Mortality From Lung Cancer and Tobacco Smoking in Ohio (U.S.): Will Increasing Smoking Prevalence Reverse Current Decreases in Mortality?

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Abstract

Background: **Despite significant changes in smoking patterns within the past few decades, lung cancer remains a major cause of cancer deaths in many developed countries in people of each sex, and one of the most important public health issues. The study aims to analyze the possible impact of changes in tobacco smoking practices in the state of Ohio (U.S.) on current and future trends and patterns of lung cancer mortality.**

Materials and Methods: **Mortality rates from lung cancer were calculated for the period 1970 to 2001 on the basis of data from the National Center for Health Statistics. The Joinpoint regression approach was used to evaluate changes in time trends by sex, age, and race. Data on smoking prevalence in Ohio were retrieved from the Centers for Disease Control and Prevention website.**

Results: **Lung cancer mortality rates in Ohio have declined among men of all ages as well as in specific age groups in the 1990s, and the rate of increase among middle-aged and elderly women has dropped over time. The mortality rate among young women (ages 20-44) began to increase during the early 1990s. The prevalence of smoking in Ohio has increased since the early 1990s, especially among young persons.**

Conclusions: **Recent trends in tobacco smoking in Ohio indicate that the declining trends in lung cancer mortality might be reversed in the future. An early indicator of possible change is the recent increase in mortality among young women. Implementation of the Ohio Comprehensive Tobacco Use Prevention Strategic Plan might help to disseminate proven prevention strategies among the inhabitants of Ohio and might thus prevent future increases in lung cancer mortality rates in the state.** (Cancer Epidemiol Biomarkers Prev 2005; 14(5):1182–7)

Introduction

Lung cancer is a leading cause of cancer deaths in the U.S. among both males and females and continues to be a major oncological problem in the country (1-3). Lung cancer mortality rates differ, however, among the states of the U.S. The rate in the state with the highest mortality from lung cancer (Kentucky) is more than three times higher than that in the state at lowest risk (Utah), both in males and in females (4). Mortality rates in Ohio are higher than the U.S. average in people of each sex (5). In 1997 to 2001, the average age-adjusted mortality rates in Ohio and in the entire U.S. were $53.5/10^5$ and $47.6/10^5$ for males and $28.5/10^5$ and $26.1/10^5$ for females, respectively.

The most important modifier of lung cancer risk in the population is tobacco smoking (6, 7). The prevalence of smoking in Ohio, 26.3% in 2000 (8), is one of the highest in the U.S. and is about 13% higher than the U.S. average. The smoking rate among young persons in Ohio is also higher than the national average: 13.7% of children in grades 6 to 8 and 33.4% of those in grades 9 to 12 were current smokers at the end of the 1990s, whereas the respective national averages were 9.2% and 28.5% (9). Ohio is one of the states with the highest sales of tobacco per person: in 1999, an average of 104.0 packs were sold per person in Ohio, whereas the average for all states was 89.9 packs (9).

Our aim was to analyze trends in lung cancer mortality in the State of Ohio in light of changing smoking patterns. The ultimate goal of the study was to indicate which groups in Ohio should be the primary targets for tobacco prevention strategies.

Materials and Methods

Data on mortality from cancer of the trachea, bronchus, and lung (International Classification of Diseases-9 code 162) in Ohio and California, by age, sex, race, and year were obtained from the National Center for Health Statistics with the SEER*Stat software (version 5.2.2) of the Surveillance Research Program of the National Cancer Institute (www.seer.cancer.gov/seerstat). Corresponding population data by age, sex, race, and year were extracted from the same source.

Age-standardized mortality rates were calculated for all ages combined and for the age groups 20 to 44, 45 to 64, and 65 and over for each sex separately. Rates were calculated for all races combined and for Blacks and Whites separately. We decided not to perform separate analysis for Latinos or other ethnic groups, as few cases occurred in these groups, and the numbers were insufficient for analysis. According to the 2000 U.S. census, 85% of the population of Ohio is White, 11% are African-Americans, and 4% are of other races. We also calculated mortality rates for California (by sex) for comparison with the rates of Ohio. The World Standard Population was used for age adjustment (10, 11) in order to make our results comparable to internationally published rates and time trends, most of which are based on this standard population.

