

A Method for Identifying Abrupt Changes in U.S. Cancer Mortality Trends

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BACKGROUND. Summaries of trends in cancer rates evaluated over a fixed, short period are informative, but methods that evaluate trends over a longer time period, identifying when changes occur as well as the magnitude of the changes, can provide additional information.

METHODS. Cancer mortality trends from 1973–1995 were determined for more than 15 anatomic sites for white and black males and females using weighted piecewise linear regression analysis with a stepwise selection procedure. The dependent variable was the natural logarithm of the annual mortality rate, and the weight was the annual number of cancer deaths. The variability of estimated change points was examined by bootstrapping the residuals from the resulting models.

RESULTS. For black males, cancer mortality rates declined in the 1990s due to decreases in lung, esophageal, oral cavity, and prostate cancer rates. However, there was no significant decline for cancer of the colon and rectum. For white males, cancer mortality rates declined in the 1990s due to declines in cancer of the lung and colon/rectum since the mid-1980s and declines in prostate cancer in the 1990s. For black females and white females, total cancer mortality rates declined, but not significantly. Cancer rates for all sites except the lung declined significantly in the 1990s for white, but not black, females due to declining trends for carcinoma of the colon and rectum since the mid-1980s and for breast cancer in the 1990s.

CONCLUSIONS. A method for identifying major changes in cancer trends has been developed. Trends for cancer of the breast and colon/rectum indicate that gaps between rates for blacks and whites are widening. *Cancer* 1999;86:157–69.

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KEYWORDS: cancer mortality, stepwise selection, piecewise regression analysis, cancer trends.

One goal of cancer surveillance is to determine the nature of current trends. Recently, it was reported that cancer death rates for all sites combined decreased on average 0.5% per year during 1990–1995 after significantly increasing 0.4% per year during 1973–1990.¹ Death rates for the four major cancers (lung, female breast, prostate, and colon/rectum) decreased significantly during 1990–1995. These findings document a decline in cancer mortality rates since 1990, where 1990 was chosen arbitrarily. A more complete characterization of trends in cancer mortality rates would determine when a change occurs as well as the direction and magnitude of that change. A change in the slope of the cancer mortality rate trends may signal the introduction of, or changes in access to, an efficacious procedure for early detection, screening, or treatment; or it may signal a change in exposure to an important risk or protective factor. Recognition of a change in trends can be the first step in demonstrating the impact of

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TABLE 1
Predictor Variables for 1973–1994

Year	x_0 Intercept	x_1 1973	x_2 1974..	x_4 1976..	x_7 1979.....	x_{21} 1993	x_{22} 1994
1973	1	0	0	0	0	0	0
1974	1	1	0	0	0	0	0
1975	1	2	1	0	0	0	0
1976	1	3	2	0	0	0	0
1977	1	4	3	1	0	0	0
1978	1	5	4	2	0	0	0
1979	1	6	5	3	0	0	0
•	•	•	•	•	•	•	•
•	•	•	•	•	•	•	•
1992	1	19	18	16	13	0	0
1993	1	20	19	17	14	0	0
1994	1	21	20	18	15	1	0
1995	1	22	21	19	16	2	1

a new medical intervention,^{2,3} and the year in which the change takes place can help determine the cause of the change.

It is common practice to summarize the general trend for rates by reporting a linear regression line fit to the natural logarithm of the annual age-adjusted incidence or mortality rates.^{4,5} The slope of such a fit can be interpreted as the annual percent change in cancer rates. We have extended this practice and developed a method of determining abrupt changes in the slope of the general trend using weighted piecewise linear regression. The method starts with the best linear trend over the entire period of interest, and then uses a forward stepwise procedure to select the piecewise linear fit with the smallest number of linear components that adequately describe the overall pattern of the rates. The method, which attempts to identify major changes in the direction of trends in rates, was used to examine cancer mortality patterns for 17 anatomic sites for white and black males and 19 anatomic sites for white and black females from 1973 to 1995. The variability of the estimated change points was also examined by bootstrapping the residuals from the final piecewise linear regression model and reassessing the location of changes in slopes.

METHODS

Data Source

Site-specific cancer mortality rates were computed from data collected by the National Center for Health Statistics (NCHS), which receives death certificates from the states and compiles mortality data by race, gender, age, year, and cause of death.⁶ For the current study, white and black rates were used for 17 male and 19 female anatomic sites, and all rates were age-ad-

justed to the 1970 U.S. population.⁷ The black rates are more variable than the white rates and allow an examination of the characteristics of the methodology in dealing with more variable rates. Furthermore, white and black trends may differ, and it is important to compare their trends.

Statistical Analysis

The trends of 1973–1995 annual, age-adjusted cancer mortality rates were determined using weighted piecewise linear regression analysis.⁸ The dependent variables were the natural logarithms of the annual, site-specific, age-adjusted cancer mortality rates for each race and gender. The predictor variables are denoted x_j , with $j = 1$ to 22, where x_j represents a linear trend from $(1973 + j - 1)$ to 1995. With an intercept term, x_0 , included, the predictor variables are as shown in Table 1.

All models are required to include x_0 and x_1 , and the coefficient for x_1 , β_1 , is the slope for the basic linear trend over the entire period if there are no slope changes, or from 1973 through the year of the first change in slope if such a change is detected. At each step in the stepwise procedure, changes in the slopes of previously defined trends are examined. Accordingly, the regression coefficient, β_j , corresponding to each x_j for $j > 1$, measures the change in slope of the mortality trend occurring in $1973 + j - 1$. For each β_j (for $j \geq 1$), $100 \times \beta_j$ will be referred to as the APC (annual percent change) corresponding to x_j . The overall slope of the mortality trend in year $1973 + k$ is the sum of all β_j 's (for which $j < k$) included in the final model. To guard against making premature judgments based on the most recent rates, predictor variables for the last 2 years were not included.

