Tools of the Trade:

Cancer Trend Analysis Using Joinpoint Regression

Part 2 - Application and Use

Top Four Cancer Sites:

In 2000, the top four cancer sites of lung/bronchus, female breast, prostate, and colon/rectum represented 56.2% of all invasive cancer cases reported to the Pennsylvania Cancer Registry and 51.3% of all Pennsylvania cancer deaths. For cancers of the lung/bronchus, prostate, and colon/rectum, blacks had higher observed incidence and mortality rates than whites. For female breast cancers, the incidence rate was lower among black females, compared to whites, but higher for the corresponding mortality rate.

Background on Joinpoint Trend Analysis:

The Joinpoint Regression Program was used to find the best-fit line through several years of data by utilizing an algorithm that tests whether a multi-segmented line is a significantly better fit than a straight or less-segmented line. Trends for cancer incidence and mortality data were described via joinpoint regression analysis, which involves fitting a series of joined straight lines on a log scale to the trends in the annual age-adjusted rates. Line segments were joined at points called joinpoints. Each joinpoint denotes a statistically significant (P = .05) change in trend. The tests of significance use a Monte Carlo Permutation method (i.e. it finds “the best fit” line for each segment). In our analysis, a maximum of three joinpoints (four line segments) was allowed for each model.

Once the line segments are established, the estimated annual percent change was used to describe and test the statistical significance of the trends. Testing the hypothesis (two-sided P value = .05) that the annual percent change is equal to zero is equivalent to testing the hypothesis that the trend in incidence or mortality rates is neither increasing nor decreasing.

Cancer Incidence Trends:

Table 1 below displays the results of the joinpoint trend analysis for cancer incidence. According to the analysis, Pennsylvania cancer incidence rates for all cancer sites combined have been increasing by 1.2% per year for the sixteen-year period of 1985 through 2000. Among females, rates for all cancer sites combined have been increasing by 0.9% per year for this same time period. Among males, the long-term incidence rates for all cancer sites were relatively stable for 1985 through 1987, increased by 3.7% per year until 1992, and then stabilized. Recent incidence

rates (1995-2000) for white males increased by 0.8% per year, whereas the recent rates for black males decreased by 1.2% per year. However, the incidence rates for black males have been consistently higher than whites. In fact, the average annual age-adjusted incidence rate (1996-2000) among black males was nearly 29 percent higher than the rate for white males. Among white and black females, the long-term trend rates have increased by 0.9% and 1.1% per year, respectively.

Based on the joinpoint analysis, lung/bronchus cancer incidence rates increased by 1.3% per year from 1985 to 1998. The decrease during 1998 through 2000 was not statistically significant. The joinpoint analysis showed a change in trend for males in 1997. However, neither of the estimated annual percent changes for the two trends was significantly different than zero. Lung cancer incidence rates among females have increased by 3.2% per year from 1985 through 1998. Since 1998, the incidence rates for females have been relatively stable (i.e. the decreasing trend that started in 1998 was not statistically significant at the 95% confidence level).

In Pennsylvania, breast cancer represents the leading cancer site for females and was the second most frequent cause of cancer mortality among females. The long-term joinpoint trends for female breast cancer incidence rates increased by 0.7% per year throughout the 16-year period of 1985-2000. Breast cancer rates for black females increased by 1.1% per year for this same time period. Since 1987, no discernable trend was observed for breast cancer rates among white females. However, the average annual age-adjusted (1996-2000) breast cancer rate for white females was over 8% higher than the rate for black females.

In Pennsylvania, prostate cancer incidence rates were much higher for blacks compared to white males. This supports the fact that black males in the United States have been reported to have the highest incidence of prostate cancer than any group in the world. Prostate cancer incidence rates increased dramatically in the late 1980s and early 1990s. Since the mid to late 1980s, increased basic screening procedures have become more prevalent among physicians and clinics, especially for patients of advanced ages, thereby affecting the number of cases detected and reported. Based on this analysis, prostate cancer incidence rates among white males decreased by 7.7% from 1992 to 1995, and increased by 1.8% beginning in 1995. Rates for black males decreased by 2.0% per year beginning in 1992.

According to the joinpoint analysis, colon and rectum cancer incidence rates have decreased 0.4% per year from 1987 through 2000. For males and females, the long-term trend rates have decreased 0.7% and 0.8% per year, respectively. The colorectal cancer incidence rates for black males and females have remained relatively stable throughout the sixteen-year period of 1985-2000.

