., centigray, cycles, days)

Chemotherapy Treatment

Chemotherapy is medicine that goes through your whole body to kill cancer cells. Some chemotherapy medicines are given through a vein using an IV, and others are given as a pill. Were you offered chemotherapy as part of the treatment plan, or has a doctor suggested that you need it?

Chemotherapy treatment status

Recommended?	Yes/No
Accepted?	Yes/No
Initiated?[a]	Yes/No
(If yes,) Have you agreed to have chemotherapy?	
(If yes,) Have you begun chemotherapy yet?	

Current status of chemotherapy treatment (completed, ongoing, discontinued)

Date/s of treatment cycle/s (MM/DD/YY)

Dose of drug delivered (e.g., milligrams, cycles, days)

Hormone Treatment

Hormone therapies are medicines that target the hormone receptors on your tumor. Some hormone therapies are given through a vein using an IV, and others are given as a pill. Were you offered hormone medicines such as Tamoxifen, Femara, or something else as part of your treatment plan?

Hormone treatment status

Recommended?	Yes/No
Accepted?	Yes/No
Initiated?[a]	Yes/No
(If yes,) Have you agreed to have hormone therapy?	
(If yes,) Have you begun hormone therapy yet?	

Type of hormone therapy (name of hormone drug prescribed)

Date treatment prescribed (MM/DD/YY)

Mode of treatment delivery (oral, IV, other)

Figure 5. Treatment information obtained via in-person interviews.

[a]Based on presence or absence of treatment date, treatment plan (e.g., dose, cycles, mode of delivery)

The documented treatment information comes from the MR abstraction (Figure 6) and ISCR (Figure 7). Documented treatment was coded as follows:

- Treatment recommended =”yes” if evidence of recommendation, acceptance, or receipt/administration in the MR or ISCR; otherwise, if evidence of no recommendation then recommended =“no.”
- Treatment accepted =”yes” if evidence of acceptance or receipt/administration in the MR or ISCR; otherwise, if evidence of no acceptance then accepted =“no.”
- Treatment initiated =”yes” if evidence of receipt/administration in the MR or ISCR; otherwise, if evidence of no receipt then initiated =“no.”

In keeping with previously published validation studies, the documented treatment data (i.e., MRs and ISCR) were used as the gold standard (Gupta et al., 2011; Maunsell et al., 2005; Phillips et al., 2005; Schootman et al., 2005; Yen et al., 2010). In addition, doing so simplifies the analysis and allows for a more concise summary of the results.

Figure 6. Treatment information obtained via medical record abstraction.

Recommended	*Accepted*	*Initiated*	*Radiation Treatment Status*
Yes	Yes	Yes	Radiation therapy administered.
No	.	No	Radiation therapy not administered because not part of the planned first course treatment.
No	.	No	Radiation therapy not administered because contraindicated due to patient risk factors.
.	.	No	Radiation therapy not administered because patient died prior to the planned or recommended surgery.
Yes	.	No	Radiation therapy not administered; recommended by the patient's physician, but not performed as part of first-course therapy. No reason noted in patient record.
Yes	No	No	Radiation therapy not administered; recommended by the patient's physician, but this treatment was refused (noted in the patient record).
Yes	.	.	Radiation therapy was recommended, but it is unknown if it was administered.
.	.	.	Unknown if radiation therapy recommended or administered.
Recommended	*Accepted*	*Initiated*	*Chemotherapy Treatment Status*
.	.	No	None, chemotherapy was not part of the planned first course of therapy; diagnosed at autopsy.
Yes	Yes	Yes	Chemotherapy administered as first course therapy, but the type and number of agents is not documented in patient record.
Yes	Yes	Yes	Single-agent chemotherapy administered as first course therapy.
Yes	Yes	Yes	Multi-agent chemotherapy administered as first course therapy.
No	.	No	Chemotherapy was not recommended /administered because it was contraindicated due to patient risk factors.
No	.	No	Chemotherapy was not administered because the patient died prior to planned or recommended therapy.
Yes	.	.	Chemotherapy was not administered. Recommended by the patient's physician, but not administered as part of first course of therapy. No reason noted in patient record.
Yes	No	No	Chemotherapy was not administered. Recommended by the patient's physician, but this treatment was refused (noted in the patient record).
Yes	.	.	Chemotherapy was recommended, but it is unknown if it was administered.
.	.	.	Unknown whether a chemotherapeutic agent was recommended or administered because it is not stated in the patient record.
Recommended	*Accepted*	*Initiated*	*Hormone Treatment Status*
No	.	No	None, hormone therapy was not part of the planned first course of therapy.
Yes	Yes	Yes	Hormone therapy administered as first course therapy.
No	.	No	Hormone therapy was not recommended/administered because it was contraindicated due to patient risk factors.
.	.	No	Hormone therapy was not administered because the patient died prior to planned or recommended therapy.
Yes	.	.	Hormone therapy was not administered. Recommended by patient's physician, but not administered as part of first course of therapy. No reason noted in patient record.
Yes	No	No	Hormone therapy was not administered. Recommended by patient's physician, but this treatment was refused (noted in patient record).
Yes	.	.	Hormone therapy was recommended, but it is unknown if it was administered
.	.	.	Unknown whether a hormonal agent was recommended or administered because it not stated in patient record.

Figure 7. Treatment information obtained via the Illinois State Cancer Registry.

Using the documented treatment data (i.e., MRs and ISCR) as the gold standard, sensitivity (i.e., proportion of true positives), specificity (i.e., proportion of true negatives), and accuracy of self-reported treatment information were first estimated in order to initially evaluate the reliability of treatment recall. Accuracy was defined as "yes" if the self-reported and documented information agreed and "no"

if they did not. In addition, the false-negative (1-sensitivity) and false-positive rates (1-specificity) were calculated in an effort to quantify the level of potential under- and over-reporting, respectively.

Several variables were identified as possible predictors of potential under- and over-reporting. These include: age, educational attainment, race/ethnicity, primary language spoken, and household income, breast tumor knowledge, days from diagnosis to interview treatment, and days from diagnosis to treatment. In addition, tumor characteristics (e.g., stage, hormone receptor status), treatment factors (e.g., surgery type), and type of treatment facility were considered.

These potential explanatory factors were selected based, in part, on findings from a study that assessed the accuracy of self-reported breast cancer treatment information (Liu et al., 2010). That study found age, education, and household income to be associated with the accuracy of self-reported radiation treatment dates, oncologist consultation, and metastasis status. They also reported that compared to White patients, Black patients were less accurate in their recall of radiation treatment dates, while less acculturated Hispanic women were less accurate about their lymph node dissection. The association between tumor knowledge and accuracy of self-reported breast cancer treatment information was examined because it was expected that a patient who knows the important characteristics (e.g., stage, grade, receptor status) of her tumor might be more engaged in the treatment decision-making process and thus more likely to accurately report treatment information. Tumor and treatment factors may also affect the quality of treatment self-report. For instance, it is possible that patients with aggressive tumors and thus more complicated treatment plans (e.g., multimodal adjuvant treatment) may be more likely to misreport their treatment as compared to patients with a simpler treatment plan (e.g., RT only). The type of treatment facility may also affect the quality of documented treatment information, which can influence the level of potential over- and under-reporting. Finally, it is plausible that time from diagnosis to interview or time to treatment may influence self-reported treatment accurateness. For example, a shorter time frame may be associated

with higher levels of under-reporting because some patients may not have yet had the opportunity to be offered treatment, accept it, or initiate it.

There were several parts to the statistical analysis. First, 95% confidence intervals (CIs) were computed for the sensitivity, specificity, accuracy, false-negative (1-sensitivity) rates, and false-positive rates (1-specificity) of each treatment outcome. Second, the prevalence estimates of treatment outcomes were calculated across the various data sources (e.g., self-report, MR, ISCR) in order to assess the affect of potential over- or under-reporting on the treatment prevalence estimates. Finally, associations between the accuracy of self-reported treatment initiation and potential explanatory factors were examined. Given the exploratory nature of the study and the somewhat limited sample size, less restrictive levels of statistical significance were used. Potential predictors of treatment over- and under-reporting were identified ($p<0.20$) and considered in subsequent multivariate regression analyses. Logistic regression, using model-based standardization, was used to identify factors statistically significantly associated with the accuracy of self-report ($p<0.10$) and to report percentages. All analyses were performed with SAS version 9.2 (SAS Institute Inc, Cary, North Carolina) and STATA version 12.1 (StataCorp, College Station, Texas) software packages. Two-sided tests were used to determine statistical significance.

2. Results

Sensitivity, Specificity, and Accuracy: Generally, sensitivity is highest for treatment recommendation (76%–94%) and acceptance (96%–99%) while specificity is highest for treatment initiation (83%–98%) (Table III). Interestingly, the self-reported treatment acceptance information and all the CT information appears to be highly sensitive, specific, and accurate. On the other hand, the self-reported HT information has the lowest sensitivity, specificity, and accuracy.

Table III

USING DOCUMENTED TREATMENT INFORMATION (IN MEDICAL RECORD OR ISCR) AS THE GOLD STANDARD, ESTIMATES OF THE SENSITIVITY, SPECIFICITY, AND ACCURACY OF SELF-REPORTED TREATMENT INFORMATION

	n	*Sensitivity*	*95% CI*	*Specificity*	*95% CI*	*Accuracy*	*95% CI*
Radiation recommended	803	0.91	(0.88, 0.93)	0.71	(0.65, 0.77)	0.85	(0.83,0.88)
Radiation accepted	565	0.97	(0.95, 0.98)	0.95	(0.77, 0.99)	0.97	(0.95,0.98)
Radiation initiated	803	0.55	(0.51, 0.60)	0.98	(0.96, 0.99)	0.72	(0.69,0.75)
Chemotherapy recommended	799	0.94	(0.91, 0.96)	0.90	(0.86, 0.92)	0.92	(0.90,0.94)
Chemotherapy accepted	416	0.99	(0.97, 1.00)	0.92	(0.69, 0.98)	0.99	(0.97,1.00)
Chemotherapy initiated	799	0.81	(0.77, 0.85)	0.97	(0.97, 0.98)	0.90	(0.88,0.93)
Hormone therapy recommended	786	0.76	(0.72, 0.80)	0.62	(0.57, 0.68)	0.70	(0.67, 0.74)
Hormone therapy accepted	439	0.96	(0.93, 0.97)	0.87	(0.38, 0.99)	0.95	(0.93, 0.98)
Hormone therapy initiated	786	0.45	(0.39, 0.50)	0.83	(0.79, 0.86)	0.67	(0.64, 0.71)

Overall Under- and Over-reporting: Table IV shows the potential under- and over-reporting of treatment information as measured by the false-negative and false-positive rates, respectively. In terms of RT and CT recommendation, the potential for over-reporting (10%–29%) appears to be greater than the potential for under-reporting (6%–9%). On the other hand, RT and CT initiation is more likely to be under-reported (45% and 19%, respectively); while there is limited evidence of over-report. Information regarding HT follows a somewhat different pattern. The recommendation for HT is prone to both high levels of under- and over-reporting (24% and 37%, respectively). In addition, HT initiation information is highly under-reported (55%) and also prone to some potential over-reporting (17%).

Table IV

COMPARISON OF SELF-REPORT VERSUS DOCUMENTED (GOLD STANDARD) TREATMENT-RELATED VARIABLES

	Potential under-reporting rate			Potential over-reporting rate		
	False Negatives/n [a]	*FNR* [b] *(1-Sensitivity)*	*95% CI*	*False Positives/n* [c]	*FPR* [d] *(1-Specificity)*	*95% CI*
Radiation recommended	49/549	0.09	(0.07, 0.12)	68/235	0.29	(0.23, 0.35)
Radiation accepted	15/460	0.03	(0.02, 0.05)	1/25	0.04	(0.01, 0.23)
Radiation initiated	213/477	0.45	(0.40, 0.49)	6/297	0.02	(0.01, 0.04)
Chemotherapy recommended	23/366	0.06	(0.04, 0.09)	43/417	0.10	(0.08, 0.14)
Chemotherapy accepted	3/323	0.01	(0.00, 0.03)	2/19	0.08	(0.02, 0.31)
Chemotherapy initiated	62/332	0.19	(0.15, 0.23)	12/449	0.03	(0.02, 0.05)
Hormone therapy recommended	102/422	0.24	(0.20, 0.28)	119/320	0.37	(0.32, 0.43)
Hormone therapy accepted	13/287	0.04	(0.03, 0.07)	1/6	0.13	(0.01 0.62)
Hormone therapy initiated	162/292	0.55	(0.50, 0.61)	74/427	0.17	(0.14, 0.21)

[a]Number of patients with documented evidence of treatment in medical record or ISCR

[b]False negative rate

[c]Number of patients with no documented evidence of treatment in medical record or ISCR

[d]False positive rate

Prevalence of Treatment Outcomes: For the 824 study participants, treatment information was readily available (i.e., not missing) from the self-reported interview and ISCR data sources (Table V). In contrast, the MR abstraction did not yield treatment information for a large proportion of study patients as RT, CT, and HT information was only available for 70%, 63%, and 34% of patients, respectively.

Table V

PREVALENCE OF TREATMENT OFFERED, ACCEPTED, AND RECEIVED ACCORDING TO DATA SOURCE

	Self-reported (SR)		Medical record (MR)		ISCR		MR/ISCR		SR/MR/ISCR	
	N [a]	*(%)* [b]	*N* [a]	*(%)* [b]	*N* [a]	*(%)* [b]	*N* [a]	*(%)* [b]	*N* [a]	*(%)* [b]
Radiation recommended	804	(71)	577	(80)	774	(60)	802	(69)	823	(77)
Radiation accepted[c]	564	(88)	457	(93)	409	(95)	533	(94)	611	(90)
Radiation initiated	804	(34)	577	(68)	726	(55)	792	(61)	823	(60)
Chemotherapy recommended	800	(49)	517	(62)	785	(42)	807	(46)	823	(51)
Chemotherapy accepted[c]	386	(90)	316	(90)	324	(97)	374	(92)	419	(88)
Chemotherapy initiated	800	(36)	517	(43)	780	(40)	804	(42)	823	(43)
Hormone therapy recommended	785	(58)	292	(88)	750	(44)	781	(57)	823	(71)
Hormone therapy accepted[c]	438	(90)	235	(95)	287	(98)	404	(97)	548	(93)
Hormone therapy initiated	785	(28)	292	(14)	706	(60)	755	(41)	820	(48)

[a]Number that are not missing data on the corresponding treatment offer, accept or receipt variable.

[b]Percentage of non-missing observations coded as affirmative for that treatment-related variable

[c]Among those that received a treatment recommendation

The estimated treatment prevalence varies by data source due to the effects of potential under- and over-reporting (Table IV). For example, while 71% of self-reported (SR) having received a recommendation for RT, 69% of patients actually had documented (MR/ISCR) evidence of such a recommendation. The RT recommendation prevalence was 77% when both SR and documented treatment information (SR/MR/ISCR) were used to estimate the recommendation prevalence. Conversely, 34% of patients reported that they had initiated RT treatment, yet there was documentation that 61% had actually received it. The proportion of patients who initiated RT was 60% when both SR and documented treatment information (SR/MR/ISCR) were used. Note that because RT initiation tended to be under-reported, the prevalence of RT initiation did not differ between the documented (MR/ISCR) and combined data (SR/MR/ISCR) sources. The same patterns were generally observed for CT recommendation and initiation. The prevalence of HT varies dramatically by source as a result of the relatively high potential under- and over-reporting. Table V shows that 58% of patients reported that they received a recommendation (SR) for HT. A similar proportion (57%) had documentation (MR/ISCR) of such. However, if both SR and documented treatment information (SR/MR/ISCR) were used to estimate the recommendation prevalence, the HT recommendation prevalence would dramatically increase to 71%. The same pattern is seen for HT initiation.

Predictors of RT Under- and Over-reporting: Several potential predictors of radiation treatment under-reporting were identified (Table VI). For instance, patients that had lower education, a mastectomy, later-stage cancer, positive lymph nodes, or reportedly received CT were more likely to under-report RT recommendation and initiation. Additionally, those with lower household income and breast tumor knowledge under-reported treatment recommendation while those with non-English as a primary language, less time from diagnosis to interview, and an ER/PR-negative status more often under-reported RT initiation.

The following factors were associated with more over-reporting of RT recommendation: lower breast tumor knowledge, breast-conserving surgery, later stage cancer, and positive lymph nodes. Since the over-reporting of treatment initiation was very low (2%), factors associated with this outcome were not explored.