Weighted linear regression analysis of $\log(R_i)$, the natural logarithm of the age-adjusted mortality rate in year i , was performed using the SAS procedure REG with the "Stepwise" selection option and weights equal to d_i , the total number of site-specific cancer deaths in year i .⁹ The forward selection procedure first identifies the yearly variable that causes the most significant change in the basic trend (i.e., the overall trend from 1973 through 1995). Because there were 22 yearly predictor variables and 4 are excluded from being change points (1973–1975 and 1994), the significance level for a change in slope was taken to be $0.05/18 = 0.0028$ using the Bonferroni correction for multiple comparisons. If no variable makes a significant contribution to the basic linear trend, then the procedure ends and the basic linear trend becomes the final model. On the other hand, if the most significant yearly variable makes a significant contribution to the model (i.e., $P < 0.0028$ using the F-test for that yearly variable), it is added to the model to create a two-component piecewise linear model. Next, the procedure determines the yearly variable that causes the most significant change in the two-component model and determines the significance of this variable ($P < 0.0028$). If significant, the resulting three-component model is examined. At each stage, the stepwise procedure eliminates a variable already in the model if it is no longer significant at $P < 0.0028$ with the inclusion of a new variable. The final model is determined when the procedure stops because there are no more changes to the model.⁹

As indicated, the slope of the mortality trend in any particular year is the summation of the APC for the basic trend and the APCs for significant predictor variables preceding that year. For example, in the final regression analysis for all sites except lung carcinoma for black males, the basic trend is represented by the baseline 1973 variable, and the 1990 predictor variable was significant, indicating a change in slope in 1990. The regression coefficient for the 1973 variable indicated an APC of 0.9% (i.e., $\beta_1 = 0.009$). The regression coefficient for the 1990 variable indicated an APC of -1.9% (i.e., $\beta_{20} = -0.019$). Thus, the mortality trend, reported in Figure 1, shows an increase of 0.9% per year from 1973 through 1990 and a decrease of 1.0% per year from 1990 to 1995 (the sum of APCs for the baseline trend and the 1990 variable). We report the mortality trends in Figures 1–6 and indicate those slopes that were significantly different from zero using the Student's test. It is important to note that although some of the reported slopes were not significantly different from zero, each of the indicated changes in slope was significant (i.e., β_j was significant for each change indicated, $j > 1$). For males, the nominal level

for a slope to be significant was taken to be $0.05/17 = 0.0029$, correcting for the 17 anatomic sites examined. For females, there were 19 sites examined, so that the nominal level was taken to be $0.05/19 = 0.0026$.

A bootstrap analysis was performed to examine the stability of the final model of the stepwise procedure. The residuals for the observed rates about the final model were determined. These residuals were bootstrapped¹⁰ (sampled with replacement) and added to the expected values determined by the final model to create "new" bootstrap data sets. Then the stepwise procedure was applied to the "new" data,¹¹ and the number of changes in slope and the years of change were determined using the piecewise linear regression procedure described above. One thousand bootstrap data sets were analyzed. The bootstrap analyses were used to determine the variability in the number of slope changes and the years of these changes.

RESULTS

The 1973–1995 U.S. cancer mortality rates and their trends for 17 male anatomic sites and 19 female anatomic sites by race are displayed in Figures 1–6 for all cancers combined, all cancers except lung and site-specific cancers (in alphabetical order by organ site). The slopes of the cancer mortality trends following each significant change are also reported in the Figures 1–6. The year in which a change occurs and the 95% bootstrap confidence interval for each year of change in slope are reported for each change point. The percentage of bootstrap replicates that are consistent with the model reported is also given. For example, for all cancers for black males, the initial stepwise regression identified two change points: one in 1990 with a 95% confidence interval of 1989–1991 (from the bootstrap analysis), and another in 1982 with a 95% confidence interval of 1979–1984. This model occurred in 59% of the bootstrap replicates. In addition, the bootstrap analyses indicated that another model with a single change point in 1988 (1986–1989) occurred in 33% of the bootstrap replicates. If the bootstrap analyses indicate that another model occurs at least 15% of the time, the alternate model is reported after the initial stepwise regression model as "mod 2" in the figures (but is not plotted).

In general, the bootstrap analyses indicated little variability in the number of slope changes or the locations of the changes. The initial stepwise regression model was also the most likely bootstrap model in all but one case. Thus, the initial stepwise procedure provides a reasonable summary of major changes in trends. In the cases in which bootstrap analyses indi-

