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ORIGINAL REPORT

Causes of Death and Relative Survival of Older Women After a Breast Cancer Diagnosis

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ABSTRACT

Purpose
To understand the impact of breast cancer on older women's survival, we compared survival of older women diagnosed with breast cancer with matched controls.

Methods
Using the linked 1992 to 2003 Surveillance, Epidemiology, and End Results (SEER) -Medicare data set, we identified women age 67 years or older who were newly diagnosed with ductal carcinoma in situ (DCIS) or breast cancer. We identified women not diagnosed with breast cancer from the 5% random sample of Medicare beneficiaries residing in SEER areas. We matched patient cases to controls by birth year and registry (99% or 66,039 patient cases matched successfully). We assigned the start of follow-up for controls as the patient cases' date of diagnosis. Mortality data were available through 2006. We compared survival of women with breast cancer by stage with survival of controls using multivariable proportional hazards models adjusting for age at diagnosis, comorbidity, prior mammography use, and sociodemographics. We repeated these analyses stratifying by age.

Results
Median follow-up time was 7.7 years. Differences between patient cases and controls in sociodemographics and comorbidities were small (< 4%). Women diagnosed with DCIS (adjusted hazard ratio [aHR], 0.7; 95% CI, 0.7 to 0.7) or stage I disease (aHR, 0.8; 95% CI, 0.8 to 0.8) had slightly lower mortality than controls. Women diagnosed with stage II disease or higher had greater mortality than controls (stage II disease: aHR, 1.2; 95% CI, 1.2 to 1.2). The association of a breast cancer diagnosis with mortality declined with age among women with advanced disease.

Conclusion
Compared with matched controls, a diagnosis of DCIS or stage I breast cancer in older women is associated with better survival, whereas a diagnosis of stage II or higher breast cancer is associated with worse survival.

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INTRODUCTION

Women age 65 years and older are the fastest growing segment of the US population, and breast cancer incidence increases with age.[1] However, few studies have examined the impact of breast cancer on older women's overall survival. It is uncertain whether being diagnosed with breast cancer reduces older women's life expectancy. Prior studies have generally compared survival among older women with breast cancer by receipt of mammography screening or by age.[2-4] These studies have found that mammography screening results in a breast cancer mortality benefit for older women in good health[2-4] and that women age 80 years and older are at greater risk of breast cancer mortality than younger women.[5,6] However, because these studies used observational data, they were limited by lead time, length time, and selection bias.[7] These studies also relied on death certificates for cause of death, which may be inaccurate.[8,9]

Few studies have compared survival of older women with breast cancer with survival of similar women not diagnosed with breast cancer (relative survival).[10-15] Relative survival provides information on the impact of breast cancer alone on survival and does not rely on patient-specific cause of death information.[16] Studies examining relative survival of older women with breast cancer have used data from national life-tables to estimate the expected survival of older women.[10-15] National life-table data, however, include mortality from all causes of death, including the cancer of interest, and do not account for other differences between populations

with and without cancer, such as geography, socioeconomic factors, or health care utilization. Diab et al[15] compared 8-year relative survival of older women with breast cancer with survival of similar-aged women from US life-tables. They found that beginning at age 70 years, women with lymph node–negative breast cancer or breast cancers less than 2 cm had relative survival values of ≥ 1, indicating similar or better survival of older women with favorable breast tumors compared with women without breast cancer. However, because this study did not account for breast cancer deaths that may occur in the general population and did not account for differences in sociodemographics or health care utilization (eg, screening behaviors) between the breast cancer patients and general population, the findings may underestimate the impact of breast cancer on survival.[16] Additionally, Diab et al[15] used data from 1973 to 1995, before mammography screening and detection of ductal carcinoma in situ (DCIS) was common among older women and before many advances in treatment of breast cancer and other diseases. Better understanding of the impact of breast cancer on survival among the oldest women is necessary for informing current decision making concerning breast cancer detection and care.

