ORIGINAL INVESTIGATION

Cancer Survival Among US Whites and Minorities

A SEER (Surveillance, Epidemiology, and End Results) Program Population-Based Study

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Background: Available cancer statistics pertain primarily to white and African American populations. This study describes racial or ethnic patterns of cancer-specific survival and relative risks (RRs) of cancer death for all cancers combined and for cancers of the colon and rectum, lung and bronchus, prostate, and female breast for the 6 major US racial or ethnic groups.

Methods: Cancer-specific survival rates were analyzed for more than 1.78 million patients who resided in the 9 SEER (Surveillance, Epidemiology, and End Results) Program geographic areas and were diagnosed between 1975 and 1997 as having an incident invasive cancer, by 6 racial or ethnic groups (non-Hispanic whites, Hispanic whites, African Americans, Asian Americans, Hawaiian natives, and American Indians and Alaskan natives).

Results: Survival rates improved between 1988 to 1997 for virtually all racial or ethnic groups. However, racial or ethnic differences in RRs of cancer death persisted after controlling for age for all cancers combined and for age and stage for specific cancer sites ($P<.01$). African American, American Indian and Alaskan native, and Hawaiian native patients tended to have higher RRs of cancer death than the other groups. American Indians and Alaskan natives generally exhibited the highest RRs of cancer death, except for colorectal cancer in males.

Conclusions: Survival rates in patients with cancer have improved in recent years, but racial or ethnic differences in survival rates and in RRs of cancer death persist. Additional studies are needed to clarify the socioeconomic, medical, biological, cultural, and other determinants of these findings.

Arch Intern Med. 2002;162:1985-1993

CANCER IS the second leading cause of death in the United States, and it accounts for approximately one fourth of all deaths. In 2002, an estimated 1.28 million Americans will be diagnosed as having cancer (other than carcinomas of the skin), and 555 500 people will die of cancer.[1] The most common cancers in men are of the prostate, lung (including bronchus), colon and rectum, whereas women are most likely to develop carcinomas of the breast, lung, colon, and rectum.

United States cancer incidence and survival data are collected on a routine basis from population-based cancer registries that participate in the SEER (Surveillance, Epidemiology, and End Results) Program of the National Cancer Institute. Published SEER Program data show that for most cancers, including the 4 major ones (colorectal, lung and bronchus, female breast, and prostate), the survival rate in African American patients was poorer than that in white patients, although survival rates improved in recent years for both groups.[2] Information is limited on patient survival in other racial or ethnic minorities.

The survival measure used in this study quantifies the likelihood that a patient with cancer will not die of the neoplasm within a specified time after diagnosis. The survival rates presented herein use population-based data and, therefore, are less affected by referral patterns and other sources of bias that might be associated with hospital-based case series.

This article describes and compares cancer-specific survival rates and relative risks (RRs) of cancer death in patients diagnosed as having a first malignant neoplasm between January 1, 1975, and December 31, 1997, in 9 SEER Program areas. The cancers included in the study are all cancers combined and 4 major cancers: female breast, colorectal, lung (including bronchus), and prostate. We used the SEER Program data in which patient race

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or ethnicity was recorded into 1 of the following groups: non-Hispanic white, Hispanic white, African American, American Indian or Alaskan native, Chinese, Japanese, Filipino, Hawaiian native, other, and unknown. The analyses presented include 2 periods (January 1, 1975, to December 31, 1987, and January 1, 1988, to December 31, 1997), and 6 major US racial or ethnic groups: non-Hispanic whites, Hispanic whites, African Americans, American Indians and Alaskan natives, Asian Americans (Chinese, Japanese, and Filipino), and Hawaiian natives. These 6 groups contributed approximately 99% of the cases throughout the 1975 to 1997 period. The focus of the analysis is on racial or ethnic patterns of survival for patients diagnosed in the recent period (1988-1997). Changes over time in patient survival are also examined.

PARTICIPANTS AND METHODS

STUDY POPULATIONS AND DATA SOURCES

The SEER Program currently collects cancer incidence and survival information from 10 population-based cancer registries that encompass nearly 14% of the total US population. This study used the data from 9 geographic areas that have been included in the SEER Program since 1975 (Connecticut, Hawaii, Iowa, New Mexico, and Utah and the metropolitan areas of Atlanta, Ga; Detroit, Mich; Seattle–Puget Sound, Wash; and San Francisco–Oakland, Calif). Based on 1990 census data, these 9 SEER Program areas cover more than 9% of the US population; the percentages by race are 9% of US non-Hispanic whites, 8% of Hispanic whites, 9% of African Americans, 29% of Asian Americans (Chinese, Japanese, and Filipino), 14% of American Indians, and 66% of Hawaiian natives.

