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Mammography screening among the elderly: A research challenge

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Abstract

Background—Randomized trials demonstrate clear benefits of mammography screening in women through age 74 years. We explored age- and race-specific rates of mammography screening and breast cancer mortality among women ages 69 to 84 years.

Methods—We analyzed Medicare claims data for women residing within Surveillance, Epidemiology and End Results (SEER) geographic areas from 1995 to 2009 from 64,384 non-Hispanic women (4,886 black and 59,498 white) and ascertained all primary breast cancer cases diagnosed between ages 69 and 84 years. The exposure was annual or biennial screening mammography during the four years immediately preceding diagnosis. The outcome was breast cancer mortality during the ten years immediately following diagnosis.

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Results—After adjustment for stage at diagnosis, radiation therapy, chemotherapy, co-morbid conditions and contextual socio-economic status, hazard ratios (HR's) (and 95% confidence intervals) for breast cancer mortality relative to no/irregular mammography at 10 years for women ages 69–84 years at diagnosis were 0.31 (0.29–0.33) for annual and 0.47 (0.44–0.51) for biennial mammography among whites and 0.36 (0.29–0.44) for annual and 0.47 (0.37–0.58) for biennial mammography among blacks. Trends were similar at five years overall as well as stratified by ages 69–74, 75–78, and 79–84.

Conclusions—In these Medicare claims and SEER data, elderly non-Hispanic women who self-selected for annual mammography had lower ten-year breast cancer mortality than corresponding women who self-selected for either biennial or no/irregular mammography. These findings were similar among black and white women. The data highlight the evidentiary limitations of data used for current screening mammography recommendations.

Keywords

Breast cancer screening; mortality; racial disparity; geographic disparities

Introduction

Randomized trials demonstrate clear benefits of mammography screening in women up to age 74 years.[1] After age 74, there are no cogent data from randomized trials.[1] Data from minority populations is especially sparse. The Surveillance, Epidemiology, and End Results (SEER) program file linked to the Medicare administrative claims file allows us to identify screening mammography utilization.[2] These linked files also permit exploration of breast cancer mortality differences between elderly black or white women who self-selected for regular annual or biennial mammography screening.

Materials and Methods

Detailed methods of the SEER-Medicare linked file are previously published.[2] The SEER program, comprised of 17 highly qualified cancer registries reflecting 26% of the US population, includes diagnostic information for up to 10 diagnosed cancer cases per person. Medicare is a health insurance program which enrolls approximately 93% of non-institutionalized US men and women ages 65 years and older.[3] The SEER-Medicare linked file consists of SEER data which were successfully linked to the Medicare enrollment file for 94% of persons appearing in SEER registries. Information on socio-economic status indicators at the census tract level from the US Census Bureau is included in the database.[2, 4]

All primary female breast cancer cases diagnosed between the ages of 69 and 84 from 1995 through 2009 based on Medicare claims information[4] were eligible for inclusion. Age 69 was chosen because Medicare coverage of the general population begins at age 65 years, and the exposure of interest was regular mammography screening in the four years immediately preceding diagnosis. Three mutually exclusive exposure categories were defined: (a) no or irregular mammography screening; (b) biennial; and (c) annual. Eligibility criteria included: female, non-Hispanic white or black race, and complete consecutive months of Medicare

Parts A and B coverage with no health maintenance organization (HMO) coverage (since HMO data are not provided to Medicare) during the 4-year period prior to primary breast cancer diagnosis. Hispanics were not included because Hispanic whites have substantially lower mortality than non-Hispanic whites, and the number of Hispanic blacks is small.[5] Algorithms developed by Smith-Bindman et al.[6] and Fenton et al.[7] were used to differentiate screening from diagnostic mammograms.

The women were categorized into three mutually exclusive age groups at breast cancer diagnosis: (Group 1) women ages 69–74 years since the American Cancer Society (ACS)[8] and the United States Preventive Services Task Force (USPSTF)[1] recommend regular mammography for women in the 65–74 age group, (Group 2) women ages 75–78 years since they did not fit cleanly in the other two age categories, and (Group 3) women ages 79–84 years since ACS and USPSTF mammography recommendations are for case-by-case decisions in the 75–84 age group.