METHODS

To better understand the impact of breast cancer on older women's survival and to overcome limitations of prior studies examining relative survival, we chose to match women age 67 years and older diagnosed with breast cancer to women without breast cancer of similar insurance status using age and geographic region.

Study Sample

We used data from the National Cancer Institute's linked Surveillance, Epidemiology, and End Results (SEER) -Medicare database. Since 1992, SEER has included 11 population-based tumor registries,[17] covering approximately 14% of the US population.[18] We identified women age 67 and older who were newly diagnosed with invasive breast cancer or DCIS between 1992 and 2003, excluding women diagnosed at death or at autopsy (n = 102,184 remaining). We excluded 1,780 women diagnosed with a second cancer within 12 months after their breast cancer diagnosis because health care claims cannot reliably discriminate between procedures performed for the index cancer versus the second cancer. We further excluded 25,118 women with managed care insurance and 8,335 women with gaps in Medicare coverage within 2 years before through 1 year after diagnosis, because their claims history may be incomplete (n = 66,951 remaining).

For comparison purposes, we used data from a 5% random sample of Medicare beneficiaries residing in the same geographic areas as those covered by SEER but without breast cancer. To ensure that our controls did not have breast cancer, we excluded 4,104 women (1.3%) in the 5% random sample who had outpatient claims for breast cancer separated by 30 days (to avoid rule-out diagnoses) or a breast cancer diagnosis during a hospital admission. We reviewed all outpatient claims from 1991 to 2006 and all inpatient claims from 1986 to 2006. We then used the greedy matching algorithm (SAS Macro GMATCH; SAS Institute, Cary, NC)[19] to match women with breast cancer to women without breast cancer (n = 312,379) by calendar year of birth (within 5 years), registry location, and year. We used the date of diagnosis of patient cases as the date to begin follow-up of controls. Controls (like patient cases) were required to have 24 months of continuous fee-for-service Medicare coverage in the 24 months before follow-up. So that we would not bias our match against matching the oldest women, we first matched women age 85 years and older with a control, then we matched women age 75 to 84 years, and finally, we matched women age 67 to 74 years. We successfully matched 66,039 women (98.6%) diagnosed with breast cancer with a control.

Survival Outcomes

Follow-up information on mortality was available from Medicare for all women though 2006. We measured survival time from assigned date of diagnosis until death or end of follow-up. We censored observations of women who were alive as of December 31, 2006.

Factor of Interest

For women diagnosed with breast cancer, we obtained data on American Joint Committee on Cancer (third edition) staging at diagnosis through SEER.

Initial Treatment

For women diagnosed with stage I or II breast cancer, we used SEER and Medicare claims data within 12 months after diagnosis to classify initial treatment with surgery and/or radiation. We considered mastectomy and/or breast-conserving surgery (BCS) plus radiotherapy as standard treatment and receipt of BCS alone or no initial surgery as nonstandard treatment.[20]

Cause of Death

Cause of death was available only for women with breast cancer and only through December 31, 2005.

Covariates

We obtained data on race/ethnicity from Medicare's Denominator file.[21] We used the modification of the Charlson comorbidity index by Klabunde et al[22] to define comorbidity using inpatient and outpatient claims from 24 months before diagnosis. Because individual-level indicators of socioeconomic status are not available, we used data from individuals' census tracts (or zip codes when census tract data were unavailable) on median household income and proportion of adults with less than a high school education as proxies. Because income and educational attainment can vary geographically, we categorized women into quintiles for both median household income and educational attainment within registry and then aggregated quintiles across registries.[23,24] We determined mammography use, hospitalizations, and primary care visits in the previous 27 months, excluding the immediate 3 months before diagnosis for the latter two measures. We selected this time frame to examine 2 full years of utilization data, and we hypothesized that mammograms, hospitalizations, and/or primary clinic visits within 3 months of diagnosis might relate to diagnosis and not screening behaviors. We categorized previous mammography use sequentially as nonuse, regular use (at least two mammograms 10 months apart or one mammogram coded as screening), only diagnostic mammograms within 3 months of diagnosis/follow-up, and other.