This study included 1 779 458 patients in the 6 racial or ethnic groups who resided in the 9 SEER Program geographic areas, were diagnosed as having a first invasive cancer during 1975 to 1997, and were followed for vital status through December 31, 1998. The analyses focused on cancer-specific survival rates and on RRs of cancer death for all cancers combined and for cancers of the breast (females only), lung (including bronchus), prostate, and colorectal. These 4 cancers accounted for more than 50% of all incident cancers diagnosed in the SEER Program areas during these years.[2] Approximately 5% of patients were lost to follow-up before January 1, 1999. Excluded from the study were patients with cancer who died of unknown causes (n=36 932), those whose initial diagnosis was found on the death certificate or at autopsy (n=29 282), and those who were not being actively followed (n=3). Cancer site and morphology were coded according to the *International Classification of Diseases for Oncology, Second Edition*; cancers with histologic codes 9590 through 9989 (extranodal lymphomas) within each of the 4 cancer sites were excluded.[2]

CANCER STAGING

Cancer stage was determined by the extent of cancer spread from the site of origin at initial diagnosis. The SEER Program staging scheme classified invasive cancers into 4 stages: localized to the primary tumor site, tumor with regional spread, tumor with distant metastases, and unknown (when relevant data were unavailable or when stage was assigned >4 months after initial diagnosis). Data on cancer stage were included for breast, colorectal, lung, and prostate cancers. For prostate cancer, local and regional stages were combined because these 2 stages were no longer distinguishable in the SEER Program staging scheme after American Joint Committee on Cancer staging practices were changed in 1995.[3] For lung cancer, a coding change associated with the presence of pleural effusion for patients diagnosed after January 1, 1988, resulted in these patients being staged as having distant disease rather than localized or regional disease.[4] This change increases the number of patients coded as having distant stage disease. Therefore, analyses of trends in lung cancer survival rates over time were precluded.

STATISTICAL ANALYSIS

The statistical significance of racial or ethnic differences, by sex, in distributions over potential prognostic factors at diagnosis was assessed using χ^2 tests of associations. The 2 prognostic factors considered were cancer stage and age category (<50, 50-54, 55-59, 60-64, 65-69, 70-74, and >74 years). All tests of significance were performed separately by sex and by cancer site.

The Kaplan-Meier estimator[5] was used to estimate cancer-specific survival rates. Deaths attributed to causes other than the underlying cancer were treated as losses to follow-up at the date of death under the assumption that deaths from the underlying cancer were independent of deaths from other causes. Therefore, a cancer-specific survival rate, for example, the 5-year cancer-specific survival rate, provides an estimate of the likelihood of surviving 5 years if cancer is the only cause of death. Survival times were measured in months and were censored at the date of a patient being lost to follow-up (about 5%), the date of death from causes other than the underlying cancer, or on December 31, 1998 (whichever occurred first).

When comparing survival for patients diagnosed in 1975 to 1987 with those diagnosed in 1988 to 1997, survival times were censored at 5 years to provide equal duration of follow-up. Five-year survival rate was chosen as a conventional survival statistic that could be reliably estimated and compared for the 2 periods.

For the later period of diagnosis (1988-1997), survival curves by race or ethnicity are presented. The maximum possible follow-up was approximately 11 years (131 months); however, the survival curves were plotted only up to the last follow-up time when at least 1 cancer death occurred. The survival curves did not start from 100% because some patients died within a month of diagnosis, which resulted in "zero" survival time because only month and year were used for the calculation.

Relative risks (hazard ratios) of cancer death (by cancer type and sex) were used to access racial or ethnic differences in cancer survival for patients diagnosed during 1988 to 1997 with up to 11 years of follow-up. The RRs were calculated using the Cox regression model to adjust for age at diagnosis for all cancers combined and for age and tumor stage for each cancer site examined.[6] To avoid the strong assumption of proportional hazards, the baseline hazards were stratified by age and stage (ie, stratified Cox model). Indicator variables for each racial or ethnic group were introduced into the stratified Cox model, with non-Hispanic whites as the reference group. The assumption of proportional hazards for race or ethnicity was checked by graphing the log of the negative log of the survival functions vs the log of time for each racial group. Plotted lines were roughly parallel over time and were inferred to show proportionality.

Stratified Cox models (by age for all cancers combined or by age and stage for each common cancer site) were also used to assess racial or ethnic changes in survival rates at 5 years over time, by cancer type and sex, for patients diagnosed during 1975 to 1987 and those diagnosed during 1988 to 1997. Because of the 1988 changes in the staging classification for lung cancer, changes in survival during the 2 periods for lung cancer were not assessed. Indicator variables for the 2 periods and the racial or ethnic groups, and interactions between these pe-

Table 1. Invasive Cancers Diagnosed by Sex, Primary Cancer Site, and Race or Ethnicity for the 9 SEER Program Areas, 1975-1997*

Sex and Cancer Type	Race or Ethnicity						Total
	Non-Hispanic White	Hispanic White	African American	American Indian and Alaskan Native	Asian American	Hawaiian Native	
Males							
All cancers	765 250	27 217	84 913	2474	32 781	4386	**917 021**
Lung or bronchus	132 416	3151	18 135	307	5320	1109	**160 438**
Colorectal	95 455	3073	8246	259	5758	517	**113 308**
Prostate	192 953	6802	25 433	530	7181	621	**233 520**
Females							
All cancers	730 857	26 534	68 652	2700	28 920	4774	**862 437**
Lung or bronchus	75 324	1990	7759	174	2459	597	**88 303**
Colorectal	95 313	2676	9194	222	4052	339	**111 796**
Breast	220 661	7434	19 717	614	8600	1536	**258 562**

*Data are given as number of patients. SEER indicates Surveillance, Epidemiology, and End Results. The 9 SEER program geographic areas are Connecticut, Hawaii, Iowa, New Mexico, and Utah and the metropolitan areas of Atlanta, Ga; Detroit, Mich; Seattle–Puget Sound, Wash; and San Francisco–Oakland, Calif.

riods and race or ethnicity, were introduced as covariates into the stratified Cox model. Assumptions of proportional hazards for period of diagnosis were checked in the same manner as for race or ethnicity. *P* values from Wald χ^2 tests were used to assess the statistical significance of changes in survival rates between 1975 to 1987 and 1988 to 1997 for each of the racial or ethnic groups after taking into account the significance of interaction terms between period and race or ethnicity. These comparisons were made by sex for all cancers combined and for each of the 4 cancers studied. All tests were 2-sided. Statistical software (SAS version 6; SAS Institute Inc, Cary, NC) was used for all analyses.