The SEER-Medicare case file was used to determine breast cancer mortality among women diagnosed with primary non-metastatic breast cancer. The initial sample included all persons with a history of breast cancer identified from SEER between 1991–2009 (n=552,948). Exclusions included: male cases (n=4,344); non-white, non-black (n=67,483); women with diagnoses before 1995 (n=83,838); women with non-primary breast cancer (n=14,711); cases diagnosed by autopsy or death certificate alone (n=2,630); women with American Joint Committee on Cancer (AJCC) stage IV cancer (n=7,278); women with less than 45 months of Medicare claims prior to diagnosis (n=234,972); women with a previous diagnosis of cancer (n=17,618); women with a breast cancer diagnosis before 2006 (to allow for the possibility of detecting at least five-year post-diagnosis survival) (n=38,454), and women who were not between the ages of 65 to 74 or 75 to 84 during the four years prior to breast cancer diagnosis (n=17,236); leaving 64,384 for the analyses (Group 1, 69–74, n=26,862; Group 2, 75–78, n=17,897; Group 3, 79–84, n = 19,625). Cox proportional hazards regression was used to estimate the risk of breast cancer mortality at five years (in three age groups separately) and 10 years (all women ages 69–84 years combined) post-diagnosis associated with screening mammography rates four-years pre-diagnosis while stratifying by race and controlling for confounding factors.[9] Cause of death was available from the SEER file. Survival time was calculated in months from the date of diagnosis to the date of death or the date of last follow-up (December 31, 2010, indicated in the Medicare file). Cases lost to follow-up, those still alive at the end of the follow-up period, or those who died of causes other than breast cancer were censored. No assumptions were made about the nature or shape of the hazard function. Survival curves were generated using the Kaplan-Meier procedure and compared using the log-rank test.

Since stage at diagnosis and treatment may modify the effect of mammography screening on breast cancer mortality, we added interaction terms between mammography screening rates and AJCC stage (coded as 0/I or II/III), radiation therapy and chemotherapy to proportional hazards models and performed likelihood ratio tests to examine effect modification.[10] There was no evidence of effect modification, so AJCC stage and treatment were then assessed as confounders. Variables examined and excluded as confounders were: age at diagnosis, diagnosis year, urban/rural residence, and type of surgery as categorized in Tables 1 and 2.

Co-morbid conditions, ascertained from Medicare inpatient, outpatient and carrier claims through diagnoses made or procedures undergone one year prior to the diagnosis of breast cancer as described elsewhere,[11–14] were classified as 0, 1, ≥2 or unknown. To measure contextual socio-economic status, we calculated quartiles of a composite variable consisting of census tract-level information for median household income, the percent of persons living below the poverty level, and the percent of persons with less than a high school education for white and black women separately.[15] Based on a 10% change between crude and adjusted hazard ratios, AJCC stage, radiation therapy, and chemotherapy, confounded the association between mammography screening rates and mortality from breast cancer. Co-morbidity and contextual socio-economic status were retained for confounding adjustment to conform to other analyses.

Results

Tables 1 and 2 compare the demographic characteristics of non-Hispanic white and black women who died of breast cancer with those who were alive or censored at 5 years post diagnosis among women age 69 to 74. White women (Table 1) who had died tended to be older, have a later stage at diagnosis, received chemotherapy, and have a higher contextual socioeconomic status. White women who died were less likely to have undergone surgery, and receive radiation therapy. Similar characteristics were seen in black women (Table 2) as in white women. Age- and race-specific demographic results among the two older age groups (not shown) did not substantially alter the conclusions.

Tables 3 through 5 present the hazard ratios (HRs) and 95% confidence intervals (CIs) for 5-year and 10-year breast cancer mortality associated with mammography screening adjusted for AJCC stage, radiation therapy, chemotherapy, co-morbid conditions and contextual socioeconomic status. Women who received no or irregular mammography screening were the referent group. After adjustment, HR's (and 95% CIs) for 5-year breast cancer mortality relative to no/irregular mammography at ages 69–74, 75–78, and 79–84 years respectively among whites (Table 3) were 0.29 (0.25–0.33), 0.28 (0.24–0.32) and 0.29 (0.25–0.33) for annual and 0.50 (0.43–0.58), 0.46 (0.39–0.55), and 0.39 (0.33–0.45) for biennial screening; while among blacks (Table 4) they were 0.41 (0.29–0.57), 0.23 (0.14–0.38), and 0.34 (0.20–0.56) for annual and 0.44 (0.29–0.66), 0.47 (0.30–0.72), and 0.45 (0.28–0.72) for biennial screening. Tests for trend (no/irregular, biennial, and annual screening) were highly significant ($p < 0.0001$) throughout. From Table 5, corresponding 10-year values for women 69–84 years were 0.31 (0.29–0.33) for annual and 0.47 (0.44–0.51) for biennial mammography among whites and 0.36 (0.29–0.44) for annual and 0.47 (0.37–0.58) for biennial mammography among blacks. Tests for trend were again highly significant.