Statistical Analyses

We compared characteristics between patient cases and controls using χ^2 statistics. We used the Kaplan-Meier method to estimate survival curves and the log-rank test to statistically compare women diagnosed with breast cancer by stage with controls. We used multivariable Cox proportional hazards regression models to compare survival between women with breast cancer by stage (DCIS; stage I, II, III, or IV; or unknown) and controls, adjusting for all covariates. For each stage, we calculated the relative survival (survival of the patient cases divided by survival of the controls). We repeated these analyses stratifying by age group. We also examined the effect of initial treatments received on survival among women diagnosed with stage I or II breast cancer compared with their controls adjusting for all covariates, overall and stratified by age (67 to 79 years and ≥ 80 years). For women diagnosed with breast cancer, we examined rates of 5-year mortality and underlying cause of death by stage and age (67 to 79 years and ≥ 80 years). We limited this analysis to women diagnosed with breast cancer between 1992 and 2000 to have complete 5-year follow-up data from SEER. Among women diagnosed with stage I or II disease, we further examined cause of death by treatments received. All analyses were performed using SAS version 9.2 (SAS Institute). The Institutional Review Board of the Beth Israel Deaconess Medical Center approved this study.

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Table 1. Demographics and Clinical Characteristics of Women Diagnosed With Breast Cancer and Their Controls

Demographic or Clinical Characteristic	% of Women With Breast Cancer (n = 66,039)	% of Controls (n = 66,039)	*P*
Age, years*			
67-69	15.0	15.3	
70-74	27.3	27.5	
75-79	25.3	25.3	.25
80-84	17.9	17.7	
85-89	9.7	9.6	
≥ 90	4.7	4.7	
Mean†	77.3	77.3	.37
SD	6.8	6.8	
Median	76.3	76.3	
Interquartile range*	71.8-81.8	71.8-81.8	
Race/ethnicity			
Non-Hispanic white	88.7	84.9	
Non-Hispanic black	6.0	6.6	
Asian	2.3	3.8	< .001
Hispanic	1.0	1.9	
Other	1.7	2.4	
Unknown	0.3	0.4	
Quintile of median income for area of residence*			
Data available, No.	65,690	64,248	
Quintile 1 (lowest)	21.6	21.2	
Quintile 2	20.7	20.2	.01
Quintile 3	19.7	19.8	
Quintile 4	19.1	19.6	
Quintile 5 (highest)	18.8	19.2	
Quintile of education for area of residence*			
Data available, No.	65,691	64,249	
Quintile 1 (lowest)	20.8	20.4	
Quintile 2	20.4	20.2	.04
Quintile 3	20.0	20.0	
Quintile 4	19.7	20.0	
Quintile 5 (highest)	19.2	19.4	
Charlson comorbidity index*			
0	62.9	60.0	
1	20.5	21.1	< .001
2	9.7	10.2	
≥ 3	6.9	8.7	
Individual conditions			
Myocardial infarction	2.5	2.9	< .001
Congestive heart failure	8.1	9.0	< .001
Peripheral vascular disease	3.5	4.0	< .001
Cerebrovascular disease	6.0	7.4	< .001
Chronic obstructive pulmonary disease	10.9	12.0	< .001
Diabetes	13.8	14.1	.12
Mammography use in last 2 years‡			
Nonusers	34.2	54.5	
Screeners	47.7	36.9	< .001
Peridiagnosis mammogram	11.6	0.7	
Other	6.5	7.9	
No. of hospitalizations in last 2 years*§			
0	75.5	72.6	
1	15.4	16.2	< .001
≥ 2	9.1	11.2	
Mean	0.4	0.5	< .001
SD	1.0	1.0	

(continued on following page)

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Table 1. Demographics and Clinical Characteristics of Women Diagnosed With Breast Cancer and Their Controls (continued)