RESULTS

There were 917 021 eligible males (51.5% of all patients) and 862 437 eligible females (48.5%) diagnosed as having an incident malignant cancer in the 9 SEER Program areas in 1975 to 1997 (**Table 1**). Approximately 54% of the patients were diagnosed as having the following cancers: lung or bronchus (n = 248 741), colorectal (n = 225 104), female breast (n = 258 562), and prostate (n = 233 520). Non-Hispanic whites accounted for 84% of all patients with cancer, whereas African Americans accounted for 9%, Hispanic whites for 3%, Asian Americans for 3%, Hawaiian natives for less than 1%, and American Indians and Alaskan natives for less than 1%.

Table 2 gives the distributions of cancer stage by race or ethnicity and period of diagnosis (1975-1987 or 1988-1997) for cancers of the prostate, breast (females), colon, rectum, and lung in both sexes combined. The differences in distribution of stage by period were statistically significant for all racial and ethnic groups for each of the 3 cancers for which comparisons could be made ($P<.001$ for all). The increases in the percentage of patients with distant stage lung cancer in 1988 to 1997 reflected changes in SEER Program coding practices for lung cancer in 1988, and, therefore, these percentages should not be compared for the 2 periods. The percentage of patients with distant stage colorectal, breast, and prostate cancer declined over time for each racial or ethnic group, except for colorectal cancer in Hispanic whites and American Indians and Alaskan natives and breast cancer in American Indian and Alaskan native and Asian American women. For patients diagnosed during 1988 to 1997, American Indians and Alaskan natives had the highest percentages of distant stage cancer of the lung, breast, and prostate; American Indians and Alaskan natives and African Americans had the highest percentages of distant stage colorectal cancer. In addition, distributions by age at diagnosis differed by race or ethnicity for each of the 4 major cancer sites and for all cancers combined ($P<.001$ for all) (data not shown). Non-Hispanic whites and Asian Americans tended to be diagnosed as having cancer at older ages than the other racial or ethnic groups, possibly in part because of their longer life expectancy.

Figure 1 and **Figure 2** show sex- and site-specific cancer survival curves for patients diagnosed during 1988 to 1997. For all cancers combined, cancer-specific survival rates 5 years after diagnosis were approximately 45% to 60% in males and 50% to 65% in females in the 6 racial or ethnic groups; thereafter, the cancer survival curves approached a plateau. Survival curves for colorectal cancers mimicked those for all cancers combined, whereas lung cancer survival in both sexes declined rapidly and reached a plateau of 20% at 3 years. Survival for breast and prostate cancer showed steady declines throughout the first decade after diagnosis. American Indian and Alaskan native males and females with cancer had the lowest survival rates for cancers of the breast, lung, and prostate and for all cancers combined. African Americans had lower survival rates for colorectal, prostate, and breast cancers. In contrast, Hispanic whites, non-Hispanic whites, and Asian Americans tended to have the best survival rates for the cancer sites examined.

Table 3 gives adjusted RRs of cancer death for male and female patients diagnosed during 1988 to 1997 for the 4 cancers studied and for all cancers combined. Non-Hispanic whites are the reference group in all comparisons. The overall test for racial or ethnic differences in risk of cancer death was statistically significant for each cancer site and for all cancers combined ($P<.01$ for all). The RRs for every minority group other than Asian Americans were statistically significantly higher for each of the 4 cancers and for all cancers com-

Table 2. Stage Distributions for Primary Cancers of the Lung or Bronchus, Colorectal, Prostate, and Female Breast by Race or Ethnicity and Diagnosis Period*