Conclusions

In these data, 69 to 84 year old women receiving regular annual screening mammography during the four years immediately preceding breast cancer diagnosis had consistently lower five-year and ten-year risks of breast cancer mortality than women with no or irregular screening regardless of race. Ten-year risks were 3.3-fold higher among whites and 2.2-fold higher among blacks ages 69 to 84 years with no or irregular screening compared to annual screening. The associations with screening in these data were independent from AJCC stage, radiation therapy, chemotherapy, co-morbid conditions and contextual socio-economic status.

Two US organizations, the ACS[8] and the USPSTF,[1] offer widely recognized guidelines for screening mammography among women ages 65 years and older. Both organizations agree that in the general population, women between the ages of 65 and 74 years should have regular screening. ACS, however, recommends annual testing[8] while USPSTF favors a biennial schedule.[1] The ACS states that decisions about screening after age 74 should be individualized.[16] The USPSTF states that there is insufficient evidence for a recommendation after age 74, but adds that if screening is done, a biennial schedule is preferred.[16] The evidence base for both ACS and USPSTF recommendations is sparse. None of the randomized trials for screening mammography included women over the age of 74, and none could address annual mammography since none included women at intervals shorter than 18 months.[16] Additional observational evidence specific to the elderly is also limited.[17]

ACS recommendations for annual screening are based, in part, on data from two studies of ongoing mammography screening programs operated by single health care institutions (the University of Michigan[18] and a six-county mobile van program at the University of California San Francisco[19]). Neither is representative of the US. Also, in each study, the end points focused on tumor size at detection,[18,19] which may lead to more conservative estimates (i.e., underestimates) of benefit.[20] In the University of Michigan study,[18] a retrospective record review of women ages 65 years and older (1988 to 1995), the proportion of patients who presented with a palpable mass was significantly greater in the group with the longer inter-screening interval (48%) than in the group with the smaller inter-screening interval (15%), $p < 0.0001$. The proportion of patients with Ductal Carcinoma in Situ without invasion was greater in the group with the shorter screening interval (22% versus 7%). The University of California San Francisco study (1985 to 1997)[19] included asymptomatic participants ages 40 to 79 years. Tumor size was 27% smaller in diameter for annual versus biennial screening ($p = 0.04$). Annual mammography was associated with a 30% decrease in recall rate ($p <0.0001$), meaning that false positives were reduced, and a 28% reduction in biopsies ($p = 0.06$), making for less frequent anxiety and lower biopsy costs. There was no statistically significant difference in detection rate (19% less in the annual group, $p = 0.49$). Both studies were subject to the biases potentially introduced by use of tumor characteristics rather than death as the primary end point[20] and selection based on attendance at institutions with little basis for national representation.[21] In addition, and in contrast to the present data, classification as to annual and biennial mammography was determined by a single inter-screening interval, leaving doubt about whether mammography had been regular before the observation period.

The USPSTF,[1] as well as subsequent studies and reviews,[16, 17, 22–24] have noted the paucity of data among older populations, particularly those ages 75 and older. Rather than relying on observational studies, USPSTF placed greater reliance on multiple predictive models whose primary endpoint was breast cancer mortality. Limitations of the predictive models include reliance on self-reported mammography and national cohorts. Specifically, mammography self-report overestimates use[26] and underestimates disparities,[26, 27] while the use of national cohorts[23,25] may obscure variations in potential benefit among demographic and geographic sub-populations. For example, differences in mortality according to geographical area of residence and among Hispanics and non-Hispanics,[5] raise questions about the utility of any model which considers the general US population as a homogenous group.

