An Ecological Study of the Effectiveness of Mammography in Reducing Breast Cancer Mortality

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ABSTRACT

Objectives. The purpose of this study was to determine the relation of screening mammography to breast cancer incidence and case fatality.

Methods. In a sample of White female Medicare beneficiaries hospitalized in 1990–1991, age-adjusted breast cancer incidence and 2-year case fatality rates were estimated and compared with the frequency of mammographic screening from a population-based survey.

Results. The average rates for incidence, case fatality, and mammography within 5 years in 29 states were 414/100 000, 18.8%, and 59.2%, respectively. There was a positive state-level correlation between mammography rates and incidence and an inverse correlation between mammography and case fatality.

Conclusions. High screening mammography rates in some states are associated with reduced breast cancer case fatality rates, presumably as a result of diagnosis of earlier stage cancers. (*Am J Public Health.* 1998;88:281–284)

Introduction

In the United States, breast carcinoma is currently the most common malignancy and the second leading cause of cancer death in women.[1] Based on data from randomized controlled trials that have documented a reduction in breast cancer mortality,[2–8] routine mammography and clinical breast examination are advocated.[9–11] However, the effectiveness in patients receiving routine care has not been evaluated, and mammography is underused,[12] particularly among older, poor, and minority women.[12–16]

We conducted a population-based study of the association of mammography with incidence and case fatality rates of breast cancer. This ecological study included all White female Medicare beneficiaries more than 64 years of age, who account for about half of all breast cancer cases.[17]

Methods

The patient-level data were obtained from the Medicare Provider Analysis and Review Record (MEDPAR) files for all hospital discharges under part A of the Medicare program. Each record in the MEDPAR files contains age, gender, race, and up to five discharge diagnoses coded according to the *International Classification of Diseases, 9th Revision, Clinical Modification* (ICD-9-CM). Survival data following discharge, including date of death, are obtained from the Social Security Administration, and the database for each year includes follow-up for 2 years after hospital admission. Prior studies have validated the accuracy of the ICD-9-CM diagnostic codes[18,19] in these electronic abstracts.

The sample was assembled from all claims for women with a diagnosis of breast cancer (ICD-9-CM codes 174.0 through 174.9) in 1990 and 1991. Patients were excluded if they had a previous history of breast cancer (a claim containing diagnosis from 1984 to 1990 or 1991) or if they were less than 65 years of age. Also, Black women were excluded because there were too few above 64 years of age in many of the states. In addition, because estimates of breast cancer incidence in states with relatively small populations are less reliable, we included only the 29 states with a population of more than 300 000 White women 65 years old and older (as determined by the 1990 US census). Since the MEDPAR files do not include data on stage of cancer, 2-year case fatality rates for each state were used as a surrogate measure for stage of disease. The case fatality rate was defined as number of deaths from any cause at 2 years following hospital admission divided by number of incident cases.

To determine mammography use in each state, we used interview data from the Behavioral Risk Factor Surveillance System (BRFSS), a multistage probability sample of adults administered by the Centers for Disease Control and Prevention. The sample for this study was restricted to White female respondents 65 years old and older. The BRFSS obtains information on past use of mammography as well as interval since last mammogram. Because respondents may not be able to accurately recall the date of their last mammogram, we considered a report within 5 years as an indication of use and included only mammograms performed for screening.

For each state, we calculated a summary breast cancer incidence rate for White women 65 years old and older as the mean of the 2 years. As a means of controlling for

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age-related differences in breast cancer incidence, the state rates were age adjusted by the direct method; the 1990 US census for White women more over 64 years of age was the standard population. The binomial distribution was used in calculating standard errors for incidence rates. The average state-level 2-year case fatality rates for 1990 and 1991 were age adjusted in a manner similar to that for the incidence rates.

