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Examine the effect of geographic distance on breast cancer patients' utilization of high volume hospitals

Yin Wan
University of Iowa

EXAMINE THE EFFECT OF GEOGRAPHIC DISTANCE ON BREAST CANCER PATIENTS' UTILIZATION OF HIGH VOLUME HOSPITALS

by

Yin Wan

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Thesis Supervisor: Assistant Professor Yang Xie

Graduate College
The University of Iowa
Iowa City, Iowa

CERTIFICATE OF APPROVAL

MASTER'S THESIS

This is to certify that the Master's thesis of

Yin Wan

has been approved by the Examining Committee for the thesis requirement for the Master of Science degree in Pharmacy (Pharmaceutical Socioeconomics) at the December 2009 graduation.

Thesis Committee: ________________________
Yang Xie, Thesis supervisor

____
John M. Brooks

____
Elizabeth A. Chrischilles

To my grandfather who passed away when I was working on this thesis. I love you and miss you dearly, grandpa!

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ABSTRACT

Volume has been suggested as a surrogate quality indicator for breast cancer surgeries by several researchers. It is crucial to understand the underlying reasons as to why there is a disparity in utilization of high volume hospitals. However, the studies that investigated the mechanism underlying the disparity in high volume hospital utilization are very limited.

The objectives of this study include: 1) examine the relationship between geographic differential distance and utilization of high volume hospitals; 2) investigate other demographic, socioeconomic and clinical factors that may affect patients' utilization of high volume hospitals. Multivariate logistic regressions were used to evaluate factors that impact patients' utilization of high volume hospitals.

The study results showed that geographic distance is a significant factor that impedes patients' utilization of high volume hospitals, independent of patients' clinical, demographic, and socioeconomic characteristics. It was also found that white, non-Hispanic women, patients with higher socioeconomic status are more likely to be admitted in high volume hospitals compared to low volume hospitals. These factors are also significant to patients' choice of medium vs. low volume hospitals.

Geographic proximity is an important factor that affects patients' choice of hospital, and directing more patients to high volume hospitals should anticipate negative effects, such as increasing the cost of seeking care at high volume hospitals. Alternative strategies need to be developed to improve surgical outcomes without increasing patients' traveling related cost, such as enhancing the network between high volume hospitals and low volume hospitals, establishing radiation centers in rural areas.

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INTRODUCTION

Overview

This thesis aims at investigating the reasons underlying the disparity in the utilization of high volume hospitals among early stage breast cancer patients, focusing on examining how patients' geographic distance affect patients' utilization of high volume hospitals. High volume hospitals are associated with better outcome(Ahn et al. 2006, Gilligan MA, et al. 2007, Roohan et al. 1998, Bailie K, et al. 2007, Luther, Studnicki 2001, Ma et al. 1997) and several researchers(Gilligan MA, et al. 2007, Bailie K, et al. 2007) suggest that directing more patients to high volume hospitals could improve the outcomes of breast cancer surgical care. In reality, many factors could affect the use of high volume hospitals. A couple of studies(Liu et al. 2006, Losina et al. 2004) have reported racial, ethnic minorities are less likely to use high volume hospitals. However, to our best knowledge, no study has investigated the relationship between geographic distance and the use of high vs. low volume hospital for breast cancer surgeries. A systematic literature review(Bettencourt et al. 2007) summarized that rural patients experienced difficulty in access to treatment facilities and they were more likely to travel long distance to have breast cancer surgeries, radiotherapy and chemotherapy. Several Australian studies(Mitchell et al. 2006, Wilkinson, Cameron 2004) found that rural patients experienced poorer survival compared to their urban counterparts and Mitchell suggested that the rural-urban disparity in 5-year mortality could be largely caused by the variations in oncology related care between rural and urban areas. These findings suggested that geographic distance might be a potential barrier for some patients to obtain oncology related care, which consequently, contribute to the rural-urban disparity in cancer health. Nevertheless, whether geographic barrier is an important barrier that impedes patients' utilization of high volume hospitals remains unexplored.

Understanding geographic barrier is extremely relevant to the volume based referral policy This study examines how geographic proximity is attributed to the disparity in high volume hospital utilization among early stage breast cancer patients.

Background

The disparity in cancer health is defined as "difference in the incidence, prevalence, mortality, and burden of cancer and related adverse health conditions that exist among specific population groups......"(Wells, Roetzheim 2007) by the National Cancer Institute. The second goal in the DHHS Healthy People 2010 is to "eliminate health disparities that occur by race and ethnicity, gender, education, income, geographic location, disability status, or sexual orientation."(The U.S. Department of Health and Human Services) Underserved population is composed of patients who have less access to preventive care, high quality care and beneficial treatments(Wells, Roetzheim 2007). As suggested by Hine's report (The Expert Advisory Group on Cancer to the Chief Medical Officers of England and Wales 1995) on cancer management, "health authorities are faced with the difficulty in ensuring equal access to high quality, safe and effective treatment in a cancer care unit for all patients, irrespective of their social characteristics and place of residence". It is important to understand the factors contributing to the disparity in cancer care becomes important in terms of determining whether there are geographic or other barriers against access to high quality, safe and effective treatment in a cancer care.(Dejardin et al. 2005)It was reported that racial and ethnic minorities, uninsured persons and people with lower socioeconomic status are at great risk of being underserved in many studies.(Wells, Roetzheim 2007, Elliott et al. 2004, Engelman et al. 2002, Higginbotham, Moulder & Currier 2001, Holloway, Saskin & Paszat 2008, Huang et al. 2009, Lund et al. 2008, Onega et al. 2008a, Sabesan, Piliouras 2009, Campbell 2002) A critical review of recent literature(Wells, Roetzheim 2007) about health disparity in receipt of screening mammography concluded that patients with non-Hispanic ethnicity, higher education and income level, covered by health insurance, having recently received care from physicians are consistently associated with better adherence to screening mammography in previous studies.

Breast cancer is the most common cancer among women in the U.S. and the second leading cause of cancer death in the U.S following lung cancer.(Gilligan et al. 2007) Early stage breast cancer refers to “Stages I and II invasive breast cancer or smaller tumors that have not yet spread to distant parts of the body”.(Brooks, Chrischilles 2007) Breast-conserving surgery (lumpectomy) with radiation and modified radical mastectomy are widely used as the treatment options for the early stage breast cancer. Due to the increasing use of breast cancer screening techniques and the aging of the population, the breast cancer incidence detected in the early stage is increasing.(Arndt et al. 2008) Given the increasing number of women with early stage breast cancer in the U.S., a growing number of studies have focused on improving breast cancer patients’ long term and short term outcomes following surgical treatments. A large body of evidence documented the disparity in breast cancer outcomes from different perspectives, including racial/ethnic disparity, urban-rural disparity and the disparity among different levels of socioeconomic status.

The main purpose of our study is to investigate the disparity in patients' utilization of high volume hospitals for breast cancer surgeries, focusing on how geographic distance affects patients' choice of high vs. low volume hospitals. Several retrospective cohort studies(Roohan et al. 1998, Bailie et al. 2007, Ingram et al. 2005, McKee et al. 2002, Nattinger et al. 2007, Chen et al. 2007, Gilligan et al. 2007) examined the relationship between hospital volume and long-term mortality for breast cancer surgeries. A significant higher hospital volume-better outcome relationship was reported in these studies. Researchers have suggested that centralization of breast cancer surgeries to high volume centers could avert death among patients with breast cancer and improve other outcome measurements, such as shorten length of stay and decrease post-operative complication rates. Two studies(Liu et al. 2006, Losina et al. 2004) specifically investigated patients' utilization of high or low volume hospitals for several surgical procedures other than breast cancer surgeries. Liu's study(Liu et al. 2006) examined the factors that caused the disparities in the utilization of high volume hospitals using California hospital claims data. It was reported that the non-whites, Medicare patients, non-insured patients and Hispanic patients were less likely to receive care at high volume hospitals for most of 10 selected complex surgical procedures. Another study(Losina et al. 2004) performed survey among a group of total hip replacement patients randomly selected from 1995 Ohio, Pennsylvania, and Colorado Medicare claims data. The author found that rural residency, low socioeconomic status, geographic proximity are independently associated with higher likelihood of low volume hospital utilization for total hip replacement. Little is known regarding the relationship between geographic distance and patients' utilization of high volume hospital for breast cancer surgeries.