Aside from evidence cited by the USPSTF and the ACS, additional inquiries pertaining to frequency of mammography include a study evaluating the impact of changing from annual to biennial screening in British Columbia, Canada[28] and results from a randomized trial in the United Kingdom.[29] Neither supported the value of annual mammography. However, the former study[33] compared results from women with an average of 2.9 screens over a median 13-month interval for annual screening (covering about 38 months) to results from women averaging 2.4 screens over a median 24-month interval for biennial screening (covering about 58 months). In contrast, the present results pertain to 48 months of screening coverage for both annual and biennial screening. The latter study[29] compared annual to triennial screening. In a comment to that study, Andersson[30] expressed concerns about the possibility of beta error and suggested that greater clarity might have been achieved had more baseline data been available.

As a measure of potential harm from mammography screening, we calculated the percentage of women ages 65 to 84 years without breast cancer categorized as having no or irregular, biennial and annual screening mammography in the most recent four-year period (2002–2005) available who received breast biopsies despite being breast cancer free (false positives). Among whites, there were 288 biopsies among the 11,452 women receiving annual mammography (2.5%) which would not have occurred with biennial screening. Among blacks, there were 35 biopsies among the 1,277 women receiving annual mammography (2.7%) which would not have occurred with biennial screening. The net increase for annual screening was therefore 323 biopsies among the 54,213 women receiving either annual or biennial mammography (0.6%).

A strength of the present data is its use of SEER[2, 4] data linked to administrative claims data from the Medicare program to provide a reliable means to assess screening mammography utilization among women 65 years and older.[6] The Medicare program initiated re-imbursement for biennial screening on January 1, 1991 and expanded the reimbursement benefit to include annual screening for women on January 1, 1998.[31] While Medicare administrative claims data can be used to determine variations in screening mammography in geographic areas across the US, it is unable to assess the impact treatment and follow-up have on these screening rates. Linking the SEER program file to the Medicare file partly overcomes this problem. These data are also strengthened by use of regular mammography (as recommended by ACS[8] and USPSTF[1]) as the exposure of interest rather than the interval between diagnosis and the most recent mammogram or the most recent inter-screening interval.

Limitations of the present data include a geographic basis within SEER which underestimates the breast cancer mortality among non-Hispanic black and white elderly for the US. SEER representation declined from about 70% of US mortality levels for data available since 1992 to about 50% of US levels for data available since 2000.[32, 33] Also, better outcomes in these data among those with regular mammography may be, in part, overestimates due to biases such as lead time (disease is detected earlier but survival is not prolonged), length time (screening may tend to detect less aggressive tumors) and selection (women accessing regular screening may be healthier and may have a variety of social advantages).[16] Further, it has been estimated that the lag time between the start of screening and onset of mortality benefits may be at least 10 years.[17] Nonetheless, the better 10-year survival associated with annual mammography in these data lessens the probability that observed benefits are solely due to lead time bias. Similarly, the observation of benefits independent from AJCC stage, radiation therapy, and chemotherapy lessens the probability that observed benefits reflect less advanced disease at the time of diagnosis or treatment advantages. Additionally, the observation that benefits are independent from co-morbidity means that the results are less likely to reflect selection bias due to the fact that healthy women may be more likely to be referred for screening. Moreover, adjustment for contextual socio-economic status makes it less likely that observed benefits reflect better education and other social advantages in the community structure of counties in which these beneficiaries resided. While these data do not address individual socio-economic status, SEER-linked individual socio-economic data have, to date, yielded results that are consistent with observations based on area measures.[34] In sum, while the present data are promising, the results are not conclusive.

In 2010, there were 19,201,270 women ages 65 to 84 residing in the US, and they accounted for 41% (16,863 of 40,996) of all US breast cancer deaths during that year.[35] We believe the current evidence about potential benefits and harms from screening mammography in this population is insufficient for clinical or policy decisions.[33, 37] The need for better data is reflected by the magnitude of breast cancer as a cause of death among the elderly, the likelihood of greater numbers of women living to advanced age, and projections indicating that racial and ethnic minorities will comprise 28% of the US elderly population ages 65 and older by the year 2030.[3] While a large scale randomized trial comparing the risks and benefits of annual versus biennial mammography would be hampered by high costs and feasibility issues, this design strategy would provide the most reliable means to assess the most plausible way to discriminate small to moderate differences. In the interim, the present results highlight the evidentiary limitations of data used for current screening mammography recommendations.