A joinpoint regression was fitted to detect times at which significant changes in trends occurred and to derive estimated annual percentage changes in mortality rates for each detected trend segment (12-14). In this model, the annual age-adjusted rates over a given period are examined,

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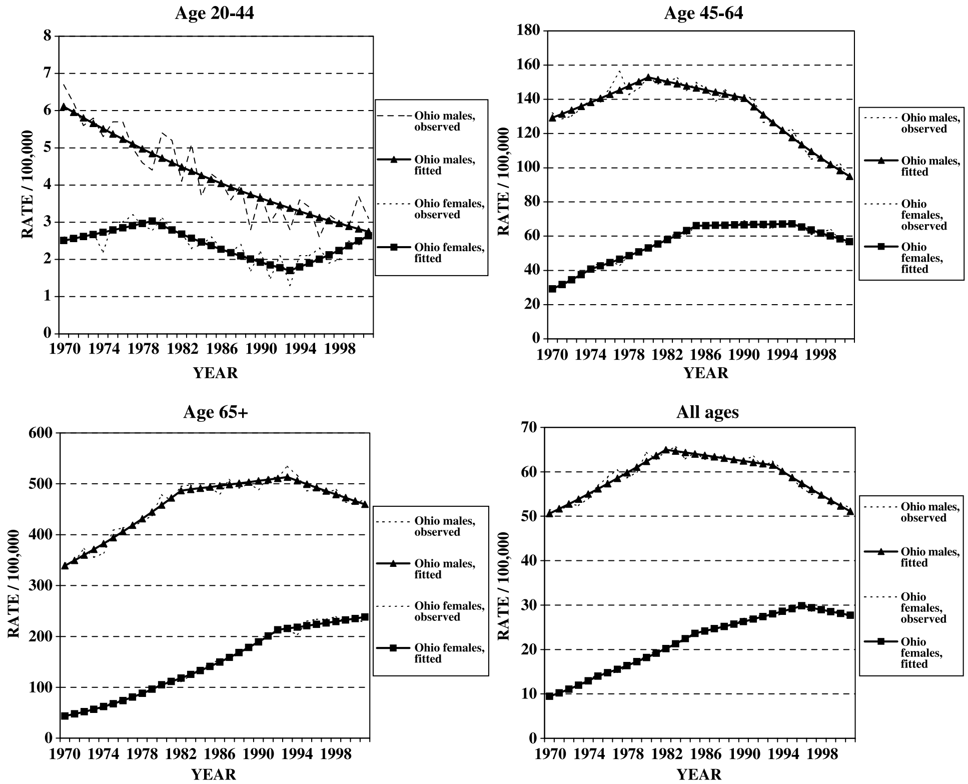

Figure 1. Trends in lung cancer mortality in Ohio, 1970 to 2001, by age and sex (observed and fitted values).

and the times at which the direction of the trends changes significantly are detected (14). Because joinpoints are detected by using the grid-search method to fit the regression function with unknown joinpoints (by performing several permutation tests for each individual data set, i.e., for each age group, sex, and race separately), the number of years between joinpoints varies for different data sets. The slopes of each neighboring pair of trend segments were tested for statistically significant difference (14). For each estimated annual percentage change, we calculated the corresponding 95% confidence interval. This type of nonlinear regression model has also been referred to in the literature as ''piecewise regression'', ''segmented regression'', ''broken line regression'', and ''multiphase regression with the continuity constraint'' (14).

Data on smoking prevalence, tobacco prices, taxes, and sales in Ohio and in the U.S. were retrieved from published reports (9, 15) and from the State Tobacco Activities Tracking and Evaluation system (via http://www2.cdc.gov/nccdphp/osh/state/index.asp). As no data were available on the prevalence of smoking among men ages 18 to 44, only the prevalence in women in that age group is presented.

In Figs. 1, 2 and 3, the term ''observed'' refers to the calculated age-adjusted mortality rates (based on the actual number of deaths), whereas the term ''fitted'' refers to values obtained from the models, i.e., fitted rates are obtained from the regression equations.

Results

General Pattern of Lung Cancer Mortality. Lung cancer is the most frequent cause of cancer deaths in Ohio among both men and women, accounting for 33.3% of all deaths from cancer in men and 24.6% in women in the period 1997 to 2001. In 1970 to 1974, lung cancer was also the most frequent cancer in men (30.9%), whereas in women it was the third most common cancer (9.3%), after breast (20.1%) and colorectal (17.0%) cancers.