A large body of evidence indicated that rural patients are more likely to be present with later stage of breast cancer at diagnosis(Mitchell et al. 2006, Elliott et al. 2004, Higginbotham, Moulder & Currier 2001, Monroe, Ricketts & Savitz 1992, Yu 2009), which is an important predictor of long term survival(Soerjomataram et al. 2008). Limited access to cancer screening detection program among rural women may be attributed to this rural-urban disparity in cancer stage presentation at diagnosis (Liff, Chow & Greenberg 1991). Several Australian studies (Mitchell et al. 2006, Wilkinson, Cameron 2004) found significant distinction of 5-year mortality between rural and urban residents with breast cancer using regional or national Cancer Registry data, indicating poorer survival among rural women. In Mitchell's study, urban patients are more likely to survive in 5 years after diagnosis (OR=1.05, 95% CI: 1.05-2.33), after adjusting for age, tumor characteristics and treatment. Moreover, Mitchell (Mitchell et al. 2006) compared the utilization of cancer care between rural and urban women using chi-square test and it was found that rural women are less likely to use high volume surgeons, diagnostic examinations, adjuvant radiotherapy, hormonal therapy and breast cancer conserving surgery compared to their urban counterparts. The author suggested that the survival difference among rural and urban patients may be large due to the discrepancy in utilization of breast cancer treatments and high volume surgeons. These urban-rural disparities in breast cancer treatments are also identified by other researchers (Bettencourt et al. 2007, Elliott et al. 2004). A systematic review (Bettencourt et al. 2007) selected 14 studies on breast cancer experience of rural patients using cancer registry data, and concluded that rural patients are likely to travel long distance to receive oncology related care. For example, 50% of the rural women with breast cancer in the study sample have to travel over 1 hour for surgery and 61% had to travel 3 hours for receiving radiotherapy according to Grey's study (Gray et al. 2004). Another survey study(Davis et al. 1998) in Australia reported that majority of rural breast cancer survivors in the study sample stayed away from their home to seek breast cancer treatments because the lack of treatment facilities in rural areas. Several U.S. based studies (Baldwin et al. 2008, Chan, Hart & Goodman 2006b, Onega et al. 2008b) also suggested that traveling distance is a barrier for rural patients to obtain cancer services. Baldwin's study (Baldwin et al. 2008) found that more than 25% of rural patients with colorectal cancer bypass their closest local small health providers using SEER-Medicare databases. Patients in most remote area had to travel the longest distance to large rural or urban areas for surgical resections (Baldwin et al. 2008). Onega (Onega et al. 2008) assessed geographic access to cancer care in the U.S. by analyzing traveling distance to nearest specialized cancer care. The traveling distance was calculated based on a network analysis of geographic centroid of every ZIP area to the centroid of ZIP at which specialized cancer center are located in the U.S. continent. Specialized cancer center was defined as the National Cancer Institute-designated Cancer Centers or academic medical centers. This study revealed that rural dwellers had longer traveling distance to nearest specialized cancer centers than the overall U.S. population. Chan' study(Chan, Hart & Goodman 2006) evaluated how the traveling distance affects Medicare patients' access to health care using 1998 Medicare claims data; it was reported that residents in rural area needed to travel 2 to 3 times farther way to visit medical specialists than urban residents and this finding is specially true for patients needing cancer or cardiac treatments. Another French study (Dejardin et al. 2005) also found that geographic distance is an important barrier for colorectal cancer patients to seek care at reference care site (refer to care centers being able to “manage serious pathologies with bad prognosis and rare pathologies”).

In an attempt to identify the factors that impact hospital choice, several researchers reviewed and summarized the factors that could be related with patients’ hospital choice.(Dealey 2005, Sloane, Tidwell & Horsfield 1999, Porell, Adams 1995, Jensen 1988, Shahian et al. 2000) Most studies (Dealey 2005, Porell, Adams 1995, Jensen 1988, Shahian et al. 2000) suggested the cost of services, range of health services, the reputation and quality, as well as the network, are major determinants of patients’ decision on choice hospital. Shahian (Shahian et al. 2000) examined the determinants of patients’ choice of cardiac surgery provider and he found that the hospital reputation, historical referral system are very important elements, as well as the distance from patients’ home to hospital. Another systematic review (Dealey 2005) summarized the issues that affected hospital choice for patients with acute conditions. The author noted that there is a clear variation between patients with acute conditions and chronic conditions in terms of hospital choice. For patients with acute conditions, 6 themes were identified as the influential factors of patients’ hospital choice: performance information, delivery of information, influence of general physicians, role of family and friends, loyalty of local hospital and hospital access. This study further explained that potential constraints for a patient to seek care at a high volume hospital include the distance from patient’s residence to the high volume hospital, the acceptance of the evidence that high volume hospital is associated with the quality of surgical care, as well as the patients’ loyalty to the local community hospital even when a further high volume hospital might provide health care with higher quality. Taylor's study(Taylor, Capella 1996) assessed how various hospital choice criteria attributes to patients' choice of hospital by a telephone survey in a sample (N=410) randomly selected from a rural town in the southeast of the U.S. Convenience location ranks as the top determinant that affects the residents' hospital choice in the study sample. Another French study(Bouche et al. 2008) found that patients who are actively involved in surgeon selection are opted to go to low volume hospitals which are closer to their residence, even though a minimum volume standard for breast cancer surgeries has been established for hospital referral in France. The author concluded that surgeons' reputation and geographic proximity are both important factors that affect patients' choice of surgeons, and the proximity might be more important than surgeons' reputation to some extent for those patients who are actively involved in the process of surgeon selection.

The majority of the previous studies found that rural residents usually need to travel significant distance to seek health care compared to their urban counterparts. A study(West, Weeks & Wallace 2008) used the VA and Medicare hospital discharge data from 2000 to 2001 to evaluate rural veterans' access to high quality care for high risk cardiac and cancer surgeries. This study also found that rural veterans had to travel longer distance to receive cancer resections in hospital with lower mortality compared to urban veterans. However, the distance for patients to go to closet higher mortality hospital or lower mortality hospital didn't differ greatly, regardless of the patients' residence. This study suggested that accessing hospitals with lower mortality does not necessarily add significant traveling burden for rural veteran patients who are in need of complex cancer surgeries. Nevertheless, this study results may be not generalized to low-risk surgeries or non-veteran patients. It reinforces that it is worthy to investigate the relationship between breast cancer patients' geographic distance to nearest high volume hospitals relative to low volume hospitals and choice of high vs. low volume hospitals. A recent study (Kronebusch 2009) examined the trend of high volume hospital utilization for 19 high risk and low risk surgical procedures using Arizona, Florida, New Jersey, and Wisconsin State Inpatient data. This study found that utilization rate for breast cancer surgeries didn't increase during two time periods: 1995-1996, and 2001-2002. The underlying reasons for the phenomena could be complex. A study found that patients would rather go to local small hospital instead of traveling to a distant high volume hospital with lower mortality within a hypothetical scenario of resectable pancreatic cancer. Patients' preference of local small hospitals may partially explain why there was no increase in high volume hospital utilization for breast cancer surgeries reported in Kronebusch's study. It is important to consider the factors that drive patients' preference of hospital selection when making decisions on the strategies for volume based referral policies. As described in this section, geographic factor could be an important element affecting breast cancer patients' utilization of high volume hospitals. The goal of our study is to examine how geographic distance and other factors associated with the patients' choice of high vs. low volume hospitals, providing more evidence for understanding the inequity of the delivery of high quality breast cancer surgical care services.

Objective

This study aims at identifying demographic, socioeconomic and clinical factors that influence the patients' choice of high vs. low volume hospitals, with a focus on geographic distance. The demographic factors include patients' race/ethnicity, age and marital status. Patients' socioeconomic status is obtained by zip code linked median income and education level from census data. Tumor characteristics include tumor grade and tumor size, cancer stage, hormonal receptor status and histology status. Co-morbidity is measured using Hierarchical Condition Categories. Geographic distance is the key variable that will be used in our study. Using the approach to define volume described in Nattinger' study (Nattinger et al. 2007), we categorize hospital volume into three groups: low, medium and high volume hospitals. The detailed information as to defining the hospital volume will be described in the Measurement section. Because our study focuses on evaluating how the geographic factor affect patients' use of high volume hospital vs. low volume hospital, and medium volume hospital vs. low volume hospital, it is appropriate to use differential distance as the geographic factor, which indicates the relative geographic distance from patients' home to closest high vs. closest low volume hospital and patients' home to closest medium vs. closest low volume hospitals. The detailed information on calculation of geographic distance is also illustrated in the Measurement section.

Three hypotheses about the relationship between predictors of patients' choice of high versus low volume hospitals are stated as follows:

Hypothesis 1: patient's differential distance of the distance from the patient's residence to nearest high volume hospital minus the distance to nearest low volume hospital is significantly negatively associated with the patient's choice of high vs. low volume hospital; patient's differential distance of the distance from the patient's residence to nearest medium volume hospital minus the distance to nearest low volume hospital is significantly negatively associated with the patient's choice of medium vs. low volume hospital

Hypothesis 2: Early stage breast cancer patients' race, Hispanic ethnicity and socioeconomic status are significant predictors of patients' choice of high vs. low volume hospital; early stage breast cancer patients' race, Hispanic ethnicity and socioeconomic status are significant predictors of patients' choice of medium vs. low volume hospital.

Hypothesis 3: patients' clinical characteristics are associated with the patients' hospital choice.

