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Socioeconomic status and survival after an invasive breast cancer diagnosis

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Abstract

Background—Women living in geographic areas with high poverty and low education levels experience poorer survival after a breast cancer diagnosis than those living in communities with indicators of high socioeconomic status (SES). However, very few studies have examined individual-level SES in relation to breast cancer survival or assessed the contextual role of community-level SES independent of individual-level SES.

Methods—We examined both individual- and community-level SES in relation to breast cancer survival in a population-based cohort of women aged 20–69 years diagnosed with breast cancer in Wisconsin during 1995–2003 (N=5,820).

Results—Compared to college graduates, women with no education beyond high school were 1.39 (95% CI: 1.10, 1.76) times more likely to die from breast cancer. Women with household income <2.5 times the poverty level were 1.44 (95% CI: 1.08, 1.93) times more likely to die from breast cancer than women with household income ≥5 times the poverty level. Adjustment for use of screening mammography, stage at diagnosis, and lifestyle factors eliminated the disparity by income, but the disparity by education persisted (HR=1.27; 95% CI: 0.99, 1.61). In multi-level analyses, low community-level education was associated with increased breast cancer mortality even after adjustment for individual-level SES (HR=1.56; 95% CI: 1.05, 2.31 for ≥20% vs. <10% of adults without a high school degree).

Conclusions—These results indicate that screening and early detection explain some of the disparity by SES, but further research is needed to understand the additional ways in which individual- and community-level education are associated with survival.

Keywords

Breast neoplasms; healthcare disparities; socioeconomic factors; epidemiologic studies; survival analysis

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INTRODUCTION

Significant progress has been achieved over the past 30 years in improving survival rates following an invasive breast cancer diagnosis in the United States. Nationally, five-year relative survival among women diagnosed in 1999–2005 exceeds 90%, compared to 75% for women diagnosed in 1975–1977.[1] This improvement is likely the result of advances in the efficacy of breast cancer treatments, as well as the widespread use of screening mammography to detect cancers at an early stage.[2] Early screening both improves treatment effectiveness and also makes survival rates appear longer via lead-time bias and overdiagnosis.[3]

Unfortunately, all women have not benefited equally from these advances in breast cancer detection and treatment. Women living in communities with high poverty rates and low levels of education experience poorer survival rates after a breast cancer diagnosis.[5–11] These disparities according to community-level socioeconomic status (SES) may be due to a number of factors, including differences in use of screening, tumor aggressiveness, lifestyle behaviors and environmental exposures, and access to treatment.[6,12,13] Elucidation of the relative roles of these factors could guide interventions to reduce disparities in survival.

One primary limitation in the evaluation of the role of socioeconomic factors in breast cancer survival has been a dependence on community-level markers of SES.[14,15] Nearly all studies to date have relied on geography-based (e.g. United States Census) measures of SES as a proxy for individual-level SES.[12,13,16] While both individual- and community-level socioeconomic status can influence health,[14,17] very few studies have been able to evaluate both in relation to breast cancer survival.

We examined individual- and community-level SES in relation to breast cancer survival in a population-based cohort formed of women with incident invasive breast cancer diagnosed in Wisconsin during 1995–2003. We also examined variation in individual-level screening utilization, stage at diagnosis, and lifestyle factors as potential mediators of a relation between SES and survival.

MATERIALS AND METHODS

We used data on Wisconsin women with breast cancer from two population-based case-control studies of breast cancer, both of which have previously been described.[18,19] The studies were conducted according to protocols approved by the University of Wisconsin Institutional Review Board. All subjects provided verbal informed consent.

Study population

Female residents of Wisconsin, ages 20 to 69 years, with a first diagnosis of invasive breast cancer during 1995 to 2003 were identified from the mandatory statewide cancer registry. Eligibility was limited to subjects with listed telephone numbers, driver's licenses verified by self-report (if <65 years of age; for comparability to controls in the case-control studies), and known dates of diagnosis (from the cancer registry). Of 7,471 eligible cases, 79% (N=5,865) were interviewed.

Data collection

Telephone interviews were conducted on average 16.4 months (standard deviation, 6.0 months) after diagnosis. The interview elicited information on socioeconomic status, reproductive and menstrual history, height and weight, use of hormones, personal and family medical history, mammography screening utilization, and demographic factors.

Socioeconomic data collected included highest degree or year of school completed, annual household income at one year prior to diagnosis, and household size at one year prior to diagnosis. Household income was assessed in categories (U.S. dollars): < 15,000; 15,000 – 29,999; 30,000 – 49,999; 50,000 – 99,999; and ≥ 100,000. Mammography screening was assessed by asking women to report the number of mammograms they had in the five years prior to their diagnosis.

Community-level socioeconomic data was collected for census tracts from the year 2000 United States Census.[20] The residential locations of all subjects were geocoded to census tracts based on home address and zip code using previously described methods.[21,22] Each subject was then assigned census-tract level data from the 2000 U.S. census for % of families in poverty and % of the population 25 years and older without a high school diploma.