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References

1. U S. Preventive Services Task Force. Screening for breast cancer: U.S Preventive Services Task Force Recommendation Statement. Ann Intern Med. 2009; 151(10):716–726. [PubMed: 19920272]
2. Warren JL, Klabunde CN, Schrag D, et al. Overview of the SEER-Medicare data: applications and limitations. Medical Care. 2002; 40(Suppl 8):IV3–IV18.
3. United States Administration on Aging (AoA). Administration for Community Living. United States Department of Health and Human Services. A Profile of Older Americans. 2012.

4. Engels EA, Pfeiffer RM, Ricker W, et al. Use of Surveillance, Epidemiology, and End Results-Medicare data to conduct case-control studies of cancer among the US elderly. Am J Epidemiol. 2011; 174(7):860–870. [PubMed: 21821540]
5. Mejia de Grubb MC, Kilbourne B, Kihlberg C, et al. Demographic and geographic variations in breast cancer mortality among U.S. Hispanics. J Health Care Poor Underserved. 2013; 24(Suppl 1): 140–152. [PubMed: 23395952]
6. Smith-Bindman R, Quale C, Chu PW, et al. Can Medicare billing claims data be used to assess mammography utilization among women ages 65 and older? Med Care. 2006; 44(5):463–470. [PubMed: 16641665]
7. Fenton JJ, Zhu W, Balch S, et al. Distinguishing screening from diagnostic mammograms using Medicare claims data. Med Care. 2014; 52(7):e44–51. [PubMed: 22922433]
8. Smith RA, Brooks D, Cokkinides V, et al. Cancer screening in the United States, 2013: A review of current American Cancer Society guidelines, current issues in cancer screening, and new guidance on cervical cancer screening and lung cancer screening. CA Cancer J Clin. 2013; 63(2):88–105. [PubMed: 23378235]
9. Breslow, NE.; Day, NE. Statistical Methods in Cancer Research, Vol. 2, The Analysis of Cohort Studies. Lyon, France: IARC; 1980.
10. Cheng L, Swartz MD, Zhao H, et al. Hazard of recurrence among women after primary breast cancer treatment – A 10-year follow-up using data from SEER-Medicare. Cancer Epidemiol Biomarkers Prev. 2012; 21(5):800–809. [PubMed: 22426147]
11. Charlson ME, Pompei P, Ales KL, et al. A new method of classifying prognostic comorbidity in longitudinal studies: Development and validation. J Chronic Dis. 1987; 40(5):373–383. [PubMed: 3558716]
12. Deyo RA, Cherkin DC, Ciol MA. Adapting a clinical comorbidity index for use with ICD-9-CM administrative databases. J Clin Epidemiol. 1992; 45(6):613–619. [PubMed: 1607900]
13. Romano PS, Roos LL, Jollis JG. Adapting a clinical comorbidity index for use with ICD-9-CM administrative databases: Differing perspectives. J Clin Epidemiol. 1993; 46(10):1075–1079. [PubMed: 8410092]
14. Klabunde CN, Potosky AL, Legler JM, et al. Development of a comorbidity index using physician claims data. J Clin Epidemiol. 2000; 53(12):1258–1267. [PubMed: 11146273]
15. Krieger N, Chen JT, Waterman PD, et al. Geocoding and monitoring of US socioeconomic inequalities in mortality and cancer incidence: Does choice of area-based measure and geographic level matter? The Public Health Disparities Geocoding Project. Am J Epidemiol. 2002; 156(5): 471–482. [PubMed: 12196317]
16. Walter LC, Schonberg MA. Screening mammography in older women: A review. JAMA. 2014; 311(13):1336–1347. [PubMed: 24691609]
17. Braithwaite D, Mandelblatt JS, Kerlikowske K. To screen or not to screen older women for breast cancer: A conundrum. Future Oncol. 2013; 9(6):763–766. [PubMed: 23718292]
18. Field LR, Wilson TE, Strawderman M, et al. Mammographic screening in women more than 64 years old: A comparison of 1- and 2-year intervals. AJR Am J Roentgenol. 1998; 170(4):961–965. [PubMed: 9530044]
19. Hunt KA, Rosen EL, Sickles EA. Outcome analysis for women undergoing annual versus biennial screening mammography: A review of 24,211 examinations. AJR Am J Roentgenol. 1999; 173(2): 285–289. [PubMed: 10430120]
20. Swedish Organized Service Screening Evaluation Group. Effect of mammographic service screening on stage at presentation of breast cancers in Sweden. Cancer. 2007; 109(11):2205–2212. [PubMed: 17471486]
21. Berkson J. Limitations of the application of fourfold table analysis to hospital data. Biometrics Bulletin. 1946; 2(3):47–53. [PubMed: 21001024]
22. Pace LE, Keating NL. A systematic assessment of benefits and risks to guide breast cancer screening decisions. JAMA. 2014; 311(13):1327–1335. [PubMed: 24691608]
23. Mandelblatt JS, Cronin KA, Berry DA, et al. Modeling the impact of population screening on breast cancer mortality in the United States. Breast. 2011; 20(Suppl 3):S75–S81. [PubMed: 22015298]