Significance

Studies have found evidence that undergoing surgeries in high volume hospitals yields significantly better long-term outcomes for early-stage breast cancer patients (Guller et al. 2005, Ahn et al. 2006, Gilligan et al. 2007, Roohan et al. 1998, Bailie et al. 2007, Luther, Studnicki 2001, Ma et al. 1997). Based on such evidence, it was suggested that the volume based referral system needed to be implemented to improve the quality of surgical care for breast cancer patients in several studies (Shahian, Normand 2003, Gilligan et al. 2007). Billingsley and colleagues (Billingsley et al. 2007) noted that the high volume hospitals are advantageous over low volume hospitals at facilitating the multidisciplinary care, access to specialists and follow-up care or adjuvant treatments. Among all the cancers, breast cancer is the second leading cause of death for women in the US (Soerjomataram et al. 2008, Stokes et al. 2008) and it was estimated that 40,470 deaths would occur as a result of breast cancer in 2009.(American Cancer Society) Efforts to improve the quality of surgical services by establishing the referral system using the volume standard could save lives among breast cancer patients.(Birkmeyer, Skinner & Wennberg 2002, Shahian, Normand 2003) According to a recent study assessing the trend in high volume hospital use, the rate of high volume hospital use didn't increase for breast cancer surgeries following the growing interest in hospital volume outcome relationship in the early 90s (Kronebusch 2009). The study results suggest that it is important to investigate the mechanism underlying patients' utilization of high vs. low volume hospitals for developing volume based referral policy. Lack of knowledge on the cause of the disparity could mislead the volume based policy because most volume based referral strategy is based on the assumption that patients have access to the information about the hospital volume which is treated as a quality indicator, as well as their willingness and ability to seek care at high volume hospitals.(Kronebusch 2009) Nevertheless, the underlying cause of the disparity in high volume hospital utilization remained unclear and the relevant evidence based studies is limited(Liu et al. 2006, Losina et al. 2004). Several previous studies(Mitchell et al. 2006, Gray et al. 2004, Davis et al. 1998, Baldwin et al. 2008, Chan, Hart & Goodman 2006b, Onega et al. 2008b, Taylor, Capella 1996) suggested that rural residents usually need to travel longer distance to receive cancer care at specialized cancer centers or high volume providers, which could contribute to the rural urban disparity in health(Mitchell et al. 2006). However, it is still unknown how geographic distances affect patients' utilization of high vs. low volume hospitals, after controlling for other factors, such as patients' resident location and tumor characteristics.

As described above, patients' utilization of high volume hospital might contribute to the disparity in cancer health; the disparity in high volume hospital utilization could be partly due to the difference in geographic distances from patients' home to nearest high volume hospitals. Understanding the geographic barriers that patients face when making choice of high vs. low volume hospital is significant to policy makers for developing volume based policy or alternative strategies improving the quality of surgical care.

METHOD

Data source

Our data came from the Surveillance, Epidemiology, and End Results (SEER) – Medicare linked database. SEER data, which is known as Patient Entitlement and Diagnosis Summary File (PEDSF), included the each person's demographic, insurance coverage and detailed clinical information, as well as the basic zip code level socioeconomic status in 11 SEER registries.

The Medicare claims data used are comprised of Medicare Provider Analysis and Review (inpatient claims), NCH 100% Physician/Supplier data file (physicians' services and other medical services) and the Hospital Outpatient Standard Analytic file (outpatient facility services). Patients with breast cancer were identified from the three Medicare Claims files using the ICD-9 diagnosis codes and the Healthcare Common Procedure Coding System (HCPCS) code set. The hospital ID numbers can be identified from the MEDPAR claims files as well as the Hospital files which are composed by the data from 1996, 1998 and 2000-2006 year Provider of Service (POS) survey from Center for Medicare and Medicaid Services (CMS).

Surgery type information, as well as information of procedure dates, are obtained from the Medicare Claims files using ICD-9 procedure codes and HCPCS codes.

The beneficiary's residence zip code and hospital zip code information are obtained by requesting the encrypted variables of SEER-Medicare database. The longitude and latitude coordinates of zip codes came from the ZIP code databases for calculating geographic distance. ZIP code databases are obtained from Zip-codes.com, containing the 2000 census data for U.S. population. The database includes zip code in the U.S. and the longitude and latitude coordinates for each zip code.

The SEER (Surveillance, Epidemiology, and End Results) Program collected all the data on cancer cases diagnosed in five states and six U.S. metropolitan areas, which together represent approximately 14% of the U.S. population. The SEER data include demographic, survival and prognostic information on each incident cancer, including the primary cancer site, histology, tumor stage, tumor size, tumor grade, patients' age at diagnosis, census tract socioeconomic status, race, Hispanic ethnicity and marital status.

The advantage of SEER-Medicare linked database is that it uniquely provides detailed clinical and covered health care services information about elderly persons with cancer that enables an array of epidemiological and health services research.

Study population

This retrospective study cohort includes the patients who are 66 years or older, diagnosed as early stage breast cancer (stage I, and stage II) from January 1st, 1992 through December 31st, 1999 with follow-up through Dec 31st, 2002. The study sample is constricted to those patients who are continuously covered by the Medicare Part A and Part B for at least one year before first diagnosed as breast cancer, and not covered by health maintenance organizations (HMOs). Patients who don't have at least one breast cancer surgery 9 months after the diagnosis date are excluded from the study population.

69266 elderly patients were diagnosed as early stage breast cancer between Jan 1st, 1992 to Dec 31st, 2002 and they have continuous Medicare Part A and B, no HMO 12 months before and 9 months after diagnosis date. Patients with invalid residence zip code or living outside the SEER area were excluded since we were not able to determine the differential distance for these patients (n=68,147). Patients without valid hospital ID were also excluded from the study sample (n=64,579). Patients who are located in Hawaii with valid zip codes are also excluded from the study population because Hawaii is an island in the Pacific Ocean geographically separated from other seer sites and the geographic distance is not road based(n=63,372).

To obtain the outcome measurement of 5-year mortality, the data were censored at Dec 31st, 1999, leaving the study sample as 37361. Patients were excluded if the surgery was performed outside the nine states covered by one of the 11 SEER registries because the procedure volume at the hospitals outside the SEER areas can't be reliably measured (n=36,339). All the detailed inclusion and exclusion criteria are shown in Table 1(Appendix A).

Measurements

Dependent Variables

For calculating the current year hospital volume, a broader cohort than the study population was used which include all the patients 65 years or older in the SEER data. These patients are diagnosed with breast cancer in any stages during the year of 1992 to 1999 and have had at least one surgery (either lumpectomy or mastectomy) performed in that time period. All the patients with missing hospital ID are excluded from this broader cohort. The hospital volumes were calculated as the number of breast cancer surgeries (including lumpectomy and mastectomy) performed in a hospital in a given year. It is noticeable that a patient could have multiple admissions to different hospitals for various oncology related care after diagnosis of breast cancer. Each patient is assigned with only one hospital in which the breast cancer surgery was performed.

Dependent variables were created by stratifying the study population into three groups roughly evenly based on tertiles of hospital volume: low volume hospitals (1-23); medium volume hospitals (24-45); high volume hospitals (≥46). To assess whether the study results change as the approach defining hospital volume categories changes, we also examined the study results using different volume groups as the dependent variables. Hospital volume is also categorized into two groups using different cutoffs: the study population is grouped into high volume (≥46) and non-high volume (<46) groups using cutoff of 46; study population are grouped into non-high volume (<23) and high volume (≥23) groups using cutoff of 23. The detailed reason for performing this sensitivity analysis will be described in the section of statistical analysis.

Independent variables

Independent variables include patients' age at diagnosis, race, ethnicity, location, household median income, census track education level, co-morbidity index, cancer stage, tumor grade, tumor size, hormone receptor status, histology status and differential distance.

Age at diagnosis: Age is categorized into five groups: 66-70 years, 71-75 years, 76-80 years, 81-85 years, 86 years and more.

Race: The race category is white, black, other and unknown race.

Hispanic ethnicity: Hispanic ethnicity is categorized into two groups: Hispanic; non-Hispanic and unknown.

Marital status: The patients are grouped into three groups based on their marital status: married, unmarried (single, widow, divorced) and unknown.

1990 Census tract Median household income: Median household income with zip code area and it is categorized into quartiles.

1990 Census tract Percent of residents with at least 4–year college education: Percent of residents with at least 4–year college education at zip code area and it is categorized into quartiles.

Diagnosis year: Patients in the study population are diagnosed in the year from 1992 to 1999. The information came from the SEER database.

Residence: The patients' residence place is classified into five categories: metropolitan area, metropolitan county, urban area, less urban area and rural area.

Prior other cancer: it is equal to 1 if the patient has another cancer diagnosed before the breast cancer; otherwise, it is equal to 0.

ER status

Estrogen-receptor (ER) is a kind of “proteins to which estrogen will bind attached on the breast cancer cells. If the cancer cells have estrogen receptors, they may need estrogen to grow, and this may affect how the cancer is treated”(National Cancer Institute, 2009).

PR status

Progesterone receptor (PR) is a kind of “protein to which the hormone progesterone will bind attached on breast cancer cells. Cancer cells that are progesterone receptor positive need progesterone to grow and will usually stop growing when treated with hormones that block progesterone from binding”(National Cancer Institute, 2009).

Co-morbidity index: The co-morbidity index is calculated using DxCG software developed by the DxCG Company (Ellis RP, et al. 1996). DxCG software grouped the more than 15000 ICD-9 diagnosis codes into “118 clinically homogeneous condition groups” with similar resource use. Predicted cost was assigned to the 118 hierarchical condition categories and it was used to measure the disease burden for each of the patient in the study sample (Petersen, L. A., et al. 2007).

Tumor size: Breast cancer tumor size is categorized into five groups: <=10, 11-15, 16-20, 21-29, ≥30 centimeters.

Tumor grade: The breast cancer tumor grade is categorized as follows: well differentiated, moderately differentiated, poorly differentiated, undifferentiated and unknown.