Demographic or Clinical Characteristic	% of Women With Breast Cancer (n = 66,039)	% of Controls (n = 66,039)	*P*
No. of primary care visits in last 2 years*§			
0	21.4	22.1	
1-3	21.4	20.7	.02
4-6	17.4	16.5	
7-11	20.2	19.9	
≥ 12	19.6	21.0	
Median	5	5	
Interquartile range	1-10	1-10	
Mean	6.7	6.9	< .001
SD	7.4	7.9	
Registry			
Metropolitan Detroit	16.1	16.1	1.0
Iowa	14.6	14.6	
Connecticut	15.1	15.1	
Los Angeles	14.0	14.0	
Seattle/Puget Sound	11.1	11.1	
San Francisco/Oakland	7.3	7.3	
Atlanta	5.9	5.9	
Utah	4.9	4.9	
San Jose-Monterey	4.6	4.6	
New Mexico	4.1	4.1	
Hawaii	2.4	2.4	
Follow-up time, years			
Median	7.8	7.6	
Interquartile range	5.2-10.8	5.2-10.6	
Mean	8.1	8.2	< .001
SD	3.3	3.3	
AJCC breast cancer stage (third edition)			
In situ	13.1		
I	39.7		
II	24.6		
III	4.8		
IV	4.3		
Unknown	13.5		

Abbreviations: SD, standard deviation; AJCC, American Joint Committee on Cancer.
*Assessed using the Mantel-Haenszel test of trend.
†Assessed using the *t* test.
‡Mammography use was examined in the 27 months before diagnosis or follow-up.
§Hospitalizations and primary care visits were examined in the 27 months before diagnosis, excluding the 3 months immediately before diagnosis or follow-up.

RESULTS

Study Sample

Table 1 lists characteristics of patient cases and their matched controls. Matching produced a nearly identical age distribution between patient cases and controls. The presence of comorbidities, frequency of primary care visits, median household income, and proportion of women with less than a high school education by census were also similar between patient cases and controls. Modest differences in race/ethnicity were observed; 2.3% of patient cases were Asian compared with 3.8% of controls, and 1.0% of patient cases were Hispanic compared with 1.9% of controls. This was largely a result of matching within California registries, where some white women with breast cancer matched to Asian or Hispanic controls. The controls were less likely to undergo mammography than patient cases; 54.5% of controls and 34.2% of patient cases were nonusers of mammography.

Survival Outcomes

The median follow-up time for women alive at the end of the study was 7.7 years (interquartile range, 5.3 to 10.7 years). Women diagnosed with DCIS (adjusted hazard ratio [aHR], 0.7; 95% CI, 0.7 to 0.7 and stage I breast cancer: aHR, 0.8; 95% CI, 0.8 to 0.8) had slightly lower mortality than controls after adjustment (Table 2). Women diagnosed with stage II or higher disease were at an increased risk of mortality compared with controls (stage II disease: aHR, 1.2; 95% CI, 1.2 to 1.2). These findings were similar across all age groups. However, among women with stage III or IV disease, the risk of death in relation to controls decreased with age.

Figure 1 presents survival curves for women diagnosed with breast cancer by stage and for controls (Table 3). Women diagnosed with DCIS or stage I disease had slightly better survival than controls through 10 years after diagnosis, whereas women with stage II or higher disease had worse survival than controls through 10 years after diagnosis ($P < .001$).

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Table 2. Relative Survival and aHR of Death of Women With Breast Cancer by Stage and Age Compared With Controls