Among the White BRFSS respondents more than 64 years of age, we determined mean mammography rates for 1990 and 1991 in the 29 states. The mammography rates for the study states were age adjusted and adjusted for the complex sampling design of the BRFSS via SUDAAN software.[20] Relationships between mammography rates and breast cancer incidence and between mammography rates and 2-year case fatality rates were determined at the state level with nonweighted Pearson correlation coefficients. Weights based on the population of each state were not used, because the results in the 5 largest states would have unduly influenced the correlations.

Results

In 1990 and 1991, 82 278 and 80 438 women (respectively) had a discharge diagnosis of primary breast cancer. Among this total group of 162 716 patients, 21 285 (13.1%) were excluded because of a previous diagnosis of breast cancer, 20 374 (12.5%) were excluded because they resided in a nonstudy state, and 15 532 (9.5%) were excluded because race was either missing or non-White. The remaining 105 525 patients were the subject of this analysis.

A total of 11 711 White women more than 64 years of age, or an average of 404 respondents from each of the 29 states (range: 208 to 786), were surveyed in the BRFSS. The state-level 5-year mammography screening rates for White women more than 64 years of age, shown in Table 1, ranged from 49.1% to 71.7% (mean = 59.2%). Although the mean rate of mammography for 1990 was lower than that for 1991 (56.8% vs 63.8%), the annual state-level rates were highly correlated (r = .71, P < .0001). The state-level age-adjusted incidence rates and 2-year case fatality rates for each state are also shown in Table 1. For the 2-year period, the mean incidence rate and the 2-year case fatality rate for breast cancer in White women more than 64 years of age in the 29 study states were 414 ± 3.9/100 000 and 18.8%, respectively.

TABLE 1—Mammography, Breast Cancer Incidence, and 2-Year Case Fatality Rates for 29 States

State	Mammography Rate, %	Age-Adjusted Breast Cancer Incidence Rate[a]	2-Year Case Fatality Rate %
Kentucky	49.1	372 ± 9.2	18.2
Ohio	49.7	428 ± 5.8	21.0
Indiana	49.9	422 ± 8.1	21.3
Mississippi	50.3	405 ± 11.5	24.6
Louisiana	50.9	396 ± 9.5	22.7
Tennessee	51.7	392 ± 8.3	19.9
South Carolina	52.9	407 ± 10.9	20.5
Missouri	53.1	404 ± 7.7	19.6
Iowa	54.5	415 ± 10.1	16.8
Oklahoma	54.9	407 ± 10.0	15.8
Pennsylvania	55.7	441 ± 5.1	21.1
Wisconsin	55.9	454 ± 8.6	17.1
New York	56.8	407 ± 4.3	19.8
Illinois[b]	58.0	412 ± 5.5	20.9
North Carolina	58.3	418 ± 7.7	17.1
Texas	59.6	394 ± 5.1	18.6
Connecticut	60.1	398 ± 9.8	18.0
Alabama	60.7	412 ± 9.2	18.0
Florida	62.6	403 ± 4.5	15.8
Georgia	62.9	406 ± 8.3	19.7
Arizona	64.4	443 ± 10.7	16.0
Michigan	64.5	435 ± 6.5	19.2
Minnesota	64.7	409 ± 8.9	17.3
Maryland	65.8	446 ± 9.9	17.6
Washington	68.5	437 ± 9.3	17.1
Virginia	68.9	426 ± 8.5	19.4
Oregon	69.7	459 ± 11.4	14.3
California	71.3	388 ± 3.8	18.0
Massachusetts	71.7	394 ± 7.1	20.3