Histology status

Breast cancer histology status is classified as Invasive lobular carcinoma (ILC) and infiltrating ductal carcinoma (IDC)

Cancer Stage: Early stage breast cancer includes stage I and stage II of breast cancer. Stage I describes “invasive breast cancer in which the tumor measures up to 2 centimeters, and no lymph nodes are involved”. Stage II is divided into subcategories of stage IIa and stage IIb: stage IIa describe the breast cancer with “cancer cells found in the axillary lymph nodes, or tumor size 2 centimeters or less and spread to the axillary lymph nodes, or tumor size is larger than 2 centimeters and smaller than 5 centimeters and not spread to axillary lymph nodes”; stage IIb describe the breast cancer “tumor size is larger than 2 and smaller than 5 centimeters and spread to axillary lymph nodes, or tumor size is larger than 5 centimeters and not spread to axillary lymph nodes” (Stages of Breast Cancer, 2009) .

Measurement of differential distance

Geographic distance to the nearest high volume hospital was calculated as the shortest geographic distance between centroid of the patient’s zip code and closest high volume hospital’s zip code using the longitude and latitude coordinates of the zip codes. Similarly, the geographic distance to nearest medium or low volume hospitals was calculated by using the longitude and latitude coordinates of closest medium or low volume hospitals’ zip codes and patient’s zip codes.

Two differential distances were calculated in this study: high volume hospital differential distance and medium volume hospital differential distance. High volume hospital differential distance is calculated as the distance from patients’ home to the nearest high volume hospital minus the distance from patients’ home to the nearest low volume hospital; medium volume hospital differential distance is calculated as the distance from patients' home to the nearest medium volume hospital minus the distance from patients' home to the nearest low volume hospital.

Statistical analysis

Hospital volume is categorized into three groups based on tertiles of hospital volume: high (≥46), medium (23-45) and low (<23) hospital volume groups. χ^2 test was performed to compare the patients' demographic, socioeconomic, clinical characteristics among patients in high-, medium and low volume hospital groups. Multivariate logistic regressions were conducted to examine the relationship between differential distance and patients' choice of high vs. low volume hospitals and choice of medium vs. low volume hospitals, adjusting for all other available independent variables, including patients' age at diagnosis, race, Hispanic ethnicity, marital status, co-morbidity index, tumor grade, Hormone receptor status, histology status, prior other cancer status, tumor size, cancer stage, residence, SEER registry, diagnosis year. Dependent variables for the regression models were hospital volume categories: high vs. low volume hospital, medium vs. low volume hospital.

As mentioned above, the approach we used to define high, medium, and low volume hospitals are consistent with prior studies(Gilligan et al. 2007, Nattinger et al. 2007). Most previous studies reported significant difference in survival between low volume and high volume hospital for breast cancer surgeries. However, medium volume hospital may not be significantly associated with better outcome compared to low volume hospitals. For example, Ahn's study study(Ahn et al. 2006) didn't find that patients treated in medium volume hospitals (51-99) are significantly associated with better outcome compared to low volume hospitals (<=50). Medium volume hospital is not necessarily significantly associated with better outcome while survival advantage in high volume is usually more apparent in previous studies. Thus, we especially want to examine whether the relationship between patients' geographic distance and patients' utilization of high vs. non-high volume hospitals change as the high volume threshold changes from 23 (1/3 tertile of hospital volume) to 46 (2/3 tertile of hospital volume). Hospital volume was categorized into high and non-high volume hospital groups using 23 and 46 as the cutoffs for high volume hospital separately. Two additional multivariate logistic regressions were performed to examine the effect of differential distances on choice of high vs. non-high volume hospitals with the two cutoffs for high volume hospital.

All statistical analyses were performed using SAS 9.01 package (SAS Institute, Inc. 2002). $P<0.05$ was noted as statistically significant.

RESULTS

The descriptive characteristics of patients in the study sample is described in Table 2. Of the 36339 elderly female patients with early stage breast cancer in our study population, majority of the patients are white women (92.5%), and 3.2% were Hispanic women. Approximately 61% of patients lived in major metropolitan areas, and about 30% lived in Metropolitan counties or urban areas, while the remaining patients (8%) lived in the less urban or rural areas. 35.2% of the study population received surgery of lumpectomy plus radiotherapy while 45.9% of patients underwent mastectomy. Nine point eight percent of the patients had lumpectomy without radiotherapy followed, and 9.7% of them received mastectomy with radiotherapy followed. The overall mortality rate in 5 years after diagnosis of breast cancer was 24.47%.

Table 3 contains the distribution of hospital volume for study population. Patients in the study sample are divided into three groups based on tertiles of hospital volume. In other words, the patients are categorized into low, medium, and high volume groups with roughly equal number of them in each group. The distribution of hospital volume is shown in Table 3 and the cutoff for low volume hospital is less than 23 surgeries a year; high volume hospital is 46 or more; the remaining (23-45) is medium volume hospital. Patients treated in high-, medium, low-volume hospitals differ with regard to socioeconomic, demographic, clinical characteristics. Number of deaths at 5 year was 3217 (36.4%) among low volume hospitals, 2864(32.4%) among medium volume hospitals, 2758 (31.2%) among high volume hospitals.

Table 4 displays the distribution of patient characteristics across high-, medium and low-volume hospitals. Chi-square test was performed to compare the differences in the mean of the patient’s characteristics across groups. High and medium volume hospitals had greater proportions of whites (95.0% for medium volume hospitals, 91.4% for high volume hospital) than low-volume hospitals (91.0%). One point four percent of the patients admitted to high volume hospitals, 2.7% of the patients in medium volume hospitals and 5.4% in low volume hospitals are Hispanic women. Greater proportion (69.8%) of patients in high volume hospitals were residing in major metropolitan areas compared to those treated in medium volume hospitals (57.8%) and low volume hospitals

(55.2%). Thirty-seven percent of the low volume hospital patients, 29.7% of the patients in medium volume hospital and 33.2% of high volume hospital patients have the highest co-morbidity index (10^{th} decile of co-morbidity index). Patients admitted to high volume hospitals have slightly more favorable cancer stage (63.0% are at stage I), tumor size (32.0% have the smallest tumor size) compared to low volume hospital patients (58.0% of them are at cancer stage I; 27.3% of them have the smallest tumor size). A greater proportion (8.9%) of the patients admitted in high volume hospital has other prior cancers than patients in medium (8.1%) or low (7.7%) volume hospitals. To sum up, it appears that white non-Hispanic women are more likely to be treated in high volume hospitals compared to back, Hispanic women. Patients treated in high volume hospitals have a higher percentage with prior other cancer, smaller tumor size, lobular histology status, positive estrogen receptors, lower co-morbidity level, higher education level and income (zip code level measurement) compared to the patients treated in low volume hospital group. Compared with the patients in low volume hospitals, patients who seek care at medium volume hospital also have a higher percentage in whites, non-Hispanic women, patients with higher education level, positive progesterone receptors, smaller tumor size and lobular histology status, except that there is no large difference in the co-morbidity index between low and medium volume hospitals.

Two multivariate logistics models were performed to assess the effect of differential distance and other factors on patient's choice of hospital. Patients' differential distances were categorized into quartiles and used as a covariate in the multivariate logistics models. As revealed in Table 5 and Table 6, differential distances are significant predictors of patient's hospital choice of high vs. low volume hospitals, as well as hospital choice of medium vs. low volume hospitals, adjusting for patients' demographic, socioeconomic and clinical characteristics. Patients living further away from high volume hospitals relative to low volume hospitals are more likely to seek care at low volume hospitals (4^{th} quartile vs. 1^{st} quartile: OR=0.019, CI=0.016-0.023); Patients living further away from medium volume hospitals relative to low volume hospitals are more likely to seek care at low volume hospitals (4^{th} quartile vs. 1^{st} quartile: OR=0.036, CI=0.032-0.041), after adjusting for patients' demographic, clinical and socioeconomic characteristics.

Increasing co-morbidity index were associated with lower probability of high volume hospital utilization as shown in Table 5. For instance, patients in the 10^{th} deciles of co-morbidity index are much less likely to receive surgeries at high volume ($\geq$46) hospitals compared to low volume (<23) hospitals (OR: 0.644, CI: 0.541-0.767). Patients who are less sicker (less co-morbidity index), better educated, have positive nodes status, poorly differentiated tumor grade and smaller tumor size, positive hormone receptor status were more likely to seek care at high volume hospitals compared to low volume hospitals. White, non-Hispanic women, patients with higher education level are more likely to be treated in medium volume hospitals relative to low volume hospitals. Patients' clinical factors are not significantly related with the choice of medium vs. low volume hospital as shown in Table 6. In summary, patient's demographic characteristics play important role in the choice of medium vs. low volume hospital and the choice of high vs. low volume hospitals, while patient's clinical characteristics are somewhat more important factors in the choice of high vs. low volume hospital compared to the choice of medium vs. low volume hospital.

To assess whether the effect of differential distance on patients' choice of hospitals changes as high volume cutoffs change, we performed two additional multivariate logistic regressions by dividing the study sample into two groups using different cutoffs for high volume hospitals. Table 7 and Table 8 contain the multivariate logistic regression of high vs. low volume hospital choice using cutoffs of 23 and 46. For cutoff of 23, the differential distance was calculated as the distance from patients' home to the nearest high volume hospital (≥23) minus the distance from patients' home to the nearest non-high volume hospital (<23). Similarly, the differential distance for cutoff of 46 was calculated in the same way. The results show that patients' differential distance is negatively and significantly associated with the patients' choice of high (≥23) vs. non-high (<23) volume hospitals, as all the other measurements are controlled. Differential distance is also negatively and significantly associated with the patients' choice of high (≥46) vs. non-high (<46) volume hospitals.