Information regarding each subject's tumor characteristics was obtained from the Wisconsin cancer registry, including date of diagnosis, stage at diagnosis, and tumor histology. Tumor histology was defined using the International Classification of Disease – Oncology[23] codes as lobular (code 8520) or non-lobular (all other codes).

Vital status was determined through December 31, 2006, using automated searches of the National Death Index.[24] The underlying cause of death on the death certificate was assigned according to the International Classification of Diseases, Ninth Revision (ICD-9; through 1998) and Tenth Revision (ICD-10; 1999–2006).[25,26] Death from breast cancer (ICD-9 code 174 and ICD-10 code C50) and all-causes were evaluated.

Statistical analyses

The residential location of 45 subjects (0.8%) was unknown and therefore census-level SES information could not be ascertained. These 45 subjects were excluded from all analyses, leaving a total of 5,820 women available for analysis.

Household income and household size were used to determine an income-to-poverty ratio based on the federal poverty guidelines. The midpoint of each income category was taken as the household income value. For the lowest and highest categories, $15,000 and $100,000 were used as the household income values, respectively. The income-to-poverty ratio was calculated by dividing the household income value by the appropriate poverty-level income based on household size according to the year 2000 United States poverty guidelines.[27]

The inclusion of questions on household income and household size varied during the course of the studies, and some women refused to answer these questions when included. Consequently, there were 2,596 women missing data on income-to-poverty ratio. Of these, 1,642 were not asked about their income and 954 chose not to answer. Education information was missing for 68 subjects. Many covariates were missing data for a small fraction of subjects (see Table 1). Multiple imputation was used to impute missing data for individual-level income, education, and all covariates listed in Table 1. Ten imputations were conducted using the Markov Chain Monte Carlo method,[28] implemented in SAS statistical software version 9 (SAS Institute, Cary, NC). The imputation model contained all variables listed in Tables 1 and 2. For subsequent analyses, each model was fit separately to the ten imputed datasets and their results combined for statistical inferences using the methods of Rubin.[29]

Multivariable logistic regression models were fit to estimate the odds ratios (OR) and 95% confidence intervals (95% CI) describing the association between SES factors and mammography screening utilization and stage at diagnosis. Each model was adjusted for subject age and calendar year at diagnosis. Cox proportional-hazards models were used to estimate the hazard ratios (HR) and 95% CIs associated with SES factors for breast cancer and all-cause mortality. To examine potential mediators of the association between SES and mortality, variables representing screening utilization, tumor characteristics, and lifestyle factors were sequentially added to the models (as parameterized in Table 1). Additionally, a model containing both individual-level and community-level SES variables was constructed to examine the independent effects of these factors. To account for the clustering of individuals within communities, the robust sandwich estimate for the covariance matrix was used in the Cox regression model with the census tract clustering variable specified.[30] For all analyses, survival time was defined as the number of days from diagnosis to death, or until the last follow-up date, December 31, 2006, at which point all remaining subjects were censored. In analyses of breast cancer mortality, deaths from other causes were censored at the time of death. Women diagnosed with breast cancer who died before they had the chance to be interviewed could not be included in the study, so all models were adjusted for this left truncation of survival times.[31]

RESULTS

On average, the 5,820 study subjects were followed 7.2 years (standard deviation, 2.1 years) from their date of diagnosis. There were 690 total deaths, 469 (68%) of which were from breast cancer. Characteristics of the study cohort are shown in Table 1. Approximately two-thirds of the cancers were diagnosed at a local stage. Women with less education were more likely to be older, postmenopausal, obese, and to be a current smoker at the time of diagnosis, while less likely to report annual screening mammograms prior to their diagnosis or to have used postmenopausal hormones.

There was a high degree of association between each of the SES variables. Table 2 displays the distribution of each SES variable stratified by individual-level education. Women with a college degree were much more likely than those without a degree to have a high income-to-poverty ratio and live in an area with a low % of adults without a high school degree and a low % of families in poverty.

After adjusting for age and year of diagnosis, low levels of each SES indicator were associated with a reduced likelihood of having had annual screening mammograms prior to diagnosis (Table 3). For instance, women with an income-to-poverty ratio less than 2.5 were less than half as likely to have had annual mammograms as women with an income-to-poverty ratio ≥5 (OR=0.49; 95% CI: 0.39, 0.61). There was no association between individual-level education and stage at diagnosis. The likelihood of having a distant stage cancer at diagnosis was elevated among women with low income-to-poverty ratio and low levels of both community-level SES indicators (Table 3).

In models adjusted for age and year of diagnosis, breast cancer specific mortality was elevated at low levels of each SES indicator (Table 4; first column of hazard ratios). Community-level education showed the strongest association: women living in an area where at least 20% of adults did not have a high school education were 1.61 (95% CI: 1.21, 2.15) times more likely to die from their breast cancer than women living in areas with less than 10% without a high school diploma. After adjusting for stage at diagnosis, tumor histology, and mammography utilization, only individual- and community-level education continued to be associated with breast cancer mortality (Table 4; second column of hazard ratios). Further adjustment for variation in lifestyle factors had a minor attenuating effect on these associations (Table 4; third column). In the full model containing both individual- and community-level SES factors (Table 4; final column), community-level education was associated with breast cancer mortality (HR=1.57; 95% CI: 1.09, 2.27).