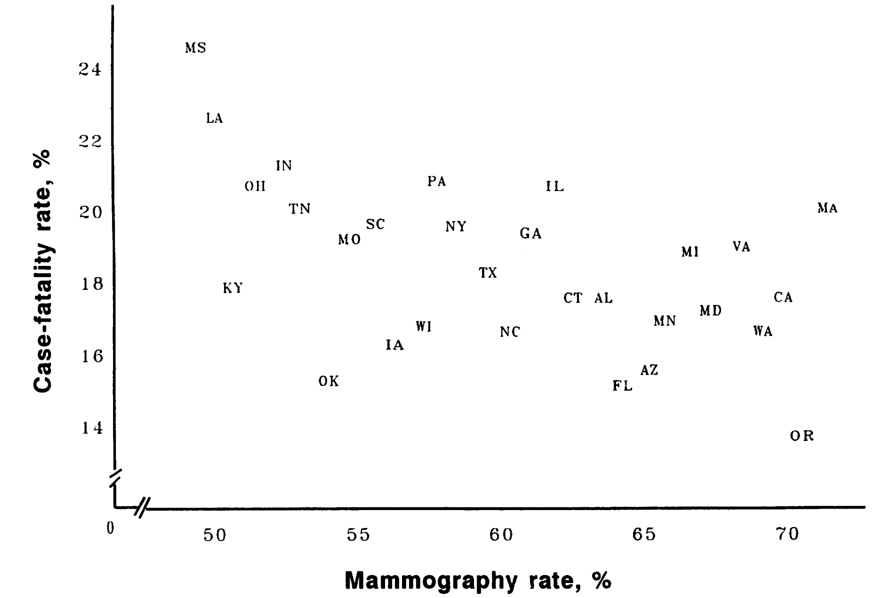
Note. Rates are based on the means of 1990 and 1991 rates.
[a] Per 100 000 ± standard error.
[b] The 1991 incidence rate for Illinois was 242/100 000, as compared with 412/100 000 in 1990; in all other states, the two rates were similar. Therefore, we assumed that the 1991 rate in Illinois reflects unexplained missing data, and only the 1990 rate was used. Of note, the results of the analysis did not change substantively when the 1991 incidence rate for Illinois was used and the mean of the 1990 and 1991 rates was included in the analysis (r = .27 for the correlation between incidence rates and mammography frequency; P = .16). Case fatality rates for Illinois were 22.6% for 1990 and 18.2% for 1991.

There was a positive but not statistically significant correlation between mammography rate and incidence rate (r = .27, P = .16). There was a significant negative correlation (r = −.48, P = .008) between mammography rate and 2-year case fatality rate (Figure 1).

Discussion

This study attempted to estimate, in essentially all elderly women in the United States, the effectiveness of efforts to recommend mammography. This population-based study suggests that current efforts to educate women about mammography have been worthwhile. Also, the results suggest that these efforts should continue, because about 40% of elderly White women in the United States are not being screened at least once every 5 years and, presumably, many fewer are adhering to recommended annual or biennial screening.[9–11] The large differences between states in mammography screening rates may be due to differences in practice patterns, educational programs, social values, health insurance coverage, or socioeconomic status.

We did not observe a statistically significant correlation between mammography rates and breast cancer incidence, although the correlation was positive. Since mammography has become an increasingly accepted procedure, fewer tumors detected each year have gone undetected for a long period of time. However, one reason for the positive correlation (and, possibly, a significant correlation if more data were available) is that mammography is in a growth stage and "old" tumors are still being detected.



Note. There was a negative association between the two measures ($r = -.48$, $P = .008$).

FIGURE 1—Relation between average 1990/91 mammography rates and 2-year case fatality rates for 29 states.

Breast cancer is currently the most commonly diagnosed malignant tumor in American women, and it apparently increased in incidence in the 1980s.[21] In contrast, long-term survival rates increased over the same time period, suggesting that a larger number of early-stage cancers were diagnosed.[21] These temporal changes have been associated with an increased use of mammography.[22] However, as recently as 1993, only 54% of older women surveyed in the United States reported receiving a mammogram within the past 2 years.[22] There are probably multiple underlying reasons for the low screening rates, including physician recommendations, barriers to appropriate medical care, and lack of education about mammography.[23–25]

