Christine Zalewski. *Four Vases.* Photograph.

High mammography rates are associated with small tumor size at diagnosis, fewer cases of advanced disease, more choices for therapy, and decreased disease-specific mortality.

Decreased Breast Cancer Tumor Size, Stage, and Mortality in Rhode Island: An Example of a Well-Screened Population

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Background: *Since the 1980s, Rhode Island has achieved one of the highest mammography screening rates in the nation. The objective of this study was to determine the effect of high mammography rates on breast cancer presentation and outcomes.*

Methods: *Using the Rhode Island Cancer Registry, the incidence of DCIS and invasive cancer, tumor size, stage, rate of BCS and mortality from breast cancer were determined from 1987 to 2001.*

Results: *Over 80% of Rhode Island women report routine mammography. From 1987 to 2001, there were 1,660 cases of DCIS and 11,301 cases of invasive breast cancer. Although the overall incidence of invasive cancer was stable, the median diameter decreased from 2 cm to 1.5 cm with a significant decrease in the incidence of stage III and IV cancers. There was an increase in BCS for women 50 to 64 years of age with stage I and II disease and for women older than 65 years with stage I disease. Disease-specific mortality decreased by 25%.*

Conclusions: *High mammography rates in Rhode Island are associated with smaller and earlier-stage breast cancers. This largely accounts for the decreased mortality from breast cancer and the increased rate of BCS.*

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Abbreviations used in this paper: DCIS = ductal carcinoma in situ; BCS = breast conservation surgery; BCDDP = Breast Cancer Detection Demonstration Project; CDC = Centers for Disease Control and Prevention; BRFSS = Behavioral Risk Factor Surveillance System; RICR = Rhode Island Cancer Registry; AJCC = American Joint Commission on Cancer; SEER = Surveillance, Epidemiology, and End Results

Introduction

Multiple randomized clinical trials have shown a decreased mortality associated with screening mammography.[1-15] The BCDDP and other nonrandomized studies of mammographic screening have demonstrated detection of decreased tumor size, as well as a decreased incidence of nodal metastasis in a well-screened study population.[16-19] However, the applicability of these results to a general population has been questioned because volunteers for the BCDDP study may have been more motivated to receive appropriate tests and treatment. The long-term results of high mammography rates in a service population showing significant reductions in mortality have only recently become available.[20-23]

Since 1986, breast cancer detection and treatment have been a public health priority in Rhode Island. As a result of an initiative led by the Department of Health and by physicians in this state, Rhode Island has a high mammography screening rate. Due to the cultural environment, there is little migration into and out of the state, making the residents a stable population for study. The objective of this study was to determine the impact of a high rate of mammographic screening on breast cancer presentation and treatment in a general population. It was hypothesized that the widespread use of mammography would result in decreased tumor size with downward stage migration, a decrease in cancer-related mortality, and an increase in the use of breast conservation.

Methods

In 1987 and 1989, the Rhode Island Department of Health conducted telephone surveys of a minimum of 850 women who were Rhode Island residents over 40 years of age. In these surveys, women were asked if they had received biannual mammography if they were 40–49 years of age, or annual mammography if they were 50 years and older. Since 1990, as part of the CDC BRFSS,[24] the Department of Health has conducted annual random digit dialing telephone surveys of 1,600 to 3,800 respondents. If the respondent was a female Rhode Island resident, age 40 years or older, she was asked if she had undergone mammography in the past 2 years. We report the proportion of women having mammography from 1990 to 2001 for three age groups: 40–49 years, 50–64 years, and 65 years and older. Because different questions and techniques were used for the surveys in 1987 and 1989, the results are given but are not included in the analysis of trends. The proportion of women reporting mammography in the prior 2 years was analyzed using a χ^2 test to compare data from 1990–1992 and 2000–2001. Stata software (Version 8, College Station, Tex) was used to analyze all data. A *P* value of less than .05 was considered statistically significant.

Since October 1, 1986, all cancers detected or treated in Rhode Island have been reported to the RICR. This database (forms created by Rocky Mountain Cancer Data Systems, Salt Lake City, Utah) is maintained as a collaboration between the Department of Health and the Hospital Association of Rhode Island. Breast cancer data are collected at the time of diagnosis with semiannual follow-up reports from all hospitals, physician offices, and radiation treatment centers. The initial data collected include tumor size, histology, hormone receptor status, nodal involvement, and summary stage defining local, regional, or distant disease. The semiannual reports include the date of visit, disease status, and additional treatments. From 1987 to 1994, 7 of 13 hospitals in Rhode Island, representing approximately 75% of all breast cancer cases, also reported the AJCC stage.[25] Since 1995, all hospitals in Rhode Island have reported both summary and AJCC stage. The data were validated by 100% visual review of all case abstracts, computerized edit checks of all cases, and 10% reabstraction audits. At the time of analysis, the last year for complete data entry was 2001.

The incidence rates of DCIS and invasive breast carcinoma in women were calculated using the cases entered into the database from 1987 to 2001. Cases in which the woman was a resident of another state but treated at a Rhode Island facility for her cancer were excluded. Lobular carcinoma in situ cases were not included in incidence calculations. All cancers that were not staged or that were reported with an unknown AJCC or summary stage were included in the calculations for invasive breast cancer incidence. Using data from the 1990 and 2000 United States Censuses, linear population growth was assumed between these two data points to calculate the yearly population for each age group (40–49 years, 50–64 years, and 65 years and older). The overall incidence was age-adjusted using the 2000 US Standard Population.[26] To calculate the percentage increase in in situ and invasive breast cancer, 3-year averages of incident data were used. Rate ratios were used to compare the difference in incidence between 1987–1989 and 1999–2001.

To determine if increased mammographic screening resulted in a decrease in tumor size, the mean and median tumor diameters were determined for in situ and invasive tumors for each year from 1987 to 2001. Cases with no tumor size recorded were excluded from the analysis. A Student's *t* test was used to determine if there was a significant decrease in the mean tumor diameter over the study period. A nonparametric *K* sample test was used to evaluate the equality of the medians.