Cancer Type and Racial or Ethnic Group	Cancer Stage			
	Localized	Regional	Distant	Unknown
Colorectal cancer†				
Non-Hispanic white	34.5/37.6	38.1/37.2	20.3/19.5	7.1/5.8
Hispanic white	33.1/36.4	40.2/37.5	19.8/20.3	6.9/5.8
African American	30.5/33.1	36.1/34.9	25.2/24.5	8.2/7.5
American Indian and Alaskan native	27.2/30.1	45.1/40.1	19.8/24.4	7.9/5.4
Asian American	37.0/41.2	40.3/38.0	18.3/16.0	4.5/4.8
Hawaiian native	40.8/35.6	31.7/37.2	22.9/22.0	4.5/5.2
Lung or bronchus cancer‡				
Non-Hispanic white	20.4/14.9	30.1/23.3	38.8/47.3	10.9/14.6
Hispanic white	21.6/14.9	29.4/24.3	38.2/47.8	10.7/13.0
African American	19.4/13.1	30.3/23.8	40.2/51.0	10.0/12.1
American Indian and Alaskan native	20.1/12.6	29.6/19.2	36.9/52.7	13.4/15.6
Asian American	19.4/13.3	30.2/26.3	40.5/48.8	9.9/11.7
Hawaiian native	19.4/11.9	34.3/27.2	41.2/49.4	5.1/11.5
Female breast cancer†				
Non-Hispanic white	50.5/62.9	38.5/28.4	6.9/5.4	4.1/3.2
Hispanic white	47.2/56.2	41.5/34.1	7.1/6.4	4.2/3.2
African American	41.6/51.5	43.4/34.2	10.4/8.8	4.6/5.4
American Indian and Alaskan native	40.7/49.9	47.6/37.6	7.4/9.4	4.3/3.1
Asian American	58.4/66.2	34.6/27.0	4.6/4.8	2.5/2.0
Hawaiian native	51.2/59.5	37.8/31.6	9.9/6.3	1.2/2.6
Prostate cancer†§				
Non-Hispanic white	73.8/80.4		18.1/7.5	8.0/12.1
Hispanic white	76.1/83.1		17.8/9.7	6.1/7.3
African American	65.5/74.5		27.2/12.4	7.3/13.1
American Indian and Alaskan native	67.0/74.3		25.1/17.1	7.9/8.6
Asian American	73.3/80.5		22.5/11.5	4.1/8.0
Hawaiian native	69.5/81.6		26.8/15.9	3.8/2.5

*Data are given as percentage of patients, 1975-1987/1988-1997.
†$P<.001$ for the overall test of racial or ethnic differences in stage distributions by period. The test performed was a χ^2 test with 15 *df*, except for prostate cancer, which had 10 *df*.
‡Differences in stage distribution over time were not tested for lung cancer because of the 1998 coding change.
§Localized and regional stages of prostate cancer were combined because they are not distinguishable after 1995.

bined. Asian American males and females had the lowest RRs for each of the 4 cancers (RR, 0.73-0.93), and Asian American females also had the lowest RR for all cancers combined. In contrast, American Indians and Alaskan natives of both sexes had the highest RRs for all cancers combined (adjusted RRs, 1.7 for males and 1.8 for females) and for most of the 4 common cancers (adjusted RRs, 1.1-2.0). Exceptions were a higher RR for colorectal cancers in African American males (RR, 1.2; 95% confidence interval, 1.2-1.3) and an equally high RR for breast cancer in African American females (RR, 1.6; 95% confidence interval, 1.6-1.7).

Table 3 also gives 5-year race- and sex-specific survival rates for patients diagnosed during 1975 to 1987 and 1988 to 1997 and changes in these rates between the 2 periods. The statistical significance of the differences in improvements in survival across the racial or ethnic groups over time for each cancer was assessed by testing for interactions between diagnosis period and racial or ethnic group based on the stratified Cox model. All tests for evidence of an interaction were significant ($P<.10$ for all comparisons), except for colorectal cancer ($P>.10$ for all comparisons). The significance of these tests was accounted for when comparing survival rates over time for each racial or ethnic group. The changes in survival for lung cancer were not tested because the 1988 changes in coding practices affect stage. Men and women in all 6 racial or ethnic groups had significantly improved survival rates in the later period for all cancers combined ($P<.01$ for all comparisons). Survival rates for Hispanic and non-Hispanic whites, African Americans, and Asian Americans with breast, colorectal, or prostate cancer were also improved significantly ($P<.01$ for males and females in each racial or ethnic group). Significant improvements in survival rates were observed for American Indians and Alaskan natives with breast or prostate cancer and for males with colorectal cancer. Survival rates for Hawaiian native females with breast cancer also improved significantly ($P<.01$), but they also had a nonsignificant decrease in the 5-year survival rate for colorectal cancer ($P=.53$).

COMMENT

Data from the SEER Program were analyzed to study racial or ethnic patterns in cancer-specific survival and RRs of cancer death by sex. Our results update and extend previously published studies[7-10] that focused largely on