CONCLUSION & DISCUSSION

Whether undergoing surgery in a high volume or low volume hospital is a choice involves trade-off. If patients recognize the importance of hospital volume as quality indicator and make informed decision on hospital choice, they will weigh the potential benefits obtained from being treated at high volume hospitals and additional cost caused by seeking care at high volume hospitals compared to low volume hospitals. Choosing a high volume hospital for surgery usually incurs access related cost, such as waiting time and traveling cost due to the fact that the number of high volume hospitals is usually less than low volume hospitals, regardless of the residence (Dimick, Finlayson 2006).

Our study found that the relative distance to high volume hospitals (measured as differential distance) significantly affects the patients' utilization of high volume hospitals, suggesting an inverse relationship between geographic distance and patients' utilization of high volume hospitals. This relationship persists after accounting for a comprehensive set of control variables. Several prior studies(Onega et al. 2008, Chan, Hart & Goodman 2006, Onega et al. 2009) suggested that patients' access or utilization of health care decrease as the traveling time and distance increase, including the cancer surgeries, breast cancer screening programs and radiotherapy. However, no studies have specially examined whether geographic distance affects high volume hospital utilization. Our study found that patients' utilization of high quality surgical services in high volume hospitals (hospital volume is used as a quality indicator) also significantly decreases as the geographic distance increases. In addition, we found that patients' demographic and socioeconomic characteristics including race, Hispanic ethnicity and education level (zip code level measurement) are all attributed to the disparity in high volume hospital utilization, as well as the disparity in medium volume hospital utilization. In general, blacks, Hispanics, patients with lower education level are less likely to undergo surgeries in high or medium volume hospitals for breast cancer, suggesting that white, patients with higher education attainment may be more willing to bypass the nearby low volume hospitals and travel long distance to get treatment at high volume hospitals.

In terms of patient clinical characteristics, the results are more complex. Patient clinical characteristics, such as co-morbidity, tumor size, tumor grade, appears to be more important determinants for patient's choice of high vs. low volume hospitals than choice of medium vs. low volume hospitals. Patients with positive nodes status, less co-morbidity index, smaller tumor size, poorly differentiated tumor are more likely to be treated in high volume hospitals compared to low volume hospitals. Patients with lower co-morbidity index are more likely to tolerance the traveling burden caused by long traveling distance, increasing the likelihood of choosing high volume over low volume hospitals. It is hard to conclude whether patients with more progressed tumors are more likely to seek care at high volume hospitals or not from the results: positive node status, tumor grade and tumor size impact the hospital choice in different directions. Patients with positive hormone receptors are more likely to be treated at high or medium volume hospitals compared to low volume hospitals. Hormonal therapy following surgery is beneficial for patients with positive hormone receptors (Which treatment for breast cancer 2009, Sukel et al. 2008). Several studies (Birkmeyer et al. 2007, Ellison et al. 2005) suggested that high volume hospitals are more effective at following the clinical guidelines and prescribe the adjuvant treatments to those patients who are likely to benefit. Therefore, patients with positive hormone receptors may be more likely to be referred to high volume hospital, and this explained the finding that patients with positive hormone receptors have a higher likelihood of being treated at high or medium volume hospitals relative to low volume hospitals. Patients with lobular histology status are more likely to seek care at high volume compared to those with ductal histology status. There is debate (Arpino et al. 2004, Li et al. 2003) over whether histology type is an independent risk factor in predicting the long term survival outcome and how histology status affects outcome for breast cancer patients. However, lobular histology is considered to be more difficult to detect by mammography and clinical breast examinations than infiltrating ductal carcinoma (Arpino et al. 2004, Li et al. 2003, Mersin et al. 2003). High volume hospitals may have more experienced oncologists and better ancillary services, such as lab tests, which make it easier to detect the infiltrating lobular carcinoma (Billingsley et al. 2007, Onega et al. 2009). This discrepancy could explain why the percentage of patients with lobular histology status in high volume hospitals is larger than that among patients treated in low volume hospitals. Different from choice of high vs. low volume hospitals, majority of these clinical characteristics are not significantly associated with patients' choice of medium vs. low volume hospitals.

Numerous studies (Dejardin et al. 2005, Elliott et al. 2004, Higginbotham, Moulder & Currier 2001, Sabesan, Piliouras 2009, Chan, Hart & Goodman 2006) reported that rural patients have less access to health care services compared to their urban counterparts, such early breast cancer screening services (Liff, Chow & Greenberg 1991) and adjuvant treatments (Bettencourt et al. 2007). Up to date, little information about the impact of geographic proximity on high volume hospital utilization is available in prior studies. Our study provided evidence to support that traveling distance is a significant barrier that impedes patients' utilization of high volume hospitals.

Currently, volume based referral policy (Shahian, Normand 2003) has been advocated for certain surgical procedures by several organizations based on the growing evidence. However, implementing volume based referral policy in rural and remote areas where there is smaller number of high volume hospitals could be problematic (Dimick, Finlayson & Birkmeyer 2004). It may further limits patients' access to health care in rural areas, and may also being against patients' willingness by increasing the burden to patients since insurance companies usually don't cover the transportation cost of seeking health care(Dejardin et al. 2005, Bouche et al. 2008, Dimick, Finlayson & Birkmeyer 2004). On the other hand, directing more patients to high volume hospitals may increase the burden of high volume hospitals, which potentially may start to decrease the quality of surgical care at high volume hospitals.(Nallamothu et al. 2001)

Volume based referral system could potentially create access problem, especially for those who live in the rural areas where high volume hospitals are far away from the patient's residence.(Bouche et al. 2008) Policy makers need to be cautious about the possible negative effects of volume based policy in terms of decreasing the patient's access to hospital and being against the patients' willingness. The Leapfrog has exempted the rural areas from the volume based referral policy.(Dimick, Finlayson & Birkmeyer 2004) Alternative strategies need to be developed for improving the quality of surgical care in rural areas lacking high volume hospitals. For instance, several studies (Nallamothu et al. 2001) suggested that only the patients with complicated disease conditions can be referred to high volume hospitals since they are most likely to benefit from the treatments in high volume hospitals. It was also suggested that it is important to identify the factors that assure the quality of surgical care in high volume hospitals and transfer the technologies or processes from high volume hospitals to low volume hospitals (Kahn 2007). Establishing radiotherapy centers in rural areas could also facilitate the beneficial adjuvant treatments for rural patients without increasing patients' traveling burden. Another approach to improve cancer care may be facilitated by developing the networks between small rural hospitals and large hospitals, such as providing specialized oncology consultations through telemedicine or other satellite care.

These strategies will potentially relieve the patients' traveling burden and meanwhile, improve patients' outcome significantly.

APPENDIX A

TABLES FOR DESRIPTIVE, UNIVARIATE, MULTIVARIATE REGRESSIONS

Table 1 Inclusion and Exclusion Criterions for Study Population

Inclusions/exclusion criteria	Number of patients
Number of breast cancer patients in PEDSF (SEER data)	242256
Breast cancer diagnosis during 1992-2002	226349
First diagnosis of breast cancer during 1992-2002	219091
Include those with known month of diagnosis	218399
Include those 66+	149221
Include patient who have complete Part A and B coverage for 12 months prior to diagnosis	141427
Include patient who have no HMO during 12 months prior to diagnosis	104532
Exclude patient with cancer diagnosed at autopsy or by death certificate	103308
Select histology for breast cancer	100976
Include patients with cancer stage I or stage II	72723
Include patient with complete part A and B coverage with no HMO and alive for 9 months after diagnosis	69788
Exclude patient who have no surgery within 9 months of diagnosis	69266
Exclude patients with invalid zip code or zip code outside their SEER registry	68147
Exclude the patient without hospital ID	64579
Exclude the patient with blank instrument	64572
Exclude patients living in Hawaii	63372
Include the patients who are diagnosed with early stage breast cancer between 1992-1999 year	37361
Exclude the patients seek care at a hospital outside the SEER area	36339

Table 2 Descriptive Statistics of the Patient Characteristics and Outcomes

Variable	Category	Total number	percentage
treatment	lumpectomy without radiation	3568	9.82
	mastectomy with radiation	3298	9.08
	mastectomy without radiation	16697	45.95
	lumpectomy with radiation	12776	35.16
5 year mortality	Alive in 5 years after diagnosis	27446	75.53
	dead in 5 years after diagnosis	8893	24.47
Registry	Connecticut	5305	14.60
	Detroit	5832	16.05
	Iowa	5545	15.26
	New Mexico	1363	3.75
	Seattle	3893	10.71
	Utah	1773	4.88
	Atlanta	2122	5.84
	Rural Georgia	48	0.13
	California	10458	28.78
Hispanic ethnicity	No/unknown	35193	96.85
	Yes	1146	3.15
Race	White	33611	92.49
	Black	1960	5.39
	Other/unknown	768	2.11
Marital status at diagnosis	z:Sing,sep,wid,div	20372	56.06
	Married	15099	41.55
	Unknown	868	2.39
Age at diagnosis	66-70	9105	25.06
	71-75	10038	27.62
	76-80	8499	23.39
	81-85	5399	14.86
	85+	3298	9.08
Residence	Major Metropolitan Area	22151	60.96
	Metropolitan County	9140	25.15
	Urban	1952	5.37
	Less Urban	2522	6.94
	Rural	574	1.58