Group	Overall			Age 67-69 Years			Age 70-74 Years			Age 75-79 Years			Age 80-84 Years			Age ≥ 85 Years		
	Relative Survival (%)*	aHR	95% CI	Relative Survival (%)	aHR	95% CI	Relative Survival (%)	aHR	95% CI	Relative Survival (%)	aHR	95% CI	Relative Survival (%)	aHR	95% CI	Relative Survival (%)	aHR	95% CI
Controls		1.0			1.0			1.0			1.0			1.0			1.0	
Women with cancer																		
DCIS	120	0.7	0.7 to 0.7	112	0.6	0.5 to 0.7	118	0.6	0.5 to 0.7	119	0.7	0.7 to 0.8	140	0.7	0.7 to 0.8	139	0.8	0.7 to 0.9
Stage I	116	0.8	0.8 to 0.8	105	0.9	0.8 to 0.9	116	0.7	0.7 to 0.8	115	0.8	0.8 to 0.9	129	0.8	0.8 to 0.8	131	0.8	0.8 to 0.8
Stage II	91	1.2	1.2 to 1.2	86	1.6	1.4 to 1.7	94	1.2	1.1 to 1.2	90	1.2	1.2 to 1.3	92	1.1	1.0 to 1.2	88	1.2	1.1 to 1.3
Stage III	51	2.3	2.2 to 2.4	56	3.5	3.0 to 4.0	51	2.5	2.3 to 2.8	49	2.6	2.4 to 2.9	51	2.0	1.8 to 2.1	42	2.0	1.8 to 2.1
Stage IV	14	7.1	6.8 to 7.4	15	11.8	10.5 to 13.3	13	9.0	8.2 to 9.7	13	8.6	8.0 to 9.4	14	5.5	5.0 to 6.0	14	4.8	4.4 to 5.3
Unknown stage	82	1.5	1.5 to 1.6	85	1.7	1.5 to 1.9	91	1.2	1.2 to 1.3	78	1.6	1.5 to 1.7	84	1.4	1.3 to 1.5	66	1.7	1.7 to 1.8

NOTE. Each model was adjusted for comorbidity (Charlson comorbidity index), educational attainment of census tract/zip code, median household income of census tract/zip code, race/ethnicity, year of diagnosis/follow-up, mammography use in the past 2 years, and hospitalizations and primary care visits in the past 2 years; the overall model was additionally adjusted by age at diagnosis (67 to 69, 70 to 74, 75 to 79, 80 to 84, 85 to 89, or ≥ 90 years).

Abbreviations: aHR, adjusted hazard ratio; DCIS, ductal carcinoma in situ.

*Relative survival = observed survival in the cancer population/expected survival (survival of the controls).

Treatment Impact

Compared with controls, women age 67 years and older with stage I disease who received standard treatment had slightly lower mortality (aHR, 0.7; 95% CI, 0.7 to 0.8), whereas women who received BCS alone had similar mortality (aHR, 1.0; 95% CI, 1.0 to 1.1; Table 4). Regardless of treatment received, women diagnosed with stage II disease had worse mortality than controls (Table 4). Within both stages, the risk of mortality compared with controls increased with receipt of less aggressive treatment. The association of nonstandard treatment with mortality was smaller for women age 80 years and older than women age 67 to 79 years ($P < .001$ for the interaction between age and treatment on mortality).

Cause of Death

Among women diagnosed with breast cancer (Table 5), we found that at each stage (excluding DCIS), women age 67 to 79 years were more likely to die of breast cancer than women age ≥ 80 years ($P < .001$). Breast cancer was the most common cause of death among all women diagnosed with stage III or IV breast cancer (70.6% died of breast cancer). In contrast, cardiovascular disease was the most common cause of death for women diagnosed with DCIS or stage I disease and for women age ≥ 80 years with stage II disease (33.0%, 30.9%, and 31.8% died of cardiovascular disease, respectively). Only 2.4% of older women diagnosed with DCIS or stage I breast cancer died of breast cancer within 5 years.

Women who received standard treatment for early-stage disease were significantly less likely to die within 5 years than women who did not (16.2% *v* 39.1%, respectively, for stage I and 33.1% *v* 64.0%, respectively, for stage II; $P < .001$ for both). Among those who died, women who received standard treatment were more likely to have breast cancer documented as the cause than women who did not receive standard treatment (16.4% *v* 10.1%, respectively, for stage I and 38.3% *v* 27.1%, respectively, for stage II; $P < .001$ for both; Appendix Table A1, online only).