The association between SES and all-cause mortality largely mirrored that observed for breast cancer mortality (data not shown). In the models adjusted only for age and year of diagnosis, all-cause mortality was elevated at low levels of each SES indicator. In the final model including all SES variables, only community-level education was associated with all-cause mortality (HR=1.42; 95% CI: 1.05, 1.92).

DISCUSSION

Few studies have been able to examine both individual- and community-level SES in relation to breast cancer survival. We observed that survival rates among women diagnosed with breast cancer were lower for women who were less educated, reported less income, or lived in areas with low community-level education or income. These lower survival rates were explained in part by lower use of screening mammography and a higher likelihood of being diagnosed with distant-staged breast cancer. Adjustment for these factors substantially attenuated, but did not eliminate, the association between SES and breast cancer survival. These results suggest that socioeconomic disparities in breast cancer survival could be substantially reduced by improving early detection among low SES women. However, independent of screening and early detection, survival rates were lower among women with less education and among those living in communities with lower education.

Previous studies of breast cancer survival in relation to SES in the United States have almost exclusively focused on community-level factors due to their ready availability in many datasets.[5–11] A recent study examined disparities in breast cancer survival among over 100,000 women with breast cancer in the Surveillance, Epidemiology, and End Results program.[7] A composite community-level SES variable was created from the % of adults with less than 12 years of education and the % of families living below the federal poverty line in the county. Women in the lowest SES quartile were 1.19 (95% CI: 1.13–1.26) times more likely to die from breast cancer than those in the highest SES group. Women living in low SES counties were also more likely to have advanced stage disease and to have not received radiation or surgery during their first course treatment. After adjusting for these differences, the association between SES and breast cancer survival was greatly attenuated (HR=1.08; 95% CI: 1.03, 1.14). Similar results were observed in the Patterns of Care study of the National Program of Cancer Registries.[6] Again the lower survival rate among women living in low SES areas (mortality HR=1.59) was substantially attenuated after adjustment for stage and treatment (HR=1.16).

Women in our study with a college degree were more likely to live in a highly educated community than women who had never attended college. However, there is substantial evidence that community-level SES variables do not serve as simple proxies for individual-level SES.[14,32] Rather, community-level socioeconomic context can affect health through independent pathways related to the physical, social, and service environments of the community.[14,17] The few studies that have examined individual-level SES in relation to breast cancer survival have focused on economic indicators of access to health care.[33–36] In a clinic-based study, Franzini et al.[36] used an “ability to pay” scale (reflecting income, number of dependents, and insurance coverage) as an SES indicator and found that all-cause mortality among women with breast cancer was 1.69 (95% CI: 1.15, 2.48) times greater in women ranked lowest in SES compared to those ranked highest, even after adjustment for stage at diagnosis, treatment, and tumor histology. In a population-based study of women diagnosed with breast cancer in New Jersey, Ayanian et al.[33] observed that uninsured patients and those covered by Medicare were more likely to be diagnosed with distant-stage disease than women with private insurance. Analyses adjusted for stage indicated that the uninsured and Medicaid patients with breast cancer experienced a 40–50% increased rate of death compared to privately-insured patients. Similar results have been reported in studies of women diagnosed with breast cancer in Michigan.[34,35]

As reviewed by Cross et al.,[13] socioeconomic status can influence breast cancer survival through a number of mechanisms. Women with low SES may develop more aggressive breast cancers, be less intensively screened for early detection, be exposed to lifestyle or environmental factors which accelerate tumor progression, or receive inadequate treatment. Elucidation of the primary mechanisms by which SES influences breast cancer survival may provide targets for interventions to reduce these disparities. We used a model building technique in which groups of variables were added sequentially in an attempt to distinguish which of these mechanisms may be most relevant to the socioeconomic disparities in breast cancer survival observed in our cohort.

In the basic model, adjusted only for age and year of diagnosis, there were marked differences in breast cancer survival according to each indicator of SES. Numerous studies have demonstrated that women with low income or education levels are less likely to receive regular screening mammography.[37–40] Due in large part to this deficit in screening, women with low education and income are also more likely to be diagnosed with late stage disease.[41–43] These patterns were also observed in our study sample. Adjustment for mammography utilization and stage at diagnosis dramatically attenuated the disparities associated with individual- and community-level income. These results are consistent with the hypothesis that women with lower household income are experiencing lower breast cancer survival because they do not receive regular screening mammograms and are thus diagnosed with later stage disease. Similarly, women living in areas with high poverty may have less access to mammography facilities. Adjustment for screening may also capture variation in other unknown factors which are associated with participation in screening. Women who participate in mammography or other cancer screening programs may be generally healthier or differ in other important ways from women who do not. For instance, women who volunteered for participation in the Prostate, Lung, Colorectal, and Ovarian Cancer Screening Trial had all-cause and breast cancer specific mortality rates that were 62% and 72% lower, respectively, than the general population.[44] Thus, some of the improved survival associated with screening in an observational study may be attributable not to screening but to other factors.[45]

In contrast to the results regarding income, the relation between individual- and community-level education remained largely elevated even after adjustment for screening utilization and stage at diagnosis.

