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BRIEF REPORT

Reduced lung cancer incidence attributable to decreased tobacco use in urban Shanghai

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Abstract
Background Lung cancer has been the most common type of cancer in the world for several decades, and by 2008, there were approximately 1.61 million new cases, representing 12.7 % of all new cancers. It has been well known for many years that smoking causes lung cancer. Tobacco control measures have been regarded as the principal causes of the declines in smoking-related mortality, including mortality from lung cancer.
Methods The Joinpoint Regression Program was used to analyze the long-term trends in lung cancer incidence rates from 1983 to 2008 in urban Shanghai. In addition, this study estimates how many fewer cases of lung cancer have occurred in urban Shanghai because of tobacco control activities.
Results The lung cancer incidence rate among males decreased slightly by 0.6 % [95 % confidence interval (95 % CI) −0.1 to 1.3 %] from 1983 to 1999 and then declined rapidly at a rate of 3.8 % (95 % CI 2.1–5.4 %). Among females, the cancer incidence rate decreased by 0.1 % (95 % CI −0.2 to 0.5 %) from 1983 to 2008. Overall, we estimated that approximately 2,711 cases of lung cancer were averted among urban men in Shanghai between 2000 and 2008 because of the reduction in tobacco smoking.
Conclusion The reduction in tobacco smoking is a major factor in the decrease in the incidence rate of lung cancer. Sustained progress in tobacco control is essential.

Keywords Lung cancer · Joinpoint Regression Program · Smoking · Tobacco control

Introduction

Lung cancer has been the most common type of cancer in the world for several decades, and by 2008, there were approximately 1.61 million new cases, representing 12.7 % of all new cancers [1]. Lung cancer is the most common type of cancer among men worldwide (1.1 million cases, 16.5 % of the total). Among females, the incidence rate is generally lower, but lung cancer is still the fourth most frequent type of cancer among women (516,000 cases, 8.5 % of all cancers) and the second most common cancer-related cause of death (427,000 deaths, 12.8 % of the total) [1].

It has been well known for many years that smoking causes lung cancer. An association was firstly clearly documented in case–control studies conducted in Germany in the 1930s [2] and in the USA and Great Britain in the 1950s [3, 4]. A survey of a large cohort conducted by the US Surgeon General concluded that "cigarette smoking is a cause of lung cancer in men, and a suspected cause of lung cancer in women" in 1964 [5].

After 1964, several initiatives (collectively called "tobacco control") were introduced, including restrictions on smoking in public places, an increase in cigarette excise

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taxes, reduced access to cigarettes, and public education about the hazards of smoking. These smoking regulations have been cited as the principal contributors to the decline in smoking-related mortality [6]. Using a straightforward demographic projection, Thun and Jemal [7] estimated that the reduction in tobacco smoking averted approximately 146,000 lung cancer deaths among US men from 1991 to 2003.

Shanghai was one of the earliest cities in China to implement tobacco control policies; in 1994, "Interim Provisions of Smoking Bans in Public Places in Shanghai" was released by the Shanghai Municipal Government. With the implementation of the policy and the increasing public awareness of the hazards of smoking, the current smoking rate decreased significantly among adult males and females from 73.2 to 3.9 %, respectively, in 1997, to 44.3 and 3.5 % in 2008 [8, 9].

In this study, we performed a joinpoint regression analysis using age-standardized lung cancer incidence rates from 1983 to 2008 for each gender to evaluate whether the trends in the incidence of lung cancer changed and to predict how many fewer lung cancer deaths have occurred in Shanghai, potentially because of tobacco control activities.

Methods

Subjects

Shanghai is the largest city in China, with 17 county-level divisions and a total population over 23 million as of 2010. Shanghai's cancer registry was established in 1963. In accordance with the provisions of the Shanghai Bureau of Health, each medical institution (inpatient or outpatient) is responsible for reporting new cases of cancer diagnosed. In the study, urban Shanghai covers approximately 6 million individuals in nine county-level divisions (Huangpu, Luwan, Xuhun, Changning, Jing'an, Putuo, Zhabei, Hongkou, and Yangpu).

The data on the number of cases and age-standardized rates (Segi's population standard by WHO) of lung cancer for each gender were obtained from official publications by the Shanghai Municipal Center for Disease Control and Prevention and the Shanghai Cancer Institute [10] and Cancer Incidence in Five Continents [11]. The number of patients suffering from lung cancer (including tracheal, bronchus, and lung cancer; based on code 162 in the International Classification of Diseases, ninth revision [ICD-9], before 1999, and code C33-34 in the International Classification of Diseases, tenth revision [ICD-10]) and the age-adjusted incidence rates (expressed as rates/100,000 persons) were used in the trend analysis. Patient consent and ethical approval were not required because the present study did not involve direct contact with patients or collect personal identifiers.