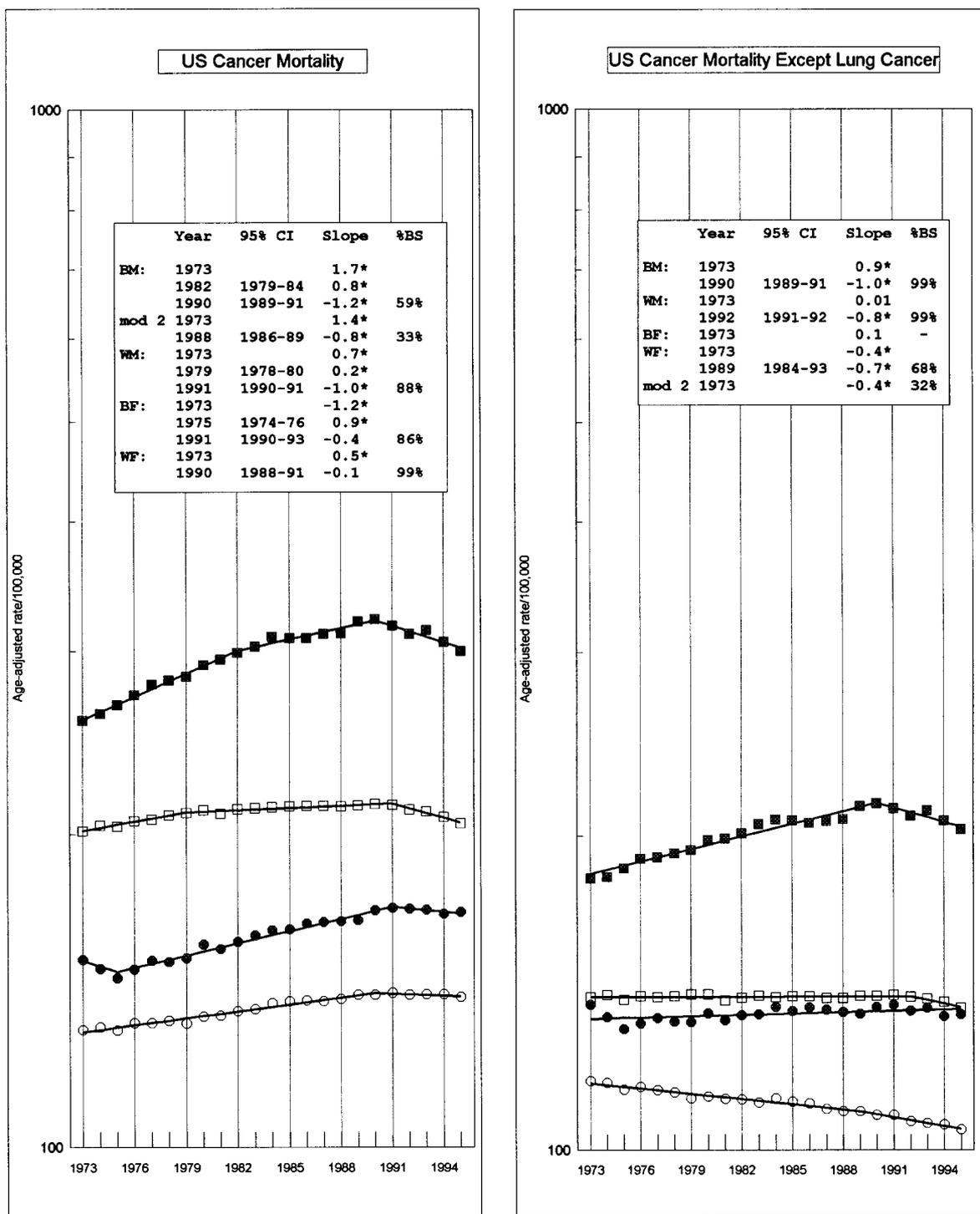


FIGURE 1. Mortality rates and trends in the U.S., for all sites and for all sites except lung cancer, are shown for black males (BM), black females (BF), white males (WM), and white females (WF). For the insert, "Year" is the year that the trend summarized by the corresponding slope starts, "95% CI" is the 95% confidence interval for the year the slope changed as determined from bootstrap replicates, "Slope" is the slope of the mortality trend from the indicated year, expressed as the percent change per year (*indicates a significant increase or decrease in mortality rates in the indicated segment), "%BS" is the percentage of times the bootstrap analysis selected the model, "mod 2" indicates that second model is reported, and "-" indicates no change point (thus, no bootstrap was performed). Closed square—black males, open square—white males; closed circle—black females, open circle—white females.

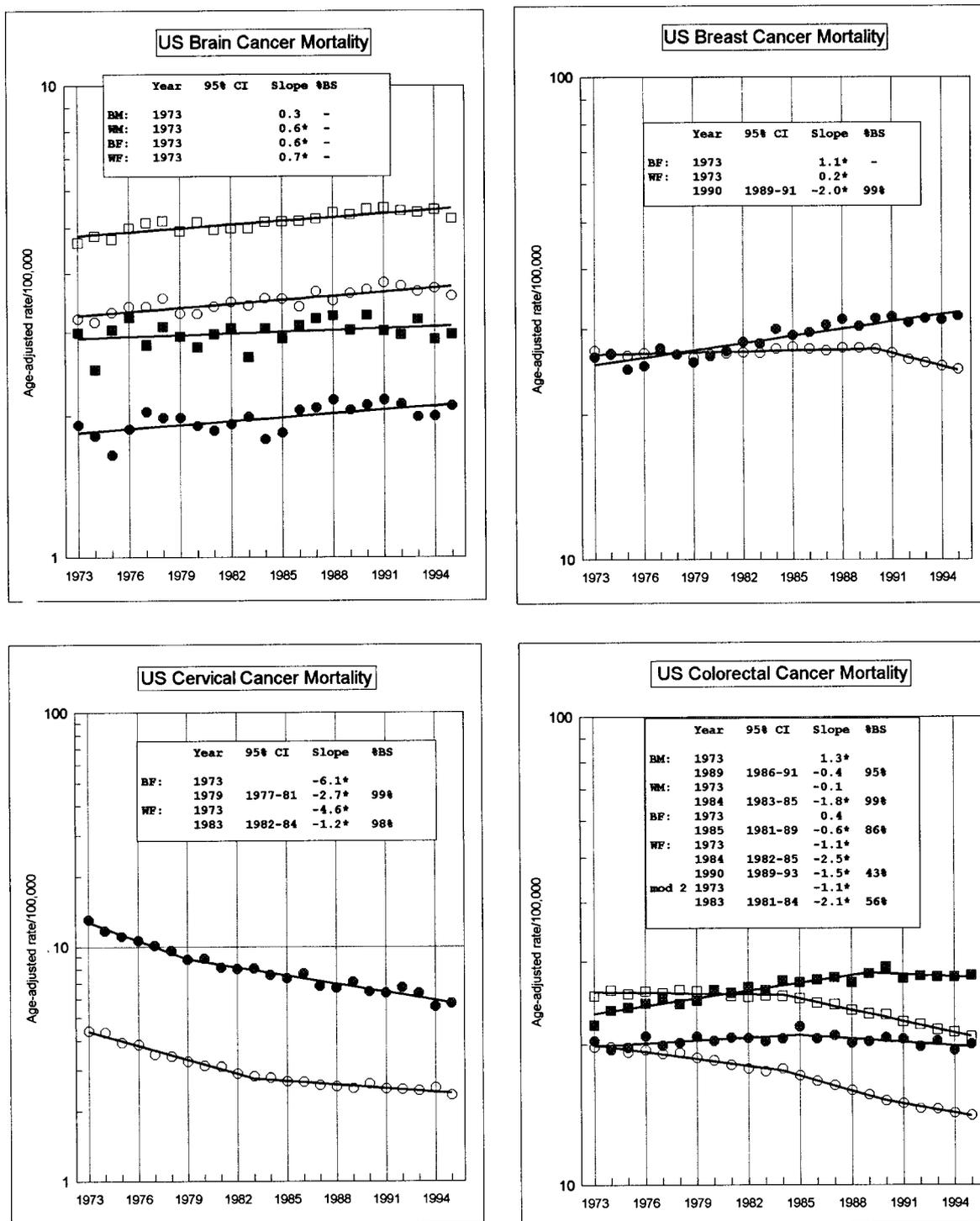


FIGURE 2. Brain, breast, cervical, and colorectal cancer mortality rates and trends in the U.S. are shown for black males (BM), black females (BF), white males (WM), and white females (WF). See Figure 1 for key for insert.

cate that multiple models are possible, we comment on these sites by race and gender.