24. Braithwaite D, Zhu W, Hubbard RA, et al. Screening outcomes in older US women undergoing multiple mammograms in community practice: Does interval, age or comorbidity score affect tumor characteristics or false positive rates? J Natl Cancer Inst. 2013; 105(5):334–341. [PubMed: 23385442]
25. Mandelblatt JS, Cronin KA, Bailey S, et al. Effects of mammography screening under different screening schedules: Model estimates of potential benefits and harms. Ann Intern Med. 2009; 151(10):738–747. [PubMed: 19920274]
26. Raucher GH, Johnson TP, Cho YI, et al. Accuracy of self-reported cancer-screening histories: A meta-analysis. Cancer Epidemiol Biomarkers Prev. 2008; 17(4):748–757. [PubMed: 18381468]
27. Njai R, Siegel PZ, Miller JW, et al. Misclassification of survey responses and black-white disparity in mammography use, Behavioral Risk Factor Surveillance System, 1995–2006. Prev Chronic Dis. 2011; 8(3):A59. [PubMed: 21477499]
28. Coldman AJ, Phillips N, Olivotto IA, et al. Impact of changing from annual to biennial mammographic screening on breast cancer outcomes in women aged 50–79 in British Columbia. J Med Screen. 2008; 15(4):182–187. [PubMed: 19106258]
29. Breast Screening Frequency Trial Group. The frequency of breast cancer screening:results from the UKCCCR Randomised Trial. United Kingdom Co-ordinating Committee on Cancer Research. Eur J Cancer. 2002; 38(11):1458–1464. [PubMed: 12110490]
30. Anderrsson J. Comment on "The frequency of breast cancer screening:results from the UKCCR Randomized Trial". Eur J Cancer. 2002; 38 (11):1427–1428. [PubMed: 12110486]
31. Habermann EB, Virnig BA, Riley GF, et al. The impact of a change in Medicare reimbursement policy and HEDIS measures on stage at diagnosis among Medicare HMO and fee-for-service female breast cancer patients. Med Care. 2007; 45(8):761–766. [PubMed: 17667310]
32. Centers for Disease Control and Prevention, National Center for Health Statistics. [Accessed at on May 12 2014 6:13:22 AM] Compressed Mortality File 1999–2011 on CDC WONDER Online Database, released January 2013. Data are compiled from Compressed Mortality File 1999–2011 Series 20 No. 2P. 2013. http://wonder.cdc.gov/cmf-icd10.html
33. Hennekens CH, DeMets D. Statistical association and causation: Contributions of different types of evidence. JAMA. 2011; 305(11):1134–5. [PubMed: 21406653]
34. National Cancer Institute. [accessed 6 August 2014] SEER Registry groupings for analyses. 2014. seer.cancer.gov/registries/terms.html
35. Centers for Disease Control and Prevention, National Center for Health Statistics. [Accessed at on May 12, 2014 5:45:40 AM] Compressed Mortality File 1979–1998, CDC WONDER On-line Database, compiled from Compressed Mortality File CMF 1968–1988, Series 20, No. 2A, 2000 and CMF 1989–1998, Series 20, No. 2E. 2003. http://wonder.cdc.gov/cmf-icd9.html
36. 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]
37. Hennekens CH, DeMets D. The need for large scale randomized evidence without undue emphasis on small trials, meta-analyses or subgroup analyses. JAMA. 2009; 302(21):2361–2362. [PubMed: 19952322]