The mortality rates from lung cancer in Ohio are higher than those in the U.S. as a whole. The rate of lung cancer in 1997 to 2001 in men in Ohio ($53.5/10^5$) was ~12% higher than the U.S. average ($47.6/10^5$), whereas that of women in Ohio ($28.5/10^5$) was ~9% higher than the U.S. rate ($26.1/10^5$).

Changes of Mortality Over Time. Table 1 and Fig. 1 present the results of the joinpoint regression analysis for all ages combined, for specific age categories, and for the Black and White populations of Ohio. Figure 2 shows the mortality trends in Ohio in comparison with those observed in California.

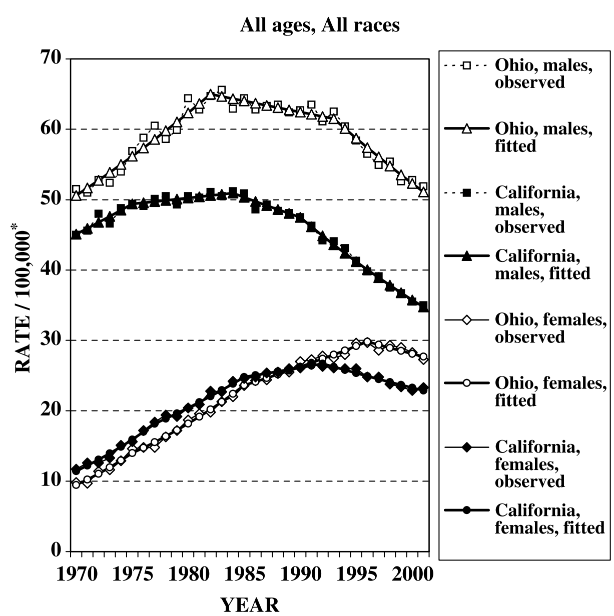

Figure 2. Trends in lung cancer mortality in Ohio and California, 1970 to 2001, by race and sex (observed and fitted values).

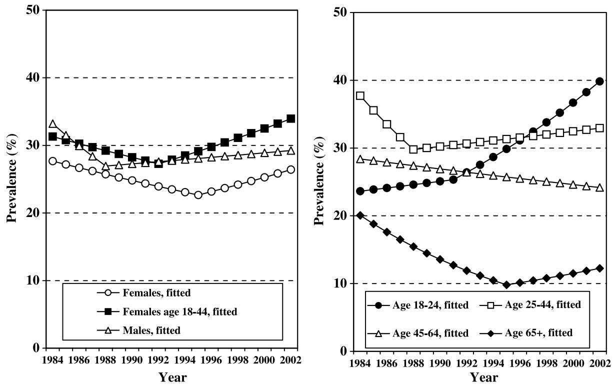

Figure 3. Trends in tobacco smoking prevalence in Ohio, 1984 to 2002, by sex and age (fitted values).

An analysis of time trends in men of all ages showed an increase in mortality during the 1970s by 2.1% per year, followed by a decline of −0.5% per year in the 1980s. An acceleration in the decline started in 1993, reaching −2.3% in the period 1993 to 2001 (Table 1). In women, a decline in the rate of mortality increase was observed, from 8.2% in the period 1970 to 1974 to 5.4% in the period 1975 to 1984 and 2.1% in the years 1985 to 1995, followed by a nonsignificant decrease (−1.5%) in the years 1996 to 2001 (Table 1).

In young adults (20-44 years of age), mortality declined by 2.5% in men throughout the period analyzed; in young women, mortality declined in the period 1979 to 1992 by 4.0% per year and then began to increase, to 5.6% per year in the period 1993 to 2001 (Table 1; Fig. 1).

In middle-aged (45-64 years of age) inhabitants of Ohio, mortality began to decrease among men in 1980 (−0.8% per year), and the decrease accelerated from 1990, to −3.5% for the period 1990 to 2001 (Table 1). In middle-aged women, a decline in the rate of increase in the 1980s and the first half of the 1990s was followed by a decrease in mortality rates in the second half of the 1990s (by −2.8%).

In the oldest age category (age 65 and over), an increase in mortality among males of 3.1% per year in the 1970s was followed by a plateau in the 1980s (nonsignificant increase of 0.5% per year). After 1993, a decrease of 1.4% per year was noted among elderly men (Table 1). In females, the rate of increase dropped, the increase of 9.2% per year in the 1970s being followed by an increase of 6.1% per year in the 1980s and 1.2% per year after 1992 (Table 1).