Health-related behaviors, including smoking and obesity, vary according to SES[37,46] and may influence breast cancer survival.[47] We observed that women with less education were more likely to be obese and to be current smokers, and were also less likely to have used postmenopausal hormones. At least two studies have reported that a history of postmenopausal hormone use is associated with better prognosis following a breast cancer diagnosis.[48,49] However, further adjustment in our models for such lifestyle factors had only a modest effect on the hazard ratios and a statistically significant association between education and breast cancer survival persisted.

The differences we observed in education and income reinforce the idea that education and income, though both measures of SES, are separate constructs and cannot be used interchangeably.[14] Though individual-level education and income were correlated in our study, education levels varied substantially across all income groups. While both education and income may be associated with economic resources, education can also reflect non-economic social characteristics that influence health such as health-related knowledge, problem-solving skills, and influence over one's life.[14] Notably, we observed that community-level education was strongly associated with breast cancer survival even after adjustment for individual-level education in the multi-level model.

A substantial portion of the decline in breast cancer mortality has been attributed to the increased use of adjuvant systemic therapy.[2,50] Education may play a pivotal role in access and adherence to adjuvant treatment regimens.[6,12,13] Unfortunately, we had limited subject data on treatment within this cohort, and thus could not examine the role of treatment in mediating the observed socioeconomic disparities in breast cancer survival. Our study has other limitations that should also be considered. The study sample was 95% non-Hispanic white, thus we had no ability to examine the potential interactions between SES and race. Women with low SES may be more likely to have tumors that are more aggressive and less responsive to treatment.[16] Breast cancers which do not express the estrogen receptor (ER), progesterone receptor (PR), or human epidermal growth factor receptor 2 (HER2) are not amenable to endocrine therapy, and women with these "triple-negative" breast cancers experience poorer survival than women with cancers expressing either ER, PR, or HER2.[51] Even after adjustment for stage and grade, Bauer et al.[51] observed that women living in low SES areas were 12% (95% CI: 1, 24) more likely to have triple negative breast cancer than women living in high SES areas. While we observed little difference in tumor histology (lobular vs. non-lobular) according to education, expression of these tumor biomarkers was not available for our study subjects and could not be addressed in this analysis.

Data on household income was missing for a large portion of our sample (45%). Many women were simply not asked about household income, while a substantial number who were asked refused to answer. Those who refused to answer were more likely to be less educated and varied according to other observed variables. In analyses limited to women who reported household income (N=3,224), we also observed elevated breast cancer mortality (HR=1.52, 95% CI: 1.07–2.17 for <2.5 vs. ≥5.0 income-to-poverty ratio). Exclusion of subjects missing data can not only reduce precision but also lead to bias due the association of missing data with other covariates.[52] Thus, we used multiple imputation to impute missing data, such that all the data could be used while accounting for the uncertainty in the missing data.

Finally, we acknowledge the challenges in measuring SES at either the individual or community level.[14] Education and income are crude measures of SES, which fail to capture variation in prestige and quality of education and accumulated wealth. With assessment at only one point in time, we also failed to capture variation in SES at earlier life stages.

This study also had a number of important strengths, including a large population-based sample, high participation rate, substantial duration of follow-up, and detailed screening history and lifestyle information.

In summary, Wisconsin women with low SES and those living in low SES communities experienced an elevated mortality rate after a breast cancer diagnosis. Lower utilization of screening mammography and late stage at diagnosis accounted for a substantial fraction of these disparities. While improving access to screening and early detection should reduce socioeconomic disparities in breast cancer survival, further research is necessary to understand the additional mechanisms through which education affects this important health outcome. These results also suggest that community-level education is associated with breast cancer survival independent of individual-level SES. Intervention strategies that target communities with low education levels should be evaluated for their potential to improve outcomes for women diagnosed with breast cancer.