Table VI

POTENTIAL PREDICTORS OF UNDER- AND OVER-REPORTING RADIATION TREATMENT INFORMATION

	Potential Under-reporting				Potential Over-reporting	
	n	*Recommended*	*n*	*Initiated*	*n*	*Recommended*
Race/Ethnicity						
nH White	184	0.07	161	0.41	82	0.30
Minority	365	0.10	316	0.46	153	0.28
Age						
<50 years old	185	0.09	164	0.47	81	0.29
>=50 years old	362	0.08	312	0.44	154	0.29
Primary language				†		
English primary language	483	0.09	420	0.44	215	0.29
English not primary language	58	0.07	51	0.53	20	0.30
Household income		*				
<=$30,000	227	0.11	195	0.47	88	0.25
>$30,000	312	0.07	274	0.42	140	0.31
Education		†		†		
<= High school education	218	0.11	190	0.49	81	0.26
> High school education	331	0.08	287	0.42	155	0.30
Breast tumor knowledge		*				†
Highest quartile	107	0.04	92	0.44	40	0.20
Lower quartiles	442	0.10	385	0.45	196	0.30
Treatment Facility Type						
NCI[a]/Academic Facility	363	0.09	316	0.46	144	0.30
Other Facility	151	0.08	131	0.39	71	0.30
Time from diagnosis to interview				†		
<90 days	162	0.10	134	0.50	72	0.24
>=90 days	388	0.09	343	0.43	163	0.31
Time from diagnosis to treatment						
<30 days	204	0.09	177	0.46	89	0.28
>=30 days	203	0.09	176	0.45	76	0.31
Surgery type		***		***		***
Breast-conserving	440	0.06	402	0.38	66	0.52
Mastectomy	94	0.19	67	0.83	156	0.18
None	15	0.19	9	0.62	13	0.32
Stage		***		***		*
0, I	323	0.05	289	0.25	142	0.24
II–IV	226	0.14	188	0.75	93	0.36
ER/PR status				***		
Positive	420	0.09	366	0.39	171	0.30
Negative	109	0.09	93	0.68	41	0.23
Lymph node status		**		***		*
Positive	142	0.15	121	0.81	57	0.39
Negative	384	0.06	339	0.31	164	0.25
Received chemotherapy[b]		**		***		
Yes	195	0.14	166	0.83	74	0.26
No	344	0.06	302	0.23	156	0.30

[a] National Cancer Institute- designated cancer center

[b] as reported at interview

†p<0.20, *p<0.10, **p<0.01, ***p<0.001

In multivariate analyses, we found that patients with lower breast tumor knowledge or who received a mastectomy may have been more likely to under-report RT recommendation (Table VII). Interestingly, patients with more aggressive-type tumors (i.e., ER/PR-negative status, node-positive status, received CT) tended to under-report RT initiation. On the other hand, patients who are generally eligible for RT, such as those that received breast-conserving surgery or had node-positive tumors, appear to have over-reported RT initiation.

Table VII

INDEPENDENT PREDICTORS OF UNDER- AND OVER-REPORTING OF RADIATION TREATMENT INFORMATION: MULTIVARIATE ANALYSES RESULTS[a]

	Potential Under-reporting		Potential Over-reporting
	Recommended	*Initiated*	*Recommended*
Breast tumor knowledge			
Highest quartile	0.04		
Lower quartiles	0.10		
Risk difference	0.06		
95% CI	0.01–0.11		
Surgery type			
Breast-conserving	0.06		0.55
Mastectomy/None	0.19		0.18
Risk difference	0.12		0.37
95% CI	0.04–0.20		0.22–0.50
ER/PR status			
Positive		0.46	
Negative		0.55	
Risk difference		0.09	
95% CI		0.00–0.20	
Lymph node status			
Positive		0.66	0.43
Negative		0.41	0.24
Risk difference		0.25	0.19
95% CI		0.13–0.37	0.04–0.33
Received chemotherapy[b]			
Yes		0.77	
No		0.30	
Risk difference		0.48	
95% CI		0.36–0.57	
n	531	428	223

[a] statistically significant at p<0.10
[b] as reported at interview

Predictors of CT Under- and Over-reporting: Factors that were associated with under-report differed by CT recommendation and initiation (Table VIII). Younger women and those with favorable tumor characteristics (e.g., early stage, ER/PR-positive status, node-negative status) tended to under-report treatment recommendation. On the other hand, minority status, less education, less breast tumor knowledge, less time from diagnosis to treatment, treatment at non-NCI/Academic institutions, and ER/PR-positive status predicted under-reporting of treatment initiation.

Table VIII

POTENTIAL PREDICTORS OF UNDER- AND OVER-REPORTING CHEMOTHERAPY TREATMENT INFORMATION

	Potential Under-reporting				Potential Over-reporting	
	n	*Recommended*	*n*	*Initiated*	*n*	*Recommended*
Race/Ethnicity				*		
nH White	119	0.06	112	0.13	156	0.12
Minority	247	0.06	220	0.22	262	0.10
Age		*				
<50 years old	119	0.09	109	0.16	139	0.12
>=50 years old	247	0.05	223	0.20	276	0.10
Primary language						
English primary language	318	0.06	289	0.20	379	0.11
English not primary language	43	0.09	38	0.13	32	0.07
Household income						
<=$30,000	147	0.07	126	0.21	161	0.10
>$30,000	211	0.06	197	0.18	247	0.10
Education				†		†
<= High school education	143	0.08	130	0.22	142	0.14
> High school education	223	0.05	202	0.16	275	0.09
Breast tumor knowledge				*		
Highest quartile	61	0.05	57	0.11	84	0.08
Lower quartiles	305	0.06	274	0.20	333	0.11
Treatment Facility Type				*		
NCI[a]/Academic Facility	245	0.06	221	0.15	262	0.11
Other Facility	99	0.05	89	0.25	123	0.10
Time from diagnosis to interview						
<90 days	117	0.07	110	0.20	116	0.07
>=90 days	249	0.06	222	0.18	302	0.11
Time from diagnosis to treatment				†		
<30 days	144	0.07	133	0.23	149	0.08
>=30 days	125	0.04	111	0.16	152	0.10
Surgery type		†				*
Breast-conserving	183	0.08	162	0.22	313	0.08
Mastectomy	160	0.05	147	0.16	97	0.15
None	25	0.00	23	0.12	8	0.34
Stage		**				***
0, I	91	0.14	71	0.19	365	0.07
II–IV	274	0.04	259	0.19	52	0.34
ER/PR status		*		†		
Positive	236	0.08	214	0.20	349	0.10
Negative	122	0.01	110	0.14	29	0.10
Lymph node status		**				***
Positive	178	0.02	175	0.21	23	0.46
Negative	162	0.11	134	0.16	376	0.08

[a] National Cancer Institute- designated cancer center

†p<0.20, *p<0.10, **p<0.01, ***p<0.001

In terms of potential over-reporting, patients who had less education, a mastectomy, or had tumors with less favorable characteristics (e.g., later-stage cancer, node-positive status) were more likely to report that CT was recommended while there was no documentation of such. As with RT, the over-reporting of CT initiation was very low (3%) and so factors associated with this outcome were not examined.

The multivariate analyses generally confirmed the bivariate associations. For instance, there is evidence that patients with more favorable characteristics (e.g., ER/PR-positive status, node-negative status) were more likely to under-report CT recommendation (Table IX). Women who attended non-NCI/Academic facilities or received treatment within 30 days of diagnosis were apparently more likely to under-report treatment initiation. As observed with RT over-reporting, patients who are likely eligible for (CT) treatment such as those with node-positive tumors, appear to over-report treatment initiation.

Table IX

INDEPENDENT PREDICTORS OF UNDER- AND OVER-REPORTING OF CHEMOTHERAPY TREATMENT INFORMATION: MULTIVARIATE ANALYSES RESULTS[a]

	Potential Under-reporting		*Potential Over-reporting*
	Recommended	*Initiated*	*Recommended*
Treatment Facility Type			
NCI[a]/Academic Facility		0.14	
Other Facility		0.30	
Risk difference		0.17	
95% CI		0.04–0.31	
Time from diagnosis to treatment			
<30 days		0.22	
>=30 days		0.13	
Risk difference		0.09	
95% CI		0.01–0.19	
ER/PR status			
Positive	0.08		
Negative	0.01		
Risk difference	0.06		
95% CI	0.02–0.11		
Lymph node status			
Positive	0.01		0.46
Negative	0.10		0.08
Risk difference	0.09		0.38
95% CI	0.03–0.14		0.15–0.63
n	359	339	367

[a] statistically significant at p<0.10
[b] National Cancer Institute-designated cancer center

Predictors of HT Under- and Over-reporting: Similar to what was observed with RT, surgery type and prognostic factors were associated with HT under-reporting (Table X). For instance, patients who had more aggressive-type tumors (e.g., later stage, node-positive status, ER/PR-negative status, received CT) were more likely to under-report treatment recommendation and initiation. Treatment at NCI/Academic institutions also predicted under-reporting. In addition, those with less education, less time from diagnosis to interview, and mastectomy tended to under-report treatment recommendation while those with more breast tumor knowledge under-reported treatment initiation.

Table X

POTENTIAL PREDICTORS OF UNDER- AND OVER-REPORTING HORMONE TREATMENT INFORMATION

	Potential Under-reporting				*Potential Over-reporting*			
	n	*Recommended*	*n*	*Initiated*	*n*	*Recommended*	*n*	*Initiated*
Race/Ethnicity								
nH White	151	0.26	104	0.54	102	0.41	141	0.16
Minority	271	0.23	189	0.56	218	0.35	286	0.18
Age								
<50 years old	149	0.24	189	0.55	108	0.42	147	0.18
>=50 years old	274	0.24	103	0.57	213	0.35	279	0.17
Primary language								
English primary language	373	0.24	261	0.55	281	0.37	371	0.17
English not primary language	43	0.30	29	0.61	33	0.37	46	0.17
Household income								
<=$30,000	162	0.24	117	0.58	129	0.42	165	0.18
>$30,000	250	0.24	169	0.53	183	0.35	250	0.16
Education		†						
<= High school education	161	0.28	112	0.58	118	0.37	154	0.17
> High school education	261	0.22	180	0.54	202	0.37	272	0.17
Breast tumor knowledge				†				
Highest quartile	83	0.21	63	0.64	57	0.40	71	0.13
Lower quartiles	339	0.25	229	0.53	263	0.37	256	0.18
Treatment Facility Type		*		*				
NCI[a]/Academic Facility	271	0.26	188	0.60	209	0.36	272	0.16
Other Facility	119	0.18	78	0.45	93	0.41	131	0.21
Time from diagnosis to interview		*						
<90 days	112	0.32	76	0.54	107	0.39	134	0.15
>=90 days	310	0.21	217	0.56	213	0.36	293	0.18
Time from diagnosis to treatment								
<30 days	154	0.27	108	0.59	120	0.41	157	0.17
>=30 days	162	0.23	112	0.60	109	0.33	150	0.15
Surgery type		**				†		
Breast-conserving	296	0.20	207	0.53	174	0.40	247	0.16
Mastectomy	123	0.32	81	0.61	118	0.36	153	0.19
None	3	0.73	3	0.73	28	0.21		
Stage		***		**		*		†
0, I	257	0.18	185	0.48	180	0.41	239	0.20
II–IV	165	0.34	108	0.68	140	0.32	187	0.14
ER/PR status		*		*		***		***
Positive	397	0.24	278	0.55	153	0.58	249	0.22
Negative	14	0.51	8	1.00	135	0.12	141	0.08
Lymph node status		***		**				*
Positive	105	0.38	65	0.72	81	0.34	116	0.12
Negative	302	0.19	216	0.51	210	0.40	280	0.20
Received chemotherapy [b]		***		***		**		*
Yes	128	0.40	70	0.85	134	0.29	181	0.13
No	285	0.17	213	0.44	182	0.44	241	0.21

[a] National Cancer Institute- designated cancer center

[b] as reported at interview

†p<0.20, *p<0.10, **p<0.01, ***p<0.001

Interestingly, potential over-reporting was associated with favorable prognostic factors. For example, patients with early-stage cancer, ER/PR-positive status, or who did not receive CT seemingly over-reported HT recommendation and initiation.

In multivariate analyses, patients who received CT and attended NCI/Academic institutions were more likely to under-report HT recommendation and initiation (Table XI). Additionally, those that were interviewed for the study within 90 days of diagnosis tended to under-report HT recommendation. Following the same pattern as with the other modes of treatment, patients who were eligible for treatment (i.e., ER/PR-positive status) appeared to over-report HT recommendation and initiation.

Table XI

INDEPENDENT PREDICTORS OF UNDER- AND OVER-REPORTING OF HORMONE TREATMENT INFORMATION: MULTIVARIATE ANALYSES RESULTS[a]

	Potential Under-reporting		*Potential Over-reporting*	
	Recommendation	*Initiation*	*Recommendation*	*Initiation*
Treatment Facility Type				
NCI[b]/Academic Facility	0.28	0.59		
Other Facility	0.19	0.47		
Risk difference	0.09	0.12		
95% CI	-0.01–0.17	-0.01–0.24		
Time from diagnosis to interview				
<90 days	0.34			
>=90 days	0.22			
Risk difference	0.13			
95% CI	0.02–0.24			
Surgery type				
Breast-conserving				
Mastectomy/None				
Risk difference				
95% CI				
ER/PR status				
Positive			0.58	0.22
Negative			0.12	0.08
Risk difference			0.46	0.14
95% CI			0.35–0.54	0.16–0.32
Lymph node status				
Positive				
Negative				
Risk difference				
95% CI				
Received chemotherapy [c]				
Yes	0.40	0.83		
No	0.17	0.45		
Risk difference	0.23	0.38		
95% CI	0.13–0.34	0.24–0.49		
n	373	247	306	401

[a] statistically significant at p<0.10
[b] National Cancer Institute- designated cancer center
[c] as reported at interview

3. Summary findings and implications

This analysis revealed that the sensitivity of SR treatment information was highest for recommendation (76%–94%) and acceptance (96%–99%) while specificity was highest for initiation (83%–98%) (Table III). Self-reported treatment acceptance information and all the CT information appeared to be highly sensitive, specific, and accurate. Conversely, the SR HT information had the lowest

sensitivity, specificity, and accuracy. Additionally, it was found that for treatment recommendation, the potential for over-reporting (10%–37%) was slightly greater than the potential for under-reporting (6%–24%). On the other hand, treatment initiation is more likely to be under-reported (19%–55%) while there is limited evidence of over-report (2%–17%). The examination of the possible predictors of under- and over-reporting also yielded interesting patterns.

In terms of treatment recommendation, it appears that a patient's treatment eligibility may play an important role in under- and over-reporting. For example, patients with early-stage cancer who have breast-conserving surgery are eligible for RT. However, according to the NCCN Clinical Practice Guidelines in Oncology (2006), RT is also recommended for early-stage cancer patients who undergo a mastectomy but have large tumors (greater than 5 cm tumor) (2006). It turns out that patients with a mastectomy were more likely to under-report an RT recommendation than patients who had breast-conserving surgery. Similarly, patients with node-negative tumors were also more likely to under-report a CT recommendation than patients with node-positive tumors. Patients with a node-positive status are eligible for CT but so are node-negative patients if they have tumors with less favorable histology (NCCN, 2006). On the other hand, patients with tumor characteristics that would generally make them eligible for a given treatment were apparently more likely to over-report treatment. As an example, patients who are generally considered eligible for CT, such as those with node-positive tumors, reported that they were offered CT while there was no documentation of such. In short, there is some evidence that patients who appear to be eligible for treatment report treatment or have documentation of the treatment.

With regard to treatment initiation, under-reporting was more of an issue than over-reporting and it appears that timing may be an important predictor. For instance, those who received CT were more likely to under-report RT and HT. Patients who receive CT typically receive it prior to their course of RT and HT. As a result, patients who receive CT may under-report the initiation of other adjuvant treatments at the time of interview as they are typically received much later in the treatment course.

Similarly, it was observed that a shorter time from diagnosis to treatment was associated with more CT under-reporting. Interestingly, patients who received treatment at an NCI/Academic center were less likely to under-report CT but more likely to under-report HT. It is unclear as to what institutional factors may explain this finding.

The findings from this analysis play an important role in the primary research aims as they help inform decisions related to the definition of the treatment outcome variables. While MRs are considered the gold standard for treatment data, they are cumbersome to obtain in population-based studies as evidenced by the extent of incomplete treatment data derived from the BCCC study's MR abstraction (Table V). In order to improve the MR data, state cancer registry data were obtained. However, cancer registries may not fully capture information on adjuvant treatments as they are not designed to collect validated treatment information and so their use as a gold standard should be questioned (Jagsi et al., 2012).

