

## **Tools of the Trade:**

### **Cancer Trend Analysis Using Joinpoint Regression**

#### **Part 1 - The Basics**

##### **Background on Joinpoint Trend Analysis:**

Like the least squares regression method, the joinpoint program is used to find the best-fit line through several years of data. However, the joinpoint program uses an algorithm that tests whether a multi-segmented line is a significantly better fit than a straight or less-segmented line. For this article, the joinpoint regression analysis involves fitting a series of joined straight lines on a log scale to the trends in the annual age-adjusted cancer incidence and mortality rates. Line segments are joined at points called joinpoints. Each joinpoint denotes a statistically significant ( $P = .05$ ) change in trend.

The test of significance uses a Monte Carlo Permutation method (i.e., it finds “the best fit” line for each segment). The user supplies the minimum and maximum number of joinpoints to be tested. For this article, a minimum of zero joinpoints (one line segment) and a maximum of three joinpoints (four line segments) were allowed for each model (time series being analyzed). The program starts with the minimum number of joinpoints (0 joinpoints would be a straight line) and tests whether more joinpoints are statistically significant and must be added to the model (up to the maximum number).

Since an additional joinpoint is only added to the model if the change in trend is statistically significant, you can interpret each of the joinpoints displayed from the chosen model as being a significant change in the trend or time series. For example, Figure 1 represents the chosen model for male cancer incidence rates. The line graph displays 2 joinpoints (3 line segments or trends) at 1987 and 1992. For this example, one can say that the trend for male cancer incidence rates significantly changed twice between 1985 and 2000.

Once the line segments are established, the estimated annual percent change is used to describe and test the statistical significance of the trends in the model. 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 the cancer rates is neither increasing nor decreasing.

##### **Cancer Incidence Trends:**

According to the results of the joinpoint analysis, it was determined that Pennsylvania age-adjusted cancer incidence rates for all cancer sites have been increasing by 1.2% per year for the 16-year period of 1985 through 2000 (see Table 1 below). The rates have been increasing by 0.9% per year among females for this same time period. Since only one straight line is displayed (see Figure 2 below), one can

interpret the 1985-2000 trend for female age-adjusted cancer incidence rates as being constant (in this case, consistently on the increase) throughout the 16-year period being studied.

Among males, the long-term incidence rates were relatively stable for 1985 through 1987, increased dramatically by 3.7% per year until 1992, and then stabilized. Since the late 1980s, increased basic screening procedures, especially the prostate-specific antigen (PSA) test, have become more prevalent among physicians and clinics thereby affecting the number of male cases diagnosed and reported. This may, at least partially, help to explain the sharp increase in male cancer incidence rates for 1987-1992.

For Pennsylvania residents, the average annual age-adjusted incidence rate for all invasive cancers from the five-year period of 1996 through 2000 was 35.9 percent higher among males, compared to female. Historically, for all cancer sites combined, age-adjusted incidence rates have been consistently higher for males.

**Table 1 - CANCER INCIDENCE**  
Average Annual Age-Adjusted Invasive Cancer Incidence Rates\* (1996-2000) and Trends (Joinpoint Analyses for 1985-2000)  
All (Total) Cancer Sites by Sex, Pennsylvania Residents

Site/Sex/Race	Average Annual Rate* (1996-2000)	Joinpoint Analyses (1985-2000)							
		Trend 1 Years	APC**	Trend 2 Years	APC**	Trend 3 Years	APC**	Trend 4 Years	APC**
All Cancer Sites	486.1	1985-2000	1.2 <sup>^</sup>						
Male	579.3	1985-1987	-0.6	1987-1992	3.7 <sup>^</sup>	1992-2000	0.0		
Female	426.3	1985-2000	0.9 <sup>^</sup>						

\* Average annual age-adjusted incidence 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

<sup>^</sup> 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)