Table 2-Continued

Variable	Category	Total number	percentage
Year of diagnosis	1992	4913	13.52
	1993	4611	12.69
	1994	4513	12.42
	1995	4593	12.64
	1996	4420	12.16
	1997	4444	12.23
	1998	4376	12.04
	1999	4469	12.30
Stage at diagnosis	Stage I	22117	60.86
	Stage IIa	9906	27.26
	Stage IIb	4021	11.07
	Stage II other	295	0.81
Grade	Well Differentiated	6316	17.38
	Moderately Differentiated	13693	37.68
	Poorly Differentiated	8707	23.96
	Undifferentiated	593	1.63
	Unknown	7030	19.35
History of prior non-breast cancer	NO	33343	91.76
	YES	2996	8.24
Tumor size	<=10	10877	29.93
	11-15	8541	23.50
	16-20	6232	17.15
	21-30	6677	18.37
	>30	3717	10.23
	unknown	295	0.81
Histology	Ductal	26099	71.82
	Lobular	3683	10.14
	Other	6557	18.04
Estrogen receptor positive	No/unknown	11352	31.24
	Yes	24987	68.76
Progesterone receptor positive	No/unknown	15854	43.63
	Yes	20485	56.37

Table 2-Continued

Variable	Category	Total number	percentage
Co-morbidity (DCG decile)	10%	4104	11.29
	20%	3445	9.48
	30%	3683	10.14
	40%	3746	10.31
	50%	3642	10.02
	60%	3696	10.17
	70%	3631	9.99
	80%	3611	9.94
	90%	3476	9.57
	100%	3305	9.09
Received chemotherapy	NO	32157	88.49
	YES	4182	11.51
Census tract median household income	1st quartile	8800	24.22
	2nd quartile	8801	24.22
	3rd quartile	8801	24.22
	4th quartile	8798	24.21
	Missing	1139	3.13
Census tract education level	1st quartile	8803	24.22
	2nd quartile	8798	24.21
	3rd quartile	8803	24.22
	4th quartile	8796	24.21
	Missing	1139	3.13
Node status	No Positive Nodes	25803	71.01
	Positive Nodes	7344	20.21
	Unknown	3192	8.78

Table 3 Distribution of Hospital Volume

Percentile	Hospital volume
0% (minimum)	1
5%	5
10%	8
25%	17
Median	33
75%	54
90%	78
95%	97
100% (maximum)	149

Table 4 Patients' Characteristics by Hospital Volume Category, 1992-1999

Patient characteristics	Low volume(<23)	Medium volume(23-45)	High volume(>=46)	P value (χ^2)
Surgical treatment (%)				<.0001
lumpectomy	10.2	9.4	9.8	
mastectomy with radiation	10.1	8.6	8.5	
mastectomy without radiation	50.5	45.8	41.5	
lumpectomy with radiation	29.1	36.1	40.2	
Registry area (%)				
Connecticut	6.6	13.6	23.5	<.0001
Detroit	7.3	12.5	28.2	
Iowa	22.5	13.7	9.6	
New Mexico	6.5	4.2	0.6	
Seattle	9.0	14.0	9.1	
Utah	7.0	6.0	1.8	
Atlanta	6.3	5.6	5.7	
Rural Georgia	*	*	*	
California	34.6	30.3	21.5	
Hispanic ethnicity (%)				<.0001
No/unknown	94.6	97.3	98.6	
Yes	5.4	2.7	1.4	
Race (%)				<.0001
White	91.0	95.0	91.4	
Black	5.8	3.3	7.1	
Other/unknown	3.2	1.7	1.5	
Marital status at diagnosis (%)				<.0001
Sing,sep, widow, divorced	57.1	54.6	56.5	
Married	40.7	43.2	40.8	
Unknown	2.2	2.2	2.8	
Age at diagnosis (%)				.0122
66-70	24.8	25.0	25.3	
71-75	26.9	27.8	28.2	
76-80	23.6	23.4	23.2	
81-85	14.8	15.1	14.7	
86+	9.9	8.7	8.6	
Residence (%)				<.0001
Major Metropolitan Area	55.2	57.8	69.8	
Metropolitan County	16.8	33.2	25.5	
Urban	10.0	4.6	1.6	
Less Urban	14.8	3.5	2.6	
Rural	3.3	0.9	0.5	

Table 4-Continued

Patient characteristics	Low volume(<23)	Medium volume(23-45)	High volume(>=46)	P value (χ^2)
Year of diagnosis (%)				<.0001
1992	13.6	13.9	13.1	
1993	12.5	13.5	12.1	
1994	12.6	12.4	12.3	
1995	12.4	12.6	13.0	
1996	12.4	12.9	11.2	
1997	12.5	10.6	13.6	
1998	12.1	12.0	12.0	
1999	12.1	12.2	12.6	
Stage at diagnosis (%)				<.0001
Stage I	58.1	61.4	63.0	
Stage II a	28.9	27.0	25.9	
Stage II b	12.0	10.9	10.3	
Stage II (other stage)	0.9	0.7	0.8	
Tumor Grade (%)				<.0001
Well Differentiated	16.1	17.8	18.2	
Moderately Differentiated	36.3	37.7	39.0	
Poorly Differentiated	23.1	23.8	24.9	
Undifferentiated	2.1	1.7	1.1	
Unknown	22.3	19.0	16.8	
History of prior other cancers (%)				0.0015
NO	92.3	91.9	91.1	
YES	7.7	8.1	8.9	
Tumor size (cm) (%)				<.0001
<=10	27.3	30.5	32.0	
11-15	22.7	23.4	24.4	
16-20	17.8	17.2	16.4	
21-30	19.6	18.4	17.1	
>30	11.7	9.8	9.3	
unknown	0.9	0.7	0.8	
Histology (%)				.0047
Ductal	71.9	71.5	72.0	
Lobular	9.6	10.1	10.7	
Other	18.5	18.4	17.2	
Estrogen receptor positive (%)				<.0001
No/unknown	34.6	28.7	30.5	
Yes	65.4	71.3	69.5	

Table 4- Continued

Patient characteristics	Low volume(<23)	Medium volume(23-45)	High volume(>=46)	P value (χ^2)
Progesterone receptor positive (%)				<.0001
No/unknown	44.8	40.8	45.3	
Yes	55.2	59.2	54.7	
Co-morbidity index (DCG deciles)				
10%	9.7	11.2	13	<.0001
20%	10.3	10.5	7.6	
30%	10.4	10.4	9.6	
40%	10.1	10.5	10.3	
50%	9.9	10.1	10	
60%	10.1	9.8	10.6	
70%	9.8	10.1	10.1	
80%	9.7	9.8	10.3	
90%	9.8	9.6	9.4	
100%	10.2	8.1	9	
Received chemotherapy (%)				<.0001
NO	88.2	89.1	88.2	
YES	11.8	10.9	11.8	
Census tract median household income (quartiles) (%)				<.0001
1st quartile	34.6	21.1	17.0	
2nd quartile	24.4	25.7	22.5	
3rd quartile	20.4	26.1	26.2	
4th quartile	17.6	24.2	30.7	
Missing	3.0	2.9	3.6	
Census tract education level (quartiles) (%)				<.0001
1st quartile	32.5	21.3	18.9	
2nd quartile	27.2	25.1	20.4	
3rd quartile	23.0	26.2	23.4	
4th quartile	14.3	24.5	33.7	
Missing	3.0	2.85	3.6	
Node status (%)				.0001
No Positive Nodes	70.7	71.6	70.7	
Positive Nodes	21.1	19.8	19.7	
Unknown	8.2	8.6	9.6	

Table 5 Multivariate Logistic Regressions of Patient Characteristics and Choice of High vs. Low Volume Hospital

Variable name	Odds Ratio	Lower bound of 95%Confidence Interval	Upper bound of 95% Confidence Interval	P-value
Differential distance				
1st quartile	1			
2nd quartile	0.297	0.266	0.332	<.0001
3rd quartile	0.071	0.064	0.080	<.0001
4th quartile	0.019	0.016	0.023	<.0001
Distance to nearest hospital	0.987	0.984	0.990	<.0001
Age at diagnosis				
84+	1			
66-70	1.128	0.962	1.322	0.1374
71-74	1.091	0.939	1.267	0.2549
75-79	1.089	0.940	1.262	0.2580
80-84	1.167	1.000	1.363	0.0512
Race				
White	1			
Black	0.758	0.652	0.881	0.0003
Other/unknown	0.680	0.540	0.856	0.0010
Hispanic ethnicity				
Yes	1			
No/unknown	2.061	1.631	2.605	<.0001
Marital status at diagnosis				
Single, sep, widow, divorced	1			
Married	1.113	1.029	1.203	0.0072
Unknown	0.960	0.757	1.218	0.7354
Urban/rural residence				
Major Metropolitan Area	1			
Less Urban	2.063	1.617	2.632	<.0001
Metropolitan County	1.811	1.564	2.098	<.0001