Several validation studies, which used MRs as the gold standard, have found that SRs were highly accurate for each of the broad categories of breast cancer treatment (Phillips et al., 2005; Maunsell et al., 2005; Yen et al., 2010; Gupta et al., 2011). The present analysis provides further evidence that SRs can be an acceptable form of study treatment information. In fact, several recent studies have used SRs in order to examine patterns of adjuvant treatment in breast cancer patients (Jagsi et al., 2010; Neugut et al., 2012b; Griggs et al., 2012; Livaudais et al., 2012; Livaudais et al., 2013). It can be argued that it is possible to readily collect accurate SR treatment information. Given the burden of collecting MR data and the absence of complete treatment data in state cancer registries, the potential value of SR treatment information cannot be understated.

The examination of the BCCC documented and SR data suggests that using SRs alongside the documented treatment information may be helpful in reducing under-ascertainment of cancer treatment. This may be preferable given that treatment recommendation, acceptance, and initiation are the primary outcome variables of the primary research aims. However, it should be noted that all three

of the BCCC study data sources are generally inadequate with regard to HT information. For instance, HT initiation cannot be properly ascertained via MRs or the cancer registry, since "prescribing" or "administering" this treatment does not imply that the patient initiated the treatment, which is typically taken orally and outside the health care setting. Therefore, SRs may be most useful in this case. However, because HT is the last form of treatment extended to patients, it is particularly prone to under-reporting if patients are questioned too soon after diagnosis (Table XI). Given these limitations, the assessment of HT disparities can only be evaluated with regard to treatment recommendation. Even then, HT recommendation may be under-ascertained (more so than CT or RT).

E. Study Variables

1. Dependent variables

The primary RT, CT, and HT variables were derived from both documented and interview data. The decision to use both sources of data was based on earlier findings that showed using both SRs and documented treatment information can help address issues of under-reporting and under-ascertainment.

Using both documented (i.e., MR and ISCR) and SR data sources, the primary (RT, CT, HT) treatment recommendation, acceptance, and initiation variables were coded as follows:

- Treatment recommendation ="yes" if documented or SR recommendation="yes"; otherwise, recommendation ="no" if documented or SR recommendation="no."
- Treatment acceptance ="yes" if documented or SR acceptance="yes"; otherwise, acceptance ="no" if documented or SR acceptance="no."
- Treatment initiation ="yes" if documented or SR initiation="yes"; otherwise, initiation ="no" if documented or SR initiation="no."

2. Confounder and mediator variables

Depending on the research question, the independent variables below will act as confounders or mediators of the relation between race/ethnicity and the treatment outcomes. Most patient-level variables, including race/ethnicity, were obtained from the BCCC study interview data. Surgery information and tumor-related variables were derived primarily from the ISCR data source. In the limited cases where relevant ISCR tumor information was missing, the MR data were used. The cancer program accreditation status of the initial treating facility comes from the American College of Surgeon's Commission on Cancer (COC) and National Accreditation Program for Breast Cancer (NAPBC). The initial treating hospital was assigned according to the SR place of surgical treatment as it is usually the surgeon who makes referrals for adjuvant treatment. In cases where surgery was not obtained, the place of first (adjuvant) treatment was used.

Below is a summary of all the independent variables that were considered in the analysis of the primary research aims. More detailed information on these variables can be found in Appendix A.

- Race/Ethnicity: SR race/ethnicity was derived from questions on race and Hispanic/Latino origin. Non-Hispanic Black or Hispanic patients were categorized as "minority" while nH White patients were considered to be "non-minority."
- Age: The patient's age was a function of date of birth and interview date.
- Education: Patients reported their highest level of education as being in one of 18 possible categories including grade levels 0–12 and concluding with doctoral degree status.
- Household income: Patients were asked about their total household income, reported from all sources and before taxes. They selected their response from one of 14 possible income ranges (e.g., <=$5,000, $30,000–40,000, $75,001–100,000).
- Neighborhood concentrated disadvantage: This area-level variable attempts to capture the level of structural disadvantage present in the patient's census-tract of

residence at time of diagnosis (Browning et al., 2006). It was comprised from the following 2000 US Bureau of the Census variables: percent below poverty; percent unemployed; percent receiving public assistance; percent in female-headed households; percent under age 18; and percent African American.

- Health Insurance: Patients were asked "What kind of insurance did you have at the time the problem was discovered that turned out to be breast cancer?" Based on the answers to several yes/no questions on a variety of insurance programs were grouped as follows: none, public, private.
- Regular Provider: Patients were asked to respond "yes" or "no" to the following question: "Think back to the time before the problem was discovered that turned out to be cancer. Around that time, did you have a doctor or health care person that you thought of as your own doctor, someone you went to regularly for care?"
- Last physical examination: Patients were asked about the timing of their last routine physical examination. They responded: never, within 12 months, within 2 years, or more than 2 years ago.
- Last clinical breast examination: In terms of clinical breast exams, patients were asked if their most recent exam was: never, within 12 months, within 2 years, or more than 2 years ago.
- Last mammogram: Patients were asked about their most recent mammogram. Patients responded: never, within 12 months, within 2 years, or more than 2 years ago.
- Surgery received: A lumpectomy or partial mastectomy was considered to be "breast-conserving surgery" while mastectomy was labeled as such.
- Tumor stage: Documented stage was based on the American Joint Committee on Cancer, which formulates and publishes systems of classification of tumors by their

anatomic site and histology through use of the Tumor, Node, Metastasis staging system.

- Tumor size: Documented tumor size was defined using centimeters.
- Lymph node status: Documented node status was defined as “negative” if there were 0 examined positive lymph nodes or if patients with Stage 0 tumors did not have nodes examined. Node status was defined as “positive” if there was 1 or more examined positive lymph node/s.
- Receptor status: Tumors that tested positive for ER or PR were coded as “positive”; otherwise, those with a negative result were coded as “negative.”
- Tumor grade: Documented histologic tumor grade was categorized as either well (low), moderately (intermediate), or poorly (high) differentiated.
- Breast tumor knowledge: This variable was comprised of responses to questions regarding the patients’ tumor stage, grade, and hormone receptor status. Briefly, for each tumor characteristic, patients were assessed a score as follows: 0 if she never heard of the term (tumor stage, grade, receptor status), 1 if she heard of the term but did not know her own status, 2 if she stated that she knew her own status but her report was discordant with the MR, and 3 if she stated that she knew her own status and her report agreed with the MR. The total score ranged from 0 to 10 and with a higher score denoting higher breast tumor knowledge.
- Trust in treatment provider: Patients were asked how they felt about the care they received from the doctors, nurses, and technicians during their treatment: “In general, how much do you trust these people to provide you with the best possible health care? Would you say: A great deal, Somewhat, Not too much, Not at all.”
- Breast cancer cultural beliefs: Patients were asked a series of questions related to cultural beliefs regarding breast cancer (screening and treatment). The four true-or-

false statements related to treatment were of primary interest and include: (1) “If a woman has enough faith in God, she won't need treatment for breast cancer,” (2) “If a woman is poor, she won't get cured from breast cancer, because she won't get the best treatment,” (3) “If breast cancer is treated correctly, it can be cured,” and (4) “It doesn't really matter if you get treated for breast cancer, because if you get it, breast cancer will kill you sooner or later.”

- Received needed social support: Questions on social support were about the patients’ emotional, spiritual, financial, and daily practical needs and assistance post-diagnosis such as: “How much [emotional] help or support have you needed?” “How much [emotional] help or support have you received, from anyone?” Patients were able to respond: none, a little, some, a great deal. If the sum of support needed was less than or equal to the sum of support received then the support variable was coded as “yes”; otherwise if needed support exceeded received support then the support variable was coded as “no.”
- Accreditation status of initial treating facility: Facility type was assigned in two ways based on the two American College of Surgeons accreditation programs. Using the COC accreditation categories, treating hospitals were classified as either “NCI-Designated Comprehensive Cancer Program/Academic comprehensive Cancer Program” or “Other.” In an effort to identify hospitals with a high-level level of care specific to breast cancer, the presence (“yes”/”no”) of NAPBC was used.
- Time from diagnosis to interview: This variable was defined based on the difference in days between date of diagnosis and date of interview.

F. Mediation Analysis Approach

In order to quantify the disparity in treatment (recommendation, acceptance, initiation), logistic regression using model-based standardization was employed to estimate age-adjusted RDs. In the presence of disparity, a series of analyses were carried out for the purpose of identifying and quantifying the effect of the hypothesized mediators. There are various pathways through which racial/ethnic disparities in treatment might occur. Therefore, structural equation modeling was employed as it is well suited for describing the relationships in hypothesized theoretical models and quantitatively testing them. Specifically, path models were used because they allows for the examination of observed/measured variables that are either continuous or discrete in nature.

In an effort to inform the path model, several steps were conducted. First, a series of cross-tabular analyses were done in order to: assess racial/ethnic differences in each of the hypothesized mediators; and examine the association between each hypothesized mediator and the treatment (outcome) variable. Factors that were associated with race/ethnicity and the treatment outcome at the $p<0.20$ level were considered potential mediators. Second, based on this initial assessment, a set of pathways between the primary independent variable (minority status), potential mediators, and the primary treatment variable were constructed. A conceptual diagram was used to depict these assumed potential causal relations**.** Third, with respect to each treatment outcome of interest, a preliminary set of logistic regression models were created for each dependent variable represented in the conceptual diagram. An assessment was made as to whether these potential mediators (adjusted for confounders as appropriate) remained significantly ($p<0.20$) associated with the dependent variable. Logistic regression results underwent model-based standardization (predictive margins) so that the results could be interpreted in terms of RDs as opposed to odds ratios. The results from the logistic regression model were compared to the path model results.

The hypothesized path model was evaluated by examining the saturated model (including all hypothesized paths depicted in the conceptual diagram) and removing non-significant paths ($p>=0.20$).

When appropriate, the ordinal form of a variable was used as opposed to its dichotomous form. Because at least one dependent variable was binary or ordinal, a robust mean- and variance-adjusted weighted least squares estimator was used to calculate the standard errors and chi-squares. Numerous criteria, including a non-significant chi-square, were used to assess the fit of the specified path model. Per the recommended guidelines (Yu, 2002), the following measures signified a reasonable data to model fit: Comparative Fit Index (CFI) ≥0.95, Root Mean Square Error of Approximation (RMSEA) ≤ 0.05, and Tucker and Lewis Index (TLI) > 0.95. In addition, individual parameters (estimates) were examined for statistical significance ($p<0.10$). Model modification was conducted if the model was less than satisfactory. The logistic regression coefficients were standardized using the variance of the background and/or outcome variables.

Analyses were performed with Stata 12 (Stata Corp., College Station, Texas), SAS 9.2 (SAS Institute, Cary, North Carolina), and Mplus 6 (Muthén & Muthén, Los Angeles, California). Two-sided tests were used to determine statistical significance.

V. RESULTS OF THE PRIMARY AIMS

A. Assessing and Examining Racial/Ethnic Disparities in Chemotherapy Treatment

The NCCN guidelines changed the CT recommendation between 2005/2006 and 2007 (Figure 2) so that CT was no longer recommended for patients with large (greater than 1 cm) Stage I–II tumors that were ER/PR-positive but HER2-negative.

The figure below shows that when the 2005/2006 guidelines were used to identify CT-eligible patients in the study, a total of 425 patients were deemed eligible. However, when the 2007 guidelines were applied only 261 patients continued to be CT-eligible. Due to missing HER2 status, the CT eligibility status became unknown for 55 patients. For the remaining 109 patients, CT became discretionary.

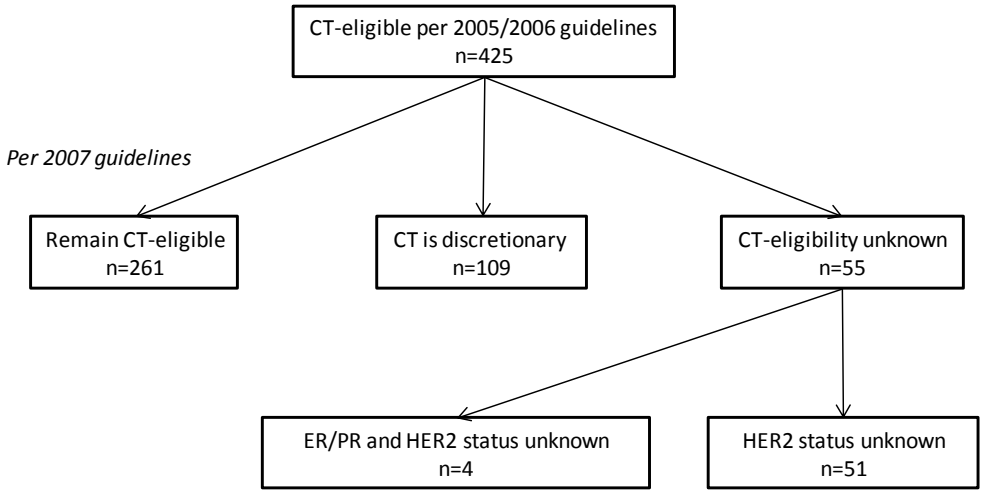


Figure 8. Chemotherapy treatment eligibility by year of guideline.

A closer look at the prevalence of CT recommendation by tumor characteristics and year of diagnosis reveals an interesting pattern (Table XII). Among study patients who remained CT-eligible under the two sets of guidelines (e.g., node-positive), the prevalence of treatment recommendation was quite high (86%–100%). On the other hand, when a patient's CT-eligibility status changed or became unclear due to the differences in the guidelines (e.g., ER/PR and/or HER2 status), treatment recommendation was lower (44%–68%). For this latter group, the lower treatment prevalence may be expected as some of these patients may no longer be deemed eligible for CT during that time period.

Table XII

PROPORTION OF STUDY PATIENTS THAT RECEIVED A CHEMOTHERAPY TREATMENT RECOMMENDATION BY TUMOR CHARACTERISTICS AND YEAR OF DIAGNOSIS

Eligibility per guidelines				*Year of Diagnosis*		
2005/2006	*2007*	*Stage I-II*[a]	*n*	*2005*	*2006*	*2007*
yes	yes	- had >=1 positive node	112	1.00	0.94	0.96
yes	yes	- had tumor>1cm and ER/PR-negative	51	1.00	1.00	1.00
yes	yes	- had tumor>1cm and ER/PR-positive and HER2-positive	15	1.00	0.83	1.00
yes	discretionary	- had tumor>1cm and ER/PR-positive and HER2-negative	109	0.56	0.54	0.44
yes	unknown[b]	- had tumor>1cm and ER/PR or HER2 status unknown	55	0.68	0.63	0.66
		Stage III				
yes	yes	-all	83	1.00	0.97	1.00

[a]Excludes tumors with favorable histology (tubular or colloid)
[b] Dependent on ER/PR and HER2 status

1. Effect of changing treatment guidelines on racial/ethnic treatment disparities observed

Table XIII presents CT outcomes as reported from patient interviews, MRs abstracted, and the ISCR. Among patients eligible for CT per the 2005/2006 guidelines, minority patients were more likely than nH White patients to receive a recommendation (0.87 versus 0.75, RD=0.12, p=0.002). However, when eligibility was determined per the 2007 guidelines, no such disparity was observed. This

appears to occur because under the 2007 guidelines only 54% of nH White patients remained CT-eligible as compared to 65% of minority patients.

Table XIII

AGE-ADJUSTED RISK DIFFERENCES (USING MODEL-BASED STANDARDIZATION) IN CHEMOTHERAPY TREATMENT BY MINORITY STATUS

Eligibility per 2005/2006 guidelines							
		All	*Minority*	*nH White*	*Risk difference*	*95% CI*	*p-value*
Chemotherapy recommended (among eligible)	p	0.82	0.87	0.75	0.12	0.04–0.19	0.002
	(n)	(425)	(268)	(157)			
Chemotherapy accepted (among recommended)	p	0.94	0.95	0.92	0.03	-0.03–0.09	0.285
	(n)	(349)	(233)	(116)			
Chemotherapy initiated (among accepted)	p	0.97	0.97	0.97	0.00	-0.04–0.04	0.903
	(n)	(327)	(221)	(106)			
Chemotherapy initiated (among eligible)	p	0.75	0.80	0.67	0.13	0.04–0.21	0.001
	(n)	(425)	(268)	(157)			
Eligibility per 2007 guidelines							
		All	*Minority*	*nH White*	*Risk difference*	*95% CI*	*p-value*
Chemotherapy recommended (among eligible)	p	0.98	0.98	0.98	0.00	-0.04–0.03	0.971
	(n)	(261)	(174)	(87)			
Chemotherapy accepted (among recommended)	p	0.98	0.98	0.99	0.01	-0.01–0.04	0.486
	(n)	(255)	(170)	(85)			
Chemotherapy initiated (among accepted)	p	0.99	0.99	0.99	0.00	-0.02–0.02	0.915
	(n)	(250)	(166)	(84)			
Chemotherapy initiated (among eligible)	p	0.95	0.94	0.95	0.01	-0.05–0.06	0.714
	(n)	(261)	(174)	(87)			

Regardless of which guideline is used, among patients who receive a CT recommendation, most all accept and initiate treatment. That is, once CT is recommended, it is virtually always initiated.