To analyze the degree of disease at presentation, the percentage of cases in each stage was calculated for AJCC and summary stage. Cases with an unknown stage were excluded from the analysis. A χ^2 test was used to compare 1987–1989 percentages to 1999–2001 percentages.

The number of women presenting in each stage was analyzed similarly to the overall incidence. Using the population of Rhode Island women age 40 years and older as the population at risk and the cases that occurred in women 40 years of age and older, an incidence rate was calculated for each stage of invasive breast cancer. Since mandatory reporting of AJCC stage began in 1995, the trend could not be explored in the earlier data. From 1987 to 1993, there was significant variation in the number of cases that were classified as unknown; from 1994 onward, there was a low, stable number of cases reported with unknown stage. Therefore, the rate ratio was analyzed for 1995–1997 and 1999–2001.

The proportion of patients with positive lymph nodes and the degree of lymph node involvement was analyzed to determine whether mammographic detection of smaller tumors had an impact on the extent of disease at presentation. Using pathology data, the number of positive lymph nodes in each case of invasive breast cancer was

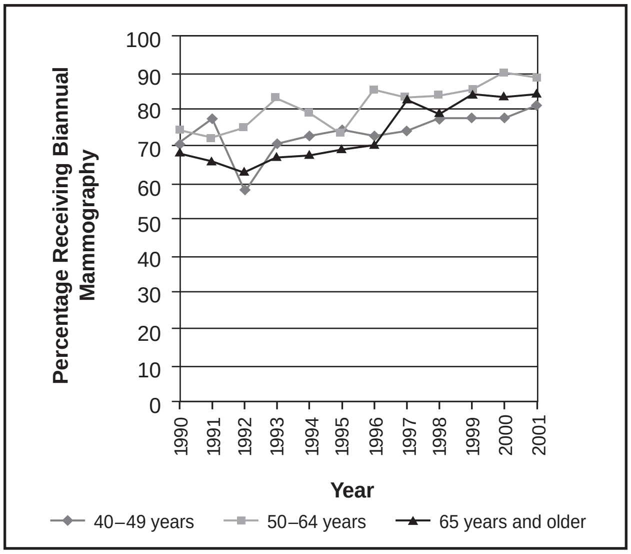

Fig 1. — Mammography rates comparing 1990–1992 and 1999–2001 for age groups in Rhode Island. Rates increased in all age groups (*P*<.05).

tabulated from 1995 to 2001. The proportion of cases with positive lymph nodes was compared between 1995–1997 and 1999–2001. A separate analysis to determine the extent of lymph node involvement was then performed. The proportion of one, two or three, and four or greater positive lymph nodes was compared between 1995–1997 and 1999–2001. Cases in which the nodal status was unknown were excluded from analysis. The data were compared using a χ^2 test.

It is easier to perform BCS in patients with smaller primary cancers. To determine if mammographic screening had an impact on breast conservation utilization, the proportion of women treated with BCS (with or without radiotherapy) was determined from 1995 to 2001 for each age group. Comparison of the rate of BCS over time was made using data from 1995–1997 and 1999–2001. When comparing the rate of BCS between age groups, data from 1999–2001 were used. Comparisons were analyzed using a χ^2 test.

For the purposes of our study, only deaths due to breast cancer were used in calculating disease-specific mortality. Age-specific and overall mortality rates were determined from death certificate information obtained from the National Center for Health Statistics. The overall rate was age-adjusted using the 2000 US Standard Population. The change in mortality was analyzed by comparing the rate ratio of 1987–1989 to 1998–2000.

Results

The healthcare community in Rhode Island has aggressively promoted breast cancer screening since 1986. Overall, there has been an increase in mammographic screening for all age groups in Rhode Island (Fig 1). For women 40–49 years of age, the rates of biannual screening mammography were 46% and 62% in 1985 and 1987, respectively; screening increased from 68% in 1990–1992 to 79% in 2000–2001 (*P*<.001). For women 50–64 years, the rates of annual screening were 40% and 50% in 1987 and 1989, respectively; biannual screening increased from 74% in 1990–1992 to 88% in 1999–2001 (*P*<.001). For the age group 65 years and older, the rates of annual screening were 34% and 44% in 1987 and 1989, respectively; biannual mammography increased from 66% in 1990–1992 to 84% in 2000–2001 (*P*<.001).

From 1987 to 2001, a total of 14,830 cases of in situ or invasive breast cancer were entered in the RICR database. Connecticut and Massachusetts residents who were treated at Rhode Island facilities comprised 1,837 cases (12%) and were excluded. Of the remaining 12,961 cases, 1660 (13%) were DCIS and 11,301 (87%) were invasive breast cancer.

Ductal Carcinoma In Situ

Over the 15-year study period, the incidence of DCIS steadily increased 169%, from 12.5 to 33.5 per 100,000 (*P*<.01) (Fig 2). For women 40–49 years of age, the incidence increased 263%, from 16.7 to 60.7 per 100,000 from 1987–1989 to 1999–2001 (*P*<.001). For the age group 50–64 years, the incidence of in situ breast cancer increased 126%, from 35.8 to 80.7 per 100,000 (*P*<.001). For women 65 years and older, the incidence increased 182%, from 30.7 to 86.6 per 100,000 (*P*<.001). Evaluation of data from the latter years of the study suggests that a plateau in the incidence of in situ breast cancer has not yet been reached.