Limitations

MEDPAR data are not designed for measurement of cancer-related characteristics such as staging or tumor histology. However, diagnostic coding for breast cancer is associated with a sensitivity of 97% and a positive predictive value of 84%.[18] Moreover, in a recent study that compared incidence rates for breast cancer determined by MEDPAR data and the corresponding Surveillance, Epidemiology, and End Results (SEER) program rates, no differences were observed between the two files.[19] We attempted to exclude patients with a prior diagnosis of breast cancer by searching files from 1984 to the year prior to hospitalization. A study of MEDPAR and SEER data concluded that eliminating patients hospitalized during the prior 6 years removed almost all prevalent cases.[19] The study also determined that fewer than 1% of all cases of breast carcinoma among Medicare beneficiaries were diagnosed before Medicare enrollment.[19] Since few women become eligible for Medicare before 65 years of age, women who were less than 71 years of age in 1990 would not have files available back to 1984. In a separate analysis, we found that the rate of error associated with not searching back more than 2 years was only about 2%.[26] Using comparisons with corresponding SEER data, we estimated that about 5% of women 65 and 66 years old with breast cancer (i.e., beneficiaries for only 1 or 2 years in 1990 and 1991) did not have incident cases.[26] Inclusion in the MEDPAR database also required admission to the hospital. Although currently some women with breast cancer receive only outpatient therapy, this practice was not widespread in 1990/91.

This study was limited to White women because many states did not have a large enough minority population to yield reliable estimates of mammography rates or breast cancer rates. However, since minority women may be less likely to receive screening mammography [14,15,22] and are more likely to present with metastatic breast cancer,[27] it is likely that the associations we found would be similar in elderly Black women in the United States. Similarly, we did not include states that had a relatively small population of women more than 64 years of age and/or did not participate in the BRFSS. However, there is no indication that our conclusions would have been different had sufficient data been available for all states.

The study may be limited by the problems inherent in ecological analyses (i.e., the overall relationships of incidence, mortality, and mammography rates may not be representative of all individuals residing in a given state). However, we cannot identify a confounding variable or bias that is the underlying reason for the significant correlation between state-level mammography and case fatality rates. Moreover, although ecological studies cannot substitute for individual-level data, a recent series of articles[28-31] and editorials[32] concluded that such studies are informative, particularly when their limitations are recognized and bias and confounding are minimized in the study design.

Implications

This study provides ecological evidence of the effectiveness of mammography in reducing breast cancer mortality, presumably through the diagnosis of earlier stage tumors. Moreover, the study suggests that mammography is underused. The findings should provide further incentive to promote population-based mammography screening programs as well as to target states with the greatest need for enhanced screening. □

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References

1. Parker SL, Tong T, Bolden S, Wingo PA. Cancer statistics, 1996. *CA.* 1996;46:5–27.
2. Shapiro S. Evidence on screening for breast cancer from a randomized trial. *Cancer.*