2. Disparities in discretionary chemotherapy treatment

Between 2005 and 2007, the treatment eligibility status changed for patients with node-negative tumors that were larger than 1 cm and were ER/PR-positive but HER2-negative (Table XIV). Specifically, CT was no longer strongly recommended but may be considered. Among this subset of patients (n=109), it appears that minority patients were more likely than nH White patients to have

been offered CT (0.64 versus 0.40 respectively). Interestingly, the level of treatment acceptance (77%) and initiation (91%) was generally lower than it was for patients for whom CT was strongly recommended (98% and 91%, respectively).

Table XIV

AGE-ADJUSTED RISK DIFFERENCES (USING MODEL-BASED STANDARDIZATION) IN DISCRETIONARY CHEMOTHERAPY TREATMENT BY MINORITY STATUS

Eligible per 2005/2006 but not 2007 NCCN guidelines[a]		*All*	*Minority*	*nH White*	*Risk difference*	*95% CI*	*p-value*
Chemotherapy recommended	p	0.53	0.64	0.40	0.24	0.01–0.37	0.050
	(n)	(109)	(57)	(52)			
Chemotherapy accepted (among recommended)	p	0.77	0.83	0.67	0.15	-0.07–0.38	0.191
	(n)	(56)	(36)	(20)			
Chemotherapy initiated (among accepted)	p	0.91	0.86	1.00	0.14	-----	0.167
	(n)	(43)	(29)	(14)			
Chemotherapy initiated	p	0.36	0.45	0.27	0.18	0.01–0.35	0.043
	(n)	(109)	(57)	(52)			

[a]includes patients with node-negative tumors > 1cm and were ER/PR-positive but HER2-negative

Table XV shows the CT recommendation prevalence by certain socioedemographic, healthcare, and tumor characteristics. Younger patients, those with lower household income, and those without health insurance were more likely to receive a CT recommendation. In terms of clinical factors, patients who had a mastectomy, larger, or higher grade tumors were more likely to receive a recommendation.

Table XV

DISCRETIONARY CHEMOTHERAPY TREATMENT RECOMMENDATION[a] BY SOCIODEMOGRAPHIC, HEALTHCARE, AND TUMOR FACTORS

		Recommendation	
	n	*(%)*	
Race/Ethnicity			*
nH White	52	(38)	
Minority	57	(63)	
Age			*
<50 years old	30	(69)	
>= 50 years old	78	(44)	
Education			
<=High school	41	(46)	
>High school	68	(53)	
Household income			†
<=$75,000	78	(55)	
>$75,000	31	(37)	
Health insurance			†
None	12	(81)	
Public	19	(49)	
Private	78	(47)	
COC[b] accreditation category			
NCI[c]/Academic	80	(52)	
Non-NCI/Academic	22	(37)	
NAPBC[d] accreditation			
Yes	56	(48)	
No	48	(50)	
Tumor size			**
<2 cm	71	(38)	
>=2 cm	38	(73)	
Tumor Grade			**
Low	35	(28)	
Moderate-high	72	(61)	
Surgery type			
Breast-conserving	75	(40)	**
Mastectomy	34	(74)	
Year of Diagnosis			
2005	15	(56)	
2006	51	(54)	
2007	43	(44)	

†p<0.20, *p<0.10, **p<0.01, ***p<0.001

[a] includes patients with node-negative tumors > 1cm and were ER/PR-positive but HER2-negative

[b] Commission on Cancer

[c] National Cancer Institute- designated cancer center

[d] National Accreditation Program for Breast Centers

It was demonstrated earlier that minority patients are more likely than nH White patients to have tumors with less favorable characteristics (Table II). Therefore, it was suspected that the racial/ethnic difference in CT recommendation would be largely explained by tumor differences. Indeed, the multivariate analysis revealed that the racial/ethnic differences observed in patients for whom CT was discretionary was primarily due to the differences in tumor characteristics (Table XVI). Patients bearing tumors with more unfavorable characteristics were more likely to receive a recommendation for CT. After considering tumor size and grade, the racial/ethnic disparity was greatly attenuated and no longer statistically significant.

Table XVI

RISK DIFFERENCES IN DISCRETIONARY CHEMOTHERAPY RECOMMENDATION[a]: LOGISTIC REGRESSION WITH MODEL-BASED STANDARDIZATION[b]

	Base Model	*Full Model*
Race/Ethnicity		
Minority	0.62	0.57
nH White	0.41	0.45
Risk difference	0.20*	0.12†
95% CI	0.06–0.42	-0.03–0.34
Tumor size		
<2 cm		0.42
>=2 cm		0.69
Risk difference		0.27**
95% CI		0.11–0.47
Tumor Grade		
Low		0.39
Moderate-high		0.57
Risk difference		0.17*
95% CI		0.11–0.40
n	109	107

†p<0.20, *p<0.10, **p<0.01, ***p<0.001

[a]includes patients with node-negative tumors > 1cm and

[b]All models adjusted for age and days from diagnosis to interview

B. Assessing and Examining Racial/Ethnic Disparities in Adjuvant Radiation Treatment

A total of 443 patients were determined to be eligible for RT, one of which did not have any available RT information. Therefore, RT disparity was only assessed among these 442 treatment eligible patients.

1. Assessment of racial/ethnic disparities in treatment

Based on the information reported from patient interviews, MRs abstracted, and the ISCR, RT was recommended to 94% of patients, most of which (97%) accepted it (Table XVII). Among patients that accepted the treatment, 90% received treatment. Overall, however, among all RT-eligible patients, a total of 79% received treatment. This lower percentage is partly reflective of under-recommendation and treatment refusal. That is, among the 93 patients who did not initiate treatment, 30% did not receive a recommendation and approximately 16% refused treatment.

Table XVII

AGE-ADJUSTED DIFFERENCES (USING MODEL-BASED STANDARDIZATION) IN RADIATION TREATMENT BY MINORITY STATUS

		All	*Minority*	*nH White*	*Risk difference*	*95% CI*	*p-value*
Radiation recommended (among eligible)	p	0.94	0.93	0.95	0.01	-0.06–0.04	0.535
	(n)	(442)	(262)	(180)			
Radiation accepted (among recommended)	p	0.97	0.96	0.98	0.02	-0.05–0.01	0.247
	(n)	(402)	(234)	(168)			
Radiation initiated (among accepted)	p	0.90	0.88	0.93	0.05	-0.01–0.10	0.115
	(n)	(388)	(224)	(164)			
Radiation initiated (among eligible)	p	0.79	0.75	0.84	0.09	0.02–0.17	0.014
	(n)	(442)	(262)	(180)			

There were no statistically significant racial/ethnic differences in RT recommendation and acceptance. However, among patients who accepted RT, minority patients were slightly less likely than White patients to have received it (0.88 and 0.93, respectively). Among all RT-eligible patients, the

disparity was more apparent (RD=0.09; 95% CI:0.02–0.17) as the small differences in recommendation and acceptance contributed slightly to the overall treatment initiation disparity.

2. Evaluation of hypothesized mediators

Several hypothesized mediators (see Figure 1) were found to be associated with race/ethnicity and RT underuse. For instance, minority patients were more likely than nH White patients to have lower breast tumor knowledge and to receive treatment at institutions without accredited cancer programs (Table XVIII). These same factors were associated with RT underuse. Only one sociocultural factor was associated with both race/ethnicity and RT underuse. Minority patients were more likely to believe that enough faith in God meant one did not need breast cancer treatment. In turn, those who held this belief were less likely to use RT (Table XIX). On the other hand, several tumor and treatment factors differed by race/ethnicity and RT use. Essentially, minority patients had more unfavorable tumor characteristics (e.g., larger size, ER/PR-negative, higher grade) and consequently received more aggressive treatment such as mastectomy and CT (Table XX).

Table XVIII

SOCIODEMOGRAPHIC AND HEALTHCARE DIFFERENCES BY RACE/ETHNICITY AND RADIATION TREATMENT UNDERUSE[a]

	Distribution by Race/Ethnicity				
	nH White (n=180)	*Minority (n=262)*		*Radiation underuse*	
	%	**%**	*n*	*(%)*	
Age					*
<65 years old	67	66	337	(19)	
>= 65 years old	33	34	105	(27)	
Education		***			
<=High school	19	56	177	(24)	
>High school	81	44	265	(20)	
Breast cancer knowledge		***			***
Top tertile	67	24	200	(14)	
Lower tertiles	33	76	242	(27)	
Household income		***			
<=$30,000	18	58	171	(23)	
>$30,000	82	42	262	(20)	
Neighborhood concentrated disadvantage		***			†
Top tertile	2	47	131	(26)	
Lower tertiles	98	57	310	(20)	
Health insurance		***			
None	4	16	53	(29)	
Public	5	25	74	(23)	
Private	92	59	315	(22)	
COC[b] accreditation category		***			†
NCI[c]/Academic	84	57	292	(18)	
Non-NCI/Academic	16	43	134	(25)	
NAPBC[d] accreditation		***			
Yes	63	26	186	(20)	
No	37	74	241	(21)	

†p<0.20, *p<0.10, **p<0.01, ***p<0.001

[a]Includes all RT-eligible patients

[b] Commission on Cancer

[c] National Cancer Institute- designated cancer center

[d] National Accreditation Program for Breast Centers

Table XIX

SOCIOCULTURAL DIFFERENCES BY RACE/ETHNICITY AND RADIATION TREATMENT UNDERUSE[a]

	Distribution by Race/Ethnicity			
	nH White (n=180)	*Minority (n=262)*		*Radiation underuse*
	%	**%**	*n*	*(%)*
High trust in treatment provider		**		
Yes	87	77	128	(22)
No	13	23	276	(20)
If enough faith in God, won't need cancer treatment.		***		*
False	99	83	394	(20)
True	1	17	45	(32)
If poor, won't get cured from breast cancer because won't get best		*		
False	62	73	301	(23)
True	38	27	134	(18)
If breast cancer is treated correctly, it can be cured.		*		
False	14	7	45	(18)
True	86	93	391	(22)
Doesn't matter if treated for cancer, because breast cancer will kill you.		***		
False	98	84	393	(21)
True	2	16	45	(24)
Received social support as needed		**		
Yes	62	47	228	(21)
No	38	53	214	(22)

†p<0.20, *p<0.10, **p<0.01, ***p<0.001

[a]Includes all RT-eligible patients

Table XX

TUMOR AND TREATMENT-RELATED FACTORS BY RACE/ETHNICITY FOR RADIATION TREATMENT-ELIGIBLE PATIENTS[a]

	Distribution by Race/Ethnicity			
	nH White (n=180)	*Minority (n=262)*		*Radiation underuse*
	%	**%**	*n*	*(%)*
Surgery type		†		***
Breast-conserving	87	82	365	(19)
Mastectomy	13	18	77	(37)
Tumor size		**		*
<=2cm	70	57	265	(18)
>2cm	30	43	172	(27)
Tumor Grade		***		***
Low	35	18	101	(10)
Moderate-high	65	82	335	(25)
Lymph node status		**		*
Positive	26	41	157	(27)
Negative	74	59	270	(18)
ER/PR status		**		
Positive	87	76	347	(20)
Negative	13	24	89	(25)
Chemotherapy received		***		*
Yes	39	60	247	(25)
No	61	40	195	(18)

†p<0.20, *p<0.10, **p<0.01, ***p<0.001

[a]Includes all RT-eligible patients

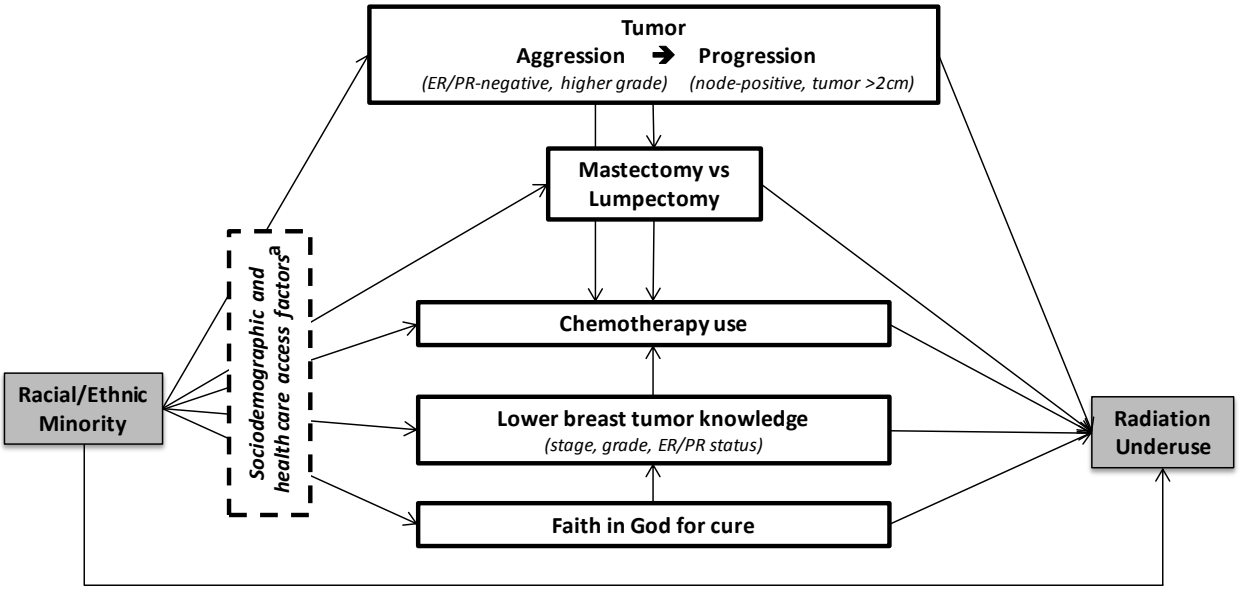
3. Assessment of hypothesized paths

The bivariate analysis results show that several of the hypothesized mediators were indeed associated with both race/ethnicity and treatment initiation. These included: breast tumor knowledge, treatment facility cancer accreditation program status, faith in God for treatment cure, and selected tumor characteristics (e.g., tumor size, grade, node status).

Perhaps not surprisingly, surgery type and CT receipt were also associated with both race/ethnicity and RT initiation. Treatment largely depends on tumor characteristics. Therefore, racial/ethnic differences in treatment reflect the differences in tumor characteristics. Furthermore,

surgery and CT often precede RT. Clearly surgery and CT are along the pathway from race/ethnicity to RT initiation.

Figure 9 illustrates a series of hypothesized paths in the relation between the independent variable (race) and the main dependent variable (RT initiation). Below is a summary of each hypothesized pathway.



[a] *Potential confounders of the association among mediators and between mediators and outcome include sociodemographic (e.g. ,age, income) and health care access (e.g., health insurance) factors.*

Figure 9. Hypothesized paths between race/ethnicity and radiation treatment underuse.

Patients with less favorable tumors are more likely to receive aggressive treatments such as mastectomy and CT. As such, tumor characteristics may act as independent predictors of RT use as well as potential confounders of the surgery-CT and CT-RT relationships. Surgery type may be associated with both CT and RT in that those who receive a mastectomy are less likely to use RT (Jagsi et al., 2010) but more likely to have initiated CT (given their more unfavorable tumor characteristics). Thus, in order to assess the independent affect of CT use on RT initiation, the relationship needs to adjust for the potential confounding effects of tumor characteristics and surgery type. Faith in God for a cure is likely

inversely associated with breast tumor knowledge. Conversely, patients with lower breast tumor knowledge may be less likely to use adjuvant treatment (Bickell et al., 2009). The relationship between tumor knowledge and RT use will need to be adjusted for the potential confounding effect of "faith in God for a cure."

Potential confounders of the aforementioned relationships include age and socioeconomic status, as well as health care access and utilization. These domains differ by race/ethnicity and are often associated with some of the factors outlined above, including the main dependent variable (RT use). As such, the relationships depicted in Figure 9 were adjusted for these potential confounders as appropriate. Factors that are conceptualized as mediators in a relationship are not adjusted for.

Based on this conceptual diagram, a series of logistic regression models representing each path was created.

4. Logistic regression models for each path

Table XXI demonstrates the independent effect of each of the hypothesized mediators on the primary dependent outcome. It shows that patients with less favorable tumor characteristics (higher grade, larger size, node-positive) were less likely to initiate RT. Independent of tumor characteristics, those who had a mastectomy were less likely to receive RT than patients who had breast-conserving surgery. On the other hand, there was no evidence that CT independently predicted RT use. Patients who had higher breast tumor knowledge or were less inclined to believe that faith in God would not necessitate treatment had a higher prevalence of RT initiation.