For black males, the bootstrap analyses indicate two possible models for all sites combined, pancreas, and prostate. For all sites combined and pros-

tate, the bootstrap analyses indicate that single-change models are possible as well as the two-change models identified by the initial stepwise regression analysis. For all sites and prostate, the two models both indicate that the most recent

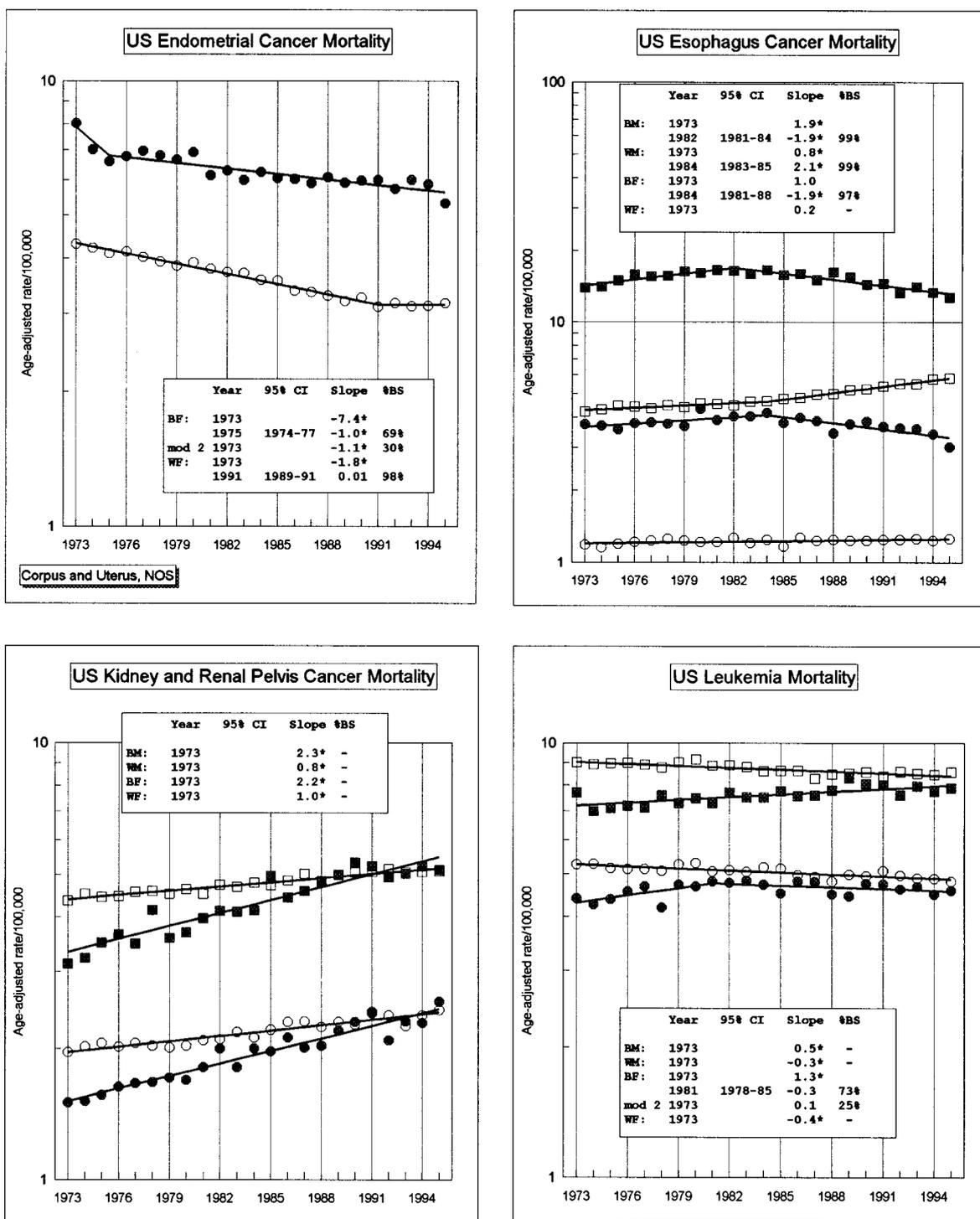


FIGURE 3. Corpus/uterus not otherwise specified; cancer of the esophagus, kidney, and renal pelvis; and leukemia mortality rates and trends in the U.S. are shown for black males (BM), black females (BF), white males (WM), and white females (WF). See Figure 1 for key for insert.

trends are decreasing. Thus, for all sites for black males there is convincing evidence of declining rates in the 1990s, and for prostate cancer for black males there is convincing evidence of a very recent decline in rates. For pancreatic cancer, the boot-

strap analyses suggest that a model with no change is almost equally as likely as the model with a change in 1992. These results indicate that there is some question as to whether pancreatic cancer rates declined recently in black men, and suggest that the