Data on in situ tumor size were available for 23% of the reported cases in the tumor registry. For the available cases, the mean tumor size of DCIS decreased from 1.8 ±

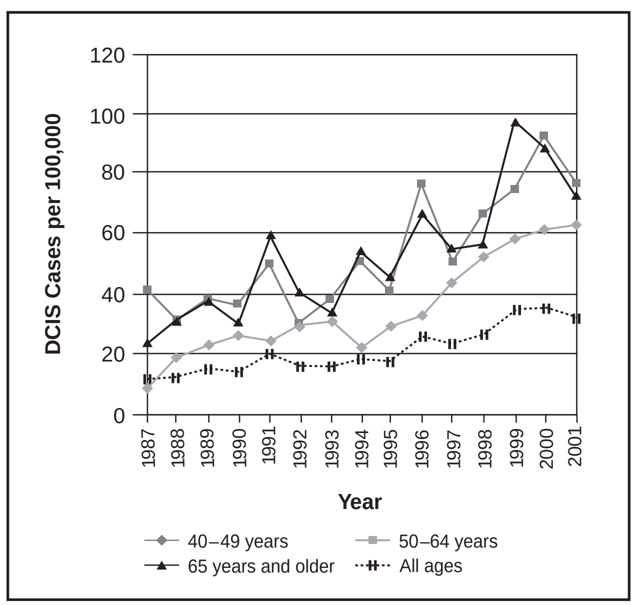

Fig 2. — Incidence of DCIS from 1987–2001 for age groups in Rhode Island. Comparing 1987–1989 vs 1999–2001, there has been a statistically significant increase in the incidence of DCIS in all age groups (*P*<.01).

Table 1. — The Rate of Breast Conservation Surgery in Rhode Island According to Disease Stage and Patient Age: 1995–1997 Compared to 1999–2001

Stage and Age (yrs)	1995–1997	1999–2001	*P* Value
DCIS:			
40–49	55%	65%	.143
50–64	65%	81%	.001*
65+	73%	74%	.716
Stage I:			
40–49	67%	73%	.2
50–64	64%	79%	<.001*
65+	66%	77%	<.001*
Stage II:			
40–49	54%	57%	.6
50–64	40%	61%	<.001*
65+	44%	47%	.4

* *P*<.05 was considered significant.

1.8 cm to 1.2 ± 1.0 cm, with a decrease in the median tumor size from 1.1 cm to 0.9 cm in 1987-1989 and 1999-2001. Statistical analysis was not performed due to the small percentage of cases with reported diameter.

To determine if there was any change in the type of surgical therapy for DCIS, the rate of BCS was analyzed from 1995 to 2001. Overall, there was a significant increase in BCS from 1995-1997 to 1999-2001 (Table 1). The increase in BCS for DCIS was most apparent in the age group 50-64 years. Subgroup analysis of the age groups 40-49 years and 65 years and older showed no significant change in the rate of BCS from 1995-1997 to 1999-2001. The likelihood of BCS for each age group was then analyzed by comparing the rate between groups for the period 1999-2001. Women age 50-64 years were significantly more likely to have BCS than women 40-49 years (*P*=.001). There was a nonsignificant trend for women age 50-64 years to be more likely to receive BCS compared with those 65 years and older (*P*=.09).

Invasive Breast Cancer

From 1987 to 2001, there were 11,301 cases of invasive breast cancer recorded in the RICR for Rhode Island women. The overall incidence of invasive breast cancer in Rhode Island did not change significantly from 1987 to 2001. The age-adjusted rate was 133.9 per 100,000 in 1987-1989 and 133.5 per 100,000 from 1999-2001 (*P*=.39) (Fig 3). The incidence rates (expressed per 100,000 women) for women age 40-49 years, 50-64 years, and 65 years and older in 1987-1989 and 1999-2001 were 144.5 and 157.9 (*P*=.22), 301.0 and 291.9 (*P*=.25), and 470.1 and 452.1 (*P*=.47), respectively.

Data were available on tumor size for 79% of invasive breast cancers reported to the RICR. The mean tumor diameter decreased 23%, from 2.5 ± 1.9 cm to 2.0 ± 1.7 cm, between 1987-1989 and 2000-2001 (*P*<.01). The median tumor size decreased 25%, from 2 cm in 1987-1989 to 1.5 cm in 2000-2001 (*P*<.001) (Fig 4).

To determine if there was stage migration over the study period, the percentage of cases in each AJCC or summary stage was calculated. The trends were similar for AJCC and summary stage, suggesting that there was no bias in the stage at presentation for the hospitals that did not initially report using AJCC stage. For all women, there was stage migration over the 15-year study period. The percentage of patients presenting with DCIS increased from 10.2% in 1987-1989 to 19.8% in 1999-2001 (*P*<.001). Because a large increase in the percentage of DCIS would cause a concurrent decrease in the percent-

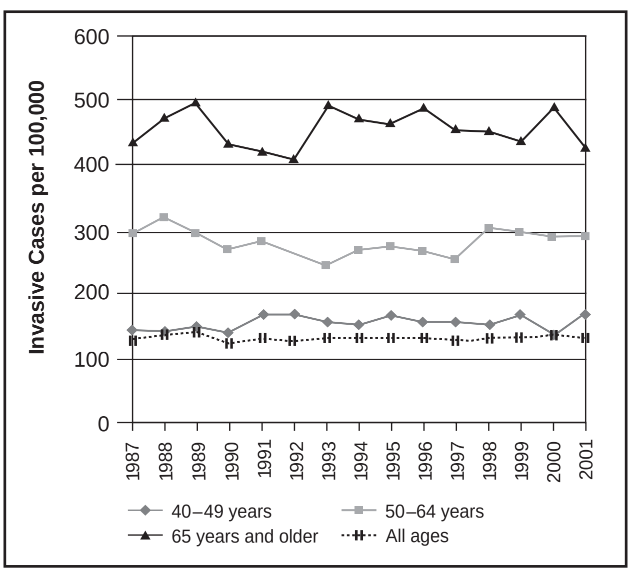

Fig 3. — Incidence of invasive breast cancer from 1987–2001 for age groups in Rhode Island. The overall and age-specific incidence of invasive breast cancer idid not change significantly from 1987–2001. The highest incidence of breast cancer was recorded in women 65 years of age and older.