Clinical Significance

- Black and white women ages 75 to 84 years who had annual mammography had lower ten-year breast cancer mortality than corresponding women who had biennial or no/irregular mammography

Table 1

Demographic characteristics of white women age 69–74 diagnosed with primary non-metastatic breast cancer who did and did not die from breast cancer by time period

	Dead (n=2,407)		Alive or Censored (n=22,289)	
Characteristic	**n**	**%**	**n**	**%**
Age (years)				
66–69	359	14.9	3515	15.9
70–74	2048	85.1	18774	84.1
Diagnosis year				
1995–1997	614	25.5	4297	19.3
1998–2000	642	26.7	5550	24.9
2001–2003	672	27.9		34.1
2004–2005	479	19.9	4850	7592
Urban/Rural				
Big metro	1261	52.4	11575	51.9
Metro	705	29.3	6568	29.5
Urban/less urban/rural	441	18.3	4145	18.6
AJCC stage				
In Situ/I	454	18.9	11779	52.9
II	962	40.0	4523	20.3
III	354	14.7	430	1.9
Unstaged/missing	637	26.4	5557	24.9
Surgery				
Yes	2077	86.3	21731	97.5
No/Unknown	330	13.7	558	2.5
Radiation therapy				
Yes	959	39.8	10644	47.7
No	1357	56.4	11096	49.8
Unknown	91	3.8	549	2.5
Chemotherapy				
Yes	1030	42.8	3840	17.2
No	1248	51.8	17548	78.7
Unknown/Missing	129	5.4	901	4.0
Charlson index score				
0	1472	61.1	15243	68.4
1	406	16.9	3895	17.5
≥2	217	9.0	1641	7.3
Unknown/Missing	312	13.0	1510	6.8
Contextual socio-economic status				
Quartile 1 (lowest)/Missing	506	21.0	5861	26.3
Quartile 2	588	24.4	5522	24.8
Quartile 3	606	25.2	5504	24.7

	Dead (n=2,407)		Alive or Censored (n=22,289)	
Characteristic	**n**	**%**	**n**	**%**
Quartile 4 (highest)	707	29.4	5402	24.2

Table 2

Demographic characteristics of black women ages 69–74 diagnosed with primary non-metastatic breast cancer who did and did not die from breast cancer

	Dead (n=335)		Alive or Censored (n=1,831)	
Characteristic	**n**	**%**	**n**	**%**
Age (years)				
66–69	63	18.8	314	17.1
70–74	272	81.2	1517	82.9
Diagnosis year				
1995–1997	57	17.0	292	16.0
1998–2000	80	23.9	407	22.2
2001–2003	104	31.0	658	35.9
2004–2005	94	28.1	474	25.9
Urban/Rural				
Big metro	223	66.6	1233	67.3
Metro	77	23.0	410	22.4
Urban/less urban/rural	35	10.4	188	10.3
AJCC stage				
In Situ/I	35	10.5	820	44.8
II	111	33.1	417	22.8
III	61	18.2	61	3.3
Unstaged/missing	128	38.2	533	29.1
Surgery				
Yes	266	79.4	1745	95.3
No/Unknown	69	20.6	86	4.7
Radiation therapy				
Yes	109	32.5	727	39.7
No	211	63.0	1051	57.4
Unknown	15	4.5	53	2.9
Chemotherapy				
Yes	133	39.7	369	20.2
No	187	55.8	1379	75.3
Unknown/Missing	15	4.5	83	4.5
Charlson index score				
0	146	43.6	921	50.3
1	66	19.7	471	25.7
≥2	70	20.9	310	16.9
Unknown/Missing	53	15.8	129	7.1
Contextual socio-economic status				
Quartile 1 (lowest)/Missing	81	24.2	471	25.7
Quartile 2	83	24.8	455	24.8
Quartile 3	77	23.0	459	25.1

	Dead (n=335)		Alive or Censored (n=1,831)	
Characteristic	**n**	**%**	**n**	**%**
Quartile 4 (highest)	94	28.0	446	24.4

Table 3

Hazard ratios of 5-year breast cancer mortality associated with mammography screening among non-Hispanic white women: (a) ages 69–74; (b) ages 75–78; and (c) ages 79–84 years