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REFERENCES

1. Horner, MJ.; Ries, LAG.; Krapcho, M., et al. SEER Cancer Statistics Review, 1975–2006. National Cancer Institute; 2009. http://seer.cancer.gov/csr/1975_2006/, based on November 2008 SEER data submission, posted to the SEER web site
2. Berry DA, Cronin KA, Plevritis SK, et al. Effect of screening and adjuvant therapy on mortality from breast cancer. N Engl J Med. 2005; 353(17):1784–1792. [PubMed: 16251534]
3. Shwartz M. Estimates of lead time and length bias in a breast cancer screening program. Cancer. 1980; 46(4):844–851. [PubMed: 7397650]
4. Jemal A, Clegg LX, Ward E, et al. Annual report to the nation on the status of cancer, 1975–2001, with a special feature regarding survival. Cancer. 2004; 101(1):3–27. [PubMed: 15221985]
5. Harper S, Lynch J, Meersman SC, Breen N, Davis WW, Reichman MC. Trends in area-socioeconomic and race-ethnic disparities in breast cancer incidence, stage at diagnosis, screening, mortality, and survival among women ages 50 years and over (1987–2005). Cancer Epidemiol Biomarkers Prev. 2009; 18(1):121–131. [PubMed: 19124489]
6. Byers TE, Wolf HJ, Bauer KR, et al. The impact of socioeconomic status on survival after cancer in the United States : findings from the National Program of Cancer Registries Patterns of Care Study. Cancer. 2008; 113(3):582–591. [PubMed: 18613122]
7. Yu XQ. Socioeconomic disparities in breast cancer survival: relation to stage at diagnosis, treatment and race. BMC Cancer. 2009; 9:364. [PubMed: 19828016]
8. Gordon NH, Crowe JP, Brumberg DJ, Berger NA. Socioeconomic factors and race in breast cancer recurrence and survival. Am J Epidemiol. 1992; 135(6):609–618. [PubMed: 1580237]
9. Bassett MT, Krieger N. Social class and black-white differences in breast cancer survival. Am J Public Health. 1986; 76(12):1400–1403. [PubMed: 3777285]
10. Gorey KM, Luginaah IN, Holowaty EJ, Fung KY, Hamm C. Breast cancer survival in Ontario and California, 1998–2006: socioeconomic inequity remains much greater in the United States. Ann Epidemiol. 2009; 19(2):121–124. [PubMed: 19185806]
11. Greenwald HP, Polissar NL, Dayal HH. Race, socioeconomic status and survival in three female cancers. Ethn Health. 1996; 1(1):65–75. [PubMed: 9395549]
12. Bigby J, Holmes MD. Disparities across the breast cancer continuum. Cancer Causes Control. 2005; 16(1):35–44. [PubMed: 15750856]
13. Cross CK, Harris J, Recht A. Race, socioeconomic status, and breast carcinoma in the U.S: what have we learned from clinical studies. Cancer. 2002; 95(9):1988–1999. [PubMed: 12404294]
14. Braveman PA, Cubbin C, Egerter S, et al. Socioeconomic status in health research: one size does not fit all. JAMA. 2005; 294(22):2879–2888. [PubMed: 16352796]
15. Baquet CR, Commiskey P. Socioeconomic factors and breast carcinoma in multicultural women. Cancer. 2000; 88(5 Suppl):1256–1264. [PubMed: 10705364]
16. Vona-Davis L, Rose DP. The influence of socioeconomic disparities on breast cancer tumor biology and prognosis: a review. J Womens Health (Larchmt). 2009; 18(6):883–893. [PubMed: 19514831]
17. Robert SA. Socioeconomic position and health: the independent contribution of community socioeconomic context. Annual Review of Sociology. 1999; 25:489–516.

18. Sprague BL, Trentham-Dietz A, Newcomb PA, Titus-Ernstoff L, Hampton JM, Egan KM. Lifetime recreational and occupational physical activity and risk of in situ and invasive breast cancer. Cancer Epidemiol Biomarkers Prev. 2007; 16(2):236–243. [PubMed: 17301255]
19. Nelson SE, Gould MN, Hampton JM, Trentham-Dietz A. A case-control study of the HER2 Ile655Val polymorphism in relation to risk of invasive breast cancer. Breast Cancer Res. 2005; 7(3):R357–R364. [PubMed: 15987431]
20. U.S. Census Bureau. Census 2000 Summary File 3. available at www.census.gov.
21. McElroy JA, Remington PL, Trentham-Dietz A, Robert SA, Newcomb PA. Geocoding addresses from a large population-based study: lessons learned. Epidemiology. 2003; 14(4):399–407. [PubMed: 12843762]
22. Robert SA, Strombom I, Trentham-Dietz A, et al. Socioeconomic risk factors for breast cancer: distinguishing individual- and community-level effects. Epidemiology. 2004; 15(4):442–450. [PubMed: 15232405]
23. Fritz, A.; Percy, C.; Jack, A., et al. International Classification of Diseases for Oncology. 3rd Edition. Geneva: World Health Organization; 2000.
24. Calle EE, Terrell DD. Utility of the National Death Index for ascertainment of mortality among cancer prevention study II participants. Am J Epidemiol. 1993; 137(2):235–241. [PubMed: 8452128]
25. WHO. International Classification of Diseases (ICD-9). Geneva: WHO; 1977.
26. WHO. International Classification of Diseases (ICD-10). Geneva: WHO; 1994.
27. United States Department of Health & Human Services. Federal Register, Vol. 65, No. 31. 2000.
28. Schafer, JL. Analysis of incomplete multivariate data. New York: Chapman and Hall; 1997.
29. Rubin, DB. Multiple imputation for nonresponse in surveys. New York: John Wiley & Sons; 1987.
30. Lin DY, Wei LJ. The robust inference for the proportional hazards model. Journal of the American Statistical Association. 1989; 84:1074–1078.
31. Klein, JP.; Moeschberger, ML. Survival Analysis: Techniques for Censored and Truncated Data. New York: Springer; 1997.
32. Geronimus AT, Bound J. Use of census-based aggregate variables to proxy for socioeconomic group: evidence from national samples. Am J Epidemiol. 1998; 148(5):475–486. [PubMed: 9737560]
33. Ayanian JZ, Kohler BA, Abe T, Epstein AM. The relation between health insurance coverage and clinical outcomes among women with breast cancer. N Engl J Med. 1993; 329(5):326–331. [PubMed: 8321261]
34. Bradley CJ, Given CW, Roberts C. Disparities in cancer diagnosis and survival. Cancer. 2001; 91(1):178–188. [PubMed: 11148575]
35. Bradley CJ, Given CW, Roberts C. Race, socioeconomic status, and breast cancer treatment and survival. J Natl Cancer Inst. 2002; 94(7):490–496. [PubMed: 11929949]
36. Franzini L, Williams AF, Franklin J, Singletary SE, Theriault RL. Effects of race and socioeconomic status on survival of 1,332 black, Hispanic, and white women with breast cancer. Ann Surg Oncol. 1997; 4(2):111–118. [PubMed: 9084846]
37. National Center for Health Statistics Health, United States, 2008 with chartbook. 2008.
38. Katz SJ, Zemencuk JK, Hofer TP. Breast cancer screening in the United States and Canada, 1994: socioeconomic gradients persist. Am J Public Health. 2000; 90(5):799–803. [PubMed: 10800435]
39. Swan J, Breen N, Coates RJ, Rimer BK, Lee NC. Progress in cancer screening practices in the United States: results from the 2000 National Health Interview Survey. Cancer. 2003; 97(6):1528–1540. [PubMed: 12627518]
40. Dailey AB, Kasl SV, Holford TR, Calvocoressi L, Jones BA. Neighborhood-level socioeconomic predictors of nonadherence to mammography screening guidelines. Cancer Epidemiol Biomarkers Prev. 2007; 16(11):2293–2303. [PubMed: 18006918]
41. Clegg LX, Reichman ME, Miller BA, et al. Impact of socioeconomic status on cancer incidence and stage at diagnosis: selected findings from the surveillance, epidemiology, and end results: National Longitudinal Mortality Study. Cancer Causes Control. 2009; 20(4):417–435. [PubMed: 19002764]