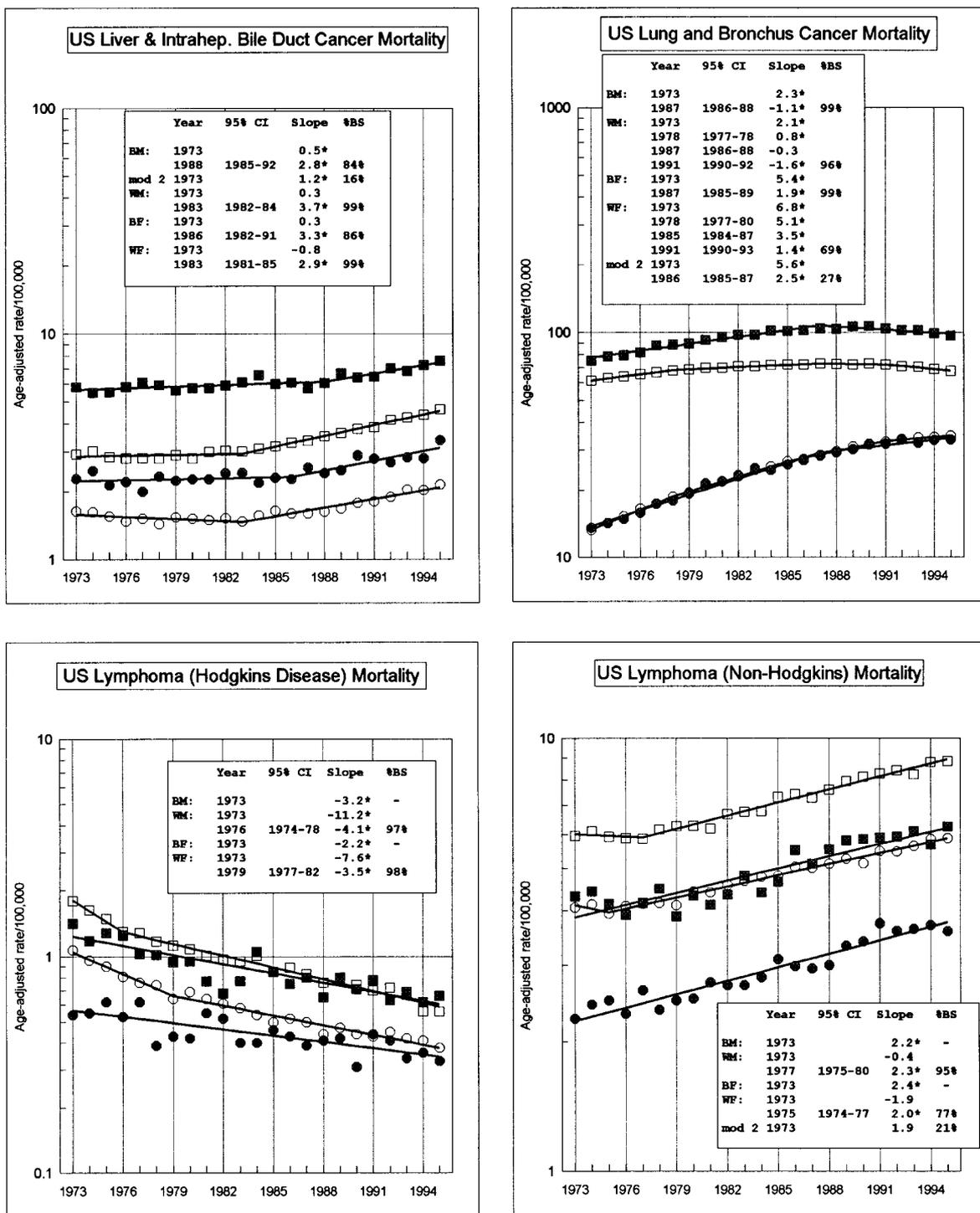


FIGURE 4. Cancer of the liver and intrahepatic bile duct, lung and bronchus, Hodgkin lymphoma, and non-Hodgkin lymphoma mortality rates and trends in the U.S. are shown for black males (BM), black females (BF), white males (WM), and white females (WF). See Figure 1 for key for insert.

significance of the recent decline in the stepwise procedure may be greatly influenced by the low 1995 rate.

For black females, the bootstrap analyses indicate that multiple models are possible for the endome-

trium (corpus/uterus not otherwise specified) and leukemia. For these two sites, the bootstrap analyses indicate that models with no changes in trend are possible as well as the models with a single change in trend. For the endometrium, both models indicate

