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Trends in mortality and mean age at death from lung cancer in Austria (1975–2007)

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ABSTRACT

Objective: To investigate trends in mortality and mean age at death from lung cancer (MADLC) compared to mean age at death from all causes (MAD) over the period 1975 - 2007 in Austria. Results are assessed with respect to secular trends in smoking habits. *Methods:* MAD and MADLC were computed by year and gender as the expected value of a fitted Weibull distribution. Age-period-cohort effects on lung cancer death rates were estimated by hierarchical Poisson models. *Results:* In females MADLC was on average about 2 years higher than in males and tended to decrease since the mid 1980s, while after the mid 1990s MADLC in males increased such that the difference between men and women shrank to about half a year in 2007. Females dying from lung cancer lost about 6 years of life during the late 1970s but more than 10 years after 2000, while males lost 2 years in the 1970s and 5 years after 2000. Males demonstrated a decreasing risk with increasing year of birth, with the exception of cohorts born during or immediately after the World Wars that showed peak relative risks (RR). Females did not show pronounced birth cohort effect except for a peak RR for cohorts born during and after World War II. *Conclusions:* MADLC provides additional information about secular trends in addition to incidence data. The declining trend of MADLC in females and in males up to the mid 1990s points to a change of smoking habits with an earlier onset of smoking in both genders. The subsequent increase in males during the last decade may be attributed to an increasing proportion of quitters because smoking cessation delays onset of lung cancer.

1. Introduction

Lung cancer is an important cause of death worldwide: it accounted for 1.4 million deaths in 2007 [1]. Approximately 3300 people (among them 70% men and 30% women) die from lung cancer every year in Austria, with lung cancer accounting for 18% of all cancer deaths (age-standardized mortality rate: 23.8 per 100,000, WHO world population 2001) [2]. In Austria lung cancer still represents the leading cause of death from cancers in males, with a proportion of 23%. However, their risk of dying from lung cancer dropped by more than 20% in the last 10 years. In females this disease is the second-most frequent cause of cancer deaths accounting for more than 10% of all deaths from malignant neoplasias and incidence increased by almost 20% during the last decade. Despite this trend, men still face a 2.5 times higher risk of dying from lung cancer than women [3]. Although the age-standardized incidence in females was about 2.4 times lower than in males in 2006 (females: 17.5/100,000, males: 42.3/100,000) [4], the crude ratio of women to men newly diagnosed with lung cancer was of 50:100 in a total of more than 3900 new cases during the same year [5].

Improvements in living conditions and in diagnosis, management and prevention of many diseases have resulted in a constant increase in life expectancy (LE) at birth over the last decades in Austria. The impact of the various causes of death on this trend in LE is quite different. In this report we concentrate on mortality trends for lung cancer in Austria over a period of more than 30 years.

Descriptive epidemiology of mortality experience in a population is based on different measures. Mortality rates and in particular age-standardized mortality (ASM) can be used to compare overall and cause-specific risk of dying during a specific period of time across different populations or segments of populations. This measure of occurrence integrates risk factors as well as factors delaying or counteracting occurrence of death (such as preventive and curative activities). We used mortality rates to compare occurrence of lung cancer in males and females during different time periods. Life expectancy (LE) is commonly

Abbreviations: APC, age-period-cohort; ICD, International Classification of Diseases; LE, life expectancy at birth; MAD, mean age at death from all causes; MADLC, mean age at death from lung cancer; RR, relative risk; WHO, World Health Organization.

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used to reflect the overall mortality level [6]. It is equal to mean age at death for a stationary population (i.e. a population with unchanged ASM). In our work we focused on mean age at death (MAD). MAD is independent of ASM. It reflects the quality of the health system, i.e. advances in prevention, diagnosis and therapy experienced by all cohorts surviving to the respective year as well as improvements of socio-economic conditions in general. Furthermore, cause-specific MAD, such as MAD from lung cancer (MADLC), as assessed in this report, also reflects temporal distribution of risk factors present in the cohorts observed within the respective time interval and the latencies from onset of the disease process (such as induction of a lung cancer) and death. While calculation of LE and ASM requires death as well as population data, MAD only requires death data and does not need standardization [7].

Hence MADLC during a specific year reflects the length and intensity of exposure to risk factors (mainly tobacco smoke and radon) but also the quality of the health system in detecting the disease and the efficacy of treatment [8]. Surprisingly, this indicator has not been widely used in the past, especially with regard to lung cancer time series. The difference between MADLC and MAD is an estimate of the average loss in life years of a person dying from lung cancer, since the contribution of lung cancer deaths to MAD is negligible (only 1–6% of annual deaths are due to lung cancer) [3].

The aim of the study was to analyse trends in MADLC in relation to MAD in the last decades. It was hypothesized that the trend of loss in life years as indicated by the difference between MAD and MADLC will differ between males and females mainly as a consequence of trends in smoking habits. Furthermore, we used age-period-cohort (APC) analysis to disentangle the time trends of mortality within age groups and cohort effects which could provide a basis for further interpretation of differences in time trends.