Compared with California (Fig. 2), mortality rates from lung cancer in Ohio men have been higher throughout the analyzed period. In women, mortality rates in California were higher compared with Ohio in the 1970s and 1980s, and then began to decline at the beginning of the 1990s. In Ohio women, the increase in rates continued until 1996 (Fig. 2).

Changes in Mortality by Race. In general, lung cancer mortality in Ohio is higher among African-Americans than in Whites for both males and females. The mortality rate in the period 1997 to 2001 was 35% higher in Black than in White men, and in females the difference was nearly 20%.

Nevertheless, the rate of decline in mortality in the 1990s among Black and White men was similar (−2.1% per year), whereas the decline was stronger among White (nonsignificant decline of 1.4% per year in 1996-2001) than among Black women (−0.5% per year, nonsignificant; Table 1).

Tobacco Smoking in Ohio. Ohio is one of the states with the highest prevalence of tobacco smoking by both men and women. Unfortunately, no data were available on tobacco smoking prevalence in Ohio before 1984, and it is therefore difficult to assess whether any changes in tobacco smoking prevalence in the state in the 1960s and 1970s had an impact on lung cancer rates in the 1980s and 1990s.

The existing data show that the prevalence of tobacco smoking among adult men in Ohio was declining in the second half of the 1980s (Fig. 3); however, this decline disappeared from the beginning of the 1990s. In females, after a decline in smoking prevalence in the 1980s and the first half of the 1990s, an increase in prevalence was observed from 1996. Among young women (ages 18-44 years), an increase in smoking prevalence commenced in the early 1990s, and it is now higher than that of the total male population (Fig. 3). The increase in smoking prevalence among young persons (18-24 years) in Ohio from the early 1990s was higher than in any other age group, and this age group had the highest smoking frequency in the beginning of the 2000s (Fig. 3).

Table 1. Lung cancer mortality time trends, 1970 to 2001, Ohio

Sex, age, race	Deaths, 1970-2001	Deaths per year (average)	Rate, 1997-2001*	Trend 1		*P* value, Trend 1 versus Trend 2
				Years	EAPC (95% CI)	
By age						
All ages						
Males	127,562	3,986	53.5	1970-1981	2.1† (*1.8, 2.4*)	<0.001
Females	62,009	1,938	28.5	1970-1974	8.2† (*6.2, 10.1*)	0.01
Age 20-44						
Males	2,596	81	3.2	1970-2001	−2.5† (*−3.0, −2.1*)	
Females	1,580	49	2.3	1970-1978	2.1 (*−0.9, 5.3*)	<0.001
Age 45-64						
Males	46,510	1,453	101.5	1970-1979	1.7† (*1.0, 2.4*)	<0.001
Females	21,567	674	60.0	1970-1973	8.8† (*5.0, 12.7*)	0.03
Age 65+						
Males	78,432	2,451	473.3	1970-1981	3.1† (*2.6, 3.5*)	<0.001
Females	38,845	1,214	232.8	1970-1979	9.2† (*8.2, 10.2*)	<0.001
By race						
Males, White	113,101	3,534	52.3	1970-1981	2.0† (*1.7, 2.4*)	<0.001
Males, Black	14,291	447	70.9	1970-1984	2.3† (*1.6, 3.0*)	<0.001
Females, White	55,749	1,742	28.1	1970-1974	8.5† (*6.7, 10.4*)	<0.001
Females, Black	6,131	192	33.3	1970-1972	−3.0 (*−11.9, 6.8*)	0.02

NOTE: Abbreviations: EAPC, estimated annual percentage change; 95% CI, 95% confidence intervals.
*Age-adjusted standardized rate (World Standard Population).
† $P < 0.05$.

Discussion

Our analysis of time trends in mortality from lung cancer in Ohio shows different tendencies in males and females. In males, mortality rates have declined for all ages combined and for specific age categories. Although this decline started at the beginning of the 1980s for all ages combined and for middle-aged men, it appeared only in the 1990s in the oldest age category. In the youngest men, a decline in mortality rates was observed throughout the study period. The trends for females are different. After significant increases in mortality in the 1970s and 1980s, the rate of increase declined in the 1990s for women of all ages and for older women, although a decrease in mortality has been observed since 1995 among middle-aged women (45-64 years of age). The situation for young women is alarming: after a decline in mortality during the period 1979 to 1992, a significant increase of 5.6% per year appeared.