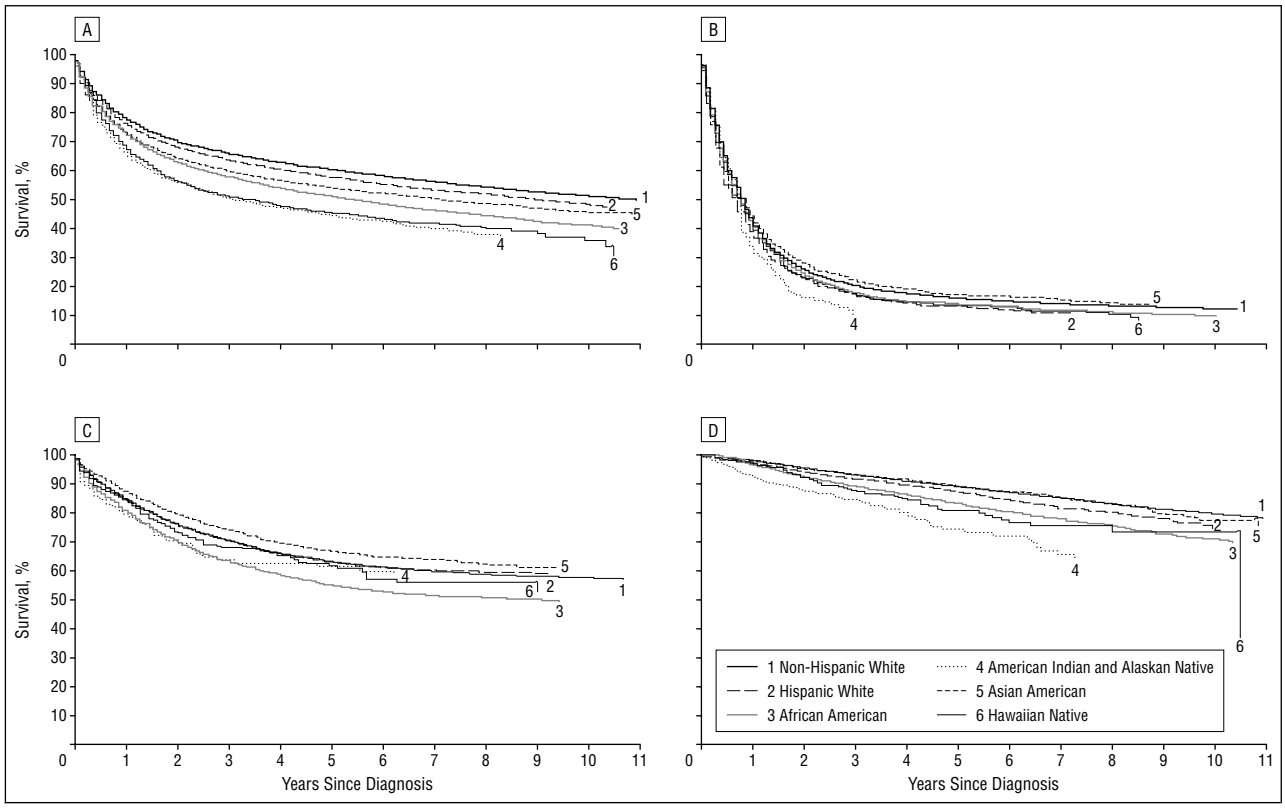

Figure 1. Male survival by race or ethnicity for all cancers combined (A) and for lung (B), colorectal (C), and prostate (D) cancers. Surveillance, Epidemiology, and End Results Program, 1988-1997.

whites and African Americans and provide first-known population-based comparisons of RRs of cancer death and cancer-specific survival among the 6 major US racial or ethnic groups. This study was facilitated by the intentional coverage by the SEER Program of certain geographic areas with relatively large racial or ethnic population subgroups so that some information on the cancer burden would be available for these groups.[11] Although geographic areas included in the SEER Program were not selected randomly, they include various levels of urbanization and socioeconomic status. Thus, descriptive studies based on SEER Program data, which cover large percentages of the populations being studied, provide insights at the national level.

Relative risks of cancer death and cancer-specific survival rates improved for the 6 racial or ethnic groups of patients with cancer diagnosed during 1988 to 1997 compared with those diagnosed during 1975 to 1987. However, the extent of improvement varied by race or ethnicity. Racial or ethnic differences in RRs of cancer death were found for patients diagnosed during 1988 to 1997 after controlling for age and stage for each of the 4 common cancers and age only for all cancers combined. In this period, non-Hispanic white, Hispanic white, and Asian American patients of both sexes tended to have lower adjusted RRs of cancer death than African Americans, American Indians and Alaskan natives, and Hawaiian natives. American Indians and Alaskan natives had the least favorable adjusted RRs of cancer death for all cancers combined and for each of the individual cancers examined compared with non-Hispanic whites, except for male patients diagnosed as having colorectal cancer. However, the numbers of American Indian and Alaskan native and Hawaiian native patients were small, and their survival rate estimates might be less stable than those for larger racial or ethnic groups. The finding that Asian American patients of both sexes had the lowest adjusted RR of cancer death (except for all cancers combined in male patients) merits additional study because the deaths would not be recorded in the United States if patients returned to their homeland for family support or terminal care.

Differences in access to and utilization of effective cancer screening and treatment services by race or ethnicity might explain some of our findings. Mammography screening has been shown in randomized clinical trials[12,13] to reduce breast cancer mortality rates, especially in women 50 years and older. In the 1994 National Health Interview Survey,[14] 62% of female respondents (aged ≥50 years) reported mammography screening in the past 2 years, a substantial increase from 27% in 1987. Our analysis of the public use data from the 1998 National Health Interview Survey indicated that the 2-year mammography screening rate for the group 50 years and older has increased to 69%; the findings by race or ethnicity were 70% for non-Hispanic whites, 67% for African Americans, 63% for Asian Americans and Pacific Islanders, 61% for Hispanic whites, and 51% for American Indians and Alaskan natives. The lower mammography screening rate and the observed small fraction of localized breast cancers found for American Indian and Alaskan native female patients could partly explain their relatively low survival rates.