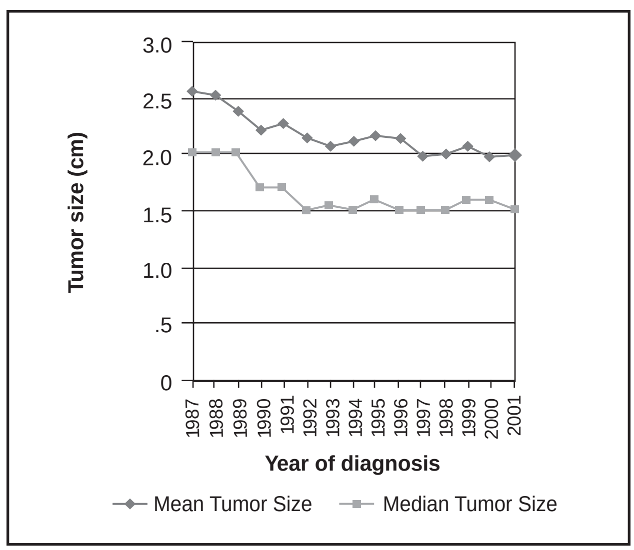

Fig 4. — Mean and median size of invasive breast cancer tumors from 1987–2001 for age groups in Rhode Island. The mean tumor size of all invasive breast cancers decreased from 2.5 cm in 1987–1989 to 2.0 cm in 1999–2001 (*P*<.01). The median tumor size decreased 25% from 2 cm to 1.5 cm in these same time periods (*P*<.01).

age of another stage cancer, the analysis was then performed including only stage I, II, III, and IV cancers.

Stage migration was noted over the 15-year study period (Fig 5). The percentage of women with stage I breast cancer increased from 44.5% in 1987–1989 to 53.5% in 1999–2001 (P<.001). There was no change in the percentage of women who presented with stage II breast cancer: 38.9% and 36.7% in 1987–1989 and 1999–2001, respectively (P=.19). There was a significant decrease in the percentage of women who presented with stage III cancer: 9.9% in 1987–1989 vs 5.7% in 1999–2001 (P<.001). Stage IV breast cancers decreased from 6.8% in 1987–1989 vs 4.1% in 1999–2001 (P=.003).

To ensure that the decrease in stage III and IV cancers was due to a decrease in absolute number of cases rather than a relative decrease in comparison to increased detection of stage I cancers, the incidence of stage I–IV cancers was calculated. Because all hospitals did not initially report AJCC stage, the comparison is made using 1995–1997 vs 1999–2001 (Table 2). There was no significant change in the incidence of stage I and II cancers from 1995–1997 compared with 1999–2001. There is a significant decrease in the incidence of stage III cancers from 21 to 16.4 per 100,000 (P=.0327). There is also a significant decrease in the incidence of stage IV cancers from 15.2 to 11.5 per 100,000 (P=.0497).

Beginning in 1995, the lymph node status and the number of lymph nodes involved with metastatic breast cancer were recorded in the RICR. Of the 5,692 cases of invasive cancer in the database from 1995–2001, 26.5% of women were diagnosed with lymph node metastasis by sentinel lymphadenectomy or axillary dissection, 48.6% had uninvolved lymph nodes, and 24.8% had an unknown nodal status. Comparing the patients with invasive cancer in 1995–1997 vs 1999–2001, there was no change in the proportion of patients diagnosed with lymph node metastases compared with those with no nodal involvement (P=.58).

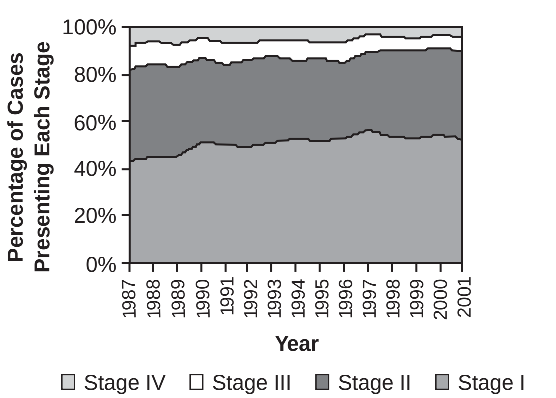

Fig 5. — Percentage of cases presenting at stage I, II, III, or IV from 1987 to 2001 in Rhode Island. The percentage of cases that presented as stage I increased from 44.5% in 1987-1989 to 53.5% in 1999-2001 (P<.001). The percentage of cases that presented as stage III in these same time periods decreased from 9.9% to 5.7% (P=.003).

Table 2. — Incidence of Stage I-IV Breast Cancers: 1995–1997 Compared to 1999–2001

Disease Stage	1995–1997	1999–2001	P Value
I	151.3	150.3	.8721
II	95.8	103.4	.1429
III	21.0	16.4	.0327*
IV	15.2	11.5	.0497*

* P<.05 was considered significant.

Although there was no difference in the percentage of women with nodal metastases, there was a significant change in the extent of lymph node involvement. Excluding unknown cases, of the patients with positive axillary node metastases, more patients presented with only one positive node: 36.9% in 1995–1997 vs 43.8% in 1999–2001. The proportion of patients with two or three positive nodes decreased from 28.3% in 1995–1997 to 27.3% in 1999–2001. Fewer patients presented with four or greater positive lymph nodes: 34.9% in 1995–1997 and 28.9% in 1999–2001. Comparing the three groups over time, there was a significant change in the extent of lymph node involvement (P=.04).

To determine if the decrease in tumor size and stage migration had any impact on surgical treatment, the proportion of women treated with BCS was analyzed by stage over time. From 1995 to 2001, the overall rate of BCS for stage I disease was 72%. There was a nonsignificant increase in BCS for stage I disease in women 40–49 years of age from 1995–1997 to 1999–2001 (Table 1) Over the same time periods, there was a significant increase in the rate of BCS for women age 50–64 years and 65 years and older for stage I cancer. There was no significant difference in the rate of BCS among the age groups for stage I cancer.

For stage II disease treated in 1995 to 2001, the overall rate of BCS for all women was 51%. There was a significant increase in the rate of BCS in the group of women 50–64 years old for stage II cancer from 1995–1997 vs 1999–2001 (Table 1). For the age groups 40–49 years and 65 years and older, there was no significant change in the rate of BCS. Women 65 years and older were significantly less likely than younger women to receive BCS for stage II disease for the period 1999–2001: 47% for those 65 years and older compared with 57% for women 40–49 years (P=.02) and 61% for women 50–64 years (P=.001).