The Black and White populations also show differences in lung cancer mortality. The mortality rates were higher among both males and females in the Black population; however, the decrease in mortality for men and the decline in the rate of increase in women commenced earlier among African-Americans than among Whites.

Despite the recent decline in lung cancer mortality in men in the U.S., this cancer site remains the most frequent cause of cancer deaths in the U.S. male population (2). Moreover, no significant decline is being noted among U.S. women (3, 16, 17). Jemal et al. showed declining mortality for subsequent birth cohorts of males in almost all age groups, whereas no decline was observed among young and middle-aged females (3). The same phenomenon was reported by Mannino et al. (16).

In Ohio, lung cancer remains the most frequent cause of cancer death for both males and females. Ohio is one of the 15 states with the highest lung cancer mortality rates in males and is the state with the 16th highest mortality rate in females.

Differences in lung cancer incidence and mortality by race have been observed in other U.S. populations (3, 18, 19). Nevertheless, it has been postulated that the risk for lung cancer is similar for Blacks and Whites with similar smoking habits (20), indicating that differences in exposure to tobacco smoke are the principal cause of differences in mortality. The National Health Interview Surveys show that the prevalence of smoking is higher among African-Americans (30.1%) than among Whites (27.3%; ref. 21). The intensity of smoking (number of cigarettes per day) and the type of cigarettes smoked seem to be more favorable for Blacks (21). There are several hypothetical explanations for the differences between Blacks and Whites. One is a difference in exposure to menthol cigarettes, which have been reported to result in a higher risk for lung cancer than non-menthol cigarettes (22, 23). In the U.S., 75% to 90% of African-American smokers prefer menthol cigarettes, whereas among White smokers this fraction is 20% to 30% (21, 24). Some other studies have not, however, confirmed the excess risk in relation to mentholated cigarettes (25, 26). Another possible explanation is the greater occupational exposure of African-Americans to carcinogens, differences in genetic susceptibility between Blacks and Whites, and differences in access to appropriate medical care (21). Bach et al. (27) documented differences between African-Americans and White patients in surgical treatment of early lung cancer. Other authors have postulated genetic predisposition, on the basis of familial aggregation of lung cancer cases, as a possible reason for racial disparities (28, 29).

One of the most effective ways of reducing the burden of lung cancer in a given population is to implement a tobacco control program. Such programs have been implemented in several states, e.g., in California, Florida, and Massachusetts (30). Barnoya and Glantz (31) showed that the California tobacco control program, enacted in 1988, may have led to the avoidance of about 11,000 lung cancer cases between 1989 and 1998. They estimated that, in the San Francisco-Oakland region of California (comprising five counties), 6% of lung cancer cases were avoided between 1988 and 1998 owing to the program. It has also been pointed out that the declines in lung cancer incidence rates in California in the 1990s were greater than in other SEER areas, and that a decline in rates among women was seen only in California (32). These observations indicate that a comprehensive tobacco control program can have a substantial effect on lung cancer rates. Jemal et al. (3) pointed out that tobacco control efforts are especially important among adolescents, as increases in smoking rates at that age could lead to a reversal of the lung cancer incidence and mortality rates in the U.S. Similar patterns of smoking by young men and women (born after 1960) have led to a convergence of lung cancer incidence and mortality rates in these birth cohorts (33).

Table 1. Lung cancer mortality time trends, 1970 to 2001, Ohio (Cont'd)