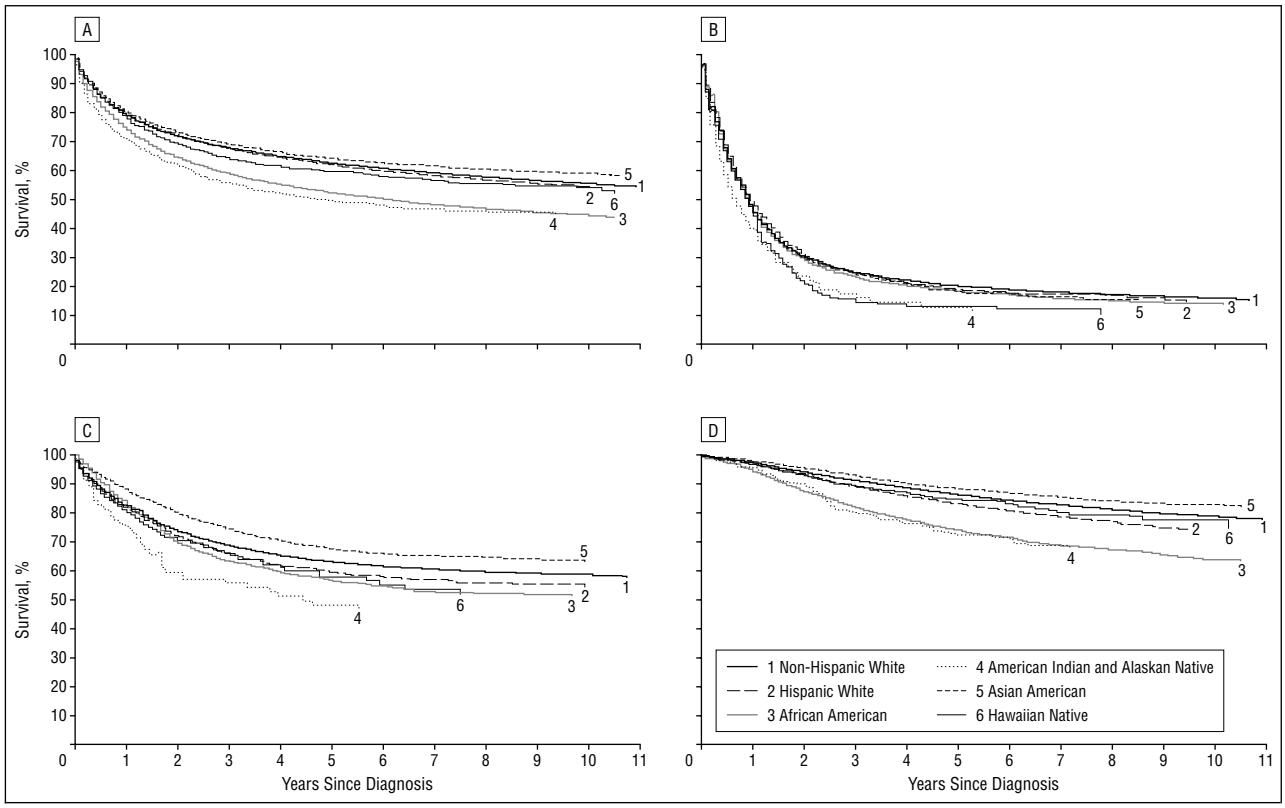

Figure 2. Female survival by race or ethnicity for all cancers combined (A) and for lung (B), colorectal (C), and breast (D) cancers. Surveillance, Epidemiology, and End Results, 1988-1997.

For 1988 to 1997, despite minor differences in their reported mammography screening rates in 1998, a smaller percentage of African American patients were diagnosed as having localized breast cancer compared with non-Hispanic whites (52% vs 63%), and they also had a 60% higher adjusted risk of breast cancer death than non-Hispanic whites. This finding might account in part for breast cancer mortality rates being higher in African American women than white women diagnosed during 1990 to 1996 in the SEER Program population[15] and the entire US population.[14] One explanation is that screening benefits in African American women have not yet been realized because decreases in breast cancer mortality rates due to screening lag behind increases in mammography utilization.

Other possible explanations for the observed racial or ethnic differences in RRs of cancer death include differences in access to optimal treatments that reduce cancer mortality rates. Some studies[16-18] have reported that as many as 30% to 50% of minority women with abnormal mammography findings did not receive timely follow-up. Low socioeconomic status, lack of health insurance, and low literacy can also delay diagnosis and reduce access to optimal therapies.[19-22] Unfavorable adjusted RRs of cancer death in American Indians and Alaskan natives and Hispanics might also be explained by cultural factors, such as reliance on only traditional health care providers.[23] In addition, unmeasured biological determinants of breast cancer survival might partly explain our findings. Nuclear atypia, high histologic grade, increased fraction of S-phase cells, and necrosis have been reported[24] as unfavorable prognostic factors more often associated with breast cancers in African American women compared with those found in white women. Mutations in the p53 gene also differ among the races, and certain p53 gene mutations might be independent predictors of lower survival among African Americans but not whites.[25,26] The lowest RRs of breast cancer death for Asian American women might be mediated by constitutional factors.[27]

Recent US guidelines[28-30] recommended that persons 50 years and older and at average risk for colorectal cancer undergo 1 or more of the following screening tests: fecal occult blood testing annually and sigmoidoscopy every 5 years, colonoscopy every 10 years, or double-contrast barium enema every 5 to 10 years. Randomized clinical trials[31-34] have demonstrated that fecal occult blood testing decreases mortality rates of colorectal cancer among those aged 50 to 80 years. Our analysis of the 1998 National Health Interview Survey indicated that non-Hispanic whites (aged ≥50 years) had the highest fecal occult blood testing rates (37% for males and 36% for females). The rate was 35% for American Indian and Alaskan native males but only 17% for American Indian and Alaskan native females (sample sizes were small). Assuming that relatively little fecal occult blood testing was done during 1975 to 1987 in American Indians and Alaskan natives, the sex difference in recent screening patterns probably contributed to the temporal increases in colorectal cancer survival rates among American Indian and Alaskan native males but not females.