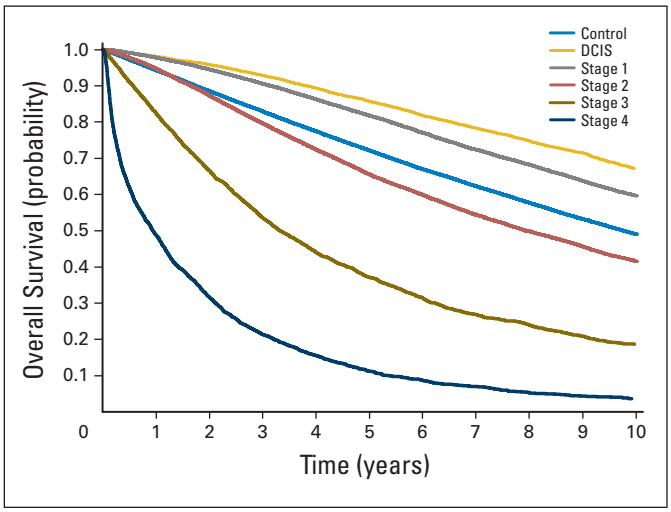

Fig 1. Overall survival of women age 67 years and older by breast cancer stage and of their controls. We excluded women with unknown stage and their matches for these analyses. DCIS, ductal carcinoma in situ.

DISCUSSION

More women age 67 years and older diagnosed with DCIS or stage I breast cancer and women age ≥ 80 years diagnosed with stage II disease die of cardiovascular disease than breast cancer. Women age 67 years and older diagnosed with DCIS or stage I breast cancer are no more likely to die in the next 10 years than women without breast cancer. However, older women diagnosed with stage II disease or higher are at greater risk of mortality than women not diagnosed with breast cancer. When deciding on breast cancer screening, older women and their clinicians must weigh the risk of detecting breast cancers that may not affect life expectancy with the possibility of finding an aggressive breast cancer early.

Consistent with Diab et al,[15] we found that women age 67 and older with stage I disease (lymph node-negative tumors, ≤ 2 cm) had survival similar to or better than women without breast cancer. We further found that older women with stage II disease had worse survival than controls; however, in the study by Diab et al,[15] some of these women would have been classified as having lymph node–negative breast cancer and would have been found to have similar or better survival compared with the general population.

Unlike Diab et al,[15] we additionally examined the impact of DCIS on older women's breast cancer survival. We found that older women

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Table 3. Women at Risk of Death at Each Time Interval*

Group	No. of Women at Risk										
	Follow-Up	1 Year	2 Years	3 Years	4 Years	5 Years	6 Years	7 Years	8 Years	9 Years	10 Years
Women with cancer											
DCIS	8,620	8,450	8,258	8,001	7,024	6,007	4,987	4,094	3,313	2,595	1,958
Stage I	26,211	25,593	24,740	23,709	20,970	18,052	15,168	12,644	10,297	8,157	6,282
Stage II	16,204	15,329	14,114	12,874	10,913	9,003	7,337	5,931	4,688	3,637	2,757
Stage III	3,220	2,653	2,145	1,724	1,338	1,040	811	618	483	364	271
Stage IV	2,861	1,396	906	611	418	271	186	122	81	58	39
Controls	57,116	53,775	50,502	47,289	40,914	34,454	28,383	23,238	18,565	14,482	10,955

Abbreviation: DCIS, ductal carcinoma in situ.
*Excluded women with unknown stage and their matches for these analyses.