The overall age-adjusted mortality attributable to breast cancer decreased 25% over the study period (Fig 6). For all women diagnosed with breast cancer in Rhode Island, mortality decreased from 38.0 per 100,000 in 1987–1989 to 28.4 per 100,000 in 1998–2000 (P<.001). For women 40–49 years, the mortality rate decreased 28%, from 32.2 to 23.2 deaths per 100,000 (P=.099). For women 50–64 years, the mortality rate decreased 39%, from 82.9 to 50.4 per 100,000 (P<.001). For women 65

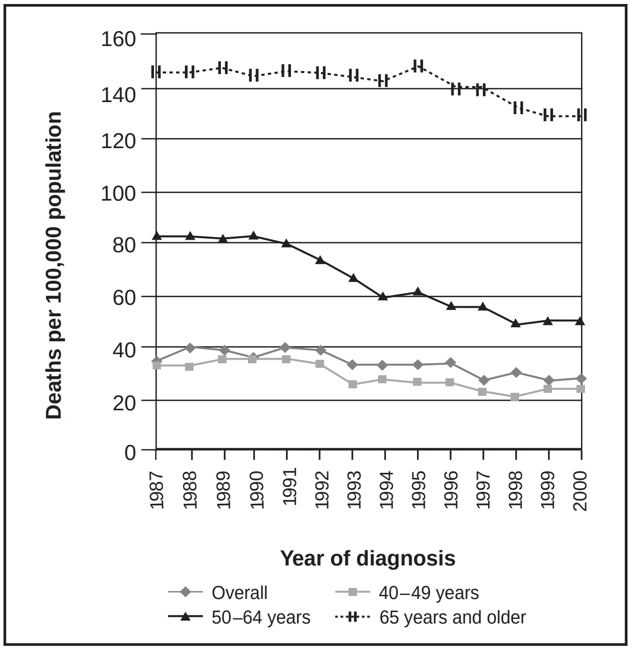

Fig 6. — Overall and age-specific breast cancer mortality from 1987–2000 for age groups in Rhode Island. For all women, the age-adjusted mortality decreased 25% from 1987–1989 to 1998–2000. Age-specific mortality decreased only in women 50–64 years of age (P<.001), although there was a trend for decreased mortality in women 40–49 years of age (P=.099).

years and older, there was a nonsignificant 12% decrease, from 146.8 to 129.7 per 100,000 (P=.37). There was no change in the all-cause mortality rate in 1987–1989 vs 1999–2001 (data not shown).

Discussion

Since 1963, eight major randomized clinical trials have been conducted to determine the effect of screening mammography on mortality from breast cancer. The relative risk of dying from breast cancer in the group invited to screening varies from 0.60 to 1.29, with most trials showing a significant decrease in mortality from breast cancer.[1-8] Given the reduction in mortality that was found by most of the trials, most advisory panels recommend annual screening for women over the age of 50 years and either annual or biannual screening for women 40–49 years.[15] However, in 1987, according to the National Health Interview Survey, only 29.1% of women age 50 years and older reported having a mammogram in the past 2 years, nationwide.[27] By 1998, the percentage had increased to 68.9%.[28] However, the BRFSS survey undertaken in 2002 by the CDC reported that of women age 40 years and above, 75.9% had received a mammogram in the prior 2 years.[24]

Since the 1980s, the Rhode Island medical community has been committed to increasing the rate of screening mammography. By 2000, the Healthy People 2010 goal of a 70% screening mammography rate had been exceeded by 20%.[29] For women over the age of 40, Rhode Island has had greater than 80% biannual mammographic screening since 1997. Of the three age groups, mammographic screening rates were highest for women 50–64 years old, with an average rate of 88% in 1999–2001. Over the study period, women age 40–49 years showed the smallest absolute gain in screening, likely due to the conflicting messages regarding the benefit of screening mammography presented in the literature and the press in the 1990s.[30-32]

Prior reports from Rhode Island and other states have suggested that women from lower socioeconomic groups and minorities are underscreened for breast cancer.[33-35] In 1996, only 37% of those women eligible for the Women's Cancer Screening Program, a CDC-sponsored program offering free mammography to women of low income, appear to have had screening mammography. Although based on a small sample size, data have shown a slight decline in the percentage of black Rhode Island women 40–49 years receiving mammography in the mid 1990s. Hispanic women in this same study showed a decrease in mammography across all age groups.[36] One of the limitations of our study is the method by which respondents are located in order to assess mammography rates. The populations likely to have the lowest rates of mammography screening are also the least likely to be included in the survey due to communication difficulties or lack of a telephone. In the continued effort to improve mammographic screening rates, these groups should be targeted. Another limitation of the assessment of mammography in this study is recall or reporting bias from the respondents.

Ductal Carcinoma In Situ

The high rate of mammographic screening in Rhode Island has had an impact on disease presentation. As with other studied populations, the incidence of DCIS has steadily increased.[37-39] From 1975–2000, SEER data show an increase in DCIS from 5.8 to 32.7 per 100,000 in all women and an increase in women older than 50 years from 11.2 to 87.7 per 100,000, similar to observations in Rhode Island.[36] For women of all ages, we have experienced a 169% increase in the incidence of DCIS over 15 years. The greatest increase, 263%, was in women 40–49 years of age. Even with high screening rates in the 1980s and 1990s, we have not seen a plateau of rates of DCIS in any age group.

The continued increase in DCIS may signify improved mammographic techniques that detect more subtle abnormalities. It may also reflect that radiologists and pathologists now diagnose DCIS in lesions that would have previously been ignored radiographically or called atypia on histology. The increased detection and diagnosis of DCIS should be further explored because this rise could lead to a higher rate of treatment of lesions that are not biologically aggressive. On the other hand, the increase in DCIS, in conjunction with relatively stable invasive cancer rates, may indicate improved detection of tumors in a preinvasive state. If this is true, further follow-up studies of well-screened populations should show a decrease in the incidence of invasive cancer.[40] To date, it is not possible to determine which cases of DCIS will progress to invasive cancer and which will remain as in situ disease.[41] Until prognostic factors are elucidated that will allow observation of the subset of DCIS that is unlikely to progress to invasive cancer, aggressive screening and excision of all cases of DCIS are warranted.