Prostate cancer screening by digital rectal examination, transrectal ultrasound, or serum prostate-

Table 3. Adjusted Relative Risk (RR) of Cancer Deaths for Patients Diagnosed in 1988-1997 and 5-Year Cancer-Specific Survival Rates for Both Periods, by Cancer Type, Race or Ethnicity, and Sex*

Cancer Type and Race or Ethnicity	Males		Females	
	Adjusted RR (95% CI) vs Non-Hispanic Whites	5-y Survival, 1975-1987/1988-1997 (Difference), %	Adjusted RR (95% CI) vs Non-Hispanic Whites	5-y Survival, 1975-1987/1988-1997 (Difference), %
All cancers†‡				
Non-Hispanic white	1.0	35.4/55.1 (19.7)§	1.0	45.9/58.0 (12.1)§
Hispanic white	1.1 (1.1-1.2)	34.8/52.7 (17.9)§	1.2 (1.1-1.2)	44.4/57.3 (12.9)§
African American	1.3 (1.3-1.4)	24.6/45.6 (21.0)§	1.5 (1.5-1.5)	36.8/47.1 (10.3)§
American Indian and Alaskan native	1.7 (1.5-1.8)	24.8/39.9 (15.1)§	1.8 (1.7-2.0)	35.9/46.5 (10.6)§
Asian American	1.2 (1.1-1.2)	32.9/49.6 (16.7)§	0.99 (0.96-1.0)	50.6/60.8 (10.2)§
Hawaiian native	1.6 (1.5-1.7)	24.2/40.3 (16.1)§	1.3 (1.2-1.4)	43.7/55.8 (12.1)§
Lung/bronchus†				
Non-Hispanic white	1.0	10.6/13.6	1.0	14.7/17.3
Hispanic white	1.1 (1.0-1.1)	9.7/11.1	1.0 (0.95-1.1)	13.7/16.4
African American	1.1 (1.0-1.1)	9.4/11.2	1.0 (1.0-1.1)	12.6/15.3
American Indian and Alaskan native	1.2 (1.1-1.5)	7.9/10.2	1.3 (1.0-1.6)	15.5/10.9
Asian American	0.93 (0.89-0.97)	11.9/15.0	0.91 (0.85-0.97)	14.0/16.1
Hawaiian native	1.0 (0.94-1.1)	9.7/10.5	1.2 (1.0-1.3)	13.3/11.5
Colorectal†				
Non-Hispanic white	1.0	49.0/59.1 (10.1)§	1.0	50.5/59.7 (9.2)§
Hispanic white	1.1 (1.0-1.2)	47.2/54.6 (7.4)§	1.2 (1.1-1.3)	49.6/56.1 (6.5)§
African American	1.2 (1.2-1.3)	41.9/50.9 (9.0)§	1.2 (1.1-1.2)	46.5/52.4 (5.9)§
American Indian and Alaskan native	1.1 (0.86-1.5)	37.9/58.0 (20.1)‖	1.5 (1.1-1.9)	41.5/46.1 (4.6)
Asian American	0.93 (0.87-1.0)	52.0/62.9 (10.9)§	0.93 (0.86-1.0)	54.4/64.6 (10.2)§
Hawaiian native	1.1 (0.94-1.4)	49.0/55.4 (6.4)	1.1 (0.89-1.4)	54.2/52.9 (–1.3)
Prostate†‡				
Non-Hispanic white	1.0	58.1/84.5 (26.4)§	. . .	. . .
Hispanic white	1.1 (1.0-1.2)	57.6/81.6 (24.0)§	. . .	. . .
African American	1.3 (1.3-1.4)	48.2/77.5 (29.3)§	. . .	. . .
American Indian and Alaskan native	2.0 (1.6-2.5)	38.0/67.9 (29.9)§	. . .	. . .
Asian American	0.73 (0.67-0.79)	58.0/84.7 (26.7)§	. . .	. . .
Hawaiian native	1.3 (1.0-1.7)	56.1/75.5 (19.4)	. . .	. . .
Breast cancer†‡				
Non-Hispanic white	. . .	. . .	1.0	63.5/81.5 (18.0)§
Hispanic white	. . .	. . .	1.1 (1.1-1.2)	61.2/77.6 (16.4)§
African American	. . .	. . .	1.6 (1.6-1.7)	52.7/67.7 (15.0)§
American Indian and Alaskan native	. . .	. . .	1.6 (1.3-2.0)	50.2/68.9 (18.7)§
Asian American	. . .	. . .	0.87 (0.80-0.95)	71.6/84.8 (13.2)§
Hawaiian native	. . .	. . .	1.1 (0.95-1.4)	63.1/79.8 (16.7)§

*Up to 11 years of follow-up. Using stratified Cox models, RRs for all cancers combined are adjusted for age, and those for individual cancers are adjusted for age and tumor stage. Survival changes over time for lung cancer were not compared because of the 1988 change in stage classification. CI indicates confidence interval.