2. Methods

Mortality data in 5 years age groups were obtained from Statistics Austria for the calendar years 1975–2007. During this period three revisions of the International Classification of Diseases (ICD) were used. MADLC was computed from deaths with the diagnosis "malignant carcinoma of trachea, bronchi and lungs" (code "162" in ICD-8 and ICD-9 and "C33-C34" in ICD-10). Mortality was standardized to the WHO Standard World Population 2000–2025. Computation of MAD and MADLC was performed separately for males and females for every calendar year and for age at death above 20 years because juvenile lung cancer is a different entity. MAD and MADLC were defined as the expected value of a fitted Weibull distribution for all deaths and for deaths from lung cancer, respectively. Estimation of the parameters of the Weibull distribution was done by the Newton–Raphson algorithm minimizing the chi-square loss function. A pseudo R^2 was computed based on the ratio of the residual sum of squares to the total some of squares according to the approach by McKelvey and Zavoina [9]. In all cases the fit was excellent and exceeded 95%. Confidence intervals for MAD and MADLC were computed based on the standard errors of the estimates assuming them to be normally distributed. Confidence intervals for the difference between MAD and MADLC were computed from the square root of the sum of the variances of MAD and MADLC, which is only slightly over-estimating the true variance because lung cancer accounts only for about 1% of deaths in females and about 5% in males. Weibull estimation instead of directly computing the average was chosen for the following reason: due to the estimation algorithm both values (direct averages and Weibull estimates) are virtually identical, but the Weibull estimates are based on the assumption the observed distribution of age at death was a random sample from a Weibull distribution with unknown parameters that are estimated from the observed data and provide for an estimate of the variance of these parameters too. Hence the advantage lies in the possibility to compute a confidence interval for MAD or MADLC that can be interpreted as the interval of MAD or MADLC, respectively, of a Weibull distributed age at death from which the observed distribution could have been sampled. The rational is equivalent to that used for incidence data that are often considered to be sampled from a Poisson distribution.

For comparison of lung cancer mortality trends in males and females age-standardized mortality was computed (rel. to the WHO Standard World Population 2000–2025). Furthermore, to assess the contribution of the different age groups cumulative standardized lung cancer mortality was determined.

Age-period-cohort (APC) analyses were done applying hierarchical Poisson regression with age entered first, followed by birth cohort (in 10 year groups) and calendar year periods (1975–1979, 1980–1984, . . ., 1995–1999, 2000–2007). Cohort and period effects were expressed as relative risks (RR). Reference cohort comprised those born between 1880 and 1889. For period effects reference category was 1975–1979. Due to the hierarchical procedure effects of birth cohorts on lung cancer mortality can be assessed independent of age effects and calendar period effects independent of both age and cohort effects.

3. Results

Compared to 1975–1979, lung cancer mortality decreased in the years 2005–2007 nationally by 13%. Substantial decrease in males (36%) was, however, accompanied by a strong increase (72%) in females (Table 1).

During the period 1975–2007 mortality from lung cancer in males has not changed much up to age 60 with the overall reduction due to the substantially reduced incidences in those aged 65 and above. In contrast, the increase of lung cancer mortality in females is present in all age groups (Fig. 1).

MADLC over the period 1975–2007 showed a distinctly different pattern in males as compared to females. MADLC in females was about 2 years higher than in males. While a decreasing trend was apparent in males until the mid 1990s, MADLC remained stable (except for the years 1975 and 1976 with a distinctly lower MADLC) with some fluctuation in females until the 1990s and started to decrease thereafter approx. 1.2 years per decade when males showed an increasing trend of approx. 0.7 years per decade (Fig. 2). The average MADLC over the 33 years period is 68.6 years (min. 67.7, max. 69.7) in males; females had an average MADLC of 70.5 years (min. 69.3, max. 71.8) (data in Fig. 2). In contrast to MADLC, MAD has been increasing continuously in Austria in both, man and women. Compared to the period 1975–1979, males gained 2.8 years and females 4.7 years during the period 2005–2007. As shown in Fig. 3 the discrepancy between MADLC and MAD

Table 1
Standardized mortality (rel. WHO Standard World Population 2000–2025) of lung cancer and percent change rel. to the years 1975–1979.

Years	Standardized mortality × 10^{-6}			Δ% (rel. 1975–1979)		
	Males	Females	Total	Males	Females	Total
1975–1979	575.7	77.8	270.8	0.0	0.0	0.0
1980–1984	553.8	89.3	268.6	−3.8	14.8	−0.8
1985–1989	518.7	96.3	262.6	−9.9	23.8	−3.0
1990–1994	494.7	106.8	263.3	−14.1	37.3	−2.8
1995–1999	450.0	118.9	256.4	−21.8	52.8	−5.3
2000–2004	405.3	128.9	246.5	−29.6	65.7	−9.0
2005–2007	366.3	133.7	235.1	−36.4	71.9	−13.2