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Lung cancer incidence in Singapore: Ethnic and gender differences

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ABSTRACT

Objectives: Lung cancer is the leading cause of cancer death in Singapore. We examine trends of lung cancer from 1968 to 2007, explore ethnic and gender-specific incidence rates, and examine period and cohort effects in Chinese and Malays using Age-Period-Cohort (APC) analysis.
Methods: Aggregated data for cancer incidences and estimated person-years for the period 1968–2007 were obtained from the Singapore Cancer Registry. An APC analysis was performed using a Poisson regression model.
Results: Lung cancer incidence rates were more than two times higher in males compared to females, and also higher in Chinese compared to Malays and Indians. While rates in Chinese men, and, to a lesser extent, Chinese women, had been declining since the early 1980s, rates in Malay men continued to increase. The full APC model described the cancer trend in Chinese males, Chinese females and Malay males, while an age-drift model described the cancer trend in Malay females. Among Chinese males, Chinese females and Malay males, there was no clear pattern to the period curvature effects, although similar cohort curvatures were seen, with positive curvature effects in older cohorts that declined towards zero and negative effects in younger cohorts.
Conclusion: There are strong gender and ethnic differences in lung cancer incidence in Singapore. Differences in smoking rates and differential ethnic effects of smoking may explain some but not all of these differences. The similar cohort curvatures suggest that environmental factors in Singapore occurring in the past but no longer present at similar intensity or frequency may explain the positive deviation from a linear trend. Apart from smoking, other environmental factors such as changes in diet, improved sanitation and ventilation, and declines in infectious diseases like tuberculosis may play a role.

1. Introduction

Lung cancer is the leading cause of cancer death in Singapore [1], and, excluding skin cancer, was the most common cancer in men and the third most common in women in Singapore between 2003 and 2007 [1]. Smoking is well-established as the main cause of lung cancer [2]. However, the proportion of lung cancer patients who smoke is much lower in Chinese populations [3] than in Western Caucasian ones. In Singapore, the prevalence of smoking among Chinese female lung cancer patients recruited in a case-control study is about 40% [4]. The prevalence of smoking in Singaporean men with lung cancer is about 85% [5]. No comparable data are available for Malay men and women, although 80–90% of lung cancer patients in neighbouring Malaysia are smokers [6].There is a relatively low prevalence of daily smoking in Singapore of about 14% [7].

In 1998, Seow et al. examined trends of lung cancer in Chinese females in Singapore from 1968 to 1992, and concluded that traditional practices such as Chinese cooking may play a role in local lung cancer etiology [8]. This paper extends this work by examining trends of lung cancer and smoking between 1968 and 2007. In addition, it examines gender-specific incidence rates in Chinese and Malays, and examines period and cohort effects in these two ethnic groups, using Age-Period-Cohort (APC) analysis. Differences in the incidence rates of lung cancer over time in these two ethnic groups, despite both groups living in the same physical environment during that time, may provide additional insights into the etiology of lung cancer in Asians.

2. Methods

2.1. Lung cancer incidence data

Aggregated data for cancer incidences and estimated person-years for the period 1968-2007 were obtained from the Singapore

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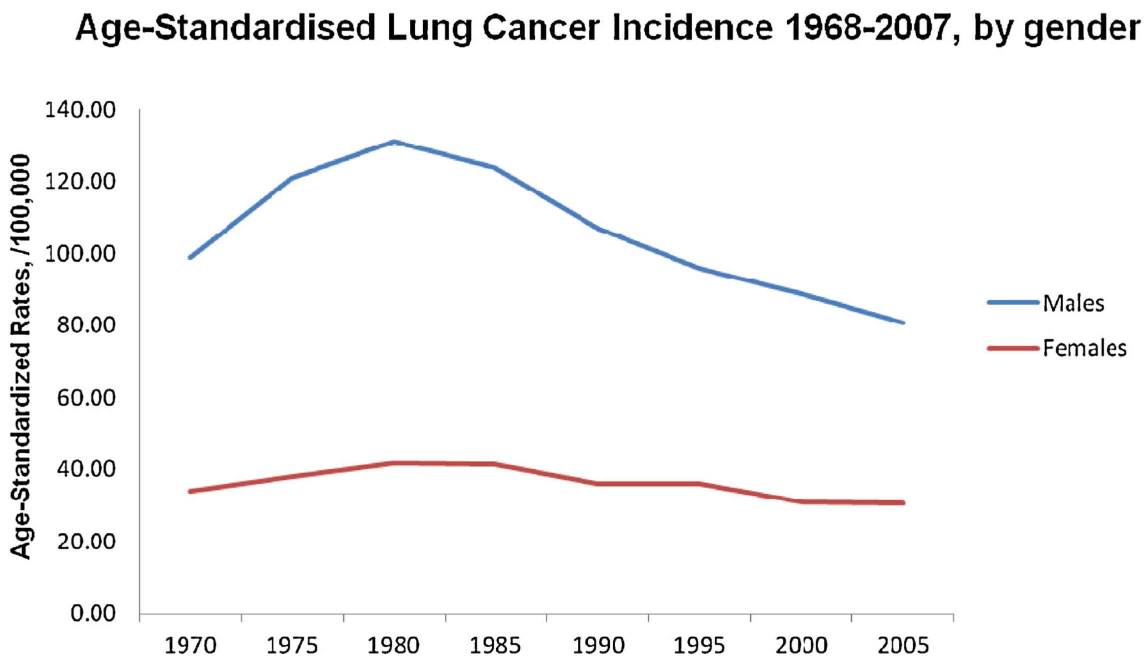