Figure 1 - Males: Age-Adjusted Cancer Incidence Rates

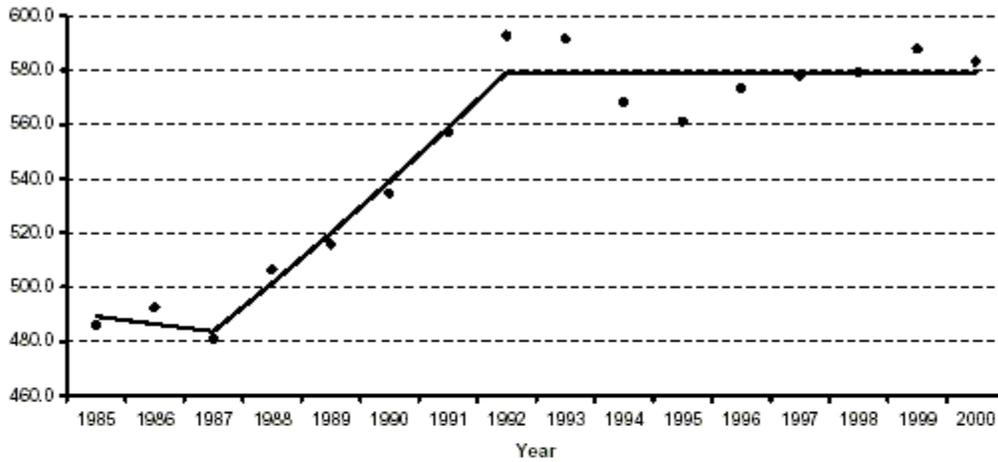
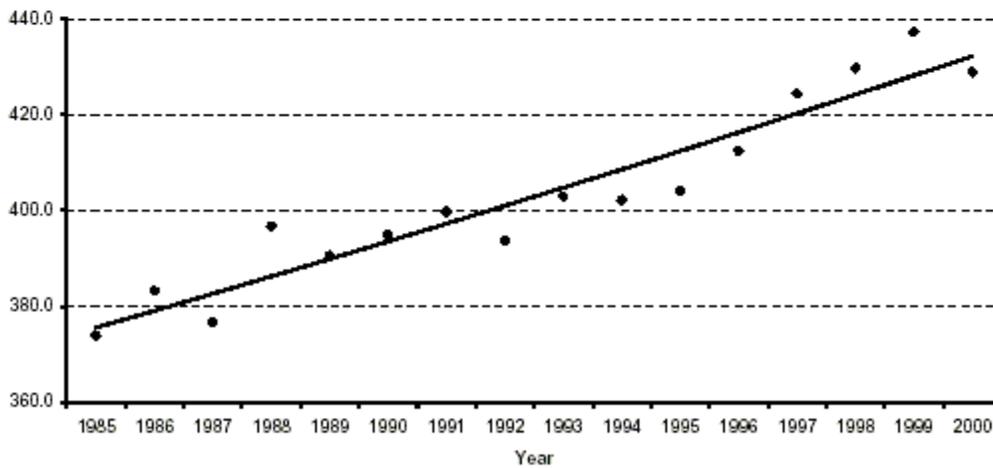


Figure 2 - Females: Age-Adjusted Cancer Incidence Rates



**Cancer Mortality Trends:**

Pennsylvania age-adjusted death rates for all cancer sites remained relatively stable from 1985 through 1990 (i.e. the slight increase in rates for this time period was not statistically significant at the 95% confidence level). Overall, cancer death rates have been decreasing by 0.8% per year from 1990 through 2001 (see Table 2 below). Among males, the cancer death rates have decreased by 1.3% per year from 1991 through 2001. Cancer death rates among females have decreased by 0.6% per year beginning in 1990.

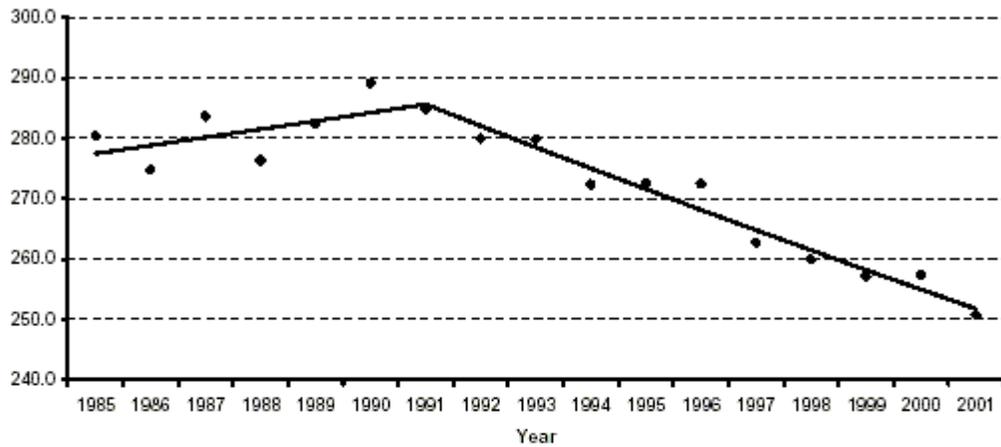
As with cancer incidence rates, the cancer mortality rates have been consistently higher for males, compared to females. The average annual age-adjusted cancer death rate for 1997-2000 among males was 48 percent higher than the rate for females (256.8 versus 173.6).