Table XXI

PREDICTORS OF THE MAIN DEPENDENT VARIABLE: RADIATION TREATMENT UNDERUSE

	n	*%*	*Risk difference*	*p-value*	*Adjustment variables considered*	*Adjustment variables included* [a]
ER/PR-positive	347	20	3	0.52	Sociodemographic,[b] health care access[c]	age, education, last clinical breast exam
ER/PR-negative	89	23				
Low grade	101	10	14	0.01	Sociodemographic,[b] health care access[c]	age, last clinical exam
Mod-high grade	335	24				
Node-negative	270	18	7	0.16	Sociodemographic,[b] health care access,[c] ER/PR status, tumor grade	age, education, last clinical breast exam, tumor grade
Node-positive	157	24				
Tumor<=2cm	265	17	8	0.05	Sociodemographic,[b] health care access,[c] ER/PR status, tumor grade	age, education, tumor grade
Tumor> 2cm	172	25				
Breast-conserving	365	18	15	0.01	Sociodemographic,[b] health care access,[c] tumor-related[d]	age, tumor grade
Mastectomy	77	33				
Chemotherapy non-use	195	18	5	0.26	Sociodemographic,[b] health care access,[c] tumor-related[d] surgery type	age, surgery type, tumor grade
Chemotherapy use	247	23				
High tumor knowledge	200	14	12	0.00	Sociodemographic,[b] health care access,[c] faith in God for cure	age, last clinical breast exam
Lower tumor knowledge	242	26				
Faith God cure-false	394	20	11	0.09	Sociodemographic,[b] health care access[c]	age, last clinical breast exam
Faith God cure-true	45	31				

[a]All models are also adjusted for time from diagnosis to interview

[b]Sociodemographic variables include: minority status, age, income, education, neighborhood concentrated disadvantage

[b]Health care access variables include: insurance status, regular provider, last clinical exam, last mammogram, last routine exam

[d]Tumor-related variables include: grade, ER/PR-receptor status, node status, tumor size

Predictors of the Main Mediating Variables: Tables XXII and XXIII illustrate that race/ethnicity predicts tumor aggressiveness (i.e., grade and receptor-status), which then predicts tumor progression (i.e., size, node-status). Race/ethnicity is also independently associated with tumor progression.

Table XXII

PREDICTORS OF TUMOR AGGRESSIVENESS VARIABLES (ER/PR STATUS AND GRADE)

	n	*%*	*Risk difference*	*p-value*	*Adjustment variables considered*	*Adjustment variables included* [a]
ER/PR-negative						
Minority	256	26	12	0.00	*age*	*age*
nH White	180	14				
Moderate-high grade						
Minority	256	84	18	0.00	age	age
nH White	180	66				

[a]All models are also adjusted for time from diagnosis to interview

Race/ethnicity is weakly associated with surgery type but strongly associated with CT (Tables XXIV and XXV). Tumor aggressiveness and progression are also associated with surgery type and CT initiation. It also appears that surgery type and breast tumor knowledge are not associated with CT use.

Table XXIII

PREDICTORS OF TUMOR PROGRESSION (NODE STATUS AND TUMOR SIZE)

	n	*%*	*Risk difference*	*p-value*	*Adjustment variables considered*	*Adjustment variables included* [a]
Node-positive status						
Minority	253	42	13	0.01	*age*	*age*
nH White	174	29				
ER/PR-positive	333	34	12	0.04	Sociodemographic,[b] health care access[c]	minority status, age, last clinical breast exam, last routine exam
ER/PR-negative	89	46				
Mod-high grade	328	42	22	0.00	Sociodemographic,[b] health care access[c]	minority status, age, income, education, last clinical breast exam
Low grade	93	20				
Tumor>2cm						
Minority	258	44	12	0.01	*age*	*age*
nH White	179	32				
ER/PR-positive	345	36	16	0.004	Sociodemographic,[b] health care access[c]	minority status, age, income, last clinical breast exam, last mammogram
ER/PR-negative	87	52				
Mod-high grade	331	46	30	0.00	Sociodemographic,[b] health care access[c]	minority status, age, income, last clinical breast exam, last mammogram
Low grade	101	16				

[a]All models are also adjusted for time from diagnosis to interview

[b]Sociodemographic variables include: minority status, age, income, education, neighborhood concentrated disadvantage

[b]Health care access variables include: insurance status, regular provider, last clinical exam, last mammogram, last routine exam

Table XXIV

PREDICTORS OF MASTECTOMY

	n	*%*	*Risk difference*	*p-value*	*Adjustment variables considered*	*Adjustment variables included* [a]
Minority	262	20	6	0.15	age	age
nH White	180	14				
ER/PR-positive	347	15	13	0.00	Sociodemographic,[b] health care access[c]	age, last clinical breast exam, last routine exam
ER/PR-negative	89	28				
Mod-high grade	335	19	10	0.03	Sociodemographic,[b] health care access[c]	age, last clinical breast exam, last routine exam
Low grade	101	9				
Node-positive	157	38	33	0.00	Sociodemographic,[b] health care access,[c] ER/PR status, tumor grade	age, income, last clinical breast exam
Node-negative	270	5				
Tumor> 2cm	172	34	29	0.00	Sociodemographic,[b] health care access,[c] ER/PR status, tumor grade	age, last clinical breast exam, last routine exam
Tumor<=2cm	265	5				

[a]All models are also adjusted for time from diagnosis to interview

[b]Sociodemographic variables include: minority status, age, income, education, neighborhood concentrated disadvantage

[b]Health care access variables include: insurance status, regular provider, last clinical exam, last mammogram, last routine exam

Table XXV

PREDICTORS OF CHEMOTHERAPY INITIATION

	n	*%*	*Risk difference*	*p-value*	*Adjustment variables considered*	*Adjustment variables included* [a]
Minority	262	64	19	0.00	age	age
nH White	180	45				
ER/PR-positive	347	49	35	0.00	Sociodemographic,[b] health care access[c]	minority status, age, insurance, last clinical breast exam
ER/PR-negative	89	84				
Mod-high grade	335	63	31	0.00	Sociodemographic,[b] health care access[c]	minority status, age, last clinical breast exam
Low grade	101	32				
Node-positive	157	83	39	0.00	Sociodemographic,[b] health care access,[c] ER/PR status, tumor grade	age, no insurance, neighborhood concentrated disadvantage, regular provider, ER/PR status, tumor grade
Node-negative	270	44				
Tumor> 2cm	172	78	36	0.00	Sociodemographic,[b] health care access,[c] ER/PR status, tumor grade	minority status, age, last clinical breast exam, last mammogram, ER/PR status, tumor grade
Tumor<=2cm	265	42				
Breast-conserving	365	60	4	0.56	Sociodemographic,[b] health care access,[c] tumor-related[d]	age, neighborhood concentrated disadvantage,last clinical breast exam, last mammogram, tumor-related[d]
Mastectomy	77	56				
High tumor knowledge	200	0.56	0	0.94	Sociodemographic,[b] health care access,[c] tumor-related[d]	minority status, age, last clinical breast exam, last mammogram
Lower tumor knowledge	242	0.56				

[a]All models are also adjusted for time from diagnosis to interview

[b]Sociodemographic variables include: minority status, age, income, education, neighborhood concentrated disadvantage

[b]Health care access variables include: insurance status, regular provider, last clinical exam, last mammogram, last routine exam

[d]Tumor-related variables include: grade, ER/PR-receptor status, node status, tumor size

Compared to nH White patients, minority patients had lower breast tumor knowledge and were more likely to believe that treatment was unnecessary due to their faith in God (Table XXVI). However, faith in God did not appear to be associated with tumor knowledge.

Table XXVI

PREDICTORS OF KNOWLEDGE AND BELIEFS

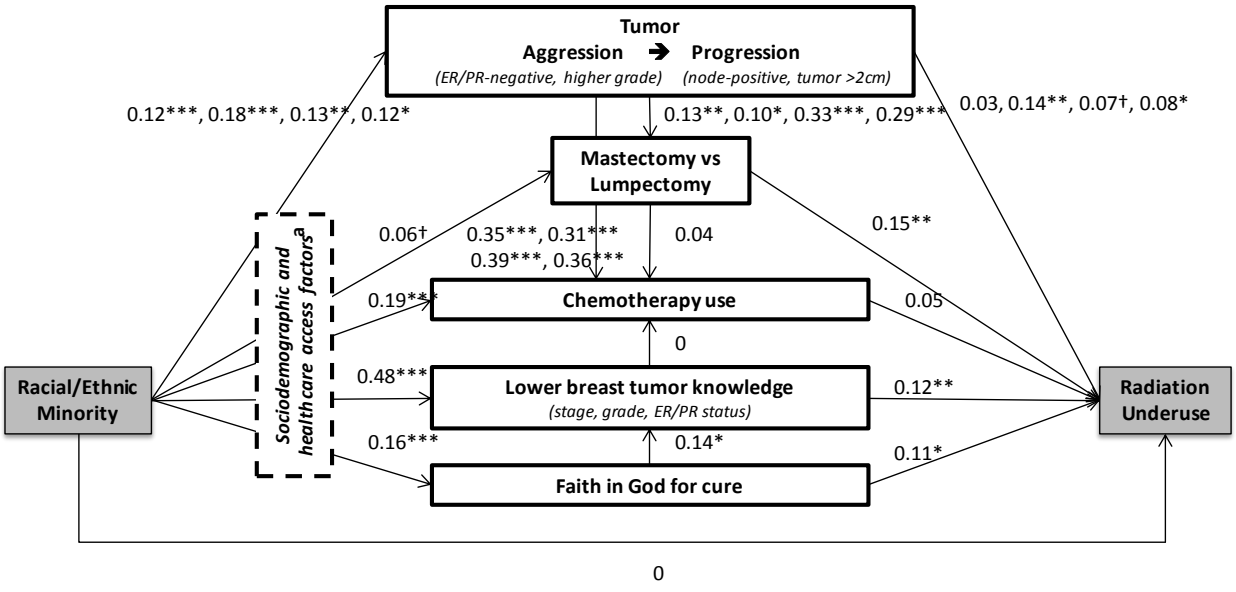
	n	*%*	*Risk difference*	*p-value*	*Adjustment variables considered*	*Adjustment variables included* [a]
Lower tumor knowledge						
Minority	262	74	48	0.00	age	age
nH White	180	26				
Faith in God for cure -false	193	48	14	0.10	Sociodemographic,[b] health care access[c]	minority status, age, education, last clinical breast exam
Faith in God for cure -true	45	34				
Faith in God for cure-true						
Minority	259	17	16	0.00	age	age
nH White	180	1				

[a]All models are also adjusted for time from diagnosis to interview

[b]Sociodemographic variables include: minority status, age, income, education, neighborhood concentrated disadvantage

[b]Health care access variables include: insurance status, regular provider, last clinical exam, last mammogram, last routine exam

A summary of the logistic regression results is depicted in Figure 10, which shows that all but a couple of hypothesized paths appear to be statistically significant. A path analysis was carried out to confirm these findings.



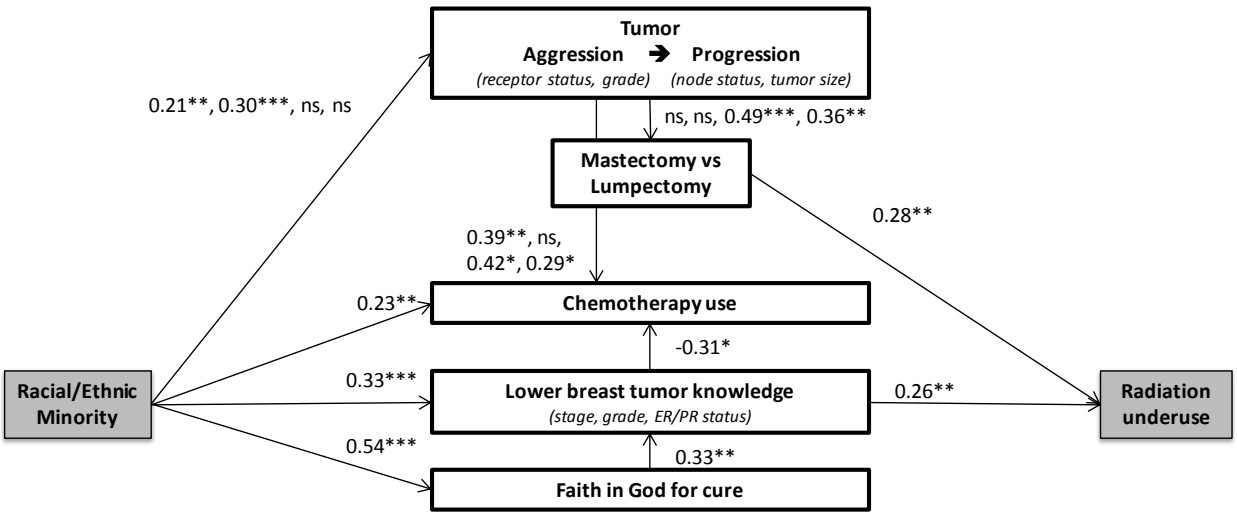
[a]*Potential confounders of the association among mediators and between mediators and outcome include sociodemographic (e.g., age, income) and health care access (e.g., health insurance) factors.*

Figure 10. Risk differences in the hypothesized paths between race/ethnicity and radiation treatment underuse.

5. Path analysis

An examination of the saturated path model revealed that some pathways were not statistically significant and thus were trimmed from the model (Figure 11). Specifically, direct paths to RT initiation that came from tumor characteristics, CT use, and faith in God were eliminated. In addition, receptor status did not predict tumor size or node status.

The final path model illustrates that minority patients were more likely than nH White patients to have aggressive tumors (i.e., receptor-negative, higher grade) that result in node-positive and larger tumors. In turn, patients with more progressed tumors were more likely to receive a mastectomy and thus underuse RT. Minority patients were also more likely than nH White patients to believe that enough faith in God meant that treatment was unnecessary. These patients were more likely to have lower breast tumor knowledge and thus underuse RT. Finally, minority patients had lower tumor knowledge, which was directly associated with both CT and RT underuse.



Standardized coefficients presented
†p<0.20, *<0.10, **p<0.01, ***p<0.001

X^2 for model fit: 28.12 (df=30)
CFI=1.00 ; TLI=1.00 RMSEA=0.000

Figure 11. Final path model of the relation between race/ethnicity and radiation treatment underuse.

The age-adjusted path model was a good fit for the data as demonstrated by the following indices: χ^2 (30)=28.12, p=0.719; RMSEA=0.000; CFI 1.00 and TLI=1.00.

C. Assessing and Examining Racial/Ethnic Disparities in Adjuvant Hormonal Treatment

A total of 303 patients were found to be eligible for HT.

1. Assessment of racial/ethnic disparities in treatment

According to SRs, MRs, and the ISCR, HT was recommended to 86% of patients of which virtually all (99%) accepted it. Racial/ethnic disparities in HT were present however. Minority patients were less likely than White patients to receive a treatment recommendation (0.80 and 0.94, respectively; p=0.00). There were no racial/ethnic differences in terms of treatment acceptance.

Table XXVII

AGE-ADJUSTED DIFFERENCES (USING MODEL-BASED STANDARDIZATION) IN HORMONAL TREATMENT BY MINORITY STATUS

		All	*Minority*	*nH White*	*Risk difference*	*95% CI*	*p-value*
Hormone treatment recommended (among eligible)	p	0.86	0.80	0.94	0.15	0.07–0.22	0.000
	(n)	(303)	(177)	(126)			
Hormone treatment accepted (among recommended)	p	0.99	0.99	0.99	0.00	-0.02–0.02	0.845
	(n)	(250)	(135)	(115)			

2. Evaluation of hypothesized mediators

Several of the hypothesized mediators (see Figure 1) were indeed associated with both race/ethnicity and treatment. Compared to nH White patients, minority patients had lower breast tumor knowledge, had higher grade tumors, and were more likely to receive treatment at institutions without an accredited breast cancer program. These same factors were associated with HT under-recommendation (Table XXVIII).