Fig. 1. Lung cancer incidence in Singaporean men and women, 1968–2007.

Cancer Registry (SCR), by ethnicity and 5-year age, period and birth cohort groups. The mid-points of the age-groups and periods of diagnosis were used to assign cohorts. This assigned value represents the mid-point of a ten-year cohort range. The SCR maintains a register of all cancer cases reported in Singapore, and information about incident cancers comes from notifications made by medical professionals, pathology reports, hospital records, and death certificates. Since 2007, cancer notifications have been made compulsory under the National Registry of Diseases Act [9]. The Registry estimates that cancer reporting is 97.8% complete for the period 1968–1977, and 99.0% for 1993–1997[10]. Person-year estimates were derived from mid-year population estimates made by the Department of Statistics Singapore. The World Standard Population was used to compute the age-standardized rates. Indians and people of other ethnic origins were excluded from the APC analysis as their numbers are too small for stable estimates. Ethics clearance was not sought as no individual data were collected, and the study used already published aggregated data.

2.2. Age-Period-Cohort model

The APC model is a Poisson regression model, where the number of events in each age group and period combination is modeled as a Poisson random variable [11]. It is a quantitative method for assessing cancer trends over time and the relative importance of age, period and cohort effects in cancer incidence risk. Period effects affect all age groups equally, such as changes in lung cancer detection and diagnosis, while birth cohort effects affect age groups unequally, such as changes in lifestyle and behavioural factors. Five models were considered in a model-building approach, using the Likelihood Ratio test (LR test) [12]. The first model had only the age factor. The second model was an age-drift model where the drift term was the temporal variation of rates indistinguishable as either period or cohort influences. The third and fourth models were the age-period and age-cohort models. Finally the full APC model was considered. To compare across five models, the Likelihood Ratio Test and the Akaike Information Criterion (AIC) were used. The goodness of fit of the models was determined using the deviance statistic. If the deviance statistic showed poor fit for the final model from the model-building approach, the *F*-test was used as it accounts for over-dispersion (as suggested from a poor fit on the deviance statistic). The exact linear relationship between age at diagnosis, birth cohort and period of cancer diagnosis results in an identifiability problem that does not allow simultaneous estimation of all three effects. To circumvent this problem, curvature effects were estimated for each factor in the full APC model. These curvature estimates are identifiable and invariant [13,14], and represent the departure from an overall linear trend that is estimated using the usual least squares estimate. All analyses were performed using STATA version 10 and R version 2.14.0 [15].

3. Results

Age-Standardised Lung Cancer Rates differed between men and women in Singapore for the period 1968–2007, with higher rates in men than women. In addition, the rates in men rose rapidly and peaked in the early 1980s, before declining sharply (about 40% between 1980 and 2005). The rates for females, although lower, also showed a peak in the early 1980s, with a decline subsequently (about 30% between 1980 and 2005) (Fig. 1).

Lung cancer incidence was highest amongst the Chinese in both males and females, with lower rates in Malays (Figs. 2 and 3). In both Chinese men and women, lung cancer incidence peaked in 1980, with a decline after. Malay male and female incidence rates both showed an increase between 1970 and 1985, and then stabilized thereafter.

The proportion of lung cancers without histological diagnosis has declined from about 46% in the period 1968–1972 to about 14% in the period 2003–2007 (Fig. 4). The proportion of squamous cell carcinoma has fluctuated in the 15–20% range, while the proportion of adenocarcinoma has increased sharply from 8% to 40%. The proportion of foreign-born among Singapore citizens and Permanent Residents with lung cancer has decreased from about 80% in 1968–1972 to about 30% in 2003–2007 (Fig. 5).

Smoking prevalence rates in Singapore [7,16–24] are tabulated in Table 1. The studies conducted after 1992 were nationally representative Ministry of Health surveys, while earlier studies were community-based studies that may not be representative. A