**Table 2 - CANCER MORTALITY**  
 Average Annual Age-Adjusted Cancer Death Rates\* (1997-2001) and Trends (Joinpoint Analyses for 1985-2001)  
 All Cancer Deaths by Sex, Pennsylvania Residents

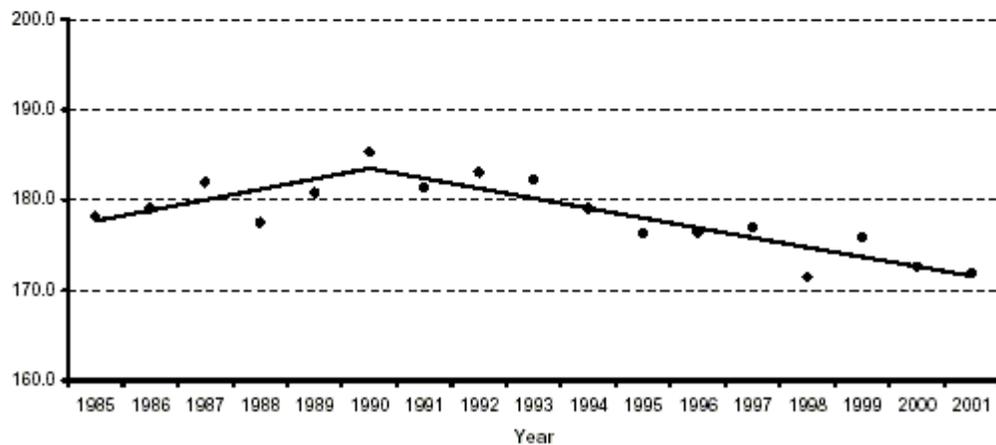
Cause/Sex/Race	Average Annual Rate* (1997-2001)	Joinpoint Analyses (1985-2001)							
		Trend 1		Trend 2		Trend 3		Trend 4	
		Years	APC**	Years	APC**	Years	APC**	Years	APC**
All Cancer Sites	206.3	1985-1990	0.5	1990-2001	-0.8 <sup>^</sup>				
Male	256.8	1985-1991	0.5	1991-2001	-1.3 <sup>^</sup>				
Female	173.6	1985-1990	0.6	1990-2001	-0.6 <sup>^</sup>				

\* 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  
<sup>^</sup> APC is significantly different from zero (two-side P<0.05)  
 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)

**Figure 3 - Males: Age-Adjusted Cancer Death Rates**



**Figure 4 - Females: Age-Adjusted Cancer Death Rates**



## Conclusions:

The joinpoint analysis of the trends in the age-adjusted cancer incidence and mortality rates allows the user to more accurately interpret changes over time and, more importantly, to determine if those changes are statistically significant. Figures 1 through 4 graphically display the results of the joinpoint analysis shown in Tables 1 and 2 by sex.

Overall, Pennsylvania cancer mortality trends show that progress is being made to reduce 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 cancer statistics can be obtained from the Health Statistics web pages of the Department's web site at [www.statistics.health.pa.gov](http://www.statistics.health.pa.gov) or by contacting the Division of Health Informatics (email: RA-DHIContactUs@pa.gov). The Division has also developed an interactive web tool, called EpiQMS, where users can create customized data tables, charts, maps, and county profiles of birth, death, cancer, and population statistics on-line. EpiQMS can also be accessed [online](#).

This article 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 report, other cancer publications, and the freeware Joinpoint Regression Program are available from the National Cancer Institute web site at [www.seer.cancer.gov](http://www.seer.cancer.gov).