Table XXVIII

SOCIODEMOGRAPHIC, HEALTHCARE, AND TUMOR DIFFERENCES BY RACE/ETHNICITY AND HORMONAL TREATMENT UNDER-RECOMMENDATION[a]

	Distribution by Race/Ethnicity			
	nH White (n=126)	*Minority (n=177)*	*Under-recommendation*	
	%	**%**	*n*	*(%)*
Age		*		
<65 years old	67	57	217	(15)
>= 65 years old	33	43	84	(11)
Education		***		
<=High school	24	54	122	(15)
>High school	76	46	180	(12)
Breast tumor knowledge		***		***
Highest quartile	71	22	139	(4)
Lower quartiles	29	78	163	(20)
Household income		***		
<=$30,000	20	56	115	(15)
>$30,000	80	44	183	(13)
Neighborhood concentrated disadvantage		***		**
Top tertile	2	53	87	(22)
Lower tertiles	98	47	215	(10)
Health insurance		***		*
None	4	12	32	(25)
Public	6	30	60	(18)
Private	89	58	210	(11)
COC[b] accreditation category		***		*
NCI[c]/Academic	86	58	206	(11)
Non-NCI/Academic	14	42	83	(19)
NAPBC[d] accreditation		***		**
Yes	60	25	125	(6)
No	40	75	266	(18)
Surgery type				*
Breast-conserving	66	67	199	(11)
Mastectomy	34	34	103	(18)
Tumor Grade		**		*
Low	33	17	67	(5)
Moderate-high	67	83	230	(16)
Tumor size				*
<=2cm	63	60	180	(10)
>2cm	37	40	120	(17)
Lymph node status				
Positive	31	32	96	(15)
Negative	69	68	194	(10)

†p<0.20, *p<0.10, **p<0.01, ***p<0.001

[a] Includes all HT-eligible patients

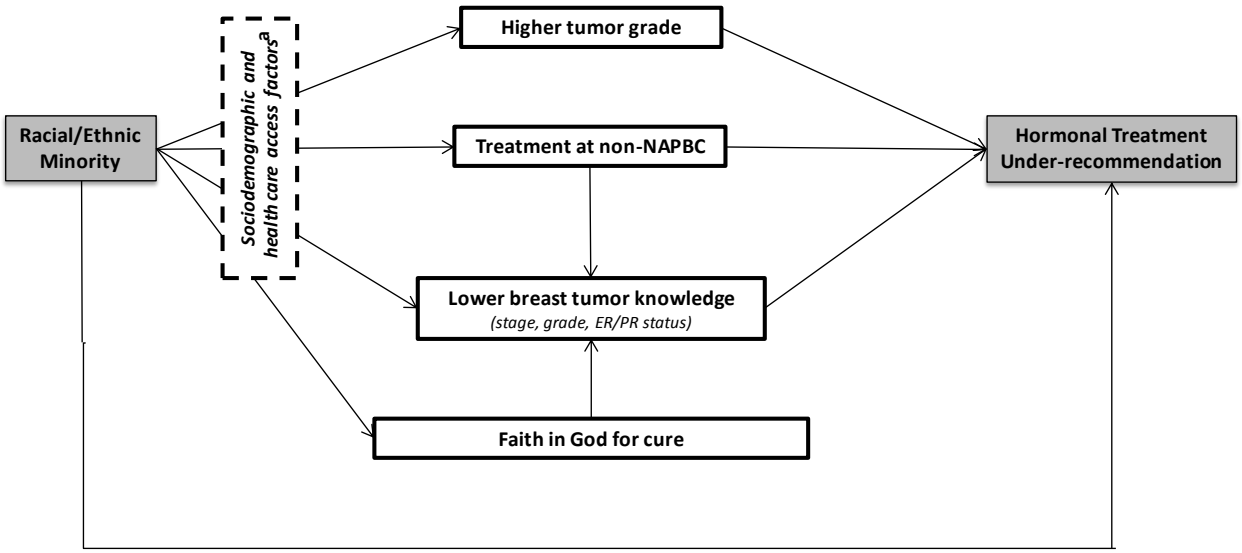
[b] Commission on Cancer

[c] National Cancer Institute-designated cancer center

[d] National Accreditation Program for Breast Centers

2. Assessment of hypothesized paths

Figure 12 illustrates the hypothesized pathways in the relation between the independent variable (minority status) and the main dependent variable (HT recommendation). Below is a summary of each pathway.



[a] *Potential confounders of the association among mediators and between mediators and outcome include sociodemographic (e.g., age, income) and health care access (e.g., health insurance) factors.*

Figure 12. Hypothesized paths between race/ethnicity and hormonal treatment under-recommendation.

Minority patients are more likely to have a higher tumor grade and receive treatment at institutions without an NAPBC. In turn, these factors are associated with HT under-recommendation. There is also evidence that minority patients have lower breast tumor knowledge and that such patients are less likely to receive a recommendation for HT. It may also be that the presence of an NAPBC program in the treating institute influences a patient's breast tumor knowledge. Furthermore, the results from the assessment and examination of disparities in RT showed that faith in God for a cure inversely influenced breast tumor knowledge and so it was added to the hypothesized paths.

Based on this conceptual diagram, a series of logistic regression models representing each path was estimated. Models were adjusted for potential confounders as appropriate. Factors that are conceptualized as mediators in a relationship are not adjusted for.

3. Logistic regression models for each path

Table XXIX demonstrates the independent effect of each of the hypothesized mediators on the primary dependent outcome. It shows that patients with a lower tumor grade, who received treatment at an institution with an accredited breast cancer program, and who had high breast tumor knowledge were more likely to receive an HT recommendation.

Table XXIX

PREDICTORS OF THE MAIN DEPENDENT VARIABLE: HORMONAL TREATMENT UNDER-RECOMMENDATION

	n	%	*Risk difference*	*p-value*	*Adjustment variables considered*	*Adjustment variables included* [a]
Grade						
Mod-high grade	230	0.16	0.09	0.02	Sociodemographic,[b] health care access[c]	minority, age
Low grade	67	0.07				
NAPBC [d]						
Yes	125	0.08	0.09	0.03	Sociodemographic,[b] health care access[c]	minority, age
No	166	0.17				
High tumor knowledge	139	0.05	0.15	0.00	Sociodemographic,[b] health care access[c]	minority, age, education
Lower tumor knowledge	163	0.20				

[a]All models are also adjust for time from treatment to interview
[b]Sociodemographic variables include: minority status, age, income, education, neighborhood concentrated disadvantage
[c]Health care access variables include: insurance status
[d]National Accreditation Program for Breast Centers

Table XXX shows that all the potential mediators are associated with the main independent variable, minority status. In addition, treatment facility breast cancer program status also independently predicted breast tumor knowledge, although faith in God did not.

Table XXX

PREDICTORS OF THE MAIN MEDIATING VARIABLES

	n	%	*Risk difference*	*p-value*	*Adjustment variables considered*	*Adjustment variables included* [a]
Moderate-high grade					age	age
Minority	172	0.84	0.15	0.00		
nH White	125	0.69				
NAPBC[c] accreditation					age	age
Minority	166	0.25	0.36	0.00		
nH White	125	0.61				
Lower tumor knowledge						
Minority	176	0.75	0.48	0.00	age	age
nH White	126	0.27				
NAPBC	125	0.43	0.19	0.00	Sociodemographic,[b] health care access[c]	minority, education, insurance status, age
non-NAPBC	166	0.62				
Faith in God for cure -false	271	0.58	0.03	0.77	Sociodemographic,[b] health care access[c]	minority, education, insurance status, age
Faith in God for cure -true	29	0.55				
Faith in God for cure-true						
Minority	174	0.15	0.13	0.00	age	age
nH White	126	0.02				

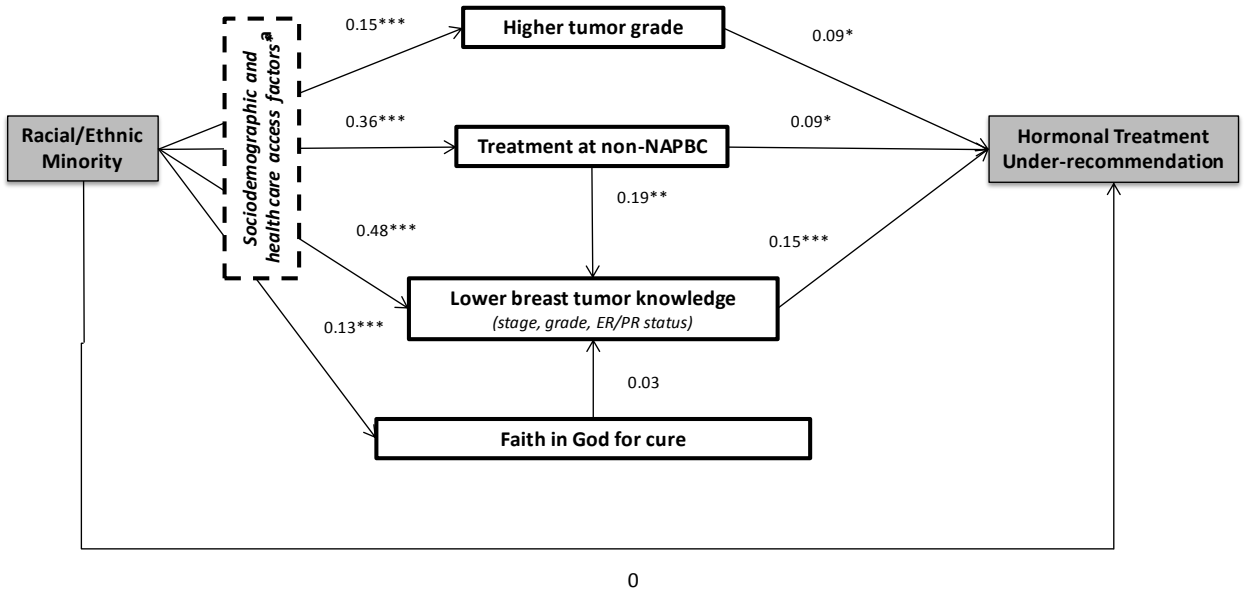
[a]All models are also adjust for time from treatment to interview

[b]Sociodemographic variables include: minority status, age, income, education, neighborhood concentrated disadvantage

[c]Health care access variables include: insurance status

[d]National Accreditation Program for Breast Centers

A summary of the logistic regression results is depicted in Figure 13 and demonstrates that all but one hypothesized pathway appear to be statistically significant. A path analysis was carried out to confirm these relationships.



[a] *Potential confounders of the association among mediators and between mediators and outcome include sociodemographic (e.g., age, income) and health care access (e.g., health insurance) factors.*

†p<0.20, *<0.10, **p<0.01, ***p<0.001

Figure 13. Risk differences in the hypothesized paths between race/ethnicity and hormonal treatment under-recommendation.

4. Path analysis

An examination of the saturated path model revealed that all but one path were statistically significant. Specifically, there appeared to be no direct path between a treating facility's NAPBC status and HT recommendation.

The final path model shows that minority patients were somewhat more likely than nH White patients to have higher grade tumors and that such patients were less likely to receive an HT recommendation. Minority patients were also more likely to receive care at non-NAPBC facilities and to believe that enough faith in God meant that treatment was unnecessary. They were also less knowledgeable about their tumor stage, grade, and receptor-status. While treatment facility type and faith in God for treatment were not directly associated with HT under-recommendation, they were indirectly associated through its relationship with breast tumor knowledge. In turn, lower knowledge

was associated with HT under-recommendation. Only tumor grade and tumor knowledge were directly associated with treatment recommendation.

The age-adjusted path model was a good fit for the data as demonstrated by the following indices: χ^2 (7)=6.35, p=0.499; RMSEA=0.000; CFI=1.00 and TLI=1.00.

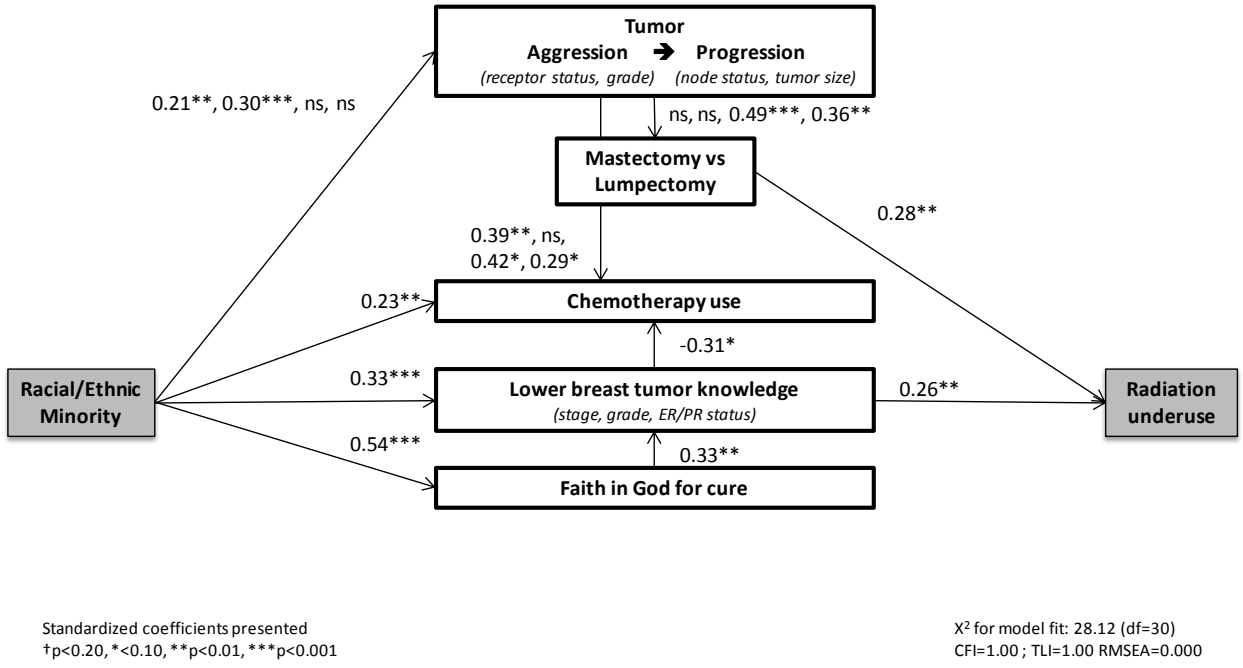


Figure 14. Final path model of the relation between race/ethnicity and hormonal treatment under-recommendation.

VI. DISCUSSION

A. Chemotherapy Treatment Disparities in the Context of Changing Treatment Guidelines

Breast cancer treatment is constantly advancing and so guidelines must integrate the new evidence on effective treatments (Llombart-Cussac, 2008). One of the primary research aims entailed examining racial/ethnic disparities in CT among treatment-eligible patients. However, the treatment guidelines changed during the study period and so an assessment of disparities had to take this change into consideration. Two important observations were made. First, the association between race/ethnicity and treatment differed, depending on which guideline was used to determine treatment eligibility. Under the 2005/2006 NCCN guidelines, minority patients appeared more likely than nH White patients to receive a treatment recommendation (0.87 versus 0.75, RD=0.12, p=0.00). However, when eligibility was determined per the 2007 guidelines, no disparity was observed. This appears to have occurred because under the new 2007 guidelines, CT became discretionary for patients with greater than 1 cm node-negative tumors that were ER/PR-positive but HER2-negative status. Non-Hispanic White patients were more likely than minority patients to have tumors with such characteristics. Second, among this group of patients for whom CT became discretionary, minority patients were more likely than nH White patients to have been treated (0.45 versus 0.27, RD=0.18, p=0.04). However, this disparity was largely explained by tumor characteristics whereby patients with larger and higher grade tumors were more likely to be offered CT. Patients with such unfavorable tumor characteristics generally receive more aggressive treatment (Kurian et al., 2013; Ademuyiwa et al., 2011) and so it appears that perhaps minority patients were not necessarily "over-treated."

The results also suggest that advances in CT for breast cancer patients are implemented in the clinical setting ahead of published NCCN guidelines. The indirect evidence comes from the treatment patterns observed among patients for whom CT became discretionary per the 2007 NCCN guidelines (greater than 1 cm node-negative tumors with ER/PR-positive but HER2-negative status). First, consider

that throughout the three main years of the study (2005–2007), treatment recommendation in this group of patients remained low and surprisingly constant (45%–56%). Thus, it seems that clinicians changed their treatment patterns well ahead of the 2007 guidelines. In addition, the role of 21-gene recurrence score (RS) testing cannot be ignored. For breast cancer patients with early stage breast tumors that are ER-positive and node-negative, RS testing predicts the rate of recurrence (Paik, 2007). Patients are recommended CT if their tumors are ER-positive but node-negative and have either a high RS (greater than 30) or RS testing was not done. Chemotherapy is considered optional or not recommended if they have an intermediate or low score, respectively. While RS testing was not introduced into the NCCN guidelines until 2008 (NCCN, 2008), it was included in the 2007 American Society of Oncology treatment guidelines (Harris et al., 2007). Recent studies show that RS testing was being used in various institutions (e.g., cancer centers, academic hospitals, inner-city hospitals) across the country as early as 2005 (Hassett et al., 2012; Malo et al., 2012; Partin and Mamounas, 2011; Ademuyiwa et al., 2011; Lund et al., 2012). Some of these studies show that RS results were more likely to predict CT use than standard clinicopathologic factors (i.e., standard guidelines), which implies that clinicians were using RS testing to guide their treatment recommendation. An increase in the use of RS testing has resulted in a reduction of CT among early stage ER-positive patients (Partin and Mamounas, 2011; Ademuyiwa et al., 2011; Malo et al., 2012). The BCCC study population came from a large urban city which has two NCI-designated cancer institutions as well as several comprehensive and community cancer centers. Therefore, it is possible that RS testing was being implemented on some level during the study period. If so, this provides further indirect evidence that among patients for whom CT became discretionary, minority patients were not necessarily more likely than nH White patients to be over-treated, as they had tumors with characteristics that are associated with higher RS scores, thus making them eligible for treatment (Lund et al., 2012; Ooi, Martinez, and Li, 2010; Banegas and Li, 2012; Geradts et al., 2010). Conversely, nH White breast cancer patients have tumors with more favorable features, including lower RS scores, thus making them less likely to require CT (Lund et al., 2008).