Statistical methods

A joinpoint regression analysis was conducted to identify points where a statistically significant change occurred in the linear slope of the trend over time [12]. The Joinpoint Regression Program has been used extensively in recent cancer studies for examining temporal associations and calculating estimates [13–15]. The program analyzes trend data (in this case, age-standardized lung cancer incidence rates) and fits the simplest inflexion model possible. The program begins with the minimum number of joinpoints (for example, 0 joinpoints, which corresponds to a straight line) and tests whether there are additional statistically significant joinpoints that must be added to the model, thus enabling the user to test whether an apparent change in a trend is statistically significant [12].

In a joinpoint analysis, the best-fitting points where the rate changes (increases or decreases) significantly are chosen. Statistical significance is assessed using a two-sided P value of 0.05. In the final model, each joinpoint indicates a statistically significant change in the trend. The annual percentage change (APC) and the average APC (AAPC) are computed for each trend using generalized linear models, assuming a Poisson distribution.

This model can locate exactly where a significant inflexion (downward trend) first occurred. Each joinpoint estimates a beta-coefficient (the slope of the line), indicating the annual percent change in incidence per year. This study used the beta-coefficients that indicated the steepest slope for each of the gender to calculate expected lung cancer incidence rates assuming no further declines in the observed lung cancer death rates after the significant inflexion points in a particular calendar year [13]. The difference between this expected lung cancer rate and the observed rate is the absolute number of excess lung cancer deaths for each calendar year [13].

Results

The permutation tests showed that there was 1 joinpoint in the age-standardized lung cancer incidence rate among the males ($p = 0.005$) and 0 joinpoint among the females ($p = 0.037$) at the two-sided significance level of 0.0125.

Figure 1 shows that the male lung cancer incidence rate decreased slightly by 0.6 % [95 % confidence interval (95 % CI) −0.1 to 1.3 %] from 1983 to 1999 and then declined rapidly by 3.8 % (95 % CI 2.1–5.4 %). In contrast, there was a constant decrease in the female rate by 0.1 % (95 % CI −0.2 to 0.5 %) from 1983 to 2008.

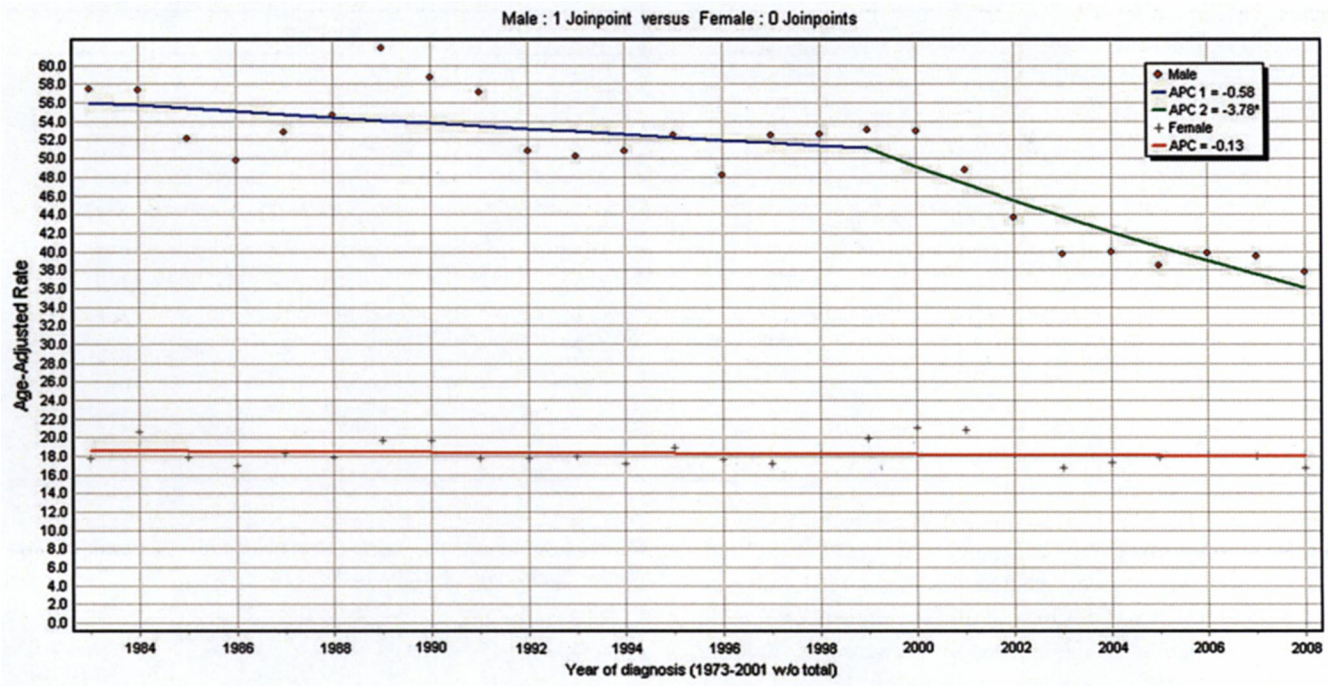

Fig. 1 Joinpoint analysis of lung cancer incidence rates among males and females, 1983–2008 (age-adjusted to Segi's population standard by WHO). Male: slope 1: 1983–1999; slope 2: 1999–2008. Female: slope 1: 1983–2008