42. Hahn KM, Bondy ML, Selvan M, et al. Factors associated with advanced disease stage at diagnosis in a population-based study of patients with newly diagnosed breast cancer. Am J Epidemiol. 2007; 166(9):1035–1044. [PubMed: 17690220]

43. Lannin DR, Mathews HF, Mitchell J, Swanson MS, Swanson FH, Edwards MS. Influence of socioeconomic and cultural factors on racial differences in late-stage presentation of breast cancer. JAMA. 1998; 279(22):1801–1807. [PubMed: 9628711]

44. Pinsky PF, Miller A, Kramer BS, et al. Evidence of a healthy volunteer effect in the prostate, lung, colorectal, and ovarian cancer screening trial. Am J Epidemiol. 2007; 165(8):874–881. [PubMed: 17244633]

45. Moss SM, Summerley ME, Thomas BT, Ellman R, Chamberlain JO. A case-control evaluation of the effect of breast cancer screening in the United Kingdom trial of early detection of breast cancer. J Epidemiol Community Health. 1992; 46(4):362–364. [PubMed: 1431707]

46. Mokdad AH, Ford ES, Bowman BA, et al. Prevalence of obesity, diabetes, and obesity-related health risk factors, 2001. JAMA. 2003; 289(1):76–79. [PubMed: 12503980]

47. Soerjomataram I, Louwman MW, Ribot JG, Roukema JA, Coebergh JW. An overview of prognostic factors for long-term survivors of breast cancer. Breast Cancer Res Treat. 2008; 107(3): 309–330. [PubMed: 17377838]

48. Newcomb PA, Egan KM, Trentham-Dietz A, et al. Prediagnostic use of hormone therapy and mortality after breast cancer. Cancer Epidemiol Biomarkers Prev. 2008; 17(4):864–871. [PubMed: 18381475]

49. Schairer C, Gail M, Byrne C, et al. Estrogen replacement therapy and breast cancer survival in a large screening study. J Natl Cancer Inst. 1999; 91(3):264–270. [PubMed: 10037105]

50. Early Breast Cancer Trialists' Collaborative Group. Effects of chemotherapy and hormonal therapy for early breast cancer on recurrence and 15-year survival: an overview of the randomised trials. Lancet. 2005; 365(9472):1687–1717. [PubMed: 15894097]

51. Bauer KR, Brown M, Cress RD, Parise CA, Caggiano V. Descriptive analysis of estrogen receptor (ER)-negative, progesterone receptor (PR)-negative, and HER2-negative invasive breast cancer, the so-called triple-negative phenotype: a population-based study from the California cancer Registry. Cancer. 2007; 109(9):1721–1728. [PubMed: 17387718]

52. Greenland S, Finkle WD. A critical look at methods for handling missing covariates in epidemiologic regression analyses. Am J Epidemiol. 1995; 142(12):1255–1264. [PubMed: 7503045]

Table 1

Characteristics of Breast Cancer Cases, Wisconsin, 1995–2003.