While it may not be surprising that clinicians change their treatment practices ahead of published guidelines in order to provide the best patient care, this practice poses some difficulty in assessing guideline-adherent CT patterns (e.g., racial/ethnic disparities). It may also be one reason as to why the literature on the assessment of disparities in CT has yielded some inconsistent results. For instance, consistent with our findings, Neugut and colleagues (2012b) did not find racial/ethnic disparities in CT among patients for whom treatment was indicated. They also noted that among patients for whom treatment was discretionary, larger tumor size and higher tumor grade were independent predictors of CT use. Conversely, in an unadjusted analysis, Freedman et al. (2011) found that among CT-eligible patients (Stage I–III with greater than 1 cm or node-positive tumors), nH White patients were less likely than nH Black or Hispanic patients to receive CT. However, after adjustment for clinicopathologic factors such as ER/PR-receptor status and grade, nH Black patients were less likely to receive treatment than nH White patients. There were no differences between Hispanic and nH White patients. The nHWhite/nH Black that was initially observed provides some evidence of an early uptake of treatment guidelines. It is likely that nH White patients were perhaps no longer really eligible to receive treatment (due to more favorable tumor characteristics), and thus were less likely to receive CT than nH Black patients. Finally, while Griggs et al. (2012) did not find an nH Black/nH White disparity they did observe that Hispanic patients were more likely to receive CT than nH White patients. While they adjusted for stage and ER/PR-receptor status, they did not adjust for tumor size, node status, and HER2 status. Given that nH Black patients generally have larger and more aggressive tumors, their study may have underestimated the nH Black/White disparity (OR=0.83; 95% CI:0.64–1.08).

In summary, the research findings with regard to CT suggest that an evaluation of racial/ethnic disparities in guideline-adherent CT must carefully consider how to best define treatment eligibility given the ongoing changes in treatment guidelines and the advent of personalized medicine (Ellsworth et al., 2010). Inadequate consideration of these changes may lead to erroneous conclusions. In addition, vigilance about possible disparities in the uptake of these new CT advances is required. Some have

already noted that among eligible patients, RS testing was lower for nH Black patients, lower-educated patients, and patients who received care at public or community hospitals (Lund et al., 2012; Hassett et al., 2012). If not all patients are benefitting equally from improved diagnostic testing, disparities in outcomes and quality of life may result.

B. Radiation Treatment Disparity: The Role of Surgery Type and Breast Tumor Knowledge

This study of breast cancer patients showed that the vast majority of RT-eligible patients received an RT recommendation (94%) that was almost always accepted (97%). There were no discernible racial/ethnic differences in treatment recommendation and acceptance. However, among all RT-eligible patients, minority patients were less likely than nH White patients to receive radiation. The disparity appears to be explained by the racial/ethnic differences in surgery type and breast tumor knowledge.

Some studies have examined treatment patterns among RT-eligible patients, including mastectomy patients (Martinez et al., 2010; Jagsi et al., 2010; Freedman et al., 2011). Two of these three studies documented similar racial/ethnic disparities. Using SEER data, Martinez et al. reported that, compared to nH White patients, nH Black (OR=0.76; 95% CI:0.67–0.76) and Hispanic (OR=0.80; 95% CI:0.70–0.90) patients were less likely to receive radiation. On the other hand, Freedman and colleagues noted that the disparity was present for nH Black (OR=0.91; 95% CI:0.88–0.94) but not Hispanic patients (OR=0.97; 95% CI:0.91–1.04). Their sample population was obtained from the hospital-based National Cancer Data Base registry. We observed a similar disparity in RT between minority and nH White patients (0.84 and 0.75, p=0.01).

Similar to these recent studies, we found evidence that RT use was lower for those that received a mastectomy versus breast-conserving surgery (Martinez et al., 2010; Jagsi et al., 2010). Minority patients were more likely to undergo a mastectomy and consequently underuse RT. While Jagsi et al.

(2010) did not find any racial/ethnic differences in RT, the study by Martinez et al. (2010) suggested that the disparity in RT was primarily among patients who received a mastectomy.

Despite established clinical guidelines based on evidence that post-mastectomy RT infers survival benefits and protection against recurrence among high-risk patients (Recht et al., 2001; Ragaz et al., 2005; Nielsen et al., 2006), it appears that providers may be under-recommending RT. Jagsi and colleagues (2010) reported that among patients who did not receive RT but for whom it was strongly indicated, most did not receive it because their doctor did not discuss RT or felt it was not needed. This was more common among patients who received a mastectomy as opposed to breast-conserving surgery (72% versus 45%, respectively). We found a similar association. Lack of treatment recommendation was much higher for patients who underwent a mastectomy compared to those who had breast-conserving surgery (43% versus 26%, respectively). It is worth noting that we did not find racial/ethnic differences in treatment recommendation even though minority patients were more likely than nH White patients to receive a mastectomy.

Besides treatment under-recommendation, there are other possible reasons as to why RT-eligible patients who receive a mastectomy are at risk of underutilizing RT. For instance, the patient-provider interaction may be critical with regard to cancer treatment recommendation and initiation. The study by Jagsi's group (2010) observed that mastectomy patients were more likely to use RT when they reported that their surgeon was highly involved in the decision-making process surrounding RT. Studies have shown that the interaction affects patient satisfaction and recommendation adherence (Ashton et al., 2003; Sheppard et al., 2010). The patient-provider communication has also been found to be associated with a patient's knowledge of treatment risk and benefit (Hawley et al., 2008). Another potential barrier to RT may be the use of CT. Mastectomy patients are more likely than breast-conserving surgery patients to require CT which is most often delivered prior to RT. As a result, mastectomy patients may not recall their RT recommendation and thus do not initiate treatment. It may also be that patients who undergo CT forego their RT due to the emotional and physical distress that

results from their systemic treatment. However, we did not find any indication that patients who underwent CT were less likely to initiate RT. In fact, others have found that among mastectomy patients, those who received CT or were most likely eligible for CT (e.g., positive node status, higher grade) were more likely to receive RT (Dragun et al., 2012; Jagsi et al., 2009). Finally, structural issues may pose barriers to treatment. For example, Hendren and colleagues (2011) found that minority breast cancer patients were more likely than nH White patients to report transportation, language, and childcare care issues as barriers to their cancer care.

It was also found that a patient's knowledge about her breast cancer stage, grade, and receptor-status was positively associated with her use of RT. The lower knowledge level found in minority patients resulted, in part, to lower RT use. The potential role of a patient's level of knowledge with regard to her tumor characteristics has not been explored in the cancer literature. We hypothesized that patients with higher breast tumor knowledge may be more likely to initiate treatment because they may be more engaged in the treatment decision-making process and thus better understand the importance of treatment initiation in relation to tumor recurrence and to their survival. There are studies that note the importance of cancer treatment knowledge in treatment decision-making (Sepucha, Ozanne, and Mulley, 2006; Polacek, Ramos, and Ferrer, 2007; Rimer et al., 2004). One study found that adjuvant treatment underuse was associated with lower treatment knowledge (Bickell et al., 2009). An increased awareness of the risks, benefits, and efficacy of treatment can improve the likelihood of treatment initiation (Neugut et al., 2012a; Neugut et al., 2012b).

Researchers have found that minority breast cancer survivors find comfort and strength in their spiritual beliefs and practices (Ashing-Giwa et al., 2004; Ashing-Giwa et al., 2006). These factors may also influence treatment acceptance and adherence. However, there is concern that too much reliance on faith to cure may delay breast cancer screening, diagnosis, and treatment (Mitchell et al., 2002; Ashing-Giwa et al., 2006; Lannin et al., 1998; Peek, Sayad, and Markwardt, 2008). We found some support for the latter. Minority patients were more likely than nH White patients to believe that enough faith in God

would make treatment unnecessary. Patients who harbored this belief also had lower breast tumor knowledge. Therefore, this cultural belief posed an indirect barrier to RT.

The research aim related to RT adds to our understanding of the factors that help perpetuate disparities in RT among breast cancer patients. For instance, it appears that the disparity in treatment is not a result of differences in recommendation or acceptance (although they may contribute some). Therefore, studies should perhaps focus on the barriers to RT initiation such as mastectomy use and tumor knowledge. Further examination of these barriers is warranted however.

C. Hormonal Treatment Disparity: The Role of Tumor Grade and Breast Tumor Knowledge

Among the 303 patients who were eligible for HT, 86% received a recommendation for HT. Once a recommendation was received, virtually all accepted it (99%). However, compared to nH White patients, minority patients were less likely to receive a recommendation (0.80 versus 0.94, p=0.00) while there were no differences in treatment acceptance. The recommendation disparity appears to be primarily explained by the racial/ethnic differences in tumor grade and breast tumor knowledge. Specifically, patients with higher grade tumors and lower breast cancer knowledge were less likely to receive a recommendation for HT.

While no other study has explicitly examined disparities in HT recommendation, several studies have assessed and found racial/ethnic disparities in HT initiation. Two studies noted that nH Black and Hispanic patients were less likely than nH White patients to receive HT (Bickell et al., 2006; Freedman et al., 2011); one study found a nH Black/nH White disparity (Wu et al., 2011); and yet another only observed a Hispanic/nH White disparity (Livaudais et al., 2012). In this context, our study findings suggest that racial/ethnic differences in HT recommendation may be perpetuating the disparities in treatment. Indeed, Neugut et al. (2012a) recently reported that compared to HT initiators, non-initiators were less likely to have discussed the treatment with their physicians (0.99 versus 0.94, p=0.004). Others

have also implied that lack of treatment recommendation may be an important contributor to treatment underuse (Jagsi et al., 2010; Griggs et al., 2012).

As with RT, we found that a patient's knowledge about her breast cancer stage, grade, and receptor-status was positively associated with HT recommendation. It was hypothesized that a patient with higher knowledge of her tumor characteristics may be more likely to obtain a treatment recommendation because she may be more engaged in the treatment decision-making and could reflect the quality of the patient-provider interaction. Indeed, a recent set of studies suggests that greater surgeon involvement in the decision-making process and higher quality of patient-provider communication were associated with increased use of adjuvant treatment (Jagsi et al., 2010; Neugut et al., 2012a). Therefore, a higher quality patient-provider interaction may contribute to a better understanding of the breast disease and its treatment implications.

The data also suggest that faith in God and the type of treatment facility may play an indirect role in treatment recommendation through their influence on breast tumor knowledge. Minority patients were more likely than nH White patients to believe that enough faith in God would make treatment unnecessary. Patients who harbored this belief also had lower tumor knowledge. As such, faith in God may pose a barrier to treatment by not allowing the patient to obtain adequate knowledge about her tumor characteristics and treatment. Some researchers do fear that too much reliance on faith to cure may impede breast cancer treatment (Mitchell et al., 2002; Ashing-Giwa et al., 2006; Lannin et al., 1998; Peek, Sayad, and Markwardt, 2008). Minority patients were also more likely to receive care at NAPBC institutions. Patients treated in these institutions had lower breast tumor knowledge. Institutions that have an NAPBC program meet high standards related to leadership, clinical management, research, community outreach, professional education, and quality improvement. As such, they may provide a higher quality patient-provider interaction that improves a patient's knowledge about her disease and treatment options. This finding is consistent with several studies that show that a treating hospital's characteristics, such as teaching status or affiliation with cancer research

networks, are associated with better treatment and care (Reeder-Hayes et al., 2011; Chen, Halpern, et al., 2008; Chaudhry, Goel, and Sawka, 2001; Gutierrez et al., 2008; Hebert-Croteau et al., 2005; Carpenter et al., 2011; Laliberte, Fennell, and Papandonatos, 2005).

It is not entirely clear why HT-eligible patients with higher grade tumors are less likely to receive a treatment recommendation. Patients with higher grade tumors are more likely to receive CT and so months may pass before providers discuss HT with their patients, or perhaps patients may not recall the recommendation. However, a sub-group analysis revealed that patients who had received CT were actually more likely to receive an HT recommendation than patients who did not receive any other adjuvant treatment (0.85 versus 0.72, respectively; p=0.07). In addition, the logistic regression models were all adjusted for time (in days) from diagnosis to interview and the results remained largely unchanged. Others have failed to see a relationship between CT use and HT treatment use (Livaudais et al., 2012; Neugut et al., 2012a). Perhaps some providers do not feel that patients with higher grade tumors benefit from HT treatment despite their positive ER/PR status. Finally, under-reporting and under-documentation of HT recommendation among patients with higher grade tumors is a possibility. The relationship between tumor grade and HT recommendation needs to be explored further.

This research aim contributes to the literature on HT disparities in a couple of ways. First, this may be the first study to explicitly examine HT recommendation. Indeed, we found that racial/ethnic differences in recommendation may be an important contributor to the treatment disparities that others have observed (Livaudais et al., 2012; Bickell et al., 2006; Freedman et al., 2011; Wu et al., 2011). If this finding is replicated elsewhere it has important implications for the development of disparity-reducing interventions. Second, this study suggests that a patient's breast tumor knowledge directly and indirectly affect her receipt of an HT recommendation. The indirect influence of faith in God and a treatment facility's NAPBC status on tumor knowledge provides some insight into possible points of intervention. It also indicates that the patient-provider interaction may be critical to a patient's decision-making process.

VII. STRENGTHS AND LIMITATIONS

The research presented has strengths worth noting. First, by using a sociodemographically diverse sample of patients from a population-based study, the findings may be generalizable to an urban population of US breast cancer patients. Second, unlike studies that use administrative or hospital datasets, SR race/ethnicity was used thereby eliminating concerns related to misclassification. Third, racial/ethnic disparities in breast cancer treatment received may be partly explained by disparities in treatment recommendation and acceptance. This is perhaps the first study to date that explicitly assesses racial/ethnic differences in treatment recommendation and acceptance. The vast majority of patients accept the treatment that is recommended; therefore, disparities in recommendation highlights an important point for intervention. Finally, this study contributes to our understanding of treatment disparities by considering several sociocultural factors such as a patient's social support, medical mistrust, and cultural beliefs around treatment. For instance, our research suggests that a patient's knowledge about her tumor characteristics and her cultural beliefs about faith and treatment may, directly and indirectly, influence her cancer treatment utilization. These sociocultural factors are potentially amenable to interventions.

The results of the research findings should be interpreted in context of certain limitations. First, given our small sample of Hispanic patients, we could not assess differences across the three racial/ethnic groups. That said, we did not find differences between Hispanic and nH Black patients in terms of surgery type, tumor size, grade, node-status, ER/PR-status, tumor knowledge, and cancer treatment. Therefore, the results we observed would probably not differ between Hispanic or nH Black patients. Second, we did not have adequate information on patient comorbidity. The number, severity, or type of chronic conditions could affect treatment recommendation and initiation, as they could pose physical and emotional barriers to undergoing treatments that may impact a patient's quality of life (Satariano and Silliman, 2003; Daskivich et al., 2010a; Daskivich et al., 2010b; Lee, Cheung, and

Krzyzanowska, 2009). Indeed, several studies have shown that women of color are more likely than White women to have one or more comorbid conditions and women with comorbidities are less likely to receive adjuvant treatment (Hershman et al., 2008; Banerjee et al., 2007; Bickell et al., 2006; Livaudais et al., 2012). Third, while SRs, MRs, and cancer registry information were used to ascertain treatment, there is a possibility that treatment was not fully captured given each data source's limitations. Hormonal treatment recommendation may be particularly under-ascertained although there was no evidence that under-ascertainment differed by race/ethnicity. Fourth, we did not adjust our path model for potential confounding effects of socioeconomic and health care access factors. However, the results from our logistic regression models did not provide evidence that adjustment for these factors changed the nature of the primary relationships observed. Therefore, we are confident that our path model would not differ much if it were fully adjusted for these confounders. Fifth, the interview response rate was 56% (proportion interviewed among total estimated eligible sample) and so selection bias cannot be ruled out. Finally, the data are cross-sectional and thus the proposed casual relationships cannot be determined definitively.