It is difficult to comment on any changes in the diagnosis and treatment of DCIS relative to diameter at presentation because tumor size was reported in only 23% of women with DCIS. This proportion has not varied significantly across the 15 years studied, with only 30% of DCIS in 2001 associated with a reported diameter. While the determination of an exact diameter of DCIS on pathology is difficult, information on the extent of DCIS will improve the care provided to women in Rhode Island. This issue needs to be addressed in education regarding the treatment of DCIS and the pathology reporting system for the state.

During the course of this study, the NSABP-B17, EORTC 10853, and other trials were published, showing that women treated with lumpectomy and radiation for DCIS had a significantly lower local recurrence rate than those treated with lumpectomy alone. Additionally, the trials also confirmed that DCIS could be treated by BCS with acceptable recurrence and mortality.[42-45] These results may have had an impact on surgical treatment for DCIS. In Rhode Island, there was a significant increase in the overall rate of BCS for DCIS from 1995–1997 to 1999–2001. This was mainly influenced by the large increase in the proportion of women 50–64 years of age receiving BCS. For the subgroup of women age 40–49 years, there was a nonsignificant increase in the rate of BCS for DCIS. However, with an overall rate of 72%, the percentage of women receiving BCS in Rhode Island is significantly higher than results reported in other regions of the country.[46-48] Although they found rates of BCS for all groups to be close to 50%, a review of the National Cancer Data Base by Winchester et al[47] also reported the highest rates in the oldest age group. The significantly lower rate of BCS for women age 40–49 years may be appropriate, considering that DCIS may have a more aggressive nature in the younger population.[49,50]

Invasive Breast Cancer

Using data from the CDC's National Program of Cancer Registries and the SEER database, from 1996 to 2000 the national age-adjusted incidence of breast cancer was estimated to be 131.7 per 100,000. This incidence ranged from 104.5 per 100,000 in Mississippi to 145.2 per 100,000 in Massachusetts.[29] We found the age-adjusted incidence rate of invasive breast cancer in Rhode Island to be 133.5 per 100,000 from 1999 to 2001.

Our results show that a high rate of screening mammography does not result in a continued increase in the incidence of invasive breast cancer. There was no significant change in the overall incidence of invasive breast cancer during our study period. Given the high penetration of screening, these rates should reflect the true incidence of breast cancer in the state.

The BCDDP and other studies have shown a decrease in tumor size with increased mammographic screening.[16-19] Our data also show that an increased rate of screening mammography has resulted in earlier detection of invasive breast cancer and smaller tumor size. Between 1987 and 2001 in Rhode Island, the mean tumor size decreased from 2.5 cm to 2.0 cm. The median tumor size, a more accurate indicator of the usual tumor size at presentation, decreased from 2.0 cm to 1.5 cm. From 1992–2001, the median tumor size has not decreased significantly. However, there has been a continued decrease in mean tumor size during the last 10 years of the study, illustrating the continued impact of screening mammography.

As would be expected with detection of smaller tumors, there was significant downward stage migration (Fig 5). Both the relative number and absolute number of women presenting with stage III and IV breast cancer decreased during the study period (Table 2). Given the trend of an increase in stage II cancer incidence, most of the decrease in stage III and IV cancers may be explained by early detection when the cancers are graded as stage II.

Further illustrating the effects of high screening rates in the state, Rhode Island women presented with earlier breast cancer than ones monitored in the SEER database during the same years. The 1992–1998 SEER data showed 48.1% stage I, 49.8% stage II, 7.3% stage III, and 4.8% stage IV breast cancer at presentation.[51] In Rhode Island for the same time period, women presented with earlier AJCC stages: 53.5% stage I, 36.2% stage II, 6.2% stage III, and 3.9% stage IV. For patients who presented with N1 disease, the extent of nodal involvement decreased during our study period, with women presenting with fewer positive lymph nodes.

A decrease in size and stage should allow for an increase in breast conservation. Overall, 72% of stage I and 51% of stage II breast cancers were treated with BCS. From 1995–1997 to 1999–2001, there was a significant increase in the rate of BCS for women in age group 50–64 years with stage I and II disease and for women 65 years and older with stage I disease. While the major trials comparing breast conservation and mastectomy were completed by 1995, reports of sentinel node biopsy for breast cancer were first published during our study period, 1995–2001.[52-57] The decreased morbidity associated with a sentinel node biopsy vs axillary dissection, along with increased physician and patient awareness of the benefits of BCS, may partially explain the increased use of BCS. However, BCS is predicated on small tumor size, so further increases in its use are explained principally by a decrease in tumor diameter. The increase in the rate of BCS for stage II disease also may be partially due to increased utilization of neoadjuvant therapy. However, a relationship cannot be determined using data from the RICR. Physician bias and known higher local recurrence in younger patients may account to some extent for the observation that there was no increase in BCS utilization in women 40–49 years of age.[49,50]

Earlier stage, smaller tumor size, and decreased rates of nodal metastases should lead to a decreased mortality.[16,17,21,58] Early detection and continued advances in the treatment of breast cancer have resulted in a 25% decrease in disease-specific mortality in Rhode Island over the past 15 years, from 35.4 to 28.1 per 100,000 (Fig 6). The US breast cancer mortality over the same time decreased only 13%, from 33.0 to 28.8 per 100,000.[34] The Healthy People 2010 goal for breast cancer mortality is 22.2 per 100,000,[29] indicating that continued screening efforts to detect smaller tumors must be encouraged. A recent study in Rhode Island showed that 73% of deaths attributed to breast cancer occurred in women who had received no mammographic screening in the prior 2 years. This population of underscreened women should be targeted in order to further reduce disease-related mortality.[59]

When the mortality is examined by age groups, the only statistically significant decrease in breast cancer mortality is within women age 50–64 years, although there is a strong trend for decreased mortality for those 40–49 years of age. Since the data are derived from death certificates, there is often difficulty in determining the primary cause of death and the number of cases with active disease who die of other competing causes. Despite this significant decrease in disease-specific mortality, there has been no decrease in the overall mortality for any age group. As the breast cancer mortality continues to decrease due to early detection and improved treatment options, perhaps there will be a decrease in overall mortality within some groups.