Table 5-Continued

Variable name	Odds Ratio	Lower bound of 95%Confidence Interval	Upper bound of 95% Confidence Interval	P-value
Rural	1.836	1.264	2.665	0.0014
Urban	0.693	0.541	0.889	0.0039
Census track Education level				
1st quartile	1			
2nd quartile	1.354	1.206	1.521	<.0001
3rd quartile	1.418	1.247	1.612	<.0001
4th quartile	2.624	2.262	3.044	<.0001
Census track income level				
1st quartile	1			
2nd quartile	1.018	0.903	1.148	0.7676
3rd quartile	0.906	0.791	1.037	0.1535
4th quartile	0.978	0.839	1.141	0.7805
Missing	1.748	1.379	2.216	<.0001
Estrogen receptor positive				
Yes	1			
No/unknown	0.631	0.567	0.703	<.0001
Progesterone receptor positive				
Yes	1			
No/unknown	0.783	0.708	0.866	<.0001
Co-morbidity index				
10%	1			
20%	1.010	0.852	1.198	0.9086
30%	0.854	0.720	1.013	0.0698
40%	0.833	0.705	0.984	0.0320
50%	0.972	0.819	1.153	0.7431
60%	0.785	0.664	0.927	0.0044
70%	0.813	0.685	0.964	0.0172

Table 5-Continued

Variable name	Odds Ratio	Lower bound of 95%Confidence Interval	Upper bound of 95% Confidence Interval	P-value
80%	0.849	0.714	1.009	0.0172
90%	0.688	0.578	0.819	<.0001
100%	0.642	0.539	0.764	<.0001
Histology				
Ductal	1			
Lobular	1.371	1.208	1.556	<.0001
Other	1.071	0.973	1.178	0.1633
Node status				
Positive Nodes	1			
No Positive Nodes	0.708	0.508	0.987	0.0416
Unknown	0.803	0.564	1.143	0.2226
Prior other cancer				
NO	1			
YES	1.088	0.945	1.253	0.2407
Registry				
California	1			
Atlanta	1.167	1.015	1.347	0.0302
Connecticut	3.876	3.375	4.451	<.0001
Detroit	5.341	4.738	6.022	<.0001
Iowa	2.867	2.306	3.564	<.0001
New Mexico	1.865	1.183	2.940	0.0073
Rural Georgia	2.940	1.006	8.592	0.0487
Seattle	2.041	1.777	2.345	<.0001
Utah	0.874	0.672	1.137	0.3149
Cancer stage				
Stage I	1			
Stage IIa	0.753	0.529	1.074	0.1172
Stage IIb	0.602	0.313	1.161	0.1300

Table 5- Continued

Variable name	Odds Ratio	Lower bound of 95%Confidence Interval	Upper bound of 95% Confidence Interval	P-value
Grade				
Well Differentiated	1			
Moderately Differentiated	1.027	0.924	1.141	0.6271
Undifferentiated	0.636	0.475	0.860	0.0031
Unknown	0.641	0.565	0.729	<.0001
Poorly Differentiated	1.181	1.051	1.334	0.0053
tumor size				
<=10	1			
11-15	0.896	0.811	0.991	0.0321
16-20	0.839	0.750	0.939	0.0022
21-30	0.978	0.682	1.402	0.9030
>30	0.887	0.592	1.330	0.5620
unknown	0.516	0.308	0.864	0.0120
Year of diagnosis				
1992	1			
1993	1.013	0.881	1.166	0.8533
1994	0.944	0.819	1.087	0.4200
1995	1.044	0.906	1.203	0.5544
1996	1.141	0.981	1.326	0.0870
1997	1.044	0.907	1.203	0.5461
1998	1.083	0.937	1.252	0.2801
1999	1.100	0.954	1.269	0.1883

Table 6 Multivariate Logistic Regressions of Patient Characteristics and Choice of Medium vs. Low Volume Hospital

Variable name	Odds Ratio	Lower bound of 95%Confidence Interval	Upper bound of 95% Confidence Interval	P-value
Differential distance				
1st quartile	1			
2nd quartile	0.346	0.316	0.379	<.0001
3rd quartile	0.130	0.119	0.142	<.0001
4th quartile	0.036	0.032	0.041	<.0001
Distance to nearest hospital	1.001	1.000	1.001	0.0002
Age at diagnosis				
84+	1			
66-70	1.027	0.897	1.175	0.7037
71-74	1.042	0.917	1.183	0.5293
75-79	1.101	0.971	1.247	0.1196
80-84	1.192	1.046	1.359	0.0084
Race				
White	1			
Black	0.621	0.532	0.724	<.0001
Other/unknown	0.501	0.412	0.607	<.0001
Hispanic ethnicity				
Yes	1			
No/unknown	1.637	1.392	1.926	<.0001
Marital status at diagnosis				
Single, sep, widow, divorced	1			
Married	1.132	1.060	1.209	0.0002
Unknown	0.939	0.758	1.162	0.5603
Urban/rural residence				
Major Metropolitan Area	1			
Less Urban	2.094	1.713	2.559	<.0001
Metropolitan County	3.200	2.802	3.654	<.0001

Table 6-Continued

Variable name	Odds Ratio	Lower bound of 95%Confidence Interval	Upper bound of 95% Confidence Interval	P-value
Rural	2.201	1.659	2.920	<.0001
Urban	1.644	1.375	1.967	<.0001
Census track Education level				
1st quartile	1			
2nd quartile	1.185	1.078	1.303	0.0004
3rd quartile	1.076	0.969	1.194	0.1690
4th quartile	1.359	1.209	1.528	<.0001
Census track income level				
1st quartile	1			
2nd quartile	1.002	0.907	1.108	0.9633
3rd quartile	1.005	0.897	1.126	0.9361
4th quartile	1.094	0.959	1.247	0.1830
Missing	1.137	0.920	1.405	0.2342
Estrogen receptor positive				
Yes	1			
No/unknown	0.773	0.704	0.849	<.0001
Progesterone receptor positive				
Yes	1			
No/unknown	0.979	0.897	1.068	0.6285
Co-morbidity index				
10%	1			
20%	1.158	1.004	1.341	0.0441
30%	0.922	0.796	1.069	0.2845
40%	0.964	0.833	1.116	0.6247
50%	0.985	0.849	1.144	0.8454
60%	0.890	0.768	1.031	0.1215
70%	0.919	0.792	1.067	0.2672

Table 6-Continued

Variable name	Odds Ratio	Lower bound of 95%Confidence Interval	Upper bound of 95% Confidence Interval	P-value
80%	0.917	0.789	1.065	0.2559
90%	0.924	0.794	1.075	0.3045
100%	0.718	0.615	0.838	<.0001
Histology				
Ductal	1			
Lobular	1.143	1.025	1.275	0.0161
Other	1.063	0.981	1.153	0.1376
Node status				
Positive Nodes				
No Positive Nodes	1.156	0.876	1.526	0.3049
Unknown	1.168	0.869	1.568	0.3033
Prior other cancer				
NO	1			
YES	1.051	0.931	1.186	0.4184
Registry				
California	1			
Atlanta	1.381	1.212	1.574	<.0001
Connecticut	1.045	0.906	1.205	0.5481
Detroit	2.365	2.110	2.651	<.0001
Iowa	0.789	0.668	0.931	0.0051
New Mexico	0.476	0.364	0.623	<.0001
Rural Georgia	0.383	0.116	1.260	0.1143
Seattle	1.562	1.394	1.751	<.0001
Utah	0.424	0.346	0.519	<.0001
Cancer stage				
Stage I	1			
Stage IIa	1.148	0.853	1.544	0.3623
Stage IIb	1.322	0.765	2.286	0.3170

Table 6-Continued

Variable name	Odds Ratio	Lower bound of 95%Confidence Interval	Upper bound of 95% Confidence Interval	P-value
Tumor Grade				
Well Differentiated	1			
Moderately Differentiated	0.994	0.908	1.087	0.8907
Undifferentiated	0.856	0.675	1.085	0.1995
Poorly Differentiated	1.074	0.971	1.189	0.1646
Unknown	0.819	0.737	0.911	0.0002
Tumor size				
<=10	1			
11-15	0.958	0.880	1.044	0.3282
16-20	0.905	0.823	0.994	0.0373
21-30	0.762	0.563	1.030	0.0771
>30	0.673	0.479	0.945	0.0222
unknown	0.777	0.496	1.218	0.2718
Year of diagnosis				
1992	1			
1993	1.023	0.910	1.152	0.6998
1994	0.968	0.859	1.090	0.5883
1995	1.071	0.950	1.206	0.2625
1996	1.028	0.911	1.161	0.6490
1997	1.014	0.897	1.146	0.8224
1998	0.955	0.844	1.081	0.4690
1999	1.028	0.910	1.162	0.6548

Table 7 Multivariate Logistic Regressions of Patient Characteristics and Choice of High (≥23) vs. Non-high (<23) Volume Hospital

Variable name	Odds Ratio	Upper bound of 95% Confidence Interval	Lower bound of 95%Confidence Interval	P-value
Differential distance				
1st quartile	1			
2nd quartile	0.598	0.542	0.660	<.0001
3rd quartile	0.251	0.228	0.276	<.0001
4th quartile	0.069	0.062	0.076	<.0001
Distance to nearest hospital	0.999	0.999	1.000	<.0001
Age at diagnosis				
84+	1			
66-70	1.072	0.954	1.204	0.2418
71-74	1.073	0.962	1.196	0.2055
75-79	1.107	0.995	1.233	0.0621
80-84	1.169	1.045	1.308	0.0064
Race				
White	1			
Black	0.809	0.717	0.914	0.0007
Other/unknown	0.534	0.453	0.629	<.0001
Hispanic ethnicity				
Yes	1			
No/unknown	1.696	1.470	1.958	<.0001
Marital status at diagnosis				
Single, sep, widow, divorced	1			
Married	1.125	1.062	1.191	<.0001
Unknown	0.933	0.779	1.118	0.4511
Urban/rural residence				
Major Metropolitan Area	1			
Less Urban	1.174	1.001	1.378	0.0490
Metropolitan County	2.252	2.018	2.513	<.0001