†$P<.01$ for the overall test of racial or ethnic differences in RRs of cancer death using stratified Cox models.

‡$P<.10$ for the overall test of interactions between race or ethnicity and period using stratified Cox models.

§$P<.01$ for testing changes over time in patient survival (taking into account significant interactions between race or ethnicity and period) using stratified Cox models.

‖$P<.05$ for testing changes over time in patient survival (taking into account significant interactions between race or ethnicity and period) using stratified Cox models.

specific antigen (PSA) is controversial because of the lack of definitive evidence of benefit, although some observational studies suggest a benefit.[35] Uncertainties regarding optimal treatment of localized cancers have added to the controversy.[36-41] However, subsequent to the introduction of the PSA test in 1986 to monitor disease status in patients with prostate cancer, the incidence of prostate cancer increased dramatically, apparently owing to use of the PSA test for diagnosis and screening rather than for disease monitoring only. Increases in prostate cancer survival rates for patients diagnosed during 1988 to 1997 are likely due in part to lead-time bias, overdiagnosis, and a benefit from screening if screening using the PSA test is, in fact, efficacious. In this study, increases in prostate cancer survival rates over time were observed for all racial or ethnic groups.

Screening and treatment for lung cancer have done little to improve disease outcomes. Randomized controlled trials have yet to demonstrate that screening with radiography, sputum cytology, or helical (spiral) computed tomography reduces lung cancer mortality rates.[42,43] Presently, smoking cessation and prevention programs represent the best strategies for reducing lung cancer mortality rates. To date, the survival data observed for lung cancer by race and sex indicate little change over time.

Welch et al[44] recently criticized the use of improvements in 5-year survival rates over time as a valid measure of success against cancer. Lead-time bias, length bias, and overdiagnosis from screening can create the appearance of an improvement in 5-year survival rates when none has occurred. These authors[44] ad-

vocated the use of population-based cancer mortality rates over time as the gold standard for assessing progress against cancer, and we do not disagree with them. Because population estimates are not available for several of the racial or ethnic groups examined in this study, it is not possible for us to calculate population-based mortality rates for them.

There is little doubt that our data reflect lead-time bias and length bias, particularly for prostate cancer. Also, the differential effect of screening over time due to variation in screening rates is a confounder when analyzing temporal changes in survival rates in diverse racial or ethnic groups. We recognized that changes in survival over time might be confounded by the differential effects of various early interventions, and our analyses focused on racial or ethnic patterns in survival for the later period. It is recognized that survival measures for 1988 to 1997 are also potentially confounded by the differential effects of cancer control interventions, although our results are consistent with SEER Program data[15] showing that during 1990 to 1996 African Americans had higher population-based mortality rates than whites for most major cancer sites other than lung cancer.

Our analysis used cancer-specific survival rather than relative survival, which is used in National Cancer Institute publications on cancer statistics.[2] Relative survival is the ratio of observed all-cause survival to expected survival as obtained from US life tables for selected periods.[45] However, reliable expected life tables are not available for Hispanic whites, Hawaiian natives, American Indians and Alaskan natives, and Asian Americans to generate valid relative survival estimates. To obtain reliable estimates of cancer-specific survival rates it is essential that classification of the underlying cause of death on death certificates is accurate. For colorectal, lung, breast, and prostate cancers, levels of accuracy exceed 90% for the underlying cause of death,[46] although it is conceivable that cause of death accuracy may vary based on health care access issues. In addition, cancer-specific survival rates are consistent with population-based cancer mortality rates, which are also based on the underlying cause of death.

Limitations of our study include the relatively small number of cancers diagnosed in some minorities, particularly American Indians and Alaskan natives and Hawaiian natives. In addition, our analyses only controlled for age and tumor stage at diagnosis because data were not available for other potential prognostic factors, such as socioeconomic status, comorbid diseases, and health insurance status. Nevertheless, our study results are consistent with previous studies showing lower breast cancer survival rates for African American women compared with white women after controlling for prognostic factors such as age and tumor stage, menopausal status,[47] socioeconomic status,[48-50] Medicaid/Medicare status,[48] tumor size,[47-49] histologic grade,[48,49] lymph node status,[47] or hormone receptor status.[47] Other researchers[51] have also found that Asian American women with breast cancer have higher survival rates compared with white women after controlling for age, tumor stage, and histologic grade. For prostate cancer, our data are consistent with a health maintenance organization–based study[51] that showed poorer survival among African Americans compared with whites after controlling for age and tumor stage.[52]

In summary, this study provides the first known population-based data on cancer-specific survival rates and RRs of cancer death for the 6 major racial or ethnic groups in the United States. Additional research is needed to clarify the role of socioeconomic, medical, biological, cultural, and other determinants of racial or ethnic differences in survival rates for patients with cancer described in this article.

Accepted for publication January 31, 2002.

This research was funded in part by grant U01CA86322 from the National Institutes of Health, Bethesda Md, and by a Harry and Elsa Jiler American Cancer Society Clinical Research Professorship (Dr Li).

We thank Otis Brawley for his helpful discussions during the early stage of this research and David Annett for his assistance with creation of the data file.

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