Conclusions

Increased public awareness and physician education in Rhode Island have led to high rates of mammography in all age groups. This has been associated with smaller tumor size and fewer women presenting with advanced disease. The disease-specific mortality rate in the state has decreased significantly. Since tumors are now found at an smaller size and earlier stage, women have more choices in therapy and treatment options that are more effective and less morbid.

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References

1. Nystrom L, Rutqvist LE, Wall S, et al. Breast cancer screening with mammography: overview of Swedish randomised trials. *Lancet*. 1993;341:973-978.
2. Frisell J, Lidbrink E, Hellstrom L, et al. Followup after 11 years: update of mortality results in the Stockholm mammographic screening trial. *Breast Cancer Res Treat*. 1997;45:263-270.
3. Roberts MM, Alexander FE, Anderson TJ, et al. Edinburgh trial of screening for breast cancer: mortality at seven years. *Lancet*. 1990; 335:241-246.
4. Bjurstam N, Bjorneld L, Duffy SW, et al. The Gothenburg breast screening trial: first results on mortality, incidence, and mode of detection for women ages 39-490 years at randomization. *Cancer*. 1997;80:2091-2099.
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. Shapiro S. Periodic screening for breast cancer: the HIP Randomized Controlled Trial Health Insurance Plan. *J Natl Cancer Inst Monogr.* 1997;22:27-30.
7. Miller AB, Baines CJ, To T, et al. Canadian National Breast Screening Study: 1. Breast cancer detection and death rates among women aged 40 to 49 years. *CMAJ*. 1992;147:1459-1476.
8. Miller AB, Baines CJ, To T, et al. Canadian National Breast Screening Study: 2. Breast cancer detection and death rates among women aged 50 to 59 years. *CMAJ*. 1992;147:1477-1488.
9. Nystrom L, Andersson I, Bjurstam N, et al. Long-term effects of mammography screening: updated overview of the Swedish randomised trials. *Lancet*. 2002:359:909-919.
10. Miller AB, To T, Baines CJ, et al. The Canadian National Breast Screening Study: update on breast cancer mortality. *J Natl Cancer Inst Monogr*. 1997;22:37-41.
11. Andersson I, Janzon L. Reduced breast cancer mortality in women under age 50: updated results from the Malmo Mammographic Screening Program. *J Natl Cancer Inst Monogr*. 1997;22:63-67.
12. Tabar L, Vitak B, Chen HH, et al. The Swedish Two-County Trial twenty years later: updated mortality results and new insights from long-term follow-up. *Radiol Clin North Am*. 2000;38:625-651.
13. Alexander FE, Anderson TJ, Brown HK, et al. 14 years of follow-up from the Edinburgh randomized trial of breast-cancer screening. *Lancet*. 1999;353:1903-1908.
14. Harris RP, Helfand M, Woolf SH, et al. Current methods of the third US Preventive Services Task Force: a review in the process. *Am J Prev Med*. 2001;20(suppl 3):21-35.
15. Berg AO, Allen JD. *Screening for Breast Cancer: Recommendations and Rationale*. US Preventive Services Task Force, Guidelines from Guide to Clinical Preventative Services. 3rd ed. 2000-2003.
16. Smart CR, Byrne C, Smith RA, et al. Twenty-year follow-up of the breast cancers diagnosed during the Breast Cancer Detection Demonstration Project. *CA Cancer J Clin*. 1997;47:134-149.
17. Simon MS, Lemanne D, Schwartz AG, et al. Recent trends in the incidence of in situ and invasive breast cancer in the Detroit metropolitan area (1975-1988). *Cancer*. 1993;71:769-774.
18. Ernst MF, Roukema JA, Coebergh JW, et al. Breast cancers found by screening: earlier detection, lower malignant potential, or both? *Br Cancer Res Treat*. 2002;76:19-25.
19. Cady B, Stone MD, Schuler JG, et al. The new era in breast cancer. invasion, size, and nodal involvement dramatically decreasing as a result of mammographic screening. *Arch Surg*. 1996;131:301-308.
20. Tabar L, Yen MF, Vitak B, et al. Mammography service screening and mortality in breast cancer patients: 20-year follow-up before and after introduction of screening. *Lancet*. 2003;361:1405-1410.
21. Chung MA, Fulton J, Cady B. Trends in breast cancer incidence and presentation in a population screened for breast cancer. *Semin Breast Dis*. 1999;2:55-63.
22. Otto SJ, Fracheboud J, Looman CW, et al. Initiation of population-based mammography screening in Dutch municipalities and effect on breast-cancer mortality: a systematic review. *Lancet*. 2003;361: 1411-1417.