Table 7-Continued

Variable name	Odds Ratio	Upper bound of 95% Confidence Interval	Lower bound of 95%Confidence Interval	P-value
Rural	1.136	0.901	1.433	0.2804
Urban	0.777	0.671	0.900	0.0008
Census track Education level				
1st quartile	1			
2nd quartile	1.176	1.087	0.247	<.0001
3rd quartile	1.350	1.235	1.476	<.0001
4th quartile	2.116	1.903	2.352	<.0001
Census track income level				
1st quartile	1			
2nd quartile	0.983	0.905	1.068	0.6899
3rd quartile	0.916	0.832	1.008	0.0714
4th quartile	0.946	0.845	1.059	0.3364
Missing	1.347	1.132	1.603	0.0008
Estrogen receptor positive				
Yes	1			
No/unknown	0.726	0.671	0.787	<.0001
Progesterone receptor positive				
Yes	1			
No/unknown	0.911	0.845	0.981	0.0139
Co-morbidity index				
10%	1			
20%	1.054	0.930	1.195	0.4100
30%	0.881	0.775	1.001	0.0516
40%	0.919	0.810	1.042	0.1872
50%	0.965	0.849	1.098	0.5912
60%	0.853	0.752	0.968	0.0141
70%	0.870	0.765	0.989	0.0333

Table 7-Continued

Variable name	Odds Ratio	Upper bound of 95% Confidence Interval	Lower bound of 95%Confidence Interval	P-value
80%	0.879	0.773	1.001	0.0520
90%	0.815	0.715	0.929	0.0021
100%	0.683	0.599	0.779	<.0001
Histology				
Ductal	1			
Lobular	1.235	1.124	1.357	<.0001
Other	1.069	0.996	1.147	0.0633
Node status				
Positive Nodes	1			
No Positive Nodes	1.031	0.809	1.313	0.8055
Unknown	1.103	0.853	1.426	0.4564
Prior other cancer				
NO	1			
YES	1.074	0.968	1.193	0.1782
Registry				
California	1			
Atlanta	1.457	1.302	1.630	<.0001
Connecticut	2.560	2.291	2.861	<.0001
Detroit	4.055	3.683	4.465	<.0001
Iowa	1.333	1.159	1.534	<.0001
New Mexico	0.980	0.777	1.237	0.8655
Rural Georgia	0.711	0.313	1.613	0.4144
Seattle	1.912	1.727	2.116	<.0001
Utah	0.726	0.610	0.865	0.0003
Cancer stage				
Stage I	1			
Stage IIa	1.040	0.803	1.347	0.7639
Stage IIb	1.121	0.695	1.807	0.6402

Table 7-Continued

Variable name	Odds Ratio	Upper bound of 95% Confidence Interval	Lower bound of 95%Confidence Interval	P-value
Tumor Grade				
Well Differentiated	1			
Moderately Differentiated	0.993	0.919	1.073	0.8617
Undifferentiated	0.755	0.614	0.928	0.0075
Unknown	0.715	0.652	0.784	<.0001
Poorly Differentiated	1.102	1.010	1.203	0.0296
Tumor size				
<=10	1			
11-15	0.936	0.869	1.007	0.0777
16-20	0.877	0.808	0.952	0.0017
21-30	0.782	0.601	1.018	0.0675
>30	0.714	0.531	0.959	0.0253
unknown	0.725	0.497	1.060	0.0970
Year of diagnosis				
1992	1			
1993	1.009	0.911	1.118	0.8614
1994	0.950	0.857	1.053	0.3294
1995	1.039	0.937	1.152	0.4682
1996	1.004	0.903	1.116	0.9413
1997	0.981	0.883	1.089	0.7177
1998	1.021	0.918	1.136	0.6963
1999	1.017	0.915	1.130	0.7573

Table 8 Multivariate Logistic Regressions of Patient Characteristics and Choice of High (≥46) vs. Non-high (<46) Volume Hospital

Variable name	Odds Ratio	Upper bound of 95% Confidence Interval	Lower bound of 95%Confidence Interval	P-value
Differential distance				
1st quartile	1			
2nd quartile	0.286	0.267	0.306	<.0001
3rd quartile	0.061	0.055	0.066	<.0001
4th quartile	0.027	0.022	0.032	<.0001
Distance to nearest hospital	0.985	0.983	0.988	<.0001
Age at diagnosis				
84+	1			
66-70	1.126	0.993	1.277	0.0638
71-74	1.098	0.976	1.235	0.1206
75-79	1.097	0.976	1.233	0.1187
80-84	1.037	0.918	1.172	0.5551
Race				
White	1			
Black	1.019	0.901	1.153	0.7603
Other/unknown	0.831	0.677	1.021	0.0787
Hispanic ethnicity				
Yes	1			
No/unknown	1.470	1.194	1.809	0.0003
Marital status at diagnosis				
Single, sep, widow, divorced	1			
Married	1.061	0.998	1.128	0.0576
Unknown	0.948	0.792	1.135	0.5625
Urban/rural residence				
Major Metropolitan Area	1			
Less Urban	3.575	2.884	4.430	<.0001
Metropolitan County	1.141	1.028	1.267	0.0131

Table 8-Continued

Variable name	Odds Ratio	Upper bound of 95% Confidence Interval	Lower bound of 95%Confidence Interval	P-value
Rural	2.970	2.094	4.212	<.0001
Urban	0.911	0.734	1.129	0.3935
Census track Education level				
1st quartile	1			
2nd quartile	1.251	1.139	1.374	<.0001
3rd quartile	1.474	1.331	1.632	<.0001
4th quartile	2.063	1.840	2.312	<.0001
Census track income level				
1st quartile	1			
2nd quartile	0.989	0.897	1.090	0.8210
3rd quartile	0.814	0.732	0.905	0.0002
4th quartile	0.868	0.770	0.979	0.0215
Missing	1.629	1.352	1.962	<.0001
Estrogen receptor positive				
Yes	1			
No/unknown	0.765	0.703	0.832	<.0001
Progesterone receptor positive				
Yes	1			
No/unknown	0.795	0.736	0.860	<.0001
Co-morbidity index				
10%	1			
20%	0.963	0.843	1.100	0.5803
30%	0.900	0.788	1.027	0.1171
40%	0.878	0.772	0.998	0.0463
50%	0.973	0.853	1.110	0.6837
60%	0.880	0.774	1.001	0.0522
70%	0.874	0.767	0.996	0.0427
80%	0.895	0.785	1.022	0.1009
90%	0.759	0.664	0.867	<.0001

Table 8- Continued

Variable name	Odds Ratio	Upper bound of 95% Confidence Interval	Lower bound of 95%Confidence Interval	P-value
100%	0.750	0.655	0.859	<.0001
Histology				
Ductal	1			
Lobular	1.309	1.185	1.446	<.0001
Other	1.059	0.981	1.142	0.1422
Node status				
Positive Nodes	1			
No Positive Nodes	0.722	0.554	0.941	0.0160
Unknown	0.776	0.587	1.026	0.0748
Prior other cancer				
NO	1			
YES	1.051	0.942	1.173	0.3752
Registry				
California	1			
Atlanta	1.110	0.984	1.252	0.0893
Connecticut	2.491	2.236	2.775	<.0001
Detroit	2.726	2.486	2.989	<.0001
Iowa	2.445	2.076	2.881	<.0001
New Mexico	2.587	1.780	3.759	<.0001
Rural Georgia	2.602	0.907	7.461	0.0752
Seattle	1.399	1.256	1.559	<.0001
Utah	1.446	1.162	1.798	0.0009
Cancer stage				
Stage I	1			
Stage IIa	0.719	0.542	0.953	0.0217
Stage IIb	0.570	0.338	0.961	0.0351

Table 8-Continued

Variable name	Odds Ratio	Upper bound of 95% Confidence Interval	Lower bound of 95%Confidence Interval	P-value
Tumor Grade				
Well Differentiated	1			
Moderately Differentiated	1.037	0.955	1.126	0.3855
Undifferentiated	0.819	0.637	1.052	0.1181
Poorly Differentiated	1.145	1.044	1.256	0.0042
Unknown	0.685	0.620	0.757	<.0001
Tumor size				
<=10	1			
11-15	0.972	0.899	1.050	0.4662
16-20	0.868	0.795	0.948	0.0016
21-30	1.132	0.850	1.508	0.3957
>30	1.067	0.773	1.474	0.6929
unknown	0.618	0.410	0.931	0.0214
Year of diagnosis				
1992	1			
1993	0.946	0.848	1.056	0.3252
1994	0.961	0.861	1.074	0.4845
1995	0.953	0.853	1.064	0.3922
1996	1.060	0.943	1.192	0.3286
1997	1.036	0.927	1.158	0.5320
1998	1.045	0.932	1.172	0.4478
1999	0.957	0.856	1.070	0.4422

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