diagnosed with DCIS or stage I disease had slightly lower mortality than controls, which may be a result of a healthy user effect.[16,25] To account for this bias, we adjusted our models for mammography use, comorbidity, and health care utilization. Importantly, women diagnosed with DCIS or stage I breast cancer visited primary care with similar frequency to controls (mean visits, 7.0 visits for patient cases and 6.9 visits for controls) and had similar comorbidity (64.4% of patient cases had no Charlson comorbidities compared with 61.1% of controls). If there is a mortality risk for DCIS or stage I breast cancer among women age 67 years and older, the risk is likely low and not strong enough to counterbalance a healthy user effect. Additionally, our findings may be explained by the fact that women diagnosed with early-stage breast cancer may seek more medical attention after diagnosis, allowing for earlier diagnosis and treatment of other diseases and improved overall survival. Our data can be used to reassure women age 67 years and older diagnosed with DCIS or stage I breast cancer (particularly those receiving standard treatment) that their diagnosis is unlikely to significantly affect their life expectancy. Our data also suggest that older women diagnosed with early-stage breast cancer should be counseled about their cardiovascular risk factors because many will die from cardiovascular disease.

Women who received standard treatment for stage I breast cancer had better survival than controls, whereas those who did not receive standard treatment had similar or worse survival than controls. These data suggest that some older women in good health benefit from being diagnosed and treated for stage I breast cancer, preventing progression to more advanced disease, which is clearly associated with worse survival. We also found a dose response to treatment, suggesting that older women be offered standard treatment for early-stage disease.

This study has important limitations. Women with breast cancer may have differed from their controls in ways for which we do not have data (eg, functional status, tobacco use). It is plausible that some controls were misclassified as not having breast cancer. However, because we excluded potential controls if they had claims indicative of breast cancer since 1986, the only ways controls could be misclassified is if they were diagnosed with breast cancer before 1973 (when SEER began) or were somehow not captured by SEER between 1973 and 1985. If any of these women died of breast cancer, they would have been captured in SEER via death certificates. We performed sensitivity analyses to determine the extent to which misclassification of 1% to 2% of our controls would alter our findings (because 1.3% of the control pool had claims for breast cancer after 1985) and found no change in point estimates.

Additionally, data on socioeconomic status were community level rather than individual level; however, studies demonstrate moderate associations between individual and aggregate socioeconomic characteristics.[24] American Joint Committee on Cancer staging

Table 4. Relative Survival and aHR of Death of Women With Stage I or II Breast Cancer by Treatment Received Compared With Controls

Group	Women Age 67-79 Years			Women Age ≥ 80 Years		
	Relative Survival (%)*	aHR	95% CI	Relative Survival (%)*	aHR	95% CI
Women without cancer		1.0			1.0	
Women with cancer						
Stage I and received BCS + XRT or mastectomy	114	0.8	0.7 to 0.8	135	0.7	0.7 to 0.8
Stage I and received BCS alone	94	1.1	1.0 to 1.2	114	1.0	0.9 to 1.1
Stage I and received no initial surgery	85	2.6	1.7 to 4.1	48	2.2	1.6 to 2.9
Stage II and received BCS + XRT or mastectomy	92	1.2	1.2 to 1.3	95	1.1	1.1 to 1.2
Stage II and received BCS alone	61	2.0	1.7 to 2.3	65	1.3	1.2 to 1.4
Stage II and received no initial surgery	58	3.5	2.6 to 4.8	50	2.6	2.0 to 3.2

NOTE. Each model was adjusted for comorbidity (Charlson comorbidity index), educational attainment of census tract/zip code, median household income of census tract/zip code, race/ethnicity, year of diagnosis/follow-up, mammography use in the last 2 years, hospitalizations and primary care visits in the last 2 years, and age (67 to 69, 70 to 74, and 75 to 79 years for the first model and 80 to 84, 85 to 89, and ≥ 90 years for the second model).
Abbreviations: aHR, adjusted hazard ratio; BCS, breast-conserving surgery; XRT, radiotherapy.
*Relative survival = observed survival in the cancer population/expected survival (survival of the controls).