Characteristic	All Subjects n (%) N=5,820[a]	No College n (%) N=2,728	Some College/ College Degree n (%) N=3,024
Age at diagnosis			
20–34	147 (2.5)	49 (1.8)	96 (3.2)
35–44	889 (12.3)	336 (12.3)	547 (18.1)
45–54	1,897 (32.6)	737 (27.0)	1,145 (37.9)
55–64	2,037 (35.0)	1,057 (38.8)	951 (31.5)
≥65	850 (14.6)	549 (20.1)	285 (9.4)
Menopausal status[b]			
Premenopausal	2,134 (36.7)	810 (30.0)	1,322 (43.7)
Postmenopausal	3,252 (55.9)	1,775 (65.1)	1,444 (47.8)
Unknown	434 (7.5)	143 (5.2)	258 (8.5)
Family history of breast cancer[c]			
No	4419 (75.9)	2,062 (75.6)	2,354 (77.8)
Yes	1,217 (20.9)	611 (22.4)	606 (20.0)
Unknown	184 (3.2)	55 (2.0)	64 (2.1)
Recent mammography utilization[d]			
None	388 (10.0)	243 (12.1)	145 (8.0)
<1 per year	742 (19.1)	402 (20.0)	340 (18.7)
Annual	2,685 (68.9)	1,358 (67.4)	1,327 (72.8)
Unknown	80 (2.1)	11 (0.6)	11 (0.6)
History of postmenopausal hormone use[b,e]			
Never	1,292 (39.7)	848 (47.8)	442 (30.6)
Ever	1,925 (59.2)	925 (52.1)	999 (69.2)
Unknown	35 (1.1)	2 (0.1)	3 (0.2)
Body mass index (kg/m^2)[b]			
<18.5	77 (1.3)	33 (1.2)	44 (1.5)
18.5–24.9	2,537 (43.6)	1,055 (38.7)	1,471 (48.6)
25.0–29.9	1,838 (31.6)	912 (33.4)	915 (30.3)
≥30.0	1,282 (22.0)	695 (25.5)	579 (19.2)
Unknown	86 (1.5)	33 (1.2)	15 (0.5)
Smoking history[b]			
Never	2,956 (50.8)	1,295 (47.5)	1,651 (54.6)
Former	1,714 (29.5)	809 (29.7)	901 (29.8)
Current	1,083 (18.6)	614 (22.5)	466 (15.4)
Unknown	67 (1.2)	10 (0.4)	6 (0.2)
Stage of disease at diagnosis			
Localized	3,911 (67.2)	1,825 (66.9)	2,041 (67.5)
Regional	1,678 (28.8)	780 (28.6)	881 (29.1)

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Characteristic	All Subjects n (%) N=5,820[a]	No College n (%) N=2,728	Some College/ College Degree n (%) N=3,024
Distant	107 (1.8)	50 (1.8)	54 (1.8)
Unknown	124 (2.1)	73 (2.7)	48 (1.6)
Histological type			
Lobular	554 (9.5)	270 (9.9)	278 (9.2)
Nonlobular	5,266 (90.5)	2,458 (90.1)	2,746 (90.8)

[a] Includes 68 women missing information on education.

[b] At one year prior to diagnosis.

[c] At the time of the interview.

[d] During the five years preceding the date of diagnosis; limited to women age 50 or older.

[e] Limited to postmenopausal women.

Table 2

Socioeconomic Status Among Breast Cancer Cases, Wisconsin, 1995–2003.

	All subjects n (%) N=5,820[a]	No High School Degree n (%) N=277	High School Degree n (%) N=2,451	Some College n (%) N=1,497	College Degree n (%) N=1,527
Individual-level variables					
Income-to-poverty ratio					
≥5.0	1,079 (18.5)	13 (4.7)	292 (11.9)	299 (20.0)	475 (31.1)
2.5–4.9	1,312 (22.5)	41 (14.8)	566 (23.1)	368 (24.6)	337 (22.1)
<2.5	833 (14.3)	71 (25.6)	458 (18.7)	206 (13.8)	98 (6.4)
Unknown	2,596 (44.6)	152 (54.9)	1,135 (46.3)	624 (41.7)	617 (40.4)
Community-level variables					
% without a high school diploma					
0–9.9	1,820 (31.3)	33 (11.9)	580 (23.7)	483 (32.3)	710 (46.5)
10.0–19.9	3,224 (55.4)	166 (59.9)	1,512 (61.7)	827 (55.2)	681 (44.6)
≥20	776 (13.3)	78 (28.2)	359 (14.7)	187 (12.5)	136 (8.9)
% in poverty					
0–4.9	2,862 (49.2)	99 (35.7)	1,116 (45.5)	782 (52.2)	833 (54.6)
5–9.9	2,096 (36.0)	99 (35.7)	983 (40.1)	503 (33.6)	490 (32.1)
≥10	862 (14.8)	79 (28.5)	352 (14.4)	212 (14.2)	204 (13.4)

[a]Includes 68 women missing information on education.

Table 3

The Association Between Socioeconomic Status and Mammographic Screening Prior to Diagnosis and Stage of Disease at Diagnosis Among 5,820 Breast Cancer Cases, Wisconsin, 1995–2003.