23. Pisani P, Forman D. Declining mortality from breast cancer in Yorkshire, 1983-1998: extent and causes. *Br J Cancer*. 2004;90:652-656.
24. Centers for Disease Control and Prevention (CDC). *Behavioral Risk Factor Surveillance System Survey Questionnaire*. Atlanta, Ga: US Dept of Health and Human Services, Centers for Disease Control and Prevention; 1990-2002.
25. Greene FL, Page DL, Balch CM, et al. *AJCC Cancer Staging Manual*. 6th ed. New York, NY: Springer-Verlag; 2002.
26. Klein RJ, Schoenborn CA. Age adjustment using the 2000 projected US population. Healthy People Statistics Notes, No. 20. Hyattsville, Md: National Center for Health Statistics; 2001.
27. Swan J, Breen N, Coates RJ, et al. Progress in cancer screening practices in the United States: results from the 2000 National Health Interview Survey. *Cancer*. 2003;97:1528-1540.
28. US Cancer Statistics Working Group. *United States Cancer Statistics: 2000 Incidence*. Atlanta, Ga: Dept of Health and Human Services, Centers for Disease Control and Prevention and National Cancer Institute; 2003.
29. *Healthy People 2010. Understanding and Improving Health and Objectives for Improving Health*. 2nd ed. Washington, DC: US Dept of Health and Human Services; 2000.
30. Wells J, Marshall P, Crawley B, et al. Newspaper reporting of screening mammography. *Ann Intern Med*. 2001;135:1029-1037.
31. Marwick C. NIH Consensus Panel spurs discontent. *JAMA*. 1997;277:519-520.
32. Fletcher SW, Black W, Harris R, et al. Report of the International Workshop on Screening for Breast Cancer. *J Natl Cancer Inst*. 1993;85:1644-1656.
33. Perry DK, Marable S, Darcy D. Breast cancer control report card: Rhode Island, 1999. *Med Health R. I*. 1999;82:451-452.
34. McGinnis LS, Menck HR, Eyre HJ, et al. National Cancer Data Base survey of breast cancer management for patients from low income zip codes. *Cancer*. 2000;88:933-945.
35. Gill KS, Yankaskas BC. Screening mammography performance and cancer detection among black women and white women in community practice. *Cancer*. 2004;100:139-148.
36. Ries LAG, Eisner MP, Kosary CL, et al, eds. *SEER Cancer Statistics Review, 1975-2000*. Bethesda, Md: National Cancer Institute; 2003. http://seer.cancer.gov/csr/1975_2000, 2003.
37. Curpen BN, Sickles EA, Sollitto RA, et al. The comparative value of mammographic screening for women 40-49 years of age versus women 50-64 years old. *AJR Am J Roentgenol*. 1995;164:1099-1103.
38. Ernster VL, Barclay J. Increases in ductal carcinoma in situ (DCIS) of the breast in relation to mammography: a dilemma. *Natl Cancer Inst Monogr*. 1997;22:151-156.
39. Evans WP 3rd, Starr AL, Bennos ES. Comparison of the relative incidence of impalpable invasive breast carcinoma and ductal carcinoma in situ in patients older and younger than 50 years of age. *Radiology*. 1997;204:489-491.
40. Cady B. How to prevent invasive breast cancer: detect and excise duct carcinoma in situ. *J Surg Oncol*. 1998;69:60-62.
41. Burstein HJ, Polyak K, Wong, JS, et al. Ductal carcinoma in situ of the breast. *N Engl J Med*. 2004;350:1430-1441.
42. Fisher B, Cosantino J, Redmond C, et al. Lumpectomy compared with lumpectomy and radiation therapy for the treatment of intraductal breast cancer. *N Engl J Med*. 1993;328:1581-1586.
43. Julien JP, Bijker N, Fentiman IS, et al. Radiotherapy in breast-conserving treatment for ductal carcinoma in situ: first results of the EORTC randomized phase III trial 10853. EORTC Breast Cancer Cooperative Group and EORTC Radiotherapy Group. *Lancet*. 2000;355:528-533.
44. Solin LJ, Kurtz J, Fourquet A, et al. Fifteen years of breast-conserving surgery and definitive breast irradiation for the treatment of ductal carcinoma of the breast. *J Clin Oncol*. 1996;14:754-763.
45. Bornstein BA, Recht A, Connolly JL, et al. Results of treating ductal carcinoma in situ of the breast with conservative surgery and radiation therapy. *Cancer*. 1991;67:7-13.
46. Kotwall C, Brinker C, Covington D, et al. Local and national trends over a decade in the surgical treatment of ductal carcinoma in situ. *Am J Surg*. 2003;186:723-728.
47. Winchester DJ, Menck HR, Winchester DP. National treatment trends for ductal carcinoma in situ of the breast. *Arch Surg*. 1997;132:660-665.
48. Ernster VL, Barclay J, Kerlikowske K, et al. Incidence of and treatment for ductal carcinoma in situ of the breast. *JAMA*. 1996;275:913-918.
49. Love RR, Duc NB, Dinh NV, et al. Young age as an adverse prognostic factor in premenopausal women with operable breast cancer. *Clin Breast Cancer*. 2002;2:294-298.
50. Maggard MA, O'Connell JB, Lane KE, et al. Do young breast cancer patients have worse outcomes? *J Surg Res*. 2003;113:109-113.
51. Li CI, Malone KE, Daling JR. Differences in breast cancer stage, treatment, and survival by race and ethnicity. *Arch Intern Med*. 2003;163:49-56.
52. Fisher B, Anderson S, Redmond CK, et al. Reanalysis and results after 12 years of follow-up in a randomized clinical trial comparing total mastectomy with lumpectomy with or without irradiation in the treatment of breast cancer. *N Engl J Med*. 1995;333:1456-1461.
53. Veronesi U, Luini A, Vecchio M, et al. Radiotherapy after breast-preserving surgery in women with localized cancer of the breast. *N Engl J Med*. 1993;328:1587-1591.
54. Jacobson JA, Danforth DN, Cowan KH, et al. Ten-year results of a comparison of conservation with mastectomy in the treatment of stage I and II breast cancer. *N Engl J Med*. 1995;332:907-911.
55. van Dongen JA, Bartelink H, Fentiman IS, et al. Randomized clinical trial to assess the value of breast-conserving therapy in stage I and II breast cancer. EORTC 10801 trial. *J Natl Cancer Inst Monogr*. 1992;11:15-18.
56. Giuliano AE. Sentinel lymphadenectomy in primary breast carcinoma: an alternative to routine axillary dissection. *J Surg Oncol*. 1996;62:75-77.
57. Veronesi U, Paganelli G, Galimberti V, et al. Sentinel-node biopsy to avoid axillary dissection in breast cancer with clinically negative lymph-nodes. *Lancet*. 1997;349:1864-1867.
58. Tabar L, Duffy SW, Vitak B, et al. The natural history of breast carcinoma: what have we learned from screening? *Cancer*. 1999;86:449-462.
59. Spencer DB, Potter JE, Chung MA, et al. Mammographic screening and disease presentation of breast cancer: patients who die of disease. *Breast*. 2004 (in press).