Table 1 lists the expected lung cancer incidence rates among males from 1999 onwards if there had been a slight decline in the current rate based on the beta-coefficient (slope) for the joinpoint year (1983–1999). In other words, we assumed that the male lung cancer death rate decreased by 0.6 % per year from 1983 to 1999 and then continued at the same rate. Therefore, assuming that the steepest slope (a 0.6 % annual decrease) continued unabated from 1999 onwards, the annual expected lung cancer incidence rates were calculated based on the corresponding observed annual rate for each year. Consequently, a total of 4,143 more lung cancer deaths would have occurred in urban Shanghai from 1999 onwards if the observed trend had continued. Moreover, because the population attributable risk (PAR) of tobacco smoking is 65.44 % (i.e., 65.44 % of male lung cancer deaths are assumed to be attributable to smoking exposure alone) [16], at least 2,711 excess lung cancer deaths would have occurred in males.

Discussion

In the USA, approximately 88 % of the lung cancer deaths in men and 71 % in women are attributable to cigarette smoking [17]. Because of the tobacco control measures triggered by the 1964 US Surgeon General's Report and the comprehensive statewide Massachusetts Tobacco Control Program (MTCP) that began in 1993, it was estimated that 23,520 fewer lung cancer deaths occurred from 1977 onwards. This decline in mortality is most likely attributable to tobacco control and represents a substantial public health achievement in Massachusetts [13].

Jha [18] reported that the prevalence of smoking in China has risen dramatically since 2000 (mainly based on the mean consumption of Chinese men in cigarette production). It has also been reported that the incidence of lung cancer in China increased from 1988 to 2005 [19, 20]. The smoking rate in China decreased slightly from 1993 to 2002 [21, 22]. In Shanghai, the largest city in China, the smoking rate decreased significantly among males (from 73.2 % in 1997 to 44.3 % in 2008) and decreased slightly among females (3.9–3.5 %), but these figures are dramatically different from the rates in the rest of China [8, 9]. In this study, we showed that the incidence rate of lung cancer among males decreased slightly (0.6 % of APC) from 1983 to 1999 and then declined rapidly (3.8 % of APC) and that the rate among females decreased slightly (0.1 % of the APC), consistent with the findings that the smoking rate decreased significantly among males and decreased slightly among females [8, 9].

The "Interim Provisions of smoking bans in public places in Shanghai," released by the Shanghai Municipal Government in 1994, might be the first anti-smoking interventions initiated by officials in China. Fortunately, these provisions, combined with increasing public awareness of the hazards of the smoking, yielded significant outcomes. This study estimated that the reduction in tobacco smoking averted approximately 2,711 lung cancer

Table 1 The observed, predicated age-adjusted incidence rate and number of lung cancer cases in urban Shanghai

Years	Observed		Predicated	
	Age-adjusted incidence rate	Number of lung cancer cases	Age-adjusted incidence rate	Number of lung cancer cases
2000	53.0	2,666	50.8	2,556
2001	48.8	2,588	50.5	2,681
2002	43.7	2,541	50.2	2,921
2003	39.7	2,370	49.9	2,979
2004	40.0	2,504	49.6	3,108
2005	38.5	2,419	49.3	3,098
2006	39.9	2,461	49.1	3,029
2007	39.4	2,471	48.8	3,056
2008	37.7	2,579	48.5	3,314
Total		22,599		26,742

deaths among urban men in Shanghai from 2000 to 2008. As in the USA and in Andalusia, Spain [15], tobacco control initiatives did not have dramatic impacts on female lung cancer incidence rates, possibly because the smoking rate among females decreased only slightly [8, 9].

Thirty-year or long lag between changes in smoking prevalence and changes in lung cancer were observed in several studies [23–25]. Another study showed that the lag between changes in smoking prevalence and changes in lung cancer was 6–7 years [15]. In addition, the smoking rate is low among those who have received higher education and live in cities (compared to rural areas) [8, 9], and this study was conducted in urban Shanghai, where the residents were relatively aware of the health effects of smoking and may have quit smoking before the provisions were released.

Considering that it takes several years for smoking trends to affect the incidence of lung cancer, the deceasing trend in the incidence of lung cancer will continue, even without additional tobacco control initiatives in Shanghai. Unfortunately, tobacco control can only be truly effective in a few cities, such as Shanghai and Hangzhou; in the country as a whole, the total consumption of tobacco will still increase. The report will be useful to government officials and the public because it will encourage them to consider the effects of tobacco control in reducing the incidence of lung cancer.

China's National People's Congress announced its decision to ratify the WHO's Framework Convention on Tobacco Control (FCTC) on 28 August 2005, and on 20 May 2009, the Ministry of Health of the People's Republic of China issued a formal decision to completely ban smoking in all health administration offices and medical facilities by the year 2011. Therefore, additional tobacco control measures can be expected, and the incidence of smoking-related diseases will continue to decline in the future.

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Competing interests The authors declare that they have no competing interests.

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