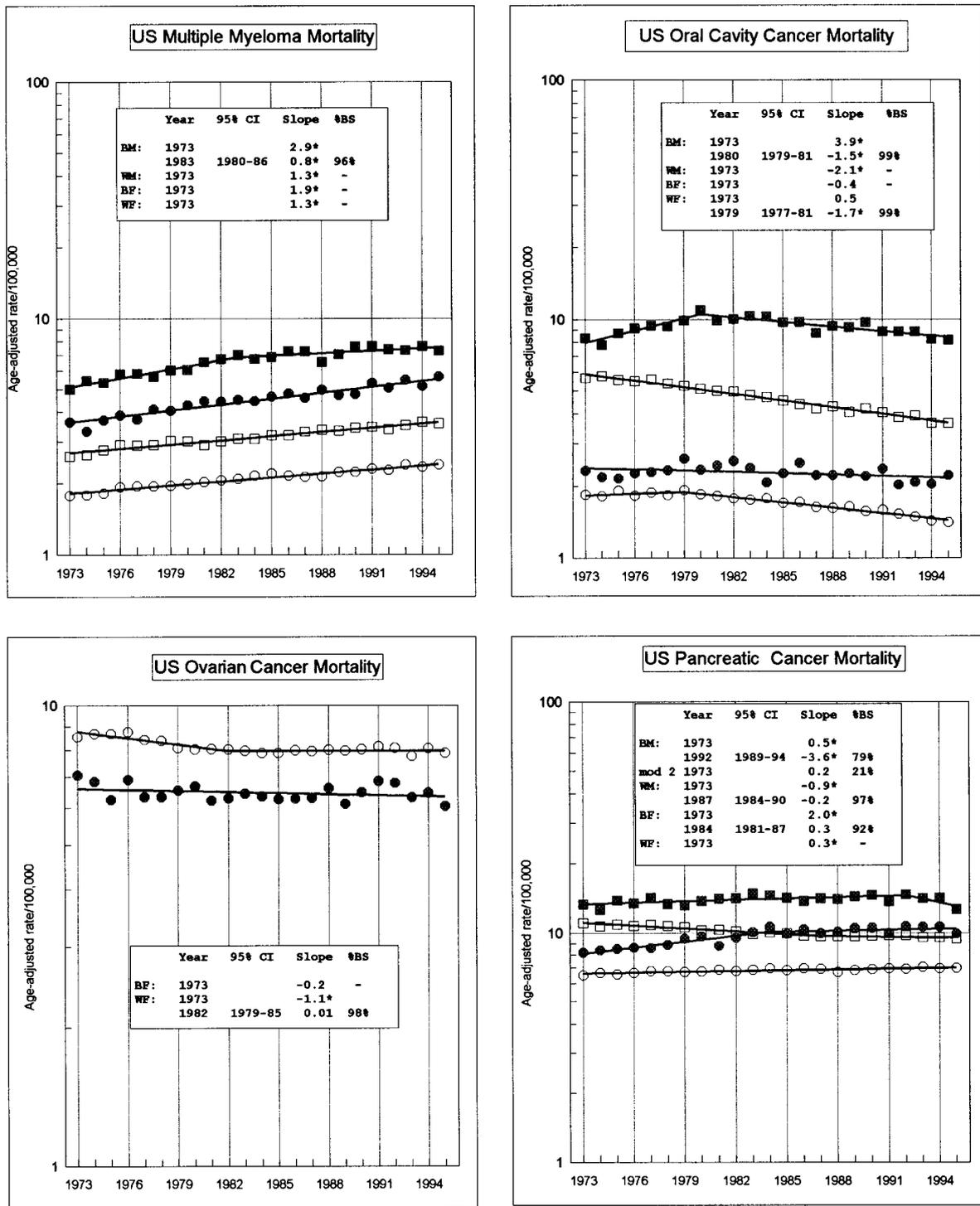


FIGURE 5. Multiple myeloma and oral cavity, ovarian, and pancreatic cancer mortality rates and trends in the U.S. are shown for black males (BM), black females (BF), white males (WM), and white females (WF). See Figure 1 for key for insert.

similar trends since the mid-1970s, giving convincing evidence of declining endometrial carcinoma mortality rates. For leukemia, both models indicate similar trends since the mid-1980s, and little change in leukemia rates.

For white males, the prostate is the only site for which the bootstrap analyses suggest that multiple models are possible. For prostate, the bootstrap analyses indicate that a model with no change point is as likely as the model with two change points. It is known

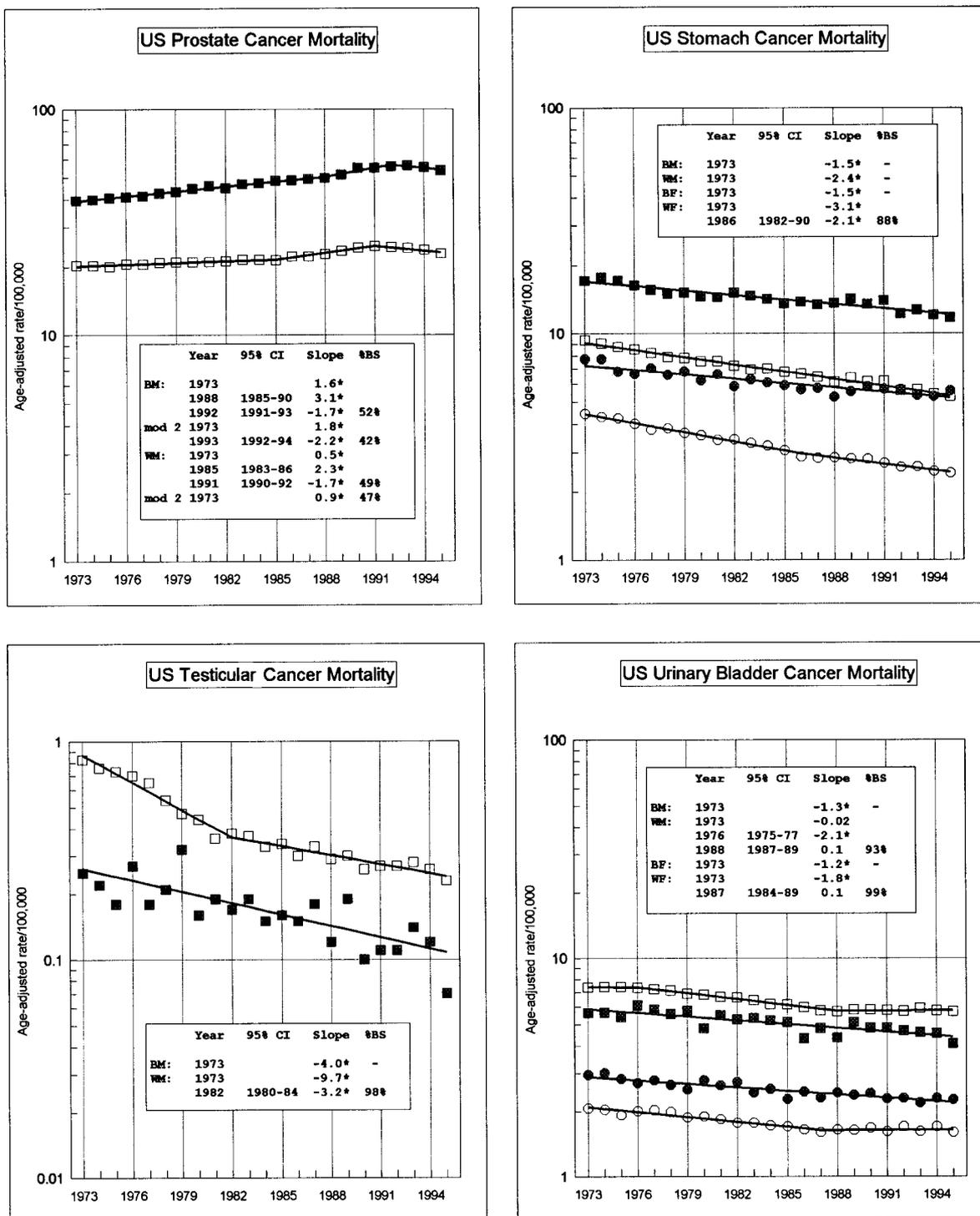


FIGURE 6. Prostate, Stomach (gastric), testicular, and urinary bladder cancer mortality rates and trends in the U.S. are shown for black males (BM), black females (BF), white males (WM), and white females (WF). See Figure 1 for key for insert.

that prostate carcinoma incidence rates for men age 65 years or older increased from 1986 to 1993 and then declined sharply,¹² and the most likely model indicates that these incidence changes are reflected in the

mortality rates (a similar pattern was observed in the most likely model for black men).