Trend 2		*P* value, Trend 2 versus Trend 3	Trend 3		*P* value, Trend 3 versus Trend 4	Trend 4	
Years	EAPC (95% CI)		Years	EAPC (95% CI)		Years	EAPC (95% CI)
1982-1992	−0.5† (*−0.9, −0.1*)	<0.001	1993-2001	−2.3† (*−2.9, −1.7*)			
1975-1984	5.4† (*4.6, 6.2*)	<0.001	1985-1995	2.1† (*−1.5, 2.8*)	<0.001	1996-2001	−1.5 (*−3.2, 0.3*)
1979-1992	−4.0† (*−5.7, −2.4*)	<0.001	1993-2001	5.6† (*1.9, 9.5*)			
1980-1989	−0.8† (*−1.6, −0.02*)	<0.001	1990-2001	−3.5† (*−4.1, −2.9*)			
1974-1984	4.5† (*3.6, 5.4*)	<0.001	1985-1994	0.2 (*−0.9, 1.2*)	0.01	1995-2001	−2.8† (*−4.6, −0.9*)
1982-1992	0.5 (*−0.1, 1.1*)	<0.001	1993-2001	−1.4† (*−2.2, −0.5*)			
1980-1991	6.1† (*5.2, 6.9*)	<0.001	1992-2001	1.2† (*0.1, 2.4*)			
1982-1992	−0.5 (*−0.9, 0.0*)	<0.001	1993-2001	−2.1† (*−2.7, −1.5*)			
1985-2001	−2.1† (*−2.7, −1.5*)						
1975-1984	5.2† (*4.5, 6.0*)	<0.001	1985-1995	2.2† (*1.6, 2.9*)	<0.001	1996-2001	−1.4 (*−3.1, 0.3*)
1973-1978	10.1† (*5.5, 15.0*)	0.01	1979-1990	3.4† (*2.1, 4.8*)	<0.001	1991-2001	−0.5 (*−2.0, 1.0*)

Gilpin et al. (34) showed a strong relationship between state tobacco control efforts, measured as a function of smoking bans at workplaces, smoking restrictions at home, and price of cigarettes (''initial outcome index''), and the prevalence of smoking in the state. At the beginning of the 1990s, Ohio was one of the states with the lowest initial outcome index, indicating little tobacco control effort (34). For instance, in Ohio, the cigarette excise tax (24.0 cents per pack) was nearly twice lower than the national average (41.9 cents per pack) in 2000 (9). From the beginning of the 2000s, however, Ohio was spending more money *per capita* for tobacco control activities ($20.82 in the fiscal year 2000; total, U.S.$236,386,232) than any other state (9).

In light of recent increases in tobacco smoking prevalence in Ohio, it is important to assess whether smokers are ready to quit. Recent surveys on smokers' stage of change showed that 39.3% of adult smokers in Ohio in 1998 to 1999 were considering quitting within the next 6 months (35). This proportion is considerably lower than that in California (49.1%), where tobacco control programs were implemented earlier than in most other states. It also means that nearly two-thirds of smokers in Ohio are not considering cessation in the near future. This is important information from the point of view of future prevention activities: in order to control lung cancer in the Ohio population, tobacco control programs must focus on smokers who are still far from taking a decision to quit. Most are probably smokers who are heavily addicted to nicotine, who are difficult subjects for cessation treatment.

The State of Ohio (like several other states, e.g., Arkansas, Colorado, and Oklahoma) has committed funds from settlements with the tobacco industry for a comprehensive program (30). The program is described in a document entitled ''*Ohio Comprehensive Tobacco Use Prevention. Strategic Plan 2004-2008*'' (36), published in June 2004. The program has five main goals: (*a*) prevent initiation of tobacco use, primarily by youth, (*b*) eliminate exposure of nonsmokers to secondhand smoke, (*c*) reduce tobacco use by those who already use tobacco, (*d*) identify and eliminate the disparities in tobacco use and its effects in population groups disproportionately affected by tobacco use, and (*e*) assure that public policy supports comprehensive tobacco control. This program should contribute to decreasing smoking rates among Ohioans and thus to diminishing lung cancer rates in the State.

Because the tobacco industry aggressively promotes its products (37-39), especially among minors (40), it is of vital importance to implement into comprehensive tobacco control programs, measures to focus on monitoring and addressing this type of influence. In California, for example, the primary goal of the Tobacco Industry Monitoring Evaluation is to assess the marketing influence of the tobacco industry across the state (30). In the case of the Ohio program (36), such an activity could be implemented within goal (*e*), i.e., ''assure that public policy supports comprehensive tobacco control.''

Conclusions. Recent increases in smoking prevalence in Ohio are likely to have a negative influence on future lung cancer incidence and mortality rates in the State. If current trends continue, a reversal in the current favorable mortality trends in men may be seen in 10 to 20 years. In women, a negative trend in mortality is already being seen in the youngest age category (20-44). Taking into account that the trends in smoking prevalence among women (especially young women) are unfavorable, prevention efforts should be concentrated on preventing a further increase in smoking in this group and on helping those who want to quit. It is hoped that the Ohio Comprehensive Tobacco Control Program will help to prevent many lung cancer deaths among Ohioans in the future.

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