(a) 69–74 years (Group 1)	Dead (n=1,569)		Alive or Censored (n=23,127)			
	n	%	N	%	HR[a]	95% CI[b]
Mammography screening						
No/Irregular	1061	67.6	8876	38.4	1.00	(referent)
Biennial	209	13.3	4179	18.1	0.50	(0.43–0.58)
Annual	299	19.1	10072	43.5	0.29	(0.25–0.33)
p-value for trend						<0.0001

(b) 75–78 years (Group 2)	Dead (n=1,245)		Alive or Censored (n=15,304)			
	N	%	n	%	HR[a]	95% CI[b]
Mammography screening						
No/Irregular	891	71.6	6415	41.9	1.00	(referent)
Biennial	150	12.1	2797	18.3	0.46	(0.39–0.55)
Annual	204	16.4	6092	39.8	0.28	(0.24–0.32)
p-value for trend						<0.0001

(c) 79–84 years (Group 3)	Dead (n=1,823)		Alive or Censored (n=16,430)			
	N	%	n	%	HR[a]	95% CI[b]
Mammography screening						
No/Irregular	1402	76.9	8189	49.9	1.00	(referent)
Biennial	168	9.2	2863	17.4	0.39	(0.33–0.45)
Annual	253	13.9	5378	32.7	0.29	(0.25–0.33)
p-value for trend						<0.0001

[a] Hazard ratios adjusted for AJCC stage, radiation therapy, chemotherapy, co-morbid conditions and contextual socio-economic status.

[b] 95% Confidence interval.

Table 4

Hazard ratios of 5-year breast cancer mortality associated with mammography screening among non-Hispanic black women: (a) ages 69–74; (b) ages 75–78; and (c) ages 79–84 years

(a) 69–74 years (Group 1)	Dead (n=258)		Alive or Censored (n=1,908)		N	%
	n	%	n	%	HR[a]	95% CI[b]
Mammography screening						
No/Irregular	192	74.4	968	50.7	1.00	(referent)
Biennial	27	10.5	396	20.8	0.44	(0.29–0.66)
Annual	39	15.1	544	28.5	0.41	(0.29–0.57)
p-value for trend						<0.0001

(b) 75–78 years (Group 2)	Dead (n=188)		Alive or Censored (n=1,160)		n	%
	N	%	n	%	HR[a]	95% CI[b]
Mammography screening						
No/Irregular	148	78.7	635	54.8	1.00	(referent)
Biennial	23	12.2	215	18.5	0.47	(0.30–0.72)
Annual	17	9.0	310	26.7	0.23	(0.14–0.38)
p-value for trend						<0.0001

(c) 79–84 years (Group 3)	Dead (n=218)		Alive or Censored (n=1,154)		n	%
	N	%	n	%	HR[a]	95% CI[b]
Mammography screening						
No/Irregular	182	83.5	753	65.2	1.00	(referent)
Biennial	19	8.7	181	15.7	0.45	(0.28–0.72)
Annual	17	7.8	220	19.1	0.34	(0.20–0.56)
p-value for trend						<0.0001

[a] Hazard ratios adjusted for AJCC stage, radiation therapy, chemotherapy, co-morbid conditions and contextual socio-economic status.

[b] 95% Confidence interval.

Table 5

Hazard ratios of 10-year breast cancer mortality associated with mammography screening among non-Hispanic white women and black women age 69–84 years

White women	Dead (n=6,303)		Alive or Censored (n=53,195)			
	n	%	n	%	HR[a]	95% CI[b]
Mammography screening						
No/Irregular	4358	69.1	22476	42.3	1.00	(referent)
Biennial	782	12.4	9584	18.0	0.47	(0.44–0.51)
Annual	1163	18.5	21135	39.7	0.31	(0.29–0.33)
p-value for trend						<0.0001

Black Women	Dead (n= 824)		Alive or Censored (n=4,062)			
	n	%	n	%	HR[a]	95% CI[b]
Mammography screening						
No/Irregular	633	76.8	2245	55.2	1.00	(referent)
Biennial	91	11.0	770	19.0	0.47	(0.37–0.58)
Annual	100	12.2	1047	25.8	0.36	(0.29–0.44)
p-value for trend						<0.0001

[a]Hazard ratios adjusted for AJCC stage, radiation therapy, chemotherapy, co-morbid conditions and contextual socio-economic status.

[b]95% Confidence interval.