For white females, bootstrap analyses suggest multiple models for all sites except the lung, colon/

rectum, lung and non-Hodgkin lymphoma. For the colon/rectum, the bootstrap analyses indicate that a model with one change point is more likely than the model with two change points that was identified by the stepwise regression analyses. Both models indicate declines in the colon/rectal cancer mortality rates since 1983–84; however, the stepwise regression model has an additional change in 1990, indicating a moderation in the magnitude of the decline. Because the most likely bootstrap model does not contain the change in 1990, this recent worsening of the trend is in question. For the lung and bronchus, a model with one change is possible as well as the model with three changes. Both models indicate moderations of the mortality rate increases in 1985–1986. For the stepwise regression model, there is additional moderation of rates in 1991. For all sites other than lung and for non-Hodgkin lymphoma, the bootstrap analyses indicate that a model with no change point is possible. For non-Hodgkin lymphoma the models have the same trends since the mid 1970s, giving convincing evidence of increasing trends since that time period. For all sites other than the lung, the stepwise procedure indicating further declines in rates for white females beginning in 1989 is supported by 68% of the bootstrap replicates, whereas 32% of the bootstrap replicates indicate a single declining trend since 1973. The strong evidence for a sharp decline in breast cancer mortality beginning in 1990 supports the initial model with a downturn after 1989 for all sites except the lung.

DISCUSSION

Methodologic Issues

The stepwise piecewise linear regression method described above provides a method to identify major changes in the slope of the trend in annual age-adjusted disease rates. The stepwise forward selection procedure begins with the basic linear trend over the entire study period and then identifies significant departures from the overall trend. The procedure was parsimonious; no more than 3 slope changes were found for any cancer site, even though changes were allowed for any of 18 years from 1976 through 1993. The use of the Bonferroni correction in determining the significance requires clear evidence of a change in slope, and thus the method should be considered primarily a surveillance tool for identifying major changes in slope.

We also examined backward elimination regression analysis, which starts with a model having a slope change at every year and sequentially eliminates the least significant changes to arrive at a final model. This procedure sometimes selected final models with numerous changes in slope. For 1 site there were 12

changes in slope in the final model, and for another there were 10 slope changes in the final model. The backward selection procedure was sensitive to short term fluctuations in the pattern of rates, and thus the forward selection procedure was chosen for surveillance, to provide a useful summary of major changes in long term trends.

Any piecewise linear model is only an approximation to the actual rate curve. Certain nonlinear aspects of a curve will be lost in the best piecewise linear summary of the curve. Because each segment of the model is linear and not a higher-order polynomial, the model is most sensitive in identifying times corresponding to a sudden change in slope, which can be fit well with linear components. The model may detect gradual changes, but the change points will not be as well estimated. Our method is aimed at identifying major changes in the direction of the curve, and not at fitting every twist and turn of the curve. The stepwise procedure with the Bonferroni correction requires highly significant changes to occur before a term is entered into the final model. This requirement may cause some smaller changes in trend to be missed, but those changes in slope identified are unlikely to be due to chance.

As with most regression procedures, outliers can have a great impact on the fit of the data. In this article, we did not attempt to identify and remove outliers. It must also be considered that the addition of new data may change existing trends, depending on the nature of the increase or decrease in the new data. This is particularly true if the bootstrap analyses indicate that multiple models may be important. The method is based on a summary measure, the age-adjusted rate. This should be sufficient for routine surveillance efforts; however, understanding the exact nature of changes in trends often requires a more detailed analysis of trends in age specific rates, as evidenced by evaluation of the recent decline in breast cancer mortality rates.^{13,14}

Our bootstrap method based on the residuals from the final model provides a useful indication of the stability of the final model. Efron and Gong used a bootstrap method based on covariate-response pairs to examine the stability of a logistic regression model.¹⁰ Our bootstrap analyses showed more stability when the final model indicated only a single change in slope. A single change in slope was selected in at least 69% of the bootstrap replicates for black males and females and 77% of the bootstrap replicates for white males and females when the final stepwise regression model indicated a single change in slope. However, when the final model indicated the presence of more than one change in slope, there was much

more variability in the number of models selected in the bootstrap replicates. Of the nine sites with more than one change in slope in the final model, the bootstrap replicates indicated stability for 4 sites (i.e., the same number of slope changes was selected in more than 86% of the replicates), but instability for the other four sites (i.e., the same number of slope changes was selected in less than 59% of the replicates) (see "Results").

Another common piecewise method involves regression splines.¹⁵ Regression splines are similar to piecewise linear regression analysis in the use of change points or knots.¹⁶ However, in this application, they differ in two fundamental ways. First, spline regression predetermines the change points (knots) and is used to smooth the changes around the knots. Second, regression splines are used to smooth the curve and reduce noise, not to determine where the knots should occur. In contrast, the piecewise linear regression analysis with stepwise selection determines the number of change points as well as their location.

Although the piecewise linear regression procedure was applied to age-adjusted cancer mortality rates for all ages, the method is applicable in the identification of trends for any age-specific rates. In addition, the methodology should be generally applicable in determining trends for incidence and survival rates. Thus, a general method for determining linear trends in vital statistics data is presented.

Cancer Mortality Trends by Race

We now compare trends among the four race/gender groups, beginning with their total cancer mortality trends. For black males, the total cancer mortality rates began to decline in the 1990s, after increasing in the 1970s and 1980s. These declines were due to decreasing lung cancer rates, a leveling in the recent colorectal cancer trend, and decreasing esophageal and oral cavity cancer mortality. In addition, declining prostate cancer rates since 1992 have contributed to the recent overall decrease. The total cancer mortality rates for white males also began declining in the early 1990s due to declines in cancer of the colon and rectum, changes in lung cancer that began to decline in the mid 1980s and accelerated in the 1990s, and declining prostate cancer trends in the 1990s.