TABLE 1
Pennsylvania Invasive Cancer Incidence Rates* (1996-2000) and Trends (Joinpoint Analyses for 1985-2000)
for All Cancers and the Top Four Cancers by Sex and Race

Site/Sex/Race	Average Annual Rate* (1996-2000)	Joinpoint Analyses (1985-2000) Trend 1 Years	Trend 1 APC**	Trend 2 Years	Trend 2 APC**	Trend 3 Years	Trend 3 APC**	Trend 4 Years	Trend 4 APC**
All Cancer Sites	486.1	1985-2000	1.2^						
Male	579.3	1985-1987	-0.6	1987-1992	3.7^	1992-2000	0.0		
Male White	560.3	1985-1987	-0.7	1987-1992	4.0^	1992-1995	-1.7^	1995-2000	0.8^
Male Black	721.3	1985-1989	0.7	1989-1993	6.5^	1993-2000	-1.2^		
Female	426.3	1985-2000	0.9^						
Female White	421.1	1985-2000	0.9^						
Female Black	431.2	1985-2000	1.1^						
Lung and Bronchus	69.5	1985-1998	1.3^	1998-2000	-1.3				
Male	95.4	1985-1997	0.1	1997-2000	-1.4				
Male White	92.0	1985-1996	0.2	1996-2000	-1.0				
Male Black	136.9	1985-2000	-0.2						
Female	51.2	1985-1998	3.2^	1998-2000	-0.7				
Female White	49.6	1985-1997	3.2^	1997-2000	1.2				
Female Black	68.5	1985-1998	3.6^	1998-2000	-8.7				
Female Breast	130.5	1985-2000	0.7^						
Female White	129.6	1985-1987	5.3	1987-2000	0.4				
Female Black	119.9	1985-2000	1.1^						
Prostate	163.9	1985-1989	5.3^	1989-1992	21.1^	1992-1995	-6.7^	1995-2000	1.6
Male White	153.4	1985-1989	5.4^	1989-1992	20.9^	1992-1995	-7.7^	1995-2000	1.8^
Male Black	256.5	1985-1989	3.0	1989-1992	23.1^	1992-2000	-2.0^		
Colon and Rectum	62.0	1985-1987	-4.6	1987-2000	-0.4^				
Male	74.7	1985-2000	-0.7^						
Male White	74.0	1985-1995	-1.4^	1995-2000	0.6				
Male Black	76.6	1985-2000	0.3						
Female	52.7	1985-2000	-0.8^						
Female White	52.0	1985-2000	-0.9^						
Female Black	56.1	1985-2000	-0.1						

Cancer Mortality Trends:

Table 2 below displays the results of the joinpoint trend analysis for cancer mortalities. Pennsylvania age-adjusted death rates for all cancer sites (combined) remained relatively stable for 1985 through 1990 (i.e. the slight increase in rates for this time period was not statistically significant at the 95% confidence level). Cancer death rates decreased by 0.8% per year from 1990 through 2001. Cancer death rates among males decreased by 1.3% per year from 1991 through 2001. Similar trends were observed for both white and black males. Death rates among white females decreased by 0.6% per year beginning in 1990. Among black females, the cancer death rates have shown no discernable trends throughout the 17-year period of 1985-2001.

Joinpoint trends for lung and bronchus cancer death rates increased by 1.3% per year from 1985 through 1991, then decreased by 0.5% per year for the period of 1991-2001. Long-term trend rates for white males decreased by 1.0% per year throughout the 17-year period of 1985-2001. Death rate trends for black males decreased by 2.0% per year beginning in 1987. Lung cancer death rates among white females increased by 4.9% per year from 1985 through 1990. This

increase slowed to 1.2% per year beginning in 1990. Long-term trend rates for black females increased by 1.8% per year from 1985 through 2001.

Breast cancer death rates for white females decreased by 2.7% per year beginning in 1990. Among black females, no discernable trends were identified for breast cancer death rates during the 17-year period of 1985-2000.

Overall, prostate cancer death rates increased by 4.6% per year from 1985 through 1991, and decreased by 3.0% beginning in 1991. The trend pattern was similar for both white and black males.

Long-term trends in colon and rectum cancer death rates decreased by 1.8% and 1.9% for males and females, respectively, throughout the 17-year period of 1985 through 2001. Larger decreases in death rates were observed among whites compared to blacks.