1977;39:2772–2782.
3. Nystrom L, Rutqvist LE, Wall S, et al. Breast cancer screening with mammography: overview of Swedish randomized trials. *Lancet.* 1993;341:973–978.
4. Tabar L, Fagerberg G, Duffy S, Day N, Gas A, Grontoft O. Update of the Swedish two county program of mammographic screening trial. *Radiol Clin North Am.* 1992;30:187–210.
5. Andersson I, Aspegren K, Janzon L, et al. Mammographic screening and mortality from breast cancer: the Malmo mammographic screening trial. *BMJ.* 1988;297:943–948.
6. Frisell J, Eklund G, Hellstrom L, Lidbrink E, Rutqvist LE, Somell A. Randomized study of mammography screening: preliminary report on mortality in the Stockholm trial. *Breast Cancer Res Treat.* 1991;18:49–56.
7. Miller AB, Baines CJ, To T, Wall C. Canadian National Breast Screening Study, 2: breast cancer detection and death rates among women aged 50 to 59 years. *Can Med Assoc J.* 1992;147:1477–1488.
8. Kerlikowske K, Grady D, Rubin SM, Sandrock C, Ernster VL. Efficacy of screening mammography: a meta-analysis. *JAMA.* 1995;273:149–154.
9. Marwick C. NCI changes its stance on mammography. *JAMA.* 1994;271:96.
10. *Summary of Current Guidelines for Cancer-Related Checkup: Recommendations.* New York, NY: American Cancer Society; 1988.
11. United States Preventive Services Task Force. *Guide to Clinical Preventive Services: An Assessment of the Effectiveness of 169 Interventions.* Baltimore, Md: Williams & Wilkins; 1989.
12. Centers for Disease Control. Mammography and clinical breast examination among women aged 50 years and older—Behavioral Risk Factor Surveillance System, 1992. *MMWR Morb Mortal Wkly Rep.* 1993;42:737–741.
13. Katz SJ, Hofer TP. Socioeconomic disparities in preventive care persist despite universal coverage: breast and cervical cancer screening in Ontario and the United States. *JAMA.* 1994;272:530–534.
14. Hayward RA, Shapiro MF, Freeman HE, Corey CR. Who gets screened for cervical and breast cancer? *Arch Intern Med.* 1988;148: 1177–1181.
15. Calle EE, Flanders WD, Thun MJ, Martin LM. Demographic predictors of mammography and Pap smear screening in U.S. women. *Am J Public Health.* 1993;83:53–60.
16. Zapka JG, Stoddard AM, Costanza ME, Greene HL. Breast cancer screening by mammography: utilization and associated factors. *Am J Public Health.* 1989;79:1499–1502.
17. Baranovsky A, Myers MH. Cancer incidence and survival in patients 65 years of age and older. *CA.* 1986;36:26–41.
18. Fisher ES, Whaley FS, Krushat WM, et al. The accuracy of Medicare's hospital claims data: progress has been made, but problems remain. *Am J Public Health.* 1992;82:243–248.
19. McBean AM, Warren JL, Babbish JD. Measuring the incidence of cancer in elderly Americans using Medicare claims data. *Cancer.* 1994;73:2417–2425.
20. Shah BV, Barnwell BG, Bieler GS. *SUDAAN Users Manual, Release 6.40.* Research Triangle Park, NC: Research Triangle Institute; 1995.
21. Ries LAG, Miller BA, Hankey BF, Kosary CL, Harras A, Edwards BK, eds. *SEER Cancer Statistics Review, 1973–1991: Tables and Graphs.* Bethesda, Md: National Cancer Institute; 1994. NIH publication 94-2789.
22. National Center for Health Statistics. *Health, United States, 1995.* Hyattsville, Md: US Public Health Service; 1996:191–192.
23. NCI Breast Cancer Screening Consortium. Screening mammography: a missed clinical opportunity? *JAMA.* 1990;264:54–58.
24. Rimer BK, Keintz MK, Kessler HB, Engstrom PF, Rosan JR. Why women resist screening mammography: patient-related barriers. *Radiology.* 1989;172:243–246.
25. Harper AP: Mammography utilization in the poor and medically underserved. *Cancer.* 1993;72:1478–1482.
26. Yuan Z. *United States Atlas of Cancer Incidence.* Milwaukee, Wis: Medical College of Wisconsin; 1992. Thesis.
27. Eley JW, Hill HA, Chen VW. Racial differences in survival from breast cancer. *JAMA.* 1994;272:947–954.
28. Schwartz S. The fallacy of the ecological fallacy: the potential misuse of a concept and its consequences. *Am J Public Health.* 1994;84: 819–824.
29. Susser M. The logic in ecological: I: the logic of analysis. *Am J Public Health.* 1994;84: 825–829.
30. Susser M. The logic in ecological: II: the logic of design. *Am J Public Health.* 1994;84: 830–835.
31. Koopman JS, Longini IM Jr. The ecological effects of individual exposures and nonlinear disease dynamics in populations. *Am J Public Health.* 1994;84:836–842.
32. Poole C. Ecological analysis as an outlook and method. *Am J Public Health.* 1994; 84:715–716.