VIII. CONCLUSION

This work contributes to our understanding of treatment disparities by providing insight into the potential role of: treatment recommendation and acceptance; and tumor, sociocultural, and institutional factors. We found that among treatment-eligible patients, those with more aggressive tumors may not be receiving RT or HT recommendation. In addition, a patient's disease knowledge may be protective against treatment underuse. These may present important avenues for disparity-reducing interventions. While racial/ethnic disparities in CT were not observed, the study findings indicate that an evaluation of treatment patterns in guideline-adherent CT must carefully consider how to best define treatment eligibility given the ongoing changes in treatment guidelines and clinical practice. Inadequate attention may lead to erroneous conclusions.

The results of this study suggest areas that need further research on potential factors that may facilitate or impede treatment. First, an examination of multi-modal treatment patterns among patients that are eligible for multiple types of treatment should be conducted. For instance, we observed that RT-eligible patients who received a mastectomy were more likely to use CT but less likely to use RT. In our study population, approximately half of the patients were eligible for more than one adjuvant treatment. Unfortunately, most studies only examine patterns in one type of adjuvant treatment. To date, one study has explored racial disparities in the overall standard of breast cancer care per NCCN guidelines (Worthington et al., 2008). Using data from a state cancer registry, they did not find disparities. However, approximately one in three patients did not receive the standard of care. Given the differences in their tumor characteristics, minority patients and nH white patients are likely to require different types of adjuvant treatment (e.g., CT versus RT and HT, respectively). A better understanding of multi-modal treatment patterns among patients is critical, as patients who fail to complete their full treatment plan may be at higher risk of recurrence and mortality (Clarke et al., 2005; EBCTCG, 2005). Second, our analyses showed that breast tumor knowledge was positively associated with treatment

recommendation and use. As noted, tumor knowledge likely reflects the patient-provider interaction, which plays a significant role in the treatment decision-making process (Sheppard et al., 2010; Hawley et al., 2008). A multi-center study is currently exploring the role of the patient-provider interaction in breast cancer treatment decision-making and treatment adherence (Neugut et al., 2012a; Neugut et al., 2012b; Neugut et al., 2012c). However, population-based and sociodemographically diverse populations are also needed, as patient-provider interactions may be influenced by context (e.g., immigrant populations, minority-serving institutions, safety-net hospitals, rural hospitals). Third, patient navigation, which has been successful in removing barriers to cancer screening and diagnosis (Paskett, Harrop, and Wells, 2011; Paskett et al., 2012; Raich et al., 2012), may provide an important starting point for examining barriers to treatment initiation and adherence (Fiscella et al., 2012).

Differences in adjuvant treatment contribute to the racial disparities in mortality (van Ravesteyn et al., 2011; Mandelblatt et al., 2004). To begin fully addressing the causes of treatment disparities it is essential to understand which factors, contribute most to the disparities along the treatment continuum. This dissertation work adds to our understanding and offers areas of research that may yield further knowledge on factors that can help address treatment disparities.

APPENDICES

APPENDIX A

DESCRIPTION AND SOURCE OF THE STUDY VARIABLES

Variable	*Description*		*Source*
Hispanic ethnicity	Do you consider yourself to be of Hispanic or Latino origin?	1 = Yes 2 = No	Interview
Race	Now I'd like to ask you about your race. What race do you consider yourself to be? (Would you say…)	1 = American Indian or Alaska Native 2 = Asian 3 = Black or African American 4 = Native Hawaiian/Other Pacific Islander 5 = White 6 = Multiracial 7 = Something else (Specify on next item) 8 = Hispanic/Latino	Interview
Education	What is the highest grade or year of school you have completed?	0 = Has not gone to school 1 = Grade school: 1 year/grade 1 2 = Grade school: 2 years/grade 2 3 = Grade school: 3 years/grade 3 4 = Grade school: 4 years/grade 4 5 = Grade school: 5 years/grade 5 6= Grade school: 6 years/grade 6 7 = Grade school: 7 years/grade 7 8 = Grade school: 8 years/grade 8 9 = High school: 1 year/freshman year 10 = High school: 2 years/sophomore year 11 = High school: 3 years/junior year 12 = Completed high school/GED 13 = Some college 14 = Associates certificate/2 year program 15 = Bachelor's degree 16 = Some graduate school 17 = Master's degree 18 = Doctorate/advanced degree	Interview
Household income	My last question is about your total household income. Please look at this card and tell me which of the categories on the card describes your total household income for the year 2006. Consider income from all sources, before taxes. Just tell me the letter from the card.	1 = A. No income, 2 = B. $5,000 or less 3 = C. $5,001 – $7,500 4 = D. $7,501 – $10,000 5 = E. $10001 – $15,000 6 = F. $15,001 – $20,000 7 = G. $20001 – $30,000 8 = H. $30001 – $40,000 9 = I. $40001 – $50,000 10 = J. $50001 – $75,000 11 = K. $75,001 – $100,000 12 = L. $100001 – $150,000 13 = M. $150001 – $200,000 14 = N. over $200000	Interview

Figure 15. Description and source of patient-related study variables.

APPENDIX A (continued)

Variable	*Description*		*Source*
Insurance	Medicare is a public health insurance program for persons aged 65 and older and for disabled persons. Did you have Medicare coverage? Did you have Medicare Part B coverage, that covers doctors' visits? Did you have any 'Medigap' supplemental insurance that covers things Medicare does not pay for? Medicaid is a public health insurance program for low-income persons. Did you have military health care coverage such as armed forces retirement benefits, the VA, CHAMPUS, or CHAMP-VA? Did you have private health insurance, such as an HMO or PPO?	1 = Yes 2 = No	Interview
	Was your health insurance an HMO, a PPO, or a fee-for- service plan?	1 = HMO 2 = PPO 3 = Fee-for-service 4 = Other (Specify on next item)	
Regular provider	Think back to the time before the problem was discovered that turned out to be cancer. Around that time, did you have a doctor or health care person that you thought of as your own doctor, someone you went to regularly for care?	1 = Yes 2 = No	Interview

Figure 15. Description and source of patient-related study variables.

Variable	*Description*		*Source*
Last physical exam	When had been your last routine physical examination, when you had to get undressed and a medical person examined you from head to toe? Was it within 12 months, 2 years, or more than 2 years before this time?	1 = Within 12 months 2 = Within 2 years 3 = More than 2 years 4 = Never	Interview
Last clinical breast exam	Do you remember if your last breast exam was within 12 months, 2 years, or more than 2 years before you found the problem that turned out to be cancer?	1 = Within 12 months 2 = Within 2 years 3 = More than 2 years	Interview
Last mammogram	Do you remember if your last mammogram was within 12 months, 2 years, or more than 2 years before the problem was discovered?	1 = Within 12 months 2 = Within 2 years 3 = More than 2 years	Interview
Breast tumor knowledge (stage)	Have you ever heard the term stage, breast cancer stage, or disease stage? Do you know what stage of breast cancer you have?	1 = Yes 2 = No	Interview
	What stage breast cancer is it?	0 = Stage 0 1 = Stage 1 2 = Stage 2 3 = Stage 3 4 = Stage 4	
	TNM pathologic stage group	Stage I–IV	Medical record

Figure 15. Description and source of patient-related study variables.

Variable	*Description*		*Source*
Breast tumor knowledge (grade)	Have you ever heard of the term breast cancer grade or tumor grade? Do you know what grade of breast cancer you have?	1 = Yes 2 = No	Interview
	What grade of breast cancer do you have?	1 = Low / grade 1 2 = Medium / grade 2 3 = High / grade 3	
	Grade	1 =G1 Low /well-differentiated 2 = G2 Medium / moderately-differentiated 3 = G3 High / poorly-differentiated	Medical record
Breast tumor knowledge (ER/PR-status)	Have you ever heard the term hormone receptor or estrogen receptor status? Do you know what your hormone receptor or estrogen receptor status is?	1 = Yes 2 = No	Interview
	What is your hormone receptor or estrogen receptor status?	1 = Positive 2 = Negative	
	Estrogen receptor result Progesterone receptor result	1 = Positive 2 = Negative	Medical record
Trust in treatment provider	Let me ask you how you feel in general about the care you received from the doctors, nurses and technicians during your treatment. In general, how much do you trust these people to provide you with the best possible health care? Would you say…	1 = A great deal 2 = Somewhat 3 = Not too much 4 = Not at all	Interview

Figure 15. Description and source of patient-related study variables.

Variable	*Description*	
Stage	American Joint Committee on Cancer Stage (6th edition)	00 = Stage 0 01 = Stage 0a 02 = Stage 0is 10 = Stage I 11 = Stage I NOS 12 = Stage IA 13 = Stage IA1 14 = Stage IA2 15 = Stage IB 16 = Stage IB1 17 = Stage IB2 18 = Stage IC 19 = Stage IS 30 = Stage II 32 = Stage IIA 33 = Stage IIB 34 = Stage IIC 50 = Stage III 51 = Stage III NOS 52 = Stage IIIA 53 = Stage IIIB 54 = Stage IIIC 70 = Stage IV 71 = Stage IV NOS 72 = Stage IVA 73 = Stage IVB 74 = Stage IVC
Tumor size	Largest dimension or diameter of the primary tumor in millimeters (mm) or centimeters (cm)	0 = No mass/tumor found 001–988 = 001 – 988 mm (code exact size in mm) 989 = 989 mm or larger 990 = Microinvasion; microscopic focus or foci only, no size given; described as less than 1 mm 991 = Described as "less than 1 cm" 992 = Described as "less than 2 cm," or "greater than 1 cm," or "between 1 cm and 2 cm" 993 = Described as "less than 3 cm," or "greater than 2 cm," or "between 2 cm and 3 cm" 994 = Described as "less than 4 cm," or "greater than 3 cm," or "between 3 cm and 4 cm" 995 = Described as "less than 5 cm," or "greater than 4 cm," or "between 4 cm and 5 cm" 996 = Mammographic/xerographic diagnosis only, no size given; clinically not palpable 997 = Paget's Disease of nipple with no demonstrable tumor 998 = Diffuse

Figure 16. Description of tumor-related study variables obtained from the Illinois State Cancer Registry.

Variable	*Description*	
Number of positive lymph nodes	Exact number of regional nodes examined by the pathologist and found to contain metastases	0=All nodes examined negative. 01 – 89= 1–89 nodes positive (code exact number of nodes positive) 90=90 or more nodes positive 95=Positive aspiration or core biopsy of lymph node(s) 97=Positive nodes – number unspecified 98=No nodes examined
ER-status	Estrogen Receptor Assay	0 = Test not done (test was not ordered and was not performed) 10 = Positive/elevated 20 = Negative/normal; within normal limits 30 = Borderline; undetermined whether positive or negative
PR-status	Progesterone Receptor Assay	0 = Test not done (test was not ordered and was not performed) 10 = Positive/elevated 20 = Negative/normal; within normal limits 30 = Borderline; undetermined whether positive or negative
Grade	Grade	1 = Grade I-well differentiated 2 = Grade II- moderately differentiated 3 = Grade III-poorly differentiated 4 = Grade IV-undifferentiated

Figure 16. Description of tumor-related study variables obtained from the Illinois State Cancer Registry.

Variable	*Description*
CoC accreditation category [a]	• Comprehensive community cancer program • Community cancer program • Academic comprehensive cancer program • Veteran's affairs cancer program • Intergrated network cancer program • NCI-designated comprehensive cancer program • Hospital associate cancer program • Pediatric cancer program • Free-standing cancer center program
NAPBC accreditation category [b]	1 = Yes 0 = No

[a] CoC= Commission on Cancer Illinois State Cancer Registry

[b] NAPBC= National Accreditation Program for Breast Centers

Figure 17. Description of hospital-related study variables obtained from the American College of Surgeons.

APPENDIX B

A NOTE ON STUDY SAMPLE WEIGHTS

The BCCC study was meant to provide population estimates, so analytic weights for the 989 study participants were created in an effort to account for the differential sampling and response by facility and race/ethnicity. Including these weights allows for the statistics computed from the BCCC study to be more representative of the population. However, the results presented in this document are not weighted results. Analytic weights were not used for two reasons. First, the weights were designed for use of the full dataset (n=989), while the research presented here only includes treatment-eligible participants. Therefore, use of the original analytic weights may not be appropriate to use, and creating a new set of weights is beyond the scope of the dissertation. Second, not all statistical packages allow the use of weights such as Mplus, which was used to conduct path analysis. Nonetheless, a sensitivity analysis was carried out in order to provide insight into how the unweighted results may differ if the BCCC study weights were used.

Selected proportions and logistic regression models were re-run in STATA using the pweight option with the fnlwt variable. Tables XXXI–XXXIII present results from each of the primary research aims. Note that the differences between the unweighted and weighted results are negligible and thus the conclusions would likely not change.

Table XXXII

AGE-ADJUSTED DIFFERENCES (USING MODEL-BASED STANDARDIZATION) IN RADIATION TREATMENT BY MINORITY STATUS (UNWEIGHTED VERSUS WEIGHTED)

		UNWEIGHTED						WEIGHTED					
		All	*Minority*	*nH White*	*Risk difference*	*95% CI*	*p-value*	*All*	*Minority*	*nH White*	*Risk difference*	*95% CI*	*p-value*
Radiation recommended (among eligible)	p	0.94	0.93	0.95	0.01	-0.06–0.04	0.535	0.94	0.94	0.94	0.00	-0.05–0.04	0.911
	(n)	(442)	(262)	(180)				(442)	(262)	(180)			
Radiation accepted (among recommended)	p	0.97	0.96	0.98	0.02	-0.05–0.01	0.247	0.96	0.96	0.97	0.02	-0.02–0.06	0.365
	(n)	(402)	(234)	(168)				(402)	(234)	(168)			
Radiation initiated (among accepted)	p	0.90	0.88	0.93	0.05	-0.01–0.10	0.115	0.90	0.88	0.93	0.05	-0.02–0.10	0.135
	(n)	(388)	(224)	(164)				(388)	(224)	(164)			
Radiation initiated (among eligible)	p	0.79	0.75	0.84	0.09	0.02–0.17	0.014	0.79	0.76	0.84	0.08	0.01–0.15	0.054
	(n)	(442)	(262)	(180)				(442)	(262)	(180)			

Table XXXI

RISK DIFFERENCES IN DISCRETIONARY CHEMOTHERAPY RECOMMENDATION[a]: LOGISTIC REGRESSION WITH MODEL-BASED STANDARDIZATION[b] (UNWEIGHTED VERSUS WEIGHTED)

	UNWEIGHTED		WEIGHTED	
	Base Model	*Full Model*	*Model*	*Full Model*
Race/Ethnicity				
Minority	0.62	0.57	0.64	0.59
nH White	0.41	0.45	0.40	0.44
Risk difference	0.20*	0.12†	0.24*	0.15†
95% CI	0.03–0.39	-0.05–0.32	0.06–0.44	-0.01–0.37
Tumor size				
<2 cm		0.42		0.43
>=2 cm		0.69		0.70
Risk difference		0.27**		0.27**
95% CI		0.09–0.49		0.09–0.47
Tumor Grade				
Low		0.39		0.39
Moderate-high		0.57		0.58
Risk difference		0.18*		0.20*
95% CI		0.03–0.37		0.00–0.42
n	109	107	109	107

†p<0.20, *p<0.10, **p<0.01, ***p<0.001

[a]includes patients with node-negative tumors > 1cm

[b] All models are adjusted for age and days from diagnosis to interview

Table XXXIII

(UNWEIGHTED VERSUS WEIGHTED)

UNWEIGHTED

	n	%	*Risk difference*	*p-value*	*Adjustment variables considered*	*Adjustment variables included*[a]
Grade						
Mod-high grade	230	0.15	0.08	0.06	Sociodemographic,[b] health care access[c]	minority, age
Low grade	67	0.07				
NAPBC[d]						
Yes	125	0.07	0.11	0.00	Sociodemographic,b health care accessc	minority, age
No	166	0.18				
High tumor knowledge	139	0.06	0.14	0.00	Sociodemographic,[b] health care access[c]	minority, age, education
Lower tumor knowledge	163	0.20				

WEIGHTED

	n	%	*Risk difference*	*p-value*	*Adjustment variables considered*	*Adjustment variables included*[a]
Grade						
Mod-high grade	230	0.16	0.09	0.02	Sociodemographic,[b] health care access[c]	minority, age
Low grade	67	0.07				
NAPBC[d]						
Yes	125	0.08	0.09	0.03	Sociodemographic,b health care accessc	minority, age
No	166	0.17				
High tumor knowledge	139	0.05	0.15	0.00	Sociodemographic,[b] health care access[c]	minority, age, education
Lower tumor knowledge	163	0.20				

[a]All models are also adjusted for time from treatment to interview
[b]Sociodemographic variables include: minority status, age, income, education, neighborhood concentrated disadvantage
[c]Health care access variables include: insurance status
[d]National Accreditation Program for Breast Centers

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