Although the total cancer mortality trends for women also showed significant improvement in the early 1990s, there is not yet evidence of significant decreases for white or black females. The moderation of cancer mortality rates for black women in the 1990s is directly related to moderation of the increase in lung cancer, although nonsignificant improvements in trends for other sites, such as breast and ovarian can-

cer, made some contribution. No site other than the lung has shown dramatic improvement, so that mortality rates for all cancer except lung are not decreasing significantly in the 1990s. For white females the total cancer mortality rates had nonsignificant declines in the 1990s after increases in the 1970s and 1980s, but all sites except the lung showed significant declines in the 1990s. The more favorable trends for white women for colorectal and breast cancer are largely responsible for their better recent mortality trends.

Sites for which mortality rate trends have worsened in recent years are of particular importance in cancer surveillance. Liver cancer rates have increased recently at similar rates for white and black men and women, but the increases began somewhat later for blacks than for whites. Esophageal cancer rates increased since the mid-1980s for white men, whereas rates decreased for black men and women over the same period. In addition, some mortality trends have worsened due to the moderation of previously declining trends. Sites for which trends have worsened include bladder cancer for white males and females after 1987, endometrial cancer for white women and cervical cancer for white and black women, and pancreatic cancer for white males in the late 1980s. The apparent recent worsening of the bladder cancer mortality trend for whites has not been previously reported.

Sites for which the recent trends differ by race are equally important. Cancers for which recent black mortality trends are worse than white mortality trends include breast cancer for women, colon and rectal cancer, renal cancer (with black rates increasing faster than white rates), leukemia, and cancer of the oral cavity for women. In contrast, cancers for which recent white mortality trends are worse than black mortality trends include bladder and esophageal cancer.

We have compared the 1990–1995 trends reported in a recent publication¹ with the final slopes determined by the stepwise analyses in Table 2. As our study indicates, changes in trends occur at different times for different sites, and examining trends only from a predetermined starting point, such as 1990, may lead to different conclusions about recent trends. Of the 20 trends in Table 2, there is good agreement between the 2 methods for 16 of them. In particular, the declining trends for breast cancer for white females, prostate cancer for white males, and lung cancer for white and black males in the late 1980s and early 1990s, and the continuing declines of colon and rectal cancer in whites since the mid 1980s caused total cancer mortality to decline for men and total cancer mortality except the lung to decline for men

TABLE 2
Comparison of Trends from Wingo et al. for 1990–1995 and from a Stepwise Approach

Site	Trend	Black males	White males	Black females	White females
All sites	1990–1995 ^a	–1.3 ^b	–0.9 ^b	–0.2	–0.1
	Relevant piecewise trend (Yrs of trend)	–1.2 ^b (1990–1995)	–1.0 ^b (1991–1995)	–0.4 ^b (1991–1995)	–0.1 (1990–1995)
All sites except lung	1990–1995 ^a	–1.0 ^b	–0.5 ^b	–0.4 ^b	–0.7 ^b
	Relevant piecewise trend (Yrs of trend)	–1.0 ^b (1990–1995)	–0.8 ^b (1992–1995)	–0.1 ^b (1973–1995)	–0.7 ^b (1989–1995)
Lung	1990–1995 ^a	–1.9 ^b	–1.5 ^b	1.0	1.7 ^b
	Relevant piecewise trend (Yrs of trend)	–1.1 ^b (1987–1995)	–1.6 ^b (1991–1995)	1.9 ^b (1987–1995)	1.4 ^b (1991–1995)
Colon/rectum	1990–1995 ^a	–0.6	–2.0 ^b	–0.9	–1.5 ^b
	Relevant piecewise trend (Yrs of trend)	–0.4 (1989–1995)	–1.8 ^b (1984–1995)	–0.6 ^b (1985–1995)	–1.5 ^b (1990–1995)
Prostate	1990–1995 ^a	–0.3	–1.2 ^b		
	Relevant piecewise trend (Yrs of trend)	–1.7 ^b (1992–1995)	–1.7 ^b (1991–1995)		
Breast	1990–1995 ^a			0.0	–1.9 ^b
	Relevant piecewise trend (Yrs of trend)			1.1 ^b (1973–1995)	–2.0 ^b (1990–1995)

^a Trends from Wingo et al.¹

^b *P* value ≤0.05; significance was determined by the conventional 5% nominal level, rather than the more stringent Bonferroni criterion.

and white women. These important declines are captured by trends determined from 1990 to 1995.

There are four cases in which the 1990–1995 trends differ from the recent trends identified in the stepwise approach. The first is prostate cancer for black males. The trend from 1990–1995 is –0.3%/year and it is not significant. The stepwise analysis indicates a significant downward trend of –1.7%/year beginning in 1992. The 1990–1995 trend is an average of the increases through 1992 and the subsequent downturn, leading to a nonsignificant slope over the period. The second example is breast carcinoma for black females. The stepwise analysis from 1973–1995 indicates an increasing trend from 1973 through 1995, whereas the 1990–1995 trend indicates level rates. In this case, the variability of the 1973–1995 rates, particularly in the 1970s, may reduce the ability of the stepwise procedure to detect a recent change. For two sites the methods differed only in determination of the significance of the recent slope. For colorectal cancer in black females the slope from 1990–1995 is –0.9%/year, but it is not significant. The stepwise analysis indicates a significant change in trend beginning in 1985, with a subsequent significant 0.6%/year decrease in rates. Finally, the 1990–1995 trend for lung cancer in black females shows an increase of 1.0%/year that is not significant. However, the stepwise analysis indicates a significant increase of 1.9%/year beginning in 1987. The conservative nature of the stepwise approach is demonstrated by its determina-

tion that the apparent recent improvements in the lung and breast cancer trends for black females are not yet statistically significant.

In closing, an objective method for identifying major changes in cancer trends has been presented. This method determines the changes in slope of the basic trend using piecewise linear regression analysis with a stepwise forward selection procedure. The stability of these changes in slope has been examined by bootstrapping the residuals of the resulting models. The method allows the identification of both differences and similarities in trends by gender and by race, which can suggest areas of future research. Explanations for changes in trends often require detailed analyses of incidence and survival trends by specific ages, perhaps using age-period-cohort analyses of the data.^{14,17} For breast cancer in females and colon and rectal cancer in males and females, the gaps between rates for blacks and whites are widening because declines observed for whites have not been observed for blacks. These gaps indicate opportunities for reducing cancer mortality among blacks.

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