	Annual screening mammogram[a]	Local stage at diagnosis	Regional stage at diagnosis	Distant stage at diagnosis
Characteristic	**OR (95% CI)[b]**	**OR (95% CI)[b]**	**OR (95% CI)[b]**	**OR (95% CI)[b]**
Individual-level variables				
Education				
College degree	1 (Ref)	1 (Ref)	1 (Ref)	1 (Ref)
Some college	**0.79 (0.64, 0.98)**	1.05 (0.90, 1.23)	0.95 (0.81, 1.11)	0.99 (0.58, 1.68)
No college[c]	**0.66 (0.55, 0.79)**	0.97 (0.84, 1.12)	1.03 (0.89, 1.19)	1.03 (0.64, 1.66)
Income-to-poverty ratio				
≥5.0	1 (Ref)	1 (Ref)	1 (Ref)	1 (Ref)
2.5–5.0	**0.72 (0.59, 0.88)**	0.86 (0.74, 1.01)	1.12 (0.95, 1.31)	1.73 (0.86, 3.48)
<2.5	**0.49 (0.39, 0.61)**	0.85 (0.70, 1.03)	1.11 (0.92, 1.35)	**2.06 (1.03, 4.11)**
Community-level variables				
% without a high school diploma				
0–9.9	1 (Ref)	1 (Ref)	1 (Ref)	1 (Ref)
10.0–19.9	**0.80 (0.68, 0.93)**	0.97 (0.86, 1.11)	1.00 (0.88, 1.14)	1.41 (0.88, 2.25)
≥20	**0.77 (0.61, 0.97)**	0.95 (0.79, 1.14)	0.99 (0.82, 1.20)	**2.00 (1.11, 3.60)**
% in poverty				
0–4.9	1 (Ref)	1 (Ref)	1 (Ref)	1 (Ref)
5–9.9	**0.85 (0.73, 0.99)**	0.99 (0.87, 1.12)	1.02 (0.90, 1.15)	0.94 (0.61, 1.46)
≥10	**0.75 (0.61, 0.92)**	0.89 (0.76, 1.05)	1.08 (0.91, 1.27)	1.53 (0.93, 2.53)

Bolded estimates are statistically significant at $P < 0.05$.

OR, odds ratio; CI, confidence interval.

[a]Limited to women age 50 or older.

[b]Adjusted for age and year of diagnosis.

[c]Includes 277 women without a high school diploma and 2,451 women with a high school diploma.

Table 4

The Association Between Socioeconomic status and Breast Cancer Mortality after a Breast Cancer Diagnosis Among 5,820 Breast Cancer Cases, Wisconsin, 1995–2003.

Characteristic	HR (95% CI)[a]	HR (95% CI)[b]	HR (95% CI)[c]	HR (95% CI)[d]
Individual-level variables				
Education				
College degree	1 (Ref)	1 (Ref)	1 (Ref)	1 (Ref)
Some college	1.28 (0.99, 1.67)	1.24 (0.95, 1.63)	1.20 (0.91, 1.57)	1.15 (0.88, 1.51)
No college	**1.39 (1.10, 1.76)**	**1.35 (1.06, 1.71)**	1.27 (0.99, 1.61)	1.20 (0.94, 1.55)
Income-to-poverty ratio				
≥5.0	1 (Ref)	1 (Ref)	1 (Ref)	1 (Ref)
2.5–5.0	1.14 (0.83, 1.55)	0.97 (0.70, 1.34)	0.95 (0.68, 1.32)	0.90 (0.64, 1.25)
<2.5	**1.46 (1.10, 1.92)**	1.14 (0.84, 1.55)	1.09 (0.79, 1.49)	0.99 (0.71, 1.38)
Community-level variables				
% without a high school diploma				
0–9.9	1 (Ref)	1 (Ref)	1 (Ref)	1 (Ref)
10.0–19.9	**1.37 (1.10, 1.70)**	**1.32 (1.06, 1.64)**	**1.29 (1.04, 1.87)**	**1.40 (1.09, 1.78)**
≥20	**1.61 (1.21, 2.15)**	**1.45 (1.09, 1.93)**	**1.40 (1.04, 1.87)**	**1.57 (1.09, 2.27)**
% in poverty				
0–4.9	1 (Ref)	1 (Ref)	1 (Ref)	1 (Ref)
5–9.9	0.97 (0.79, 1.19)	0.94 (0.76, 1.15)	0.91 (0.74, 1.12)	**0.78 (0.62, 0.98)**
≥10	1.25 (0.98, 1.61)	1.09 (0.85, 1.41)	1.06 (0.83, 1.37)	0.86 (0.63, 1.19)

Bolded estimates are statistically significant at $P < 0.05$.

HR, hazard ratio; CI, confidence interval.

[a]Adjusted for age and year of diagnosis.

[b]Adjusted for age, year of diagnosis, histologic type, stage at diagnosis, and mammography utilization.

[c]Adjusted for age, year of diagnosis, histologic type, stage at diagnosis, mammography utilization, smoking history, family history of breast cancer, body mass index, and postmenopausal hormone use.

[d]Adjusted for age, year of diagnosis, histologic type, stage at diagnosis, mammography utilization, smoking history, family history of breast cancer, body mass index, postmenopausal hormone use, and all socioeconomic variables.