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Table 5. Mortality Incidence by Underlying Cause of Death 5 Years After the Diagnosis of Breast Cancer by Stage and Age

Mortality	Women Age 67-79 Years				Women Age ≥ 80 Years			
	DCIS (n = 4,798)	Stage I (n = 14,765)	Stage II (n = 8,539)	Stage III/IV (n = 2,923)	DCIS (n = 1,325)	Stage I (n = 5,090)	Stage II (n = 3,860)	Stage III/IV (n = 1,871)
5-year mortality								
%*	11	13	26	70	30	34	54	82
95% CI	10 to 12	13 to 14	25 to 27	69 to 72	28 to 33	33 to 36	52 to 56	81 to 84
No.	513	1,960	2,227	2,058	399	1,741	2,082	1,542
Cause of death								
Breast cancer								
%	7	18	47	76	6	11	27	63
95% CI	5 to 10	16 to 20	45 to 49	74 to 78	4 to 9	10 to 13	25 to 29	61 to 66
Other cancers								
%	25	20	11	7	14	11	7	6
95% CI	22 to 29	18 to 22	9 to 12	6 to 8	11 to 17	9 to 12	6 to 8	5 to 7
Cardiovascular disease								
%	27	26	17	8	40	36	32	16
95% CI	23 to 31	24 to 28	16 to 19	7 to 9	35 to 45	34 to 39	30 to 34	14 to 17
Stroke								
%	7	7	4	1	10	10	8	3
95% CI	10 to 13	5 to 8	4 to 5	1 to 2	7 to 13	9 to 12	7 to 9	2 to 4
Infection								
%	5	4	3	1	7	6	6	3
95% CI	3 to 7	3 to 5	3 to 4	1 to 2	4 to 9	5 to 7	5 to 7	2 to 4
COPD								
%	4	6	3	1	4	4	3	1
95% CI	3 to 6	5 to 7	3 to 4	1 to 2	2 to 6	3 to 5	2 to 3	1 to 2
Other								
%	18	16	12	4	16	20	18	7
95% CI	15 to 22	15 to 18	10 to 13	3 to 5	13 to 20	18 to 22	16 to 19	6 to 8
Unknown								
%	3	3	3	2	3	2	1	1
95% CI	1 to 4	2 to 3	2 to 3	1 to 2	1 to 4	1 to 2	1 to 2	0 to 1

NOTE. Not all columns add up to 100% because of rounding.
Abbreviations: DCIS, ductal carcinoma in situ; COPD, chronic obstructive pulmonary disease.
*These percentages are calculated by dividing the number of women who died after 5 years divided by the number of women diagnosed with breast cancer between 1992 and 2000 rounded to the nearest integer for each stage.

changed in 2003, which may limit the generalizability of our findings. The greatest change in the staging system was that women with four or more positive lymph nodes are now categorized as having stage III rather than stage II disease.[26] We repeated our analyses excluding women with four or more positive lymph nodes from stage II, and our aHR decreased from 1.2 to 1.1 but remained statistically significant. Although we found that women who received standard treatment were more likely to have breast cancer documented as the cause of death than women who received nonstandard treatment, standard treatment was not associated with an increased odds of death as a result of breast cancer (adjusted odds ratio, 1.1; 95% CI, 0.9 to 1.3) after adjustment for all covariates and tumor characteristics, suggesting that the elevated unadjusted risk was likely a result of confounding by indication. Finally, we were unable to match 1.4% of women diagnosed with breast cancer to a control. However, because we matched the oldest women diagnosed with breast cancer first, those who did not match were more likely to be younger than 75 years old but were otherwise similar to women who did match on other important characteristics including race/ethnicity, comorbidity, and proxies for income and education.

Overall, survival for women age 67 years or older diagnosed with DCIS or stage I breast cancer is slightly better than survival for women not diagnosed with breast cancer. However, survival is worse for older women diagnosed with stage II disease or higher compared with women not diagnosed with breast cancer. When discussing mammography screening, clinicians should inform older women that mammography may commonly detect breast cancers that will not affect their survival but may also find an advancing breast cancer early. Older women's life expectancy and comorbid diseases should be routinely factored into mammography screening decisions.

AUTHORS' DISCLOSURES OF POTENTIAL CONFLICTS OF INTEREST

The author(s) indicated no potential conflicts of interest.

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