TABLE 2
Pennsylvania Cancer Death Rates* (1997-2001) and Trends (Joinpoint Analyses for 1985-2001)
for All Cancer Deaths and the Top Four Cancer Deaths by Sex and Race

		Joinpoint Analyses (1985-2001)							
	Average Annual	Trend 1		Trend 2		Trend 3		Trend 4	
Cause/Sex/Race	Rate* (1997-2001)	Years	APC**	Years	APC**	Years	APC**	Years	APC**
All Cancer Sites	206.3	1985-1990	0.5	1990-2001	-0.8^				
Male	256.8	1985-1991	0.5	1991-2001	-1.3^				
Male White	250.7	1985-1991	0.4	1991-2001	-1.1^				
Male Black	370.8	1985-1989	1.8	1989-2001	-1.5^				
Female	173.6	1985-1990	0.6	1990-2001	-0.6^				
Female White	170.1	1985-1990	0.5	1990-2001	-0.6^				
Female Black	229.4	1985-2001	-0.0						
Lung and Bronchus	55.8	1985-1991	1.3^	1991-2001	-0.5^				
Male	78.5	1985-1988	1.4	1988-2001	-1.4^				
Male White	76.5	1985-2001	-1.0^						
Male Black	115.7	1985-1987	7.3	1987-2001	-2.0^				
Female	40.0	1985-1992	3.9^	1992-2001	0.7^				
Female White	39.0	1985-1990	4.9^	1990-2001	1.2^				
Female Black	56.2	1985-2001	1.8^						
Female Breast	28.7	1985-1990	1.5	1990-2001	-2.6^				
Female White	28.0	1985-1990	1.4	1990-2001	-2.7^				
Female Black	39.4	1985-2001	-0.2						
Prostate	30.2	1985-1991	4.6^	1991-2001	-3.0^				
Male White	28.2	1985-1991	4.5^	1991-2001	-3.0^				
Male Black	64.4	1985-1992	3.6	1992-2001	-3.0^				
Colon and Rectum	23.1	1985-2001	-1.8^						
Male	28.0	1985-2001	-1.8^						
Male White	27.7	1985-2001	-1.9^						
Male Black	36.2	1985-2001	-0.8						
Female	19.7	1985-2001	-1.9^						
Female White	19.3	1985-2001	-2.0^						
Female Black	26.8	1985-2001	-1.1^						

* Average annual age-adjusted death rates are per 100,000 and are computed by the direct method using the 2000 U.S. standard million population.
** APC = annual percent change (based on rates that were age-adjusted to the 2000 U.S. standard million population) calculated by using joinpoint regression analysis.
^ APC is significantly different from zero (two-side P<.05).
Note: Joinpoint analyses allowed for up to three joinpoints and are based on rates per 100,000 (age-adjusted to the 2000 U.S. standard population by 5-year age groups).

Conclusions:

The joinpoint analysis of the trends in the age-adjusted cancer incidence and mortality rates allows the user to "systematically" interpret changes over time and, more importantly, to determine if those changes are statistically significant.

Overall, joinpoint trend analysis of Pennsylvania cancer mortality rates show that progress is being made in reducing the cancer burden among residents of the Commonwealth. The age-adjusted cancer mortality rates have shown a significant decline since the early 1990s for both men and women. Medical advances along with the growth in cancer knowledge, technology, and resources have contributed to this progress. Although the age-adjusted cancer incidence rates among women have risen significantly between 1985 and 2000, the incidence rates have been rather stable among men since 1992. Further reductions in the cancer burden will require continued efforts in the development, delivery, and surveillance of effective cancer prevention, early detection, and treatment strategies.

Additional Pennsylvania cancer statistics can be obtained from our web site at ***www.statistics.health.pa.gov*** or by contacting the Division of Health Informatics (email address: RA-DHIContactUs@pa.gov). We also have an interactive web tool, called EpiQMS, for health data users to create customized data tables, charts, maps, and county profiles of birth, death, cancer, and population statistics ***online***.

This two-part series was inspired by the "Annual Report to the Nation on the Status of Cancer, 1975-2000, Featuring the Uses of Surveillance Data for Cancer Prevention and Control" as published in the September 3, 2003 (Vol. 95, No. 17, pages 1276-1299), issue of the Journal of the National Cancer Institute. This national report and other cancer publications are available from the National Cancer Institute web site at ***